Management Plan

Glover's Reef Marine Reserve

2019 – 2023

A. Tewfik / WCS

GLOVER'S REEF MARINE RESERVE

MANAGEMENT GOAL

To provide protection for the physical and biological resources of Glover's Reef Atoll, in order to maintain and sustain these resources for the benefit of current and future generations.

OBJECTIVES

1. To provide protection for the physical and biological resources of Glover's Reef

2. To provide an enabling environment for economic opportunities for local communities and society, towards sustainable development

3. To increase awareness and understanding of the natural resource of Glover's Reef through education and research

4. To provide resources for recreation and tourism

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2019

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Acknowledgments

We would like to thank all the staff of the Belize Fisheries Department, both in Belize City and at Glover's Reef, and the staff of the Wildlife Conservation Society for their input into this management plan. Of equal importance is the input of the stakeholders the fishers and the tour guides, whose lives are linked to the health of the marine resources at Glover's Reef Atoll.

CONTENT

INTRODUCTION

Background and Context

Glover's Reef Marine Reserve (GRMR), encompassing the southernmost of Belize's three offshore atolls, is 32 km long and 12 km wide and covers approximately 86,653 acres (35,067 hectares). It forms part of the Mesoamerican Reef – the longest barrier reef system in the Western Hemisphere, stretching approximately 1,000 km from the Yucatan Peninsula to the Bay Islands in Honduras. GRMR was established in 1993 (SI 38 of 1993 / updated to include SI 137 of 2001) as part of Belize's National Protected Areas System, based on its recognition as one of the highest priority sites in the Mesoamerican Reef system. It is also one of seven protected areas that form the Belize Barrier Reef Reserve System - World Heritage Site, in recognition of its high global value - it is considered the prototypic atoll of the Caribbean, highlighted for its particularly rich biodiversity. It is not only the best developed Atoll biologically, but is also considered to possesses the greatest diversity of reef types (Dahl et. al. 1974).

The relatively deep Atoll lagoon is studded with about 850 patch reefs and pinnacles that rise to the surface, with six sand cayes lying on the reef crest along the Atoll's southeastern edge. The peripheral reef is broken in only three places by deep channels, allowing tidal flow of water between the lagoon and the open sea. The protected waters of the Atoll's lagoon provide nursery and feeding habitats for at least three species of sea turtles, eight species of sharks and rays, more than twenty species of aggregating reef fish, as well as numerous species of coral. The Atoll provides recruitment, nursery, feeding and dwelling areas for lobster, conch and fin-fish, supporting a rights-based fishery, and unique fish habitat in the interior lagoon. The aesthetic beauty of the cayes and reef are also central for the support of the local and national tourism industry. The spur and groove formations of the outer reef structure are world famous for their spectacular diving opportunities attracting divers, snorkellers, kayakers, and fly fishermen from all over the world.

The Glover's Reef Marine Reserve Statutory Instrument designates four management zones: the General Use, Conservation, Wilderness and Seasonal Closure Zones, each having regulations that define permitted activities. The protected area is aligned with IUCN Category VI – a Habitat/Species Management Area, with active management targeted at conservation through management intervention (IUCN, 2012). This may be reviewed The Northern Glover's (North East Point) spawning aggregation site, designated under Statutory Instrument SI 161 of 2003, is considered part of the management area, and overlaps the north east corner of the Marine Reserve.

The partnership between the government authority (the Fisheries Department) and the Wildlife Conservation Society (a research-based conservation NGO) is an opportunity for ensuring well-informed, science-based management of this marine protected area, providing a model for other marine reserves in Belize and in the region.

Summary of Key Characteristics:

- Best developed of four unique atoll formations in the MAR region (and one of three in Belize)
- Greatest diversity of reef types in Belize
- Western wall was once considered among the most diverse and densely covered sites reported anywhere in the Caribbean, exhibiting 95% living cover and as many as 11 species per square meter
- Relatively deep, protected lagoon with extensive patch reefs
- Historically, one of the Caribbean's and Belize's largest and last remaining viable Nassau grouper spawning aggregations
- Three deep water channels that allow for water exchange between the Atoll lagoon and oceanic water
- High connectivity between littoral forest, mangrove, seagrass and reef
- An important way-point for Neotropical migratory birds and nesting structure for residents
- Designated as part of the Belize Barrier Reef Reserve System - World Heritage Site

Summary of Climate Change Resilience Features

- Channels through reef barrier with strong flow and water exchange (though limited to three channels), reducing water temperatures in Atoll lagoon
- Includes reef drop off, with increased shelf / oceanic water interchange, reducing risk of higher water temperatures
- West facing slope of the Glovers Reef Atoll shades corals, reducing damaging UV radiation
- Reef relief and environmental gradient - fore reef, reef crest, back reef and lagoon with reef patches – increasing potential for coral tolerance to different temperature regimes
- Lower impacts of water contamination from land-based sources with increased distance from shore (however the enclosed lagoon also leads to increased nutrient loads)

National Protected Areas System Rationalization Report (Walker et al., 2012)

Purpose and Scope of Management Plan

This Management Plan provides the contextual background for informed management decision making, and a structured framework of activities to assist the Fisheries Department (the management authority), Wildlife Conservation Society (the key research partner) and other partners to ensure Glover's Reef Marine Reserve continues to support both biodiversity and livelihoods. The management of Glover's Reef Atoll is guided by its categorization as a marine reserve, designated under the Fisheries Act:

> *"To ensure, increase and sustain the productive service and integrity of the marine resources for the benefit of all Belizeans of present and future generations."*

This Management Plan has been developed to guide the management of the Marine Reserve through the next five years (2019 – 2023). In line with the National Protected Areas Policy and System Plan, it reflects the participatory approach to management being adopted in Belize today, with the input of key stakeholders of GRMR, through focal group meetings, Fisheries Department / GRMR staff (both at management and field level), and the Glover's Reef Marine Reserve Advisory Council.

Providing Context: The Plan includes baseline information on the physical, socio-economic, biological and ecosystem service attributes of the Marine Reserve, based on past and current research conducted in the area, and documents the legislative framework. It summarizes current uses

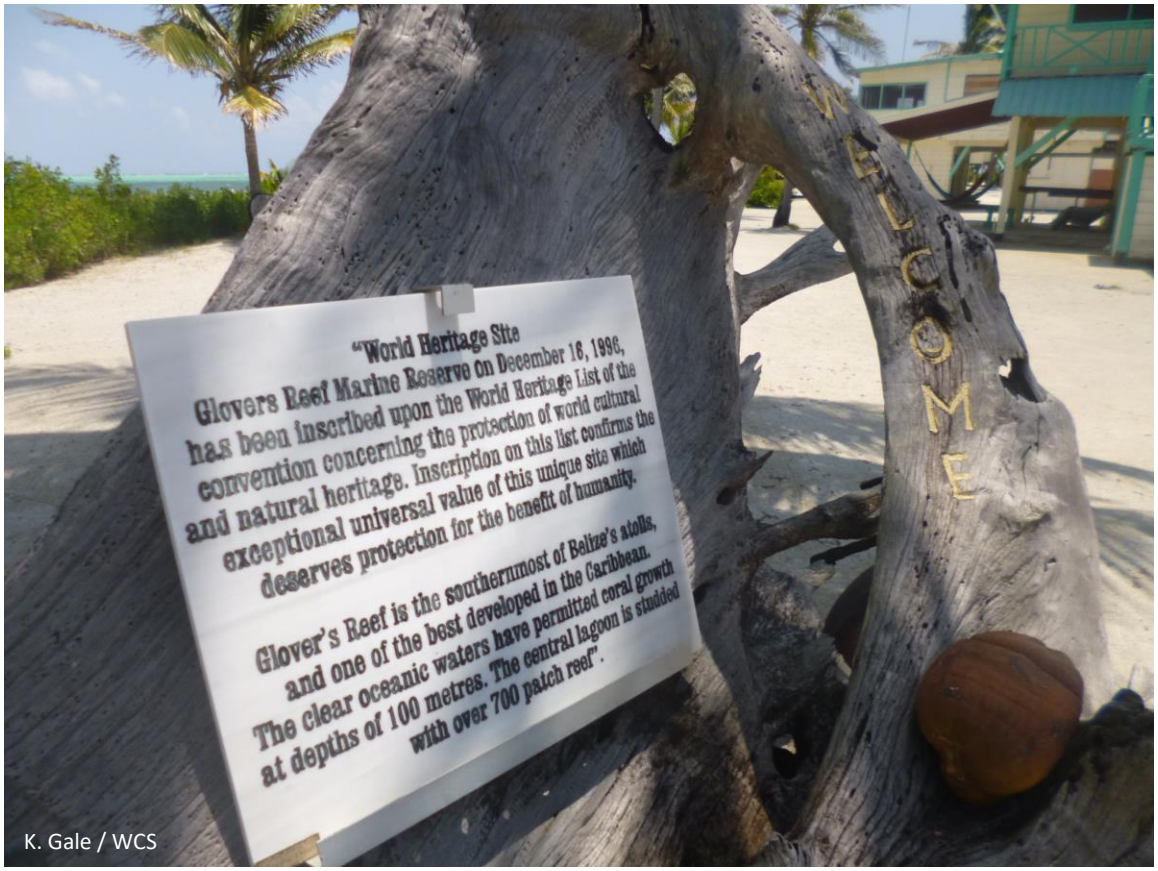
Conservation Planning: The management plan summarizes the 2018 revision of the conservation action plan developed in 2006 / 2007, integrates climate change assessment outputs, and takes into account the area's status as a World Heritage Site. It updates the information on conservation targets and threats, and identifies the current and predicted challenges to effective management for ensuring continued conservation target viability.

Management Strategies: The Plan provides a framework for management strategies. It identifies the management challenges, defines the goal and objectives of management, and provides a framework for specific activities to achieve maintenance of ecosystem functions and services and natural resource values. It outlines specific management programs, integrating conservation planning strategies, as well as relevant strategies of national and regional plans. It also sets in place the means for measuring management effectiveness through indictors of implementation, output, and outcome / impact, and includes an implementation schedule template. It integrates support for the traditional fishery of key stakeholder communities.

It seeks to continue to manage the resources of the area sustainably through the Managed Access program, with improved sustainability of extraction of marine stocks by traditional fishermen,

based on the national Managed Access framework. It also allows for the facilitation and promotion of diversification into other income-generating activities, compatible with the overall goals of the Marine Reserve, for increased socio-economic benefit for stakeholders.

It is recommended that detailed annual operational plans be developed based on the framework provided by this management plan, with an annual review of implementation success, allowing for adaptive management over the five-year period – 2019 to 2023.



GLOVER'S REEF MARINE RESERVE – A COMPONENT OF BELIZE'S WORLD HERITAGE SITE

Section One

Current Status

1. CURRENT STATUS

1.1 LOCATION

Glover's Reef Marine Reserve (GRMR) is located on the most southern of the three atolls, part of Belize's Barrier Reef System, and lies approximately 45 kilometers east of the Belize mainland (75 km south-east of Belize City) (Maps 1 to 3). Whilst to the east of the Belize Barrier Reef, this protected area is considered part of this important natural barrier, and is one of seven protected areas included within the Belize Barrier Reef Reserve System - World Heritage Site.

ACCESS

Access to the Marine Reserve is only by sea, with boats originating primarily from the mainland (Sarteneja, Belize City, Dangriga, Hopkins and Placencia), and from South Water and Tobacco Cayes. Glover's Reef also attracts yachts from around the world and visits by live-aboard dive boats.

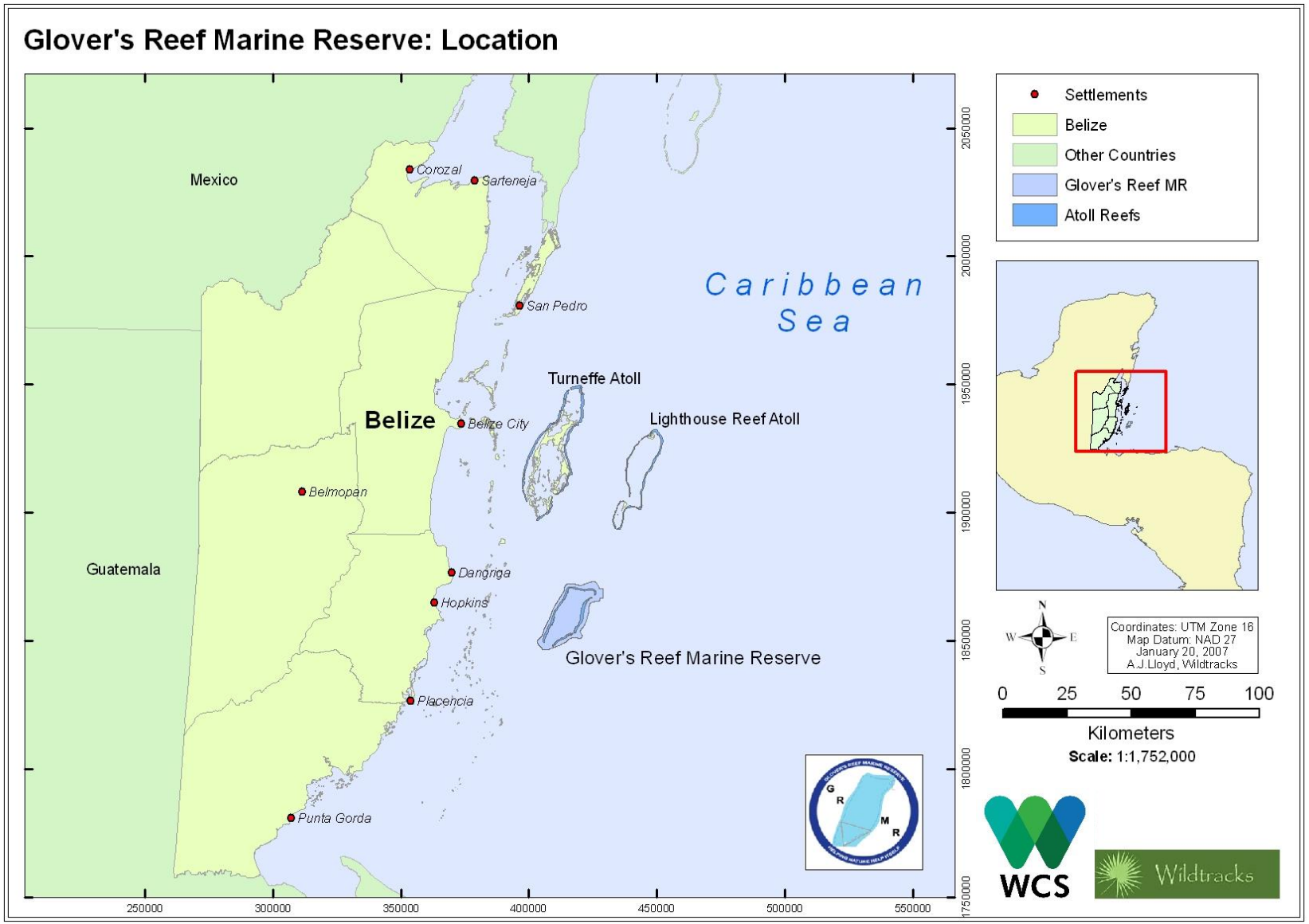
ADMINISTRATIVE LOCATION

The Fisheries Department operational facilities for management of Glover's Reef are located on Middle Caye, leased for a nominal annual rent from the Wildlife Conservation Society (WCS), providing a base of operations for the Fisheries Department from which to manage Glover's Reef Marine Reserve. The ranger station contains an office and residences for two rangers, a marine biologist and the reserve manager, supported by the Fisheries Department main office, located in Belize City. WCS, which owns the caye, operates a research base on the caye for scientific study of the Atoll.

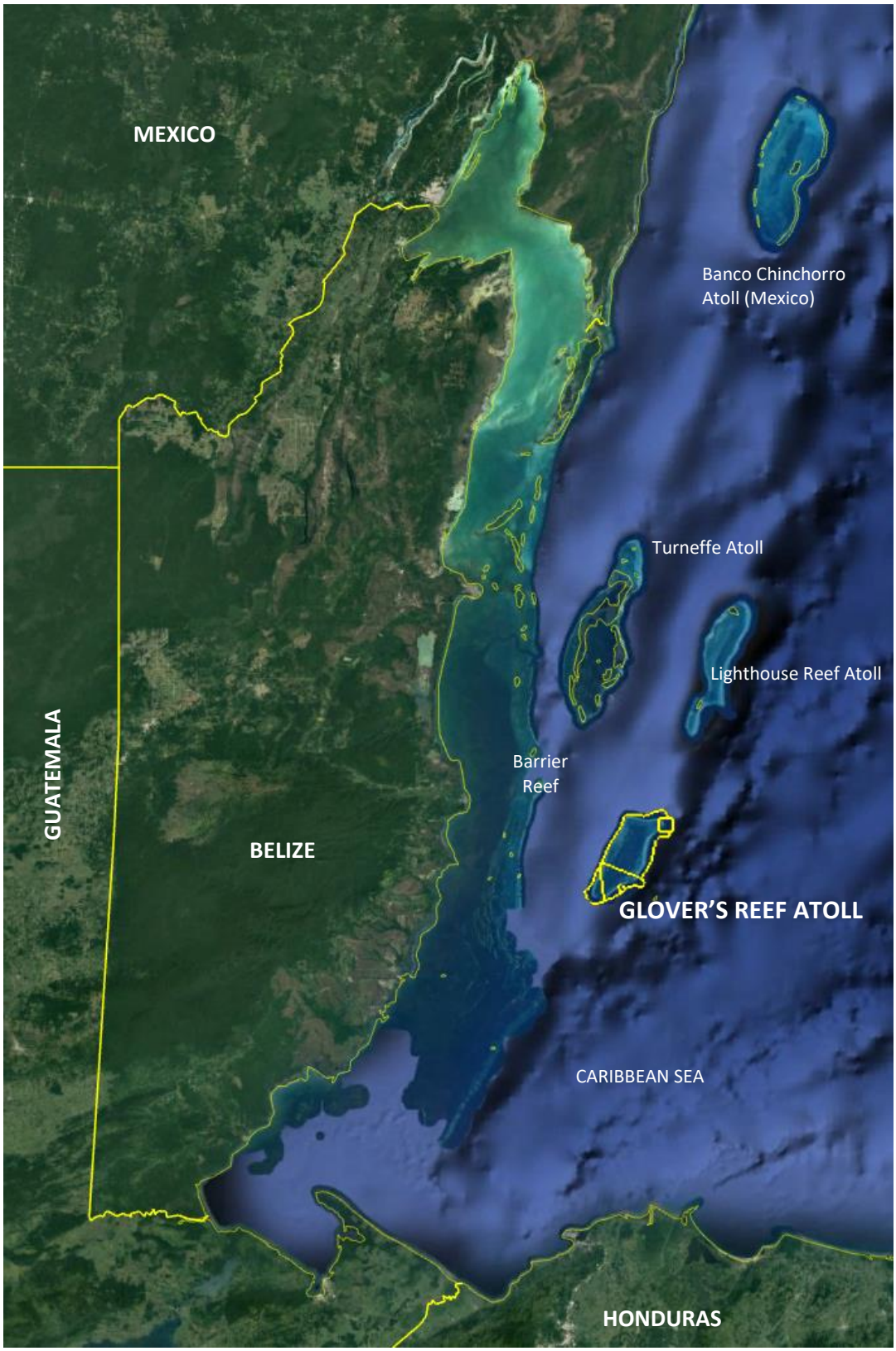
COMMUNITIES ADJACENT TO GLOVER'S REEF MARINE RESERVE

There are no communities within the Marine Reserve - however, the majority of the cayes support tourism developments, resorts or private residences with local or international ownership, and resident staff or watchmen.

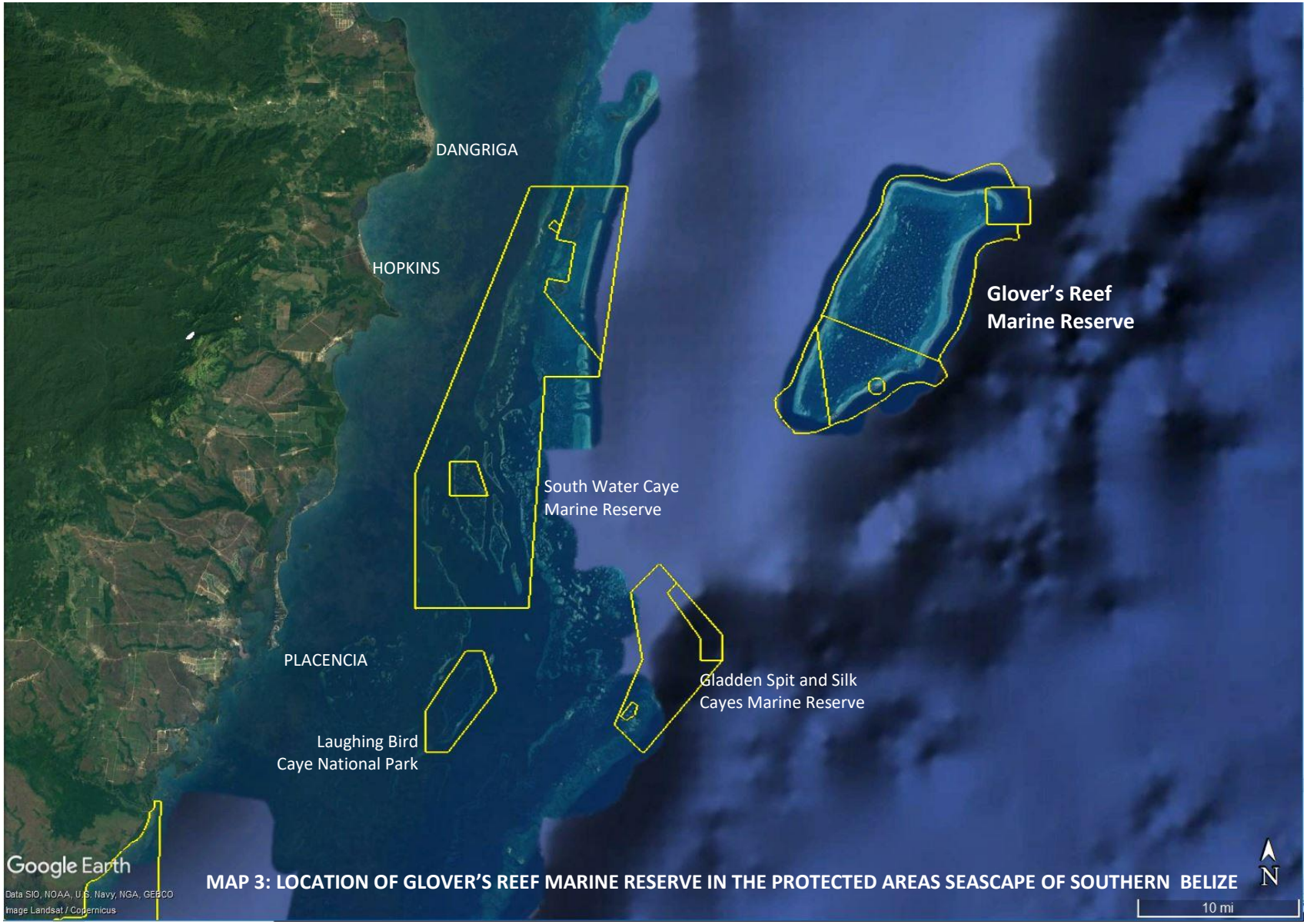
The primary stakeholders of GRMR are the fishing, tourism and research sectors, based both from the mainland and from the cayes within the protected area. Fishing communities are located on the mainland, with the majority of boats originating primarily from four key communities (Dangriga, Sittee River, Hopkins and Sarteneja). Tourism traffic is predominantly from Dangriga, Hopkins, Sittee River, Belize City and Placencia.



MAP 1: THE LOCATION OF GLOVER'S REEF MARINE RESERVE



MAP 2: LOCATION OF GLOVER'S REEF ATOLL, ONE OF FOUR ATOLLS OF THE MESOAMERICAN REEF SYSTEM



MAP 3: LOCATION OF GLOVER'S REEF MARINE RESERVE IN THE PROTECTED AREAS SEASCAPE OF SOUTHERN BELIZE

1.2 REGIONAL AND INTERNATIONAL CONTEXT

> *The Belize Barrier Reef Reserve System contains an intact ecosystem gradient ranging from the terrestrial to the deep ocean: including, littoral, wetland, and mangrove ecosystems, to seagrass beds interspersed with lagoonal reefs, to the outer barrier reef platform and oceanic atolls. This ecological gradient provides for a full complement of life-cycle needs, supporting critical spawning, nesting, foraging, and nursery ecosystem functions. Maintaining these ecological and biological processes ensures robust and resilient reefs, which are themselves one of the world's most ancient and diverse ecosystems.*
>
> **Belize Statement of Outstanding Value, BBRRS World Heritage Site (2011)**

Glover's Reef Marine Reserve (GRMR) encompasses the marine portion of Glovers Reef Atoll, the southern-most of Belize's three atolls, and one of only four such atolls in the Western Hemisphere. It is part of the Mesoamerican Reef (MAR), which stretches for more than 1,000 km (625 miles) from Mexico to Honduras, parallel to the coast. One of the most diverse ecosystems on earth, the MAR is considered outstanding on a global scale, and a priority for conservation action, stabilizing and protecting coastal landscapes, maintaining coastal water quality, sustaining species of commercial importance, and providing employment in the fishing and tourism industries to more than a million people living in coastal areas in the three countries. The Barrier Reef seascape is included on a list of the 18 richest centers of endemism and has been highlighted as one of the most threatened by human impacts (Roberts et al., 2002). It lies at the intersection of two regions – Central America and the Wider Caribbean - with characteristic flora and fauna from both, leading to the area being highlighted as a world biodiversity hotspot, as well as an ecoregional priority for conservation planning efforts (MAR, 2017).

Glover's Reef Marine Reserve is a component of Belize's World Heritage Site, (the Belize Barrier Reef Reserve System - World Heritage Site), a serial nomination of seven marine protected areas that showcase the high biodiversity and variety of reef types that result in the Belize reef being considered one of the best examples of this ecosystem in the world. It protects assemblages of regionally important ecosystems and several species of global conservation concern, among them the critically endangered staghorn and elkhorn corals (*Acropora cervicornis* and *Acropora palmata*), hawksbill turtle (*Eretmochelys imbricata*) and Nassau grouper (*Epinephelus striatus*) (Table 1). The area also protects the endangered green and loggerhead turtles (*Chelonia mydas* and *Caretta caretta*), and a number of endemics unique to the Atoll and Belize. GRMR is also important in its contribution towards the regional viability of important commercial species, including the queen conch (*Lobatus (Strombus) gigas*) and Caribbean spiny lobster (*Panulirus argus*). The mangroves of the cayes and coastal habitats are important nursery areas for many species of economic importance for both fishers and the tourism industry, contributing to local coastal economies.

GLOVER'S REEF MARINE RESERVE Species of international Concern	
Critically Endangered	
Staghorn Coral	*Acropora cervicornis*
Elkhorn Coral	*Acropora palmata*
Hawksbill Turtle	*Eretmochelys imbricata*
Nassau Grouper	*Epinephelus striatus*
Endangered	
Green Turtle	*Chelonia mydas*
Goliath Grouper	*Epinephelus itajara*
Boulder Star Coral	*Orbicella annularis*
Star Coral	*Orbicella faveolata*
Whale Shark	*Rhincodon typus*
Splendid Toadfish	*Sanopus splendidus*
Scalloped Hammerhead	*Sphyrna lewini*
Great Hammerhead	*Sphyrna mokarran*
Vulnerable	
Lamarck's Sheet coral	*Agarica lamarcki*
Gray Triggerfish	*Balistes capriscus*
Dusky Shark	*Carcharhinus obscurus*
Silky Shark	*Carcharhinus falciformis*
Loggerhead Turtle	*Caretta caretta*
Pallid Goby	*Coryphopterus eidolon*
Glass Goby	*Coryphopterus hyalinus*
Peppermint Goby	*Coryphopterus lipernes*
Masked Goby	*Coryphopterus personatus*
American Crocodile	*Crocodylus acutus*
Pillar Coral	*Dendrogyra cylindrus*
Leatherback Turtle	*Dermochelys coriacea*
Elliptical Star Coral	*Dichocoenia stokesii*
Seafan Blenny	*Emblemariopsis pricei*
Lined seahorse	*Hippocampus erectus*
Hogfish	*Lachnolaimus maximus*
Cubera Snapper	*Lutjanus cyanopterus*
Manta Ray	*Manta birostris*
Atlantic Blue Marlin	*Makaira nigricans*
Boulder Star Coral	*Orbicella franksi*
Yellowmouth grouper	*Myctoperca interstitialis*
Rough Cactus coral	*Mycetophyllia ferox*
Belize Leaf-toed Gecko	*Phylodactylus insularis*
Sperm Whale	*Physeter macrocephalus*
Whitespotted Toadfish	*Sanopus astrifer*
Cerulean Warbler	*Setophaga cerulea*
Antillean Manatee	*Trichechus manatus*
Glover's Reef Toadfish	*Vladichthys gloverensis*

TABLE 1: GRMR SPECIES OF INTERNATIONAL CONCERN, IUCN, 2019

Belize has signed a series of conventions and agreements designed to ensure continued viability of natural resources and biodiversity. As a signatory of the **Convention on Biological Diversity (CBD) (1992),** Belize is committed to ensuring it has measures in place to protect biodiversity, with promotion of sustainable use, contributing to the 2011 – 2020 CBD strategic goals. GRMR is known to protect at least 39 species of international concern, recognized under the IUCN Redlist as Critically Endangered (4), Endangered (8) or Vulnerable (27) Table1: IUCN, 2019).

More specific targets of the CBD relevant to Glover's Reef Marine Reserve include (CBD, 2010):

- promoting the conservation of the biological diversity of ecosystems, habitats and biomes;
- promoting sustainable use and consumption, by encouraging use of products derived from sources that are sustainably managed;
- addressing threats to biodiversity related to the pressures of habitat loss, land use change and degradation, and unsustainable water use;
- addressing challenges to biodiversity from climate change, and pollution;
- maintaining the capacity of ecosystems to deliver goods and services that support sustainable livelihoods, local food security and health care, especially of poor people

The goals and objectives for the Marine Reserve, and the wider goal, mission and activities of the Belize Fisheries Department and the Wildlife Conservation Society, contribute towards these CBD targets (Table 2).

Recognition as a Site of Outstanding Universal Value

Cultural and/or natural significance that is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity. As such, the permanent protection of this heritage is of the highest importance to the international community as a whole.

Convention Concerning the Protection of the World Cultural and Natural Heritage

Under the **Convention Concerning the Protection of the World Cultural and Natural Heritage,** Belize has a serial nomination of seven sites, designated in 1996 as components of the Belize Barrier Reef Reserve System - World Heritage Site. These seven sites, which include Glover's Reef Marine Reserve, comprise 12% of the entire Reef Complex and are seen as representative of the Belize Barrier Reef as the largest reef complex in the Atlantic-Caribbean region and second largest reef system in the world (UNESCO, 1996) under criteria (iii), in recognition of their global value and based on the classic examples of fringing, barrier and atoll reef types.

In 2009, Belize's World Heritage Site was placed on the List of World Heritage in Danger based on the sale and lease of public lands for development within the serial sites, leading to the destruction of mangroves and marine ecosystems. Also of concern was the issuing of past oil and gas leases within the WHS. Both are in contravention of the Convention commitment that "*No areas within the property and in its immediate vicinity are developed in ways that affect the property's natural outstanding beauty and status as a globally significant natural phenomenon of Outstanding Universal Value".* This "in Danger" status was lifted at the recent sitting of the WHS Committee (UNESCO, 2018), in recognition of the steps Belize has taken to address the identified issues and strengthen protection of the Belize Barrier Reef Reserve System.

Belize is a signatory to the **Convention on the International Trade in Species of Wild Fauna and Flora,** focused on ensuring that international trade in wild animals and plants does not threaten their survival. Belize CITES listed species include the queen conch, with annual quotas set to meet the commitments to the Convention. This has impacts on the commercial fishery and local fisher income, with the season closing once the quota is met, generally earlier than legislated, but is designed to ensure that in the long term, the fishery remains sustainable.

Under this convention, it is also illegal to take CITES species across international boundaries without valid permits – there is a current issue of illegal movement of harvested conch to Guatemala and Honduras. The illegal killing and smuggling of turtle and shark products to Guatemala was also in contravention of CITES, as well as being illegal in Belize. Transboundary

smuggling is predicted to increase as economic pressures in all three countries increase (Guatemala, Honduras and Belize), increasing the effort needed by Belize to comply with this convention.

In 1983, Belize signed the **Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region** (the 'Cartagena Convention'), with the primary objective of protecting the ecosystems of the marine environment, based on the regional importance of the Mesoamerican Reef System, and consistent with the goals of the United Nation's Convention on Biological Diversity's International Coral Reef Initiative.

With the increasing threats to the overall health of the reef system, the Governments of Mexico, Belize, Guatemala and Honduras (the four countries bordering the Mesoamerican Barrier Reef System (MBRS)) committed to the development of a 15-year Action Plan – the **Mesoamerican Barrier Reef System Project** - through the **Tulum Declaration (1997),** for the conservation and sustainable use of this globally important ecosystem**.** This initiative, adopted by the Heads of State in June 1999, was supported by the **Central American Commission on Environment and Development (CCAD),** which seeks to harmonize environmental policies within the region. A second phase project is now underway – the Integrated Transboundary Ridges-to-Reef Management of the Mesoamerican Reef (MAR2R) - focused on enhancing regional collaboration for the ecological integrity of the Mesoamerican Reef, scaling up the ridge to reef approach to its management.

International Conventions and Agreements of Relevance to Glover's Reef Marine Reserve

Convention on Biological Diversity (Rio de Janeiro, 1992) Ratified in 1993	**To conserve biological diversity to promote the sustainable use of its components, and encourage equitable sharing of benefits arising from the utilization of natural resources** *GRMR is an important and integral part of Belize's national protected areas system, protecting biodiversity and threatened species, as per Belize's commitment under the CBD.*
Alliance for the Sustainable Development of Central America (ALIDES) (1994)	**Regional alliance supporting sustainable development initiatives.** *As a national protected area, GRMR provides sustainable benefits to communities through fishing and tourism, whilst also protecting biodiversity and threatened species, as per Belize's commitment under ALIDES.*
Central American Commission for Environment and Development (CCAD) (1989)	**Regional organization of Heads of State formed under ALIDES, responsible for the environment of Central America. Initiated Mesoamerican Biological Corridors and Mesoamerican Barrier Reef Systems Programs.** *Belize is working with other ALIDES members towards the implementation of MAR2R, focusing on integrated watershed management for the protection of the reef. GRMR, in protecting the unique Atoll, has an important role in conservation of reef ecosystems in Belize. Data gathered through monitoring initiatives are shared regionally.*
International Convention for the Protection and Conservation of Sea Turtles for the Western Hemisphere (December 21st, 1997)	**To protected and conserve sea turtle species of the Western Hemisphere** *Glover's Reef protects important feeding and nesting areas for sea turtles, including the Critically Endangered hawksbill. The Fisheries Department is a member of the Belize Sea Turtle Conservation Network, one of a number of national biodiversity working groups in Belize that provides recommendations to inform national decisions.*
Convention Concerning the Protection of the World Cultural and Natural Heritage (Paris, 1972)	**The World Heritage Convention requires parties to take steps to identify, protect and conserve the cultural and natural heritage within their territories.** *As part of Belize's World Heritage Site, GRMR is important in protecting one of the best representations of Atolls in the region.*
Convention on International Trade in Endangered Species of Wild Fauna and Flora	**CITES has been established to ensure that the international trade in specimens of wild animals and plants does not threaten their survival.** *GRMR is important for maintaining queen conch populations, harvested for export through the fishing cooperatives. CITES regulates the level of exportation, and therefore the level of harvest, to ensure sustainability.*

International Conventions and Agreements of Relevance to Glover's Reef Marine Reserve	
Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention Cartagena de Indias, Colombia, 1983) ▪ Protocol Concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region (adopted in 1983 and entered into force on 11 October 1986. Ratified by Belize in 1999). ▪ Protocol Concerning Specially Protected Areas and Wildlife (SPAW) in the Wider Caribbean Region (adopted on 18 January 1990 and entered into force on 18 June 2000. Ratified by Belize in 2008). ▪ Protocol Concerning Pollution from Land-Based Sources and Activities (LBS) (adopted on 6 October 1999 and entered into force on 13 August 2010. Ratified by Belize in 2008).	**Regional convention with the objective of protecting the marine environment of the Wider Caribbean through promoting sustainable development and preventing pollution.** *Belize takes measures to prevent, reduce and control pollution in the marine environment. It also seeks to protect and preserve rare or fragile ecosystems, habitats of depleted, threatened or endangered species; and to develop technical and other guidelines for land use planning and environmental impact assessments of large scale development projects in order to prevent or reduce harmful impacts within coastal waters. This is achieved primarily through the Integrated Coastal Zone Management Plan (South Northern Region), the National Sustainable Tourism Master Plan, enforcement of relevant legislation and the EIA / ECP process.* *GRMR was one of two sites listed under the SPAW in recognition of its significant contribution to the conservation of marine and coastal biological diversity in the Caribbean providing an important and integral part of the National Protected Areas System, protecting biodiversity and threatened species, as per Belize's commitment under this Convention.*

TABLE 2: INTERNATIONAL CONVENTIONS AND AGREEMENTS OF RELEVANCE TO GLOVER'S REEF MARINE RESERVE

1.3 NATIONAL CONTEXT

As well as the regional and global importance, Glover's Reef Marine Reserve is also important at the national level. The marine resources of the protected area support traditional fishers and the growing tourism industry in south-central Belize.

1.3.1 NATIONAL PLANNING STRATEGIES

The national goals and objectives for conservation revolve around the sustainable use, conservation and protection of Belize's natural resources within the context of sustainable human development. These objectives are targeted by Critical Success Factor 3 (CSF3) of the **Growth and Sustainable Development Strategy (GSDS),** part of the 15-year national development framework under Horizon 2030. The GSDS recognizes effective implementation of both the NBSAP and NPAPSP as critical in achieving national development goals. CSF3 is implemented primarily through the **National Biodiversity Strategy and Action Plan** (GoB, 2016), which recognizes the importance of protected areas such as GRMR, and the need to mainstream biodiversity across all sectors in Belize, improve integration of biodiversity and protected areas into national planning strategies, and build both human and institutional capacity to effectively manage the biodiversity resources. It provides a framework for strategies under five national goals:

> ***GOAL A. MAINSTREAMING:*** *Improved environmental stewardship is demonstrated across all society in Belize, as is an understanding and appreciation of marine, freshwater and terrestrial biodiversity, its benefits and values.*
>
> ***GOAL B. REDUCING PRESSURES:*** *Direct and indirect pressures on Belize's marine, freshwater and terrestrial ecosystems are reduced to sustain and enhance national biodiversity and ecosystem services*
>
> ***GOAL C. PROTECTION:*** *Functional ecosystems and viable populations of Belize's biodiversity are maintained and strengthened*
>
> ***GOAL D. BENEFITS:*** *Strengthened provision of ecosystem services, ecosystem-based management and the equitable sharing of benefits from biodiversity*
>
> ***GOAL E. IMPLEMENTATION:*** *Effective implementation of the NBSAP through capacity building, strategic decision making and integrated public participation*

The **National Protected Areas Policy and System Plan (NPAPSP**) (GoB, 2005; revised: 2015) guides system-level and individual protected area management efforts to support the national objectives of ecological and economic sustainability over the long term, with the development of human and institutional capacity to effectively manage biodiversity resources within the National Protected

Areas System. The NPAPSP centres on the following policy statement, which has been taken into consideration in the development of this plan:

> *The Government of Belize shall promote the sustainable use of Belize's protected areas by educating and encouraging resource users and the general public to properly conserve the biological diversity contained in these areas in order to maintain and enhance the quality of life for all. This shall be achieved by facilitating the participation of local communities and other stakeholders in decision-making and the equitable distribution of benefits derived from them, through adequate institutional and human capacity building and collaborative research and development.*

GRMR is a multiple use Marine Reserve, allowing for regulated fishery extraction and tourism use, and contributes towards a key goal of the NPAPSP - to ensure that the "*National Protected Areas System includes high quality examples of the full range of environment types within Belize, with balanced representation of the ecosystem types they represent*" (NPAPSP, 2005). These include the Atoll structure and highly diverse reef ecosystems, endemic species, the Northern Glover's spawning aggregation site, and the rich biodiversity of the Marine Reserve.

Under a National Protected Areas System Rationalization exercise (2012), a number of recommendations were made for GRMR to improve representation or protection of specific national targets:

Priority Ecosystem / Species Protection

- Alignment with IUCN WCPA Category VI
- Investigate potential to extend 5 nautical miles east to incorporate representative **Caribbean Open Sea - Bathyal**

National Protected Areas System Rationalization Recommendations (Walker et al., 2012)

The **Coastal Zone Management Authority and Institute** was established under the Coastal Zone Management Act to ensure conservation of coastal resources, and the planning, management and sustainable development of resources within the coastal zone. The Act is focused on monitoring, planning and coordination to ensure that activities within the coastal zone are integrated and sustainable, but does not have any legislated implementation or enforcement capacity. Implementation and enforcement is therefore achieved through more specific agencies – the Fisheries Dept. (Fisheries Act), the Forest Department (Wildlife Protection Act, Forest Act, Mangrove Regulations), Department of the Environment (Development regulations, EIAs and ECPs) and Geology and Petroleum Department (dredging and oil exploration).

The GRMR falls under the ICZMP South-Northern Region, with a number of overarching objectives identified under **the Integrated Coastal Zone Management Plan**. Whilst this development plan focuses on a larger scope than just Glover's Reef Marine Reserve in the regional seascape, it provides the development context within which GRMR operates:

1. *Encourage and promote the sustainable development of coastal and offshore areas within the South Northern Region that will promote economic growth while simultaneously ensuring ecosystem stability and the efficient delivery of ecosystem services.*

2. *Protect and preserve the traditional way of life of the stakeholders within the South Northern Region*

3. *Ensure sustainability of coastal resources by identifying areas in need of conservation and reducing user conflicts*

A series of key principles have also been identified under the Coastal Management Plan:

Principle 1: *Recognition that the South-Northern Region needs special protection and management because of their physical, economic, scientific, cultural and aesthetic attributes*

Principle 2: *Recognition of the need to avoid placing undue strain on the terrestrial and aquatic environment of the regions by ensuring that proposed development activities do not exceed the carrying capacity*

Principle 3: *Recognition of the rights and interests of traditional users and stakeholders while acknowledging the national development policy which promotes tourism and job creation*

Principle 4: *Recognition that environmental concerns are best handled with the participation of all concerned stakeholders at all levels and from all sectors*

Principle 5: *Recognition that planning guidelines represent a preventative and precautionary approach to environmental degradation and a tool for pursuing sustainable development of the region*

Recommended actions under the South Northern ICZMP include:

- Increased collaboration among local stakeholders, interest groups and the agencies responsible for land allocation, including the conditions applied to lease approval and the regulation of lot sizes
- Limit the number of piers per property or caye
- Prohibit the construction of buildings on piers

- Preserve remaining crown lands in the region
- All new developments must be constructed using the standards developed by LUA, CBA, DoE and CZMAI in the creation of these management guidelines.
- Although permitted, coastal agriculture and aquaculture activities must be closely monitored and not allowed to occur near important watersheds and lagoons. Relating to this, proper pesticide use and waste water disposal is key to ensuring that the marine environment is not polluted. Therefore enforcement agencies will be required to conduct regular water testing.

The last of these is less relevant to the Atoll, but should be borne in mind when caye maanagement includes spraying against insects.

The national objective of the **Sustainable Tourism Master Plan** is to *"more than double overnight tourist arrivals while enhancing average length of stay and daily expenditure"***.** The qualities of the environment and the need to conserve these qualities are recognised in the MasterPlan, with the sustainable development program providing the framework that will *"ensure the NSTMP maintains a balance of the three pillars of sustainable development: social accountability, environmental conservation and economic prosperity."* The NSTDP is primarily focused on destination development, financing and marketing, but does recognize the importance of conservation and environmental management in supporting Belize's tourism industry. Placencia has been a focus of the Sustainable Development Project investments, with the potential to increase visitor use of the area, and economic benefits to the communities, though with associated potential impacts on the natural resources. This, however, has little direct impact on the two most relevant stakeholder coastal communities – Dangriga and Hopkins.

1.3.2 LEGAL FRAMEWORK

Six key laws have been enacted to protect ecosystems, ecosystem services and biodiversity, contributing to the conservation framework of Belize. The Ministry of Agriculture, Fisheries, Forestry, Environment and Sustainable Development is the administrative agency for the **National Protected Areas System Act (2015), Fisheries Act (1948), Forest Act (1927),** and the **Wildlife Protection Act (1981).**

The **Fisheries Act,** administered under the Fisheries Department, is the principal governing legislation regulating the fishing industry, and is directly concerned with maintaining sustainable fish stocks and protecting the marine and freshwater environments. The Fisheries Act and associated regulations requires that fishers and fishing vessels using the General Use Zone of Glover's Reef Marine Reserve are licensed for Managed Access Area 8. This is supported by Managed Access – a rights-based fisheries management regime to better regulate fishing in Belize, piloted originally at GRMR. The Fisheries Act is currently being revised and updated as the Fisheries Resource Bill. The Belize Fisheries Department, the authority responsible for GRMR, enforces the fisheries regulations in the protected area and actively implements the Managed Access program.

The **Wildlife Protection Act (1982)** falls under the Forest Department, and provides protection for manatees, dolphins, whales, crocodiles and nesting bird colonies, with the prohibition of hunting and commercial extraction. This Act is scheduled for revision and significant strengthening in 2019.

The **Environmental Protection Act (1992)** was enacted under the Department of the Environment (DoE) with the aim of ensuring

KEY NATIONAL LEGISLATION PROTECTING FAUNA, FLORA, AND NATIONAL HERITAGE

The National Protected Areas Systems Act (2015)
Provides a framework for establishment and maintenance of the national protected areas system.

The Fisheries Act (1980)
Principal governing legislation regulating the fishing industry, and is directly concerned with maintaining sustainable fish stocks and protecting the marine and freshwater environments (including the Fisheries Regulations)

The Wildlife Protection Act (1981)
Provides for the conservation, restoration and development of wildlife and regulation of its use.

The Forest Act (1927)
Promotes the forestry industry, with the implementation of conservation techniques; Responsible for forestry activities in all types of forest, including littoral forests and mangroves.

Environmental Protection Act (1992)
Promotes the preservation and improvement of the environment, the rational use of natural resources, the control of pollution, and associated actions. This is achieved through the EIA / ECP process (currently under revision).

The National Integrated Water Resources Act (2011)
Provides for management of water resources. Its role includes estimating water availability and value, and implementing measures to ensure wise use and long term sustainability of Belize's water resources.

that development initiatives within Belize are planned and implemented with minimum environmental impact. The EPA also mandates DoE to carry out surveillance and response to environmental pollution. In the context of Glover's Reef Marine Reserve, this is particularly important when ensuring that the impacts from development taking place on cayes within the Marine Reserve are minimized through the Environmental Impact Assessment (EIA) process. As a Marine Reserve, and part of Belize's reef system, any caye development is required to have an approved Environmental Impact Assessment and associated Environmental Compliance Plan before development can take place. This provides some measure of control over activities that have the potential to significantly impact the reef. A series of recommendations on lot size, housing density, solid and liquid waste disposal and dredging have been developed per caye, dependent on the height above sea level and ecosystems (Integrated Coastal Zone Management Authority, 2015). These recommendations guide the review process for Environmental Impact Assessments. The EIA process and associated regulations are currently under revision.

The Belize Port Authority is mandated to ensure the safety of navigational channels, through the installation of navigational aids and installation and maintenance of demarcation buoys (**Belize Port Authority Act,** 1976; revised, 2003). It also has a key role in the registration of boats and monitoring of vessels using navigational channels and the removal of boats from the reef when groundings occur.

The **Pesticides Control Act (1990)** provides a mechanism for the registration and regulation of pesticide importation and use through the Pesticide Control Board, important for improving pesticide management, and reducing contamination of the rivers feeding into the Mesoamerican Reef.

Tourism legislation in Belize falls under the mandate of the Ministry of Tourism through the **Belize Tourism Board.** This regulates tourism activities such as guide: visitor ratios, guide training and certification, and licensing of tour operators and accommodation and is focused on maintaining standards for tourism in Belize.

Whilst the above are the legislative acts most relevant to Glover's Reef Marine Reserve, there are others such as the **Mines and Minerals Act (1989)** and the **Petroleum Act (1991)**, which regulate the exploration and extraction of all non-renewable resources. These Acts regulate activities such as dredging of the seabed, as well as the exploration and extraction of all non-renewable resources, including oil. The Belize Government has declared a policy-based moratorium on oil exploration in the marine environment, and a permanent ban on offshore oil exploration along the Belize Barrier Reef System and within the country's seven World Heritage Sites, including GRMR.

Financial sustainability for protected area and natural resource management is partially addressed at Government level through the Protected Areas Conservation Trust (**PACT Act, 1996; revised 2015)**. A 'conservation tax' of Bz$7.50 is levied on non-residents as they leave the country providing a funding mechanism to assist in management and development activities within protected areas. Since its establishment, PACT has assisted local conservation organizations with funding for projects assisting in the maintenance of effective protected areas and providing leverage for funding from external sources. PACT's investments are aligned with the operational framework of the National Protected Areas Policy and System Plan (NPAPSP), focused on building management effectiveness of the NPAS, and strengthening biodiversity conservation in Belize.

The functions of PACT are:

"…to contribute to the sustainable management and development of Belize's natural and cultural assets for the benefit of Belizeans and the global community, both now and for future generations."

Protected Areas Conservation Trust (Amendment) Act, 2015)

Also developed under the Forest Department is the **Forest (Protection of Mangrove) Regulations** (SI 52 of 1989; revised 2018), which provides for the protection of mangroves, with restrictions on mangrove alteration and / or clearance. Before granting a permit for mangrove alteration, Belize law requires the Forest Department to consider whether the project will adversely affect the conservation of the area's wildlife, water flow, erosion and values of marine productivity.

Marine turtles and their nest sites have also been given some protection since the original Fisheries Ordinance in 1940. This was strengthened in 1993, when Belize revised its fisheries regulations to prohibit fishing, possession, or trade in products of all six species of marine turtle that might potentially be found in Belize's waters **(Fisheries (Amendment) Regulations, 1993 (S.I. No. 55 of 1993).**

The **Sport Fishing Regulations (SI 114** and **115 of 2009**) have been developed to improve management and conservation of the economically important sport fishing species in Belize - particularly bonefish, tarpon and permit. These three "Grand Slam" species can only be caught using 'catch and release' best practices. These regulations, however, do not extend to protecting nursery areas or adult habitat – only to the sport fish species themselves.

SITE LEVEL LEGISLATION

Glover's Reef Marine Reserve is a national protected area, established in 1996 (SI 70 of 1996) under the Fisheries Act (1948 (1983 amendment)). The area is designated as a 'Marine Reserve' under the mandate of the Fisheries Department to "....*afford special protection to the aquatic fauna and flora of such areas and to protect and preserve the natural breeding grounds and habitats of aquatic life to allow for the natural regeneration of aquatic life in areas where such life*

has been depleted" (Fisheries Department, 1983). The Marine Reserve is managed directly by the Fisheries Department, with zoned multiple use, incorporating areas open for extractive use and closed, no-take areas, regulated under a zoning system that is embedded within the Statutory Instrument (SI 137 of 2001). There are a series of legislated regulations within the statutory instrument that guides all activities within the protected area – both tourism-related and commercial fishing practices.

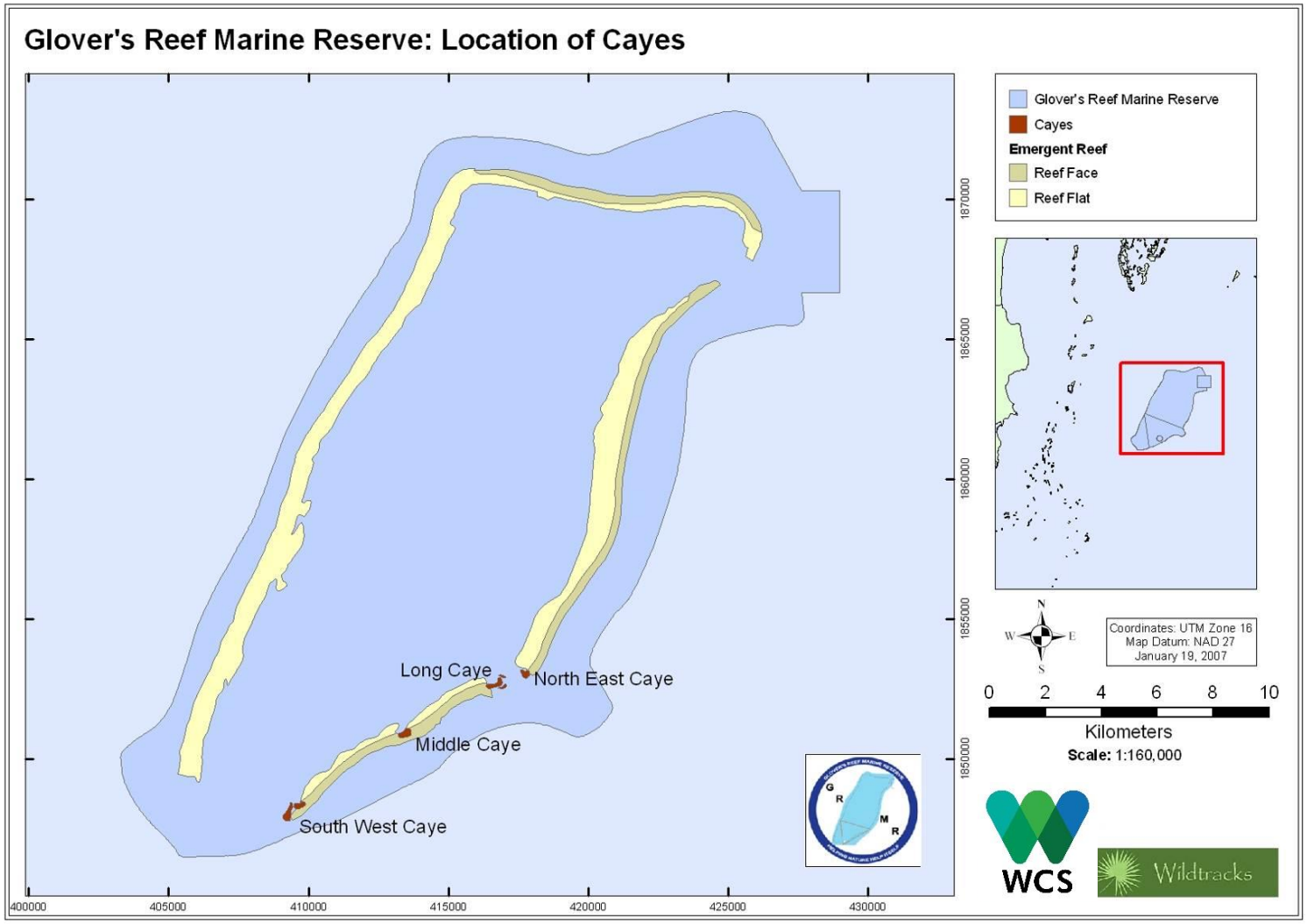
The North Glover's spawning aggregation site is also part of the NPAS, and is one of 11 Spawning Aggregation Sites protected across Belize under SI 161 of 2003. The SPAG site overlaps the Special Management and General Use zones of Glover's Reef Marine Reserve, and is managed as a single unit with GRMR.

1.3.3 LAND TENURE

The Marine Reserve is defined as the Caribbean Sea, and excludes the cayes. The seabed is national land, and permission is required from the Lands Department for the construction of over-water structures (including docks), seawalls and marinas, and from the Department of Mining for any dredging – as well as permission from the Fisheries Department. The six recognized cayes of the Atoll are all privately owned (Table 3), with the exception of a small southern portion of national land on Southwest Caye II where the lighthouse is located. One of the cayes, Long Caye North, has been heavily eroded by Hurricane Mitch, which also cleared away the infrastructure and vegetation, and it is suggested that in future management plans, this should not be included in the list of cayes, unless its size increases again significantly. As all six islands are located within the Conservation Zone of the marine reserve, the development that occurs on them needs to be compatible with the objectives of this Zone and fall within the guidelines of the Integrated Coastal Zone Plan (Map 4).

NAME OF CAYE	AREA OF OWNERSHIP	OWNERSHIP	CURRENT USE / ICZMP RECOMMENDATION
Northeast Caye	5 ha	Lamont Family	Tourism / Commercial 1
Long Caye North		Lamont Family	Eroded / inundated
Long Caye			
▪ Northern	2.14 ha	Slickrock Ltd.	Tourism (for sale) / Commercial 1
▪ Central	3.52 ha	Off-the-Wall Dive Shop	Tourism / Commercial 1
▪ Southern	2.7 ha	Sanctuary Belize	Recently sold to Sanctuary Belize
Middle Caye	4 ha	Wildlife Conservation Society	Research and Administration
Southwest Caye I	6 ha	Usher Family	Tourism – Isla Marisol / Island Expeditions base / vacation homes
Southwest Caye II	3.32 ha	M. Feinstein	For sale / Conservation 1
Southwest Caye II		Government of Belize / Port Authority	Port Authority Lighthouse

TABLE 3: CAYE OWNERSHIP AND USE AT GLOVER'S REEF MARINE RESERVE



MAP 4: LOCATION OF CAYES OF GLOVER'S REEF MARINE RESERVE

With its status as part of Belize's World Heritage Site, UNESCO has strongly recommended that the Belize Government consider establishing a system to remove lands within the Marine Reserve completely from the jurisdiction of the Lands Department, eliminating the chances of issuing leases or private land grants within the Belize Barrier Reef Reserve System (UNESCO, 2009). However, as all of the cayes are within private ownership with the exception of the lighthouse site, there are limited options for inclusion of cayes within the Marine Reserve at this time. More recent UNESCO recommendations have focussed on strengthening the framework for regulating development on the cayes to minimize impact on the values of the WHS site, in the recognition that there are limited actions that can be imlemented for privately owned property (UNESCO, 2018.

1.3.4 EVALUATION OF NATIONAL IMPORTANCE

Glover's Reef Marine Reserve has been designated as one of seven components of the Belize Barrier Reef Reserve System - World Heritage Site, in recognition of the uniqueness of its contribution to Belize's reef system, a large percentage of the largest, and possibly the least impacted reef complex in the Atlantic–Caribbean area. It has been extensively studied through activities under Wildlife Conservation Society, providing information on coral reef ecology, commerical species and resilience to impacts such as bleaching.

The Atoll supports extraordinarily high biological diversity, with the greatest range of reef types in the Caribbean Sea. The shallow protected waters provide nursery and feeding habitats for at least three species of sea turtles, twelve species of sharks and rays, more than twenty species of aggregating reef fish, and numerous species of coral.

KEY CHARACTERISTICS OF NATIONAL IMPORTANCE: GRMR

- Best developed of four unique atoll formations in the MAR region (and one of three in Belize)
- Greatest diversity of reef types in Belize
- Western wall was once considered among the most diverse and densely covered reef sites reported anywhere in the Caribbean, exhibiting 95% living coral cover and as many as 11 species per square meter
- Relatively deep, protected lagoon with extensive patch reefs
- One of the Caribbean's largest and last remaining viable Nassau grouper spawning aggregations in Belize
- Three deep water channels that allow for water exchange with oceanic water
- High connectivity between littoral forest, mangrove, seagrass and reef
- An important way-point for Neotropical migrants, with littoral forest and mangrove nesting structure for resident birds
- Designated as part of Belize's World Heritage Site

Protected Area Rationalization Report (Walker, 2012)

GRMR is known to protect at least 39 species of international concern, recognized under the IUCN Redlist as Critically Endangered (4), Endangered (8) or Vulnerable (27) (IUCN, 2019). The northeastern corner of the Atoll – North East Point - is the site of one of the Caribbean's last remaining Nassau grouper spawning aggregations, a spectacular biological phenomenon with cultural and economic importance that is severely threatened across the Caribbean. Recent surveys show low numbers of spawning fish and signs of illegal fishing - the effective protection of the spawning aggregation site is important for the maintenance of national populations of the Endangered Nassau grouper (*Epinephelus striatus*), as well as the Near Threatened yellowfin grouper (*Mycteroperca venenosa*) (Kramer and Kramer, 2002), black grouper, tiger grouper and mutton snapper also use the site for spawning (*Lutjanus analis*) (Heyman et. al. 2002, Heymen et al., 2003, GRMR annual reports).

The Vulnerable, endemic Belize Atoll gecko (*Phyllodactylus insularis*) has been recorded from two of the cayes on the Atoll, and may be present on the others. The Vulnerable American Crocodile (*Crocodylus acutus*) and the Endangered Antillean manatee (*Trichechus manatus manatus* – a sub-species of the West Indian manatee) have also been reported, though neither is considered as permanent residents of the Atoll.

The Atoll is recognized as particularly important for biodiversity protection, with a rich species diversity. GRMR provides habitat for fish that have restricted ranges, such as the Glover's Reef toadfish (*Emblemariopsis pricei*), only found from Belize to the Roatan Island, Honduras. The area has also seen the discovery of a number of new species such as the endangered social wrasse (*Halichoeres socialis*), originally thought to be endemic to the Peican Cayes. A number of species listed are transient, such as the vulnerable cerulean warbler (*Setophaga cerulea*) and other migratory bird species, and oceanic species such as the sperm whale (*Physeter macrocephalus*) and orca (*Orcinus orca*).

Coral sand cayes on the Atoll have provided historical nesting sites for hawksbill, loggerhead and green turtles, though the highly attractive nature of these cayes for tourism ventures has reduced much of the viability of these beaches for turtle nesting with caye development. Several of the cayes, particularly Middle Caye, have representative examples of littoral forest, one of Belize's most threatened ecosystems.

ECOSYSTEM SERVICES OF GLOVER'S REEF MARINE RESERVE

Glover's Reef Marine Reserve is of economic importance to Belize as a lobster, conch and fin-fish resource for traditional fishers from mainland fishing communities, with 74% of fishers coming from four communities - Sarteneja, Hopkins, Dangriga and Belize City (Fisheries Department data, 2017). The Marine Reserve also supports a range of tourism uses - sport fishing, snorkelling, scuba diving, kayaking and bird watching, attracting visitors from all over the world, and benefiting not only local tour guides, but also helping to sustain the resorts, hotels, guest houses, restaurants and a range of other assosciated local businesses in the coastal communities. Fly-fishers utilize

the extensive flats of the Atoll, famous for their bonefish and permit. The spur and groove formations of the outer reef structure are world-renowned for their spectacular diving opportunities, and encircle a shallow lagoon that is dotted with many patch reefs. These sheltered waters benefit Belize's growing number of tourism operations, based from both the cayes and the mainland, attracting snorkelers and divers, as well as providing the perfect environment for kayaking packages (Table 4).

The Atoll has an important protective function, providing the first lne of buffering before tropical storms and hurricanes reach the barrier reef, reducing the strength of storm waves and the impacts of caye and coastal erosion, protecting property and life in the cayes and coastal zone in its protective shadow. The Atoll walls and reef crest protect the inner lagoon and cayes from rough seas.

The complex root systems of mangroves fringing the cayes provide an ideal nursery habitat for juvenile fish and invertebrate species, and the close connectivity of mangroves, seagrass and reef significantly increases the survivorship of juvenile reef fish species (Mumby et al., 2004). In addition to the services the marine ecosystems provide in terms of fisheries, the extensive mangrove and seagrass coverage protected within the Marine Reserve also play a significant role in building Belize's resilience to climate change, and contribute to global mitigation efforts. Marine ecosystems represent the largest long-term sink for carbon as well as storing and redistributing approximately 93% of the Earth's carbon dioxide (CO_2) (Nellemann et al., 2009). Mangroves, salt marshes and seagrasses account for more than 50%, possibly as much as 71%, of global carbon storage in ocean sediments (Nellemann et al. 2009).

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ECOSYSTEM SERVICES OF GLOVER'S REEF MARINE RESERVE	
Provisioning	▪ Provision of freshwater on the cayes, maintained within aquifers beneath the cayes (though salt intrusion is resulting in brackish water) ▪ Production of fish as an important protein source
Regulation	▪ First line protection of the barrier reef and coastline from wave action and storm surges in the Atoll protection shadow. ▪ The reefs provide coral, a major component in the formation of beaches and cayes ▪ The prop roots of red mangroves protect the cayes from erosion. ▪ Seagrass and mangroves are important in filtering sediment and pollutants in runoff from the cayes ▪ Seagrass plays an important role in stabilizing the substrate and settling turbidity in the water ▪ Coral fragments form a major component of beaches and cayes
Recruitment	▪ No-take zones within the protected area ensure viable populations of harvested species for subsistence, recreational, sport and commercial fishing ▪ Mangrove and seagrass provide important nursery areas for both commercial and non-commercial species ▪ Sand beaches provide nesting areas for marine turtles ▪ Mangroves and littoral forest provide nesting sites for bird species using the Atoll
Cultural and Socio-Economic	▪ GRMR is an important, traditional commercial fishing ground in central Belize for the capture fisheries industry ▪ Coral reefs are important resources for tourism and recreation - tourism-related income contributed 38.1% to the national GDP in 2016, much of it based on reef tourism. ▪ Coral reefs and the scenic vistas are appreciated by both residents and visitors for their beauty ▪ The Atoll provides recreational opportunities for both local and international visitors
Support	▪ Coral reefs and mangroves play an important role in the cycling of nutrients ▪ Coral reefs, seagrass beds and mangroves within the protected area provide ecosystems necessary for different life stages of commercial and non-commercial species ▪ Coral reefs are among the most productive habitats globally, producing 2,000 decagrams of carbon per square meter per year ▪ Seagrass and mangroves are effective as a CO_2 sink ▪ Mangroves provide nesting and roosting structure for bird species, including the osprey, an important top predator ▪ Littoral forest and mangroves provide important stop-over habitat for migratory bird species

TABLE 4: ECOSYSTEM SERVICES OF GLOVER'S REEF MARINE RESERVE (ADAPTED FROM UNEP-WCMC, 2006)

1.3.5 SOCIO-ECONOMIC CONTEXT

NATIONAL CONTEXT

Belize has a population currently estimated at approximately 398,000 (Table 5; SIB, 2016), with the lowest population density in Central America, at just over 14.6 persons per sq. km., concentrated primarily on the northern plain, southern coastal plain, Cayo District, Belize City and the district towns. Much of the remaining country is less suited to habitation, with swampy lowlands and steep terrain in the Maya Mountains.

Belize Demographic Statistics (Average)	
Population (2018 est.)	398,050
Population density (2015)	14.6/sq. km.
Urban Population (2015)	43.1%
Annual growth rate (2015 est)	2.1%
Life expectancy (2011 est.)	73.7
Below Poverty Level	33.5% (2002) 43% (2010)
Literacy rate (2015)	82.3%
Unemployment rate (2018)	9.4%
GDP (per capita, 2017)	Bz$7,243.12
Annual GDP Growth (2015)	1.9%

TABLE 5: BELIZE DEMOGRAPHIC STATISTICS, (SIB, 2018)

It is a country of many cultures, with Maya, Garifuna, Creole and Mestizo forming the major population groups. The indigenous Maya of Belize are the descendants of the original Central American civilization, at its height approximately 2,000 years ago. Dangriga and Hopkins, two of the key communities closest to Glover's Reef Marine Reserve, lie on the south-central coastal plain, and were settled in the early 1800's, by the Garifuna people - immigrants of Amerindian and African ancestry fleeing persecution, who arrived from St. Vincent via the Roatan Islands. The Creole also settled in Stann Creek in the 18th century, working in the logging industry in the area, and established a thriving fishing industry. Sarteneja, one of the northern coastal fishing communities, whilst not located on the southern coastal plain, is also an important stakeholder of GRMR, and is predominantly Mestizo, first settled in the 1850's by refugees from Mexico forced south by the Mexican Caste War.

Over the last 25 years, there has been a shift in the cultural demographic of the country as a whole, with a significant influx of Central American refugees – primarily from Guatemala and Honduras – in 2013, an estimated 20% of heads of households were born outside of Belize (SIB, 2010). There is also an ongoing emigration of Belizeans to the United States – about 16% of Belizeans live abroad (CIA, 2018), generally those from urban areas who have completed secondary school or have professional training. At the more local scale, there is also immigration of people to Hopkins and other coastal communities, predominantly from the USA, Canada and Europe, either as seasonal residents or as retirees.

The economy of Belize has been based largely on agriculture, with fisheries, banana, sugar and citrus forming some of the key traditional exports that have contributed significantly towards the economy. More recently, revenue from oil extraction has been significant in supporting the

economy, but this has now declined. There is also an increasing reliance on the developing tourism industry, which is rapidly becoming the major foreign exchange earner.

Glover's Reef Marine Reserve contributes towards support of the national fishing industry, providing direct employment for over 2,640 fishers (Belize Fisheries Department data, 2017), and supporting an estimated 15,000 Belizeans from 20 communities, with a further 1,000 people involved indirectly in processing and export (Belize Fisheries Department, 2013). In 2016, the capture fishery produced over 1,648,400 lbs of product – primarily lobster and conch for the export market (SIB, 2017). Lobster exports (tail and meat) were valued at approximately Bz$18,259,380, with conch and other mollusk exports at Bz$10,522,230 (Table 6; SIB, 2017).

Product	*2016 (lbs)*	*2017 (lbs)*
Lobster Tail	432,013	546,788
Lobster Meat	40,367	47,841
Whole lobster	447,874	405,270
Conch	849,475	564,760
King Crab	1,713	3,919
Whole Fish	170,496	33,720
Fish Fillet	300	5,135
Sea cucumber	87,407	-
Shark	24,383	41,000
Total	***2,054,028***	***1,648,433***

TABLE 6: CAPTURE FISHERY PRODUCTION, 2016 – 2017 (SIB, 2017)

The majority of the Glover's Reef Marine Reserve traditional fishermen originate primarily from four coastal communities (Sarteneja, Dangriga, Hopkins, and Belize City) and harvest lobster, conch, and fin-fish. These fishermen free-dive for spiny lobster (*Panulirus argus*) and Queen conch (*Lobatus (Strombus) gigas*) (primarily fishermen of Sarteneja) and use hand lines for fin-fish (primarily fishers from Dangriga and Hopkins), fishing throughout the shallow protected lagoon of the Atoll. Long lines are also used in the deeper channels and on the fore-reef. Alternative job opportunities in many of these coastal communities are limited, though a number – Hopkins, and Placencia in particular – have shifted to an increasing dependence on tourism.

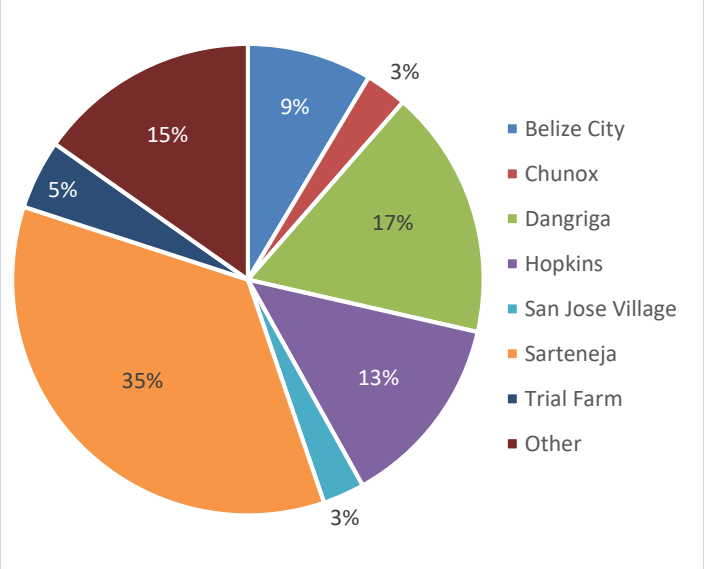


FIGURE 1: ORIGIN OF FISHERS WITH PRIMARY MANAGED ACCESS LICENSES FOR GRMR (n=105)

In 2017, 105 fishers were registered under the Managed Access Program as users of Managed Access Area 8 (GRMR) as their primary fishing area (Fisheries Department, 2017). 35% of the fishers originate from Sarteneja,

and use traditional sailboats to reach the area. It should be noted that the Sarteneja crews also include fishers resident in other communities such as Carmelita and Orange Walk. 30% originate from the central Belize communities – Dangriga (17%) and Hopkins (13%), accessing the area by skiff. Belize City is identified as the origin for 9% of the fishers (Table 7; Figure 1). A further 15% are classified as 'other', composed of communities that are only represented by one or two fishers.

The northern and central communities represent two very different fishing sectors. Those from Sarteneja use larger traditional sailboats with between 7 and 13 fishers to reach the Marine Reserve, each fisher having a dug-out canoe for daily fishing, with extracted product being stored in an ice box on the sailboat. These fishermen camp on their boats or on adjacent cayes, spending up to 12 days at sea, free-diving primarily for lobster and conch, and some fin-fish (depending on the season). The Stann Creek fishermen (primarily from Dangriga and Hopkins) generally use smaller skiffs, and access the area on shorter fishing trips, with an average of 2 to 3 fishermen per boat. Fishing methods include lines, as well as free diving for conch and lobster.

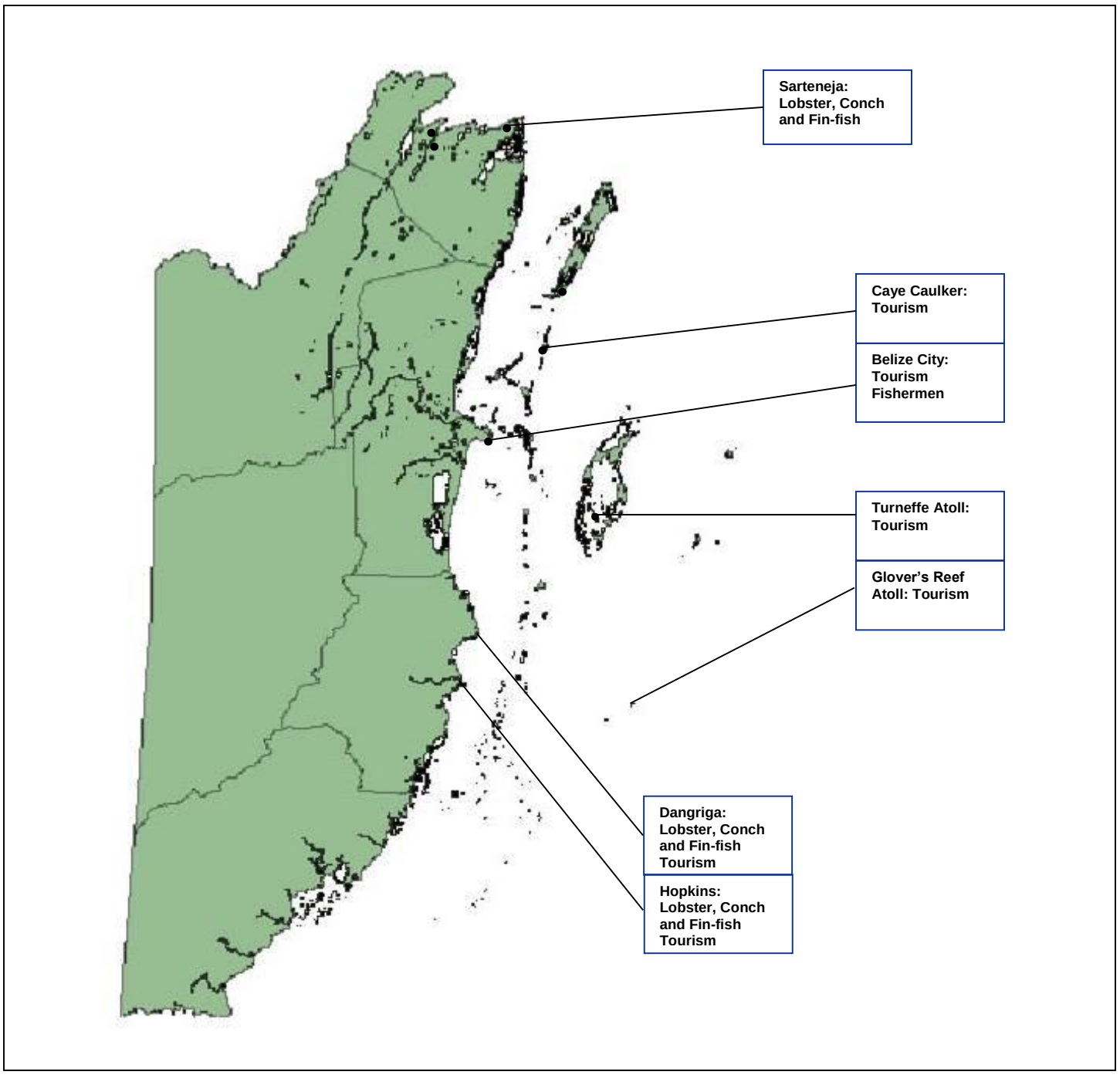
STAKEHOLDER COMMUNITIES OF GLOVER'S REEF MARINE RESERVE

Community	Location (UTM) Distance (km)	Population (est.)	Comments
Sarteneja	E16 0378750 N18 2029500 (158 km NW)	2,300	Largest fishing community, concentrating on lobster and conch throughout Belize waters using traditional sail boats. Largest number of fishermen utilizing natural resources of GRMR.
Dangriga	E16 0370200 N18 1876300 (11.4km ESE)	11,600	Fishing skiffs utilizing GRMR – fin-fish, lobster and conch Tourism
Hopkins	E16 0363200 N 18 1864680 (13km E)	1,027	Small number of skiffs, focused on GRMR - fin-fish, lobster and conch Tourism developments (eg. Hamanasi)
Belize City	E 16 0373776 N18 1935141	61,460	Business centre of Belize, with major port and international airport. Northern fisher sailboats sail from Belize City, and some crew members reside there
Placencia	E16 03653894 N18 26544 (14.3km NE)	1,200	Historically a fishing community – now a primarily tourism-based economy

TABLE 7: KEY STAKEHOLDER COMMUNITIES OF GLOVER'S REEF MARINE RESERVE

With its scenic beauty, vibrant reef and idyllic sand cayes, Glover's Reef Marine Reserve provides an important tourism service for south-central Belize. From Dangriga southwards, the coastline is rapidly changing as more resorts, retirement developments and other tourism developments,

bringing employment to the coastal communities. Despite its touristic values, however, it is under-utilized, with only 11.8% of overnight visitors visiting Dangriga / Stann Creek during their stay in Belize in 2015 (BTB, 2016).



MAP 5: STAKEHOLDER COMMUNITIES OF GLOVER'S REEF MARINE RESERVE

Belize's tourism industry, one of the fastest growing sectors in Belize, is rapidly becoming the major foreign exchange earner, with over 1,441,306 tourists arriving in Belize in 2017. 427,075 of these were overnight visitors, the remaining approximately 1 million are day visitors through the cruise industry (Figure 2; BTB, 2018). Tourism is primarily natural- and cultural-resource based, with visitors focusing on the cayes, coastal communities and coral reef (particularly snorkelling, diving and sport fishing activities), and inland protected areas.

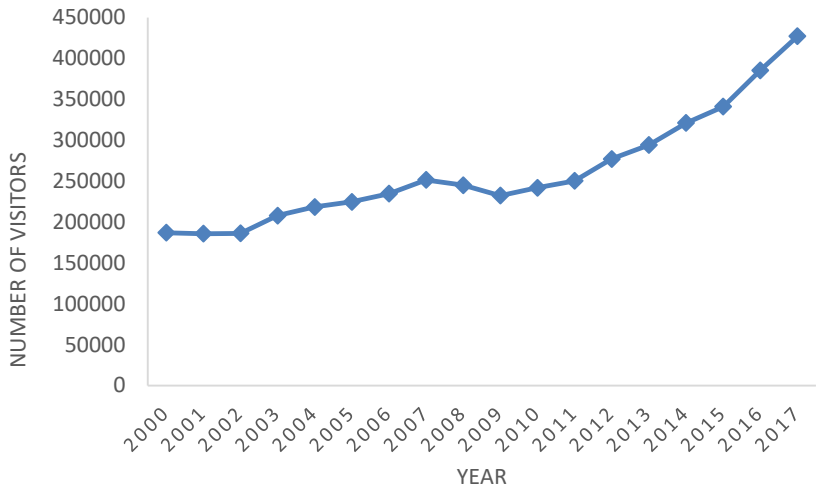


FIGURE 2: BELIZE OVERNIGHT TOURISM ARRIVALS 2000 – 2017, BTB, 2018

Overnight tourism in Belize shows a distinct seasonality, with the majority of visitors arriving in the first quarter of the year (BTB, 2018). The lowest months are September and October, the main tropical storm season (Figure 3).

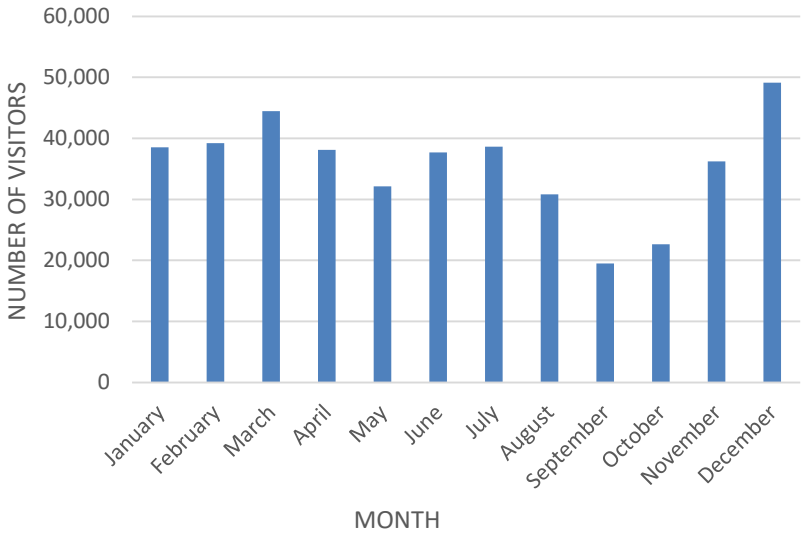


FIGURE 3: BELIZE OVERNIGHT TOURISM ARRIVALS PER MONTH (AVERAGE: 2000 – 2017) (BTB, 2018)

Direct tourism expenditure in Belize exceeded Bz$555.3 million in 2017 – 15% of the total GDP (WTTC, 2018). When indirect contributions are taken into account from related support industries, this rises to 41.3% of the GDP. In 2017, the tourism industry supported over 21,000 direct jobs – 13.4% of total employment, expanding to 37.3% of total employment when related support industries are taken into account (WTTC, 2018).

The tourism sector is an important component of Belize's economy, providing employment for one out of seven people at the national level. In Stann Creek District, the tourism industry employs

approximately 1,787 people (1,002 men and 785 women), only 9.2% of the national total (Table 8; BTB / Social Security Board, 2017).

TOURISM STATISTICS FOR STANN CREEK DISTRICT, 2016

Average daily expenditure for guests in Stann Creek: Bz$350.42
Annual revenue generation (accommodation sector): Bz$20.28 million
Average hotel occupancy: 31.7%
Number of registered tour guides: 147
Number of registered tour operators: 37

TABLE 8: TOURISM STATISTICS FOR STANN CREEK DISTRICT, 2017 (BTB, 2018)

DANGRIGA

Dangriga, once known as Stann Creek Town, is the largest community in the proximity of Glover's Reef Marine Reserve. It is an expanding coastal town located at the mouth of the Stann Creek River. with a population estimated at 9,592 in 2010, growing to 10,328 in 2017, approximately 27.3% of the 42,230 people resident in Stann Creek District (SIB, 2017)). The town is predominantly Garifuna, with almost 60% of the population considering themselves as Garifuna in 2010 (Figure 4; SIB, 2010) - 27% of the national Garifuna population. Dangriga is considered a vibrant cultural centre of the Garifuna people, with strong ties to the history, language and culture. This includes Garifuna Settlement Day, celebrated each year on November 19th with the re-enactment of the arrival of the Garinagu after being driven out of St. Vincent.

As the district center, Dangriga is the financial, commercial, medical and educational center for the district, with a transient population coming in to the town each day from the rural communities. Many of the district government offices are located here, as are the high schools.

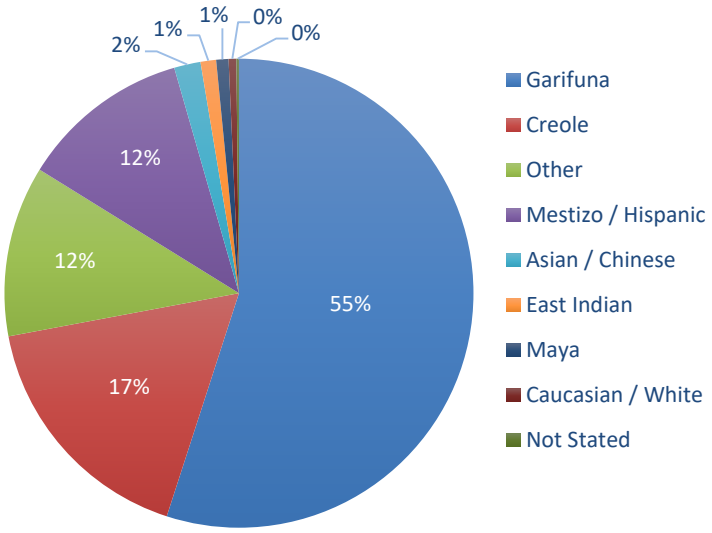


FIGURE 4: CULTURAL COMPOSITION OF DANGRIGA (SIB, 2017)

Dangriga's economy is based on fishing, agriculture, tourism and farming, with citrus and cultivation being almost synonymous with the Stann Creek Valley. 18 fishers have area-specific licenses as traditional users of GRMR under the Managed Access program. It has an increasing role to play in tourism as an access point to the cayes, though this is currently under-utilized. There us a trend of 'working out', with young adults leaving the town for other areas in Belize with higher employment opportunities, or travelling to the United States to seek work. Many maintain strong links with Dangriga, sending funds back to support their families. This migration of young adults out of the town is of concern, with those that leave including the

entrepreneurs – those that have the vision and innovation to be able to start businesses that provide local employment opportunities for others.

There has also been an increase in migrants into the community from Honduras, Guatemala and El Salvador, hired originally as seasonal workers on the citrus, banana and shrimp farms, and then settling in the area.

HOPKINS

Hopkins is a largely Garifuna community located on the coastal strand of Stann Creek District, in central Belize with an economy that was traditionally based on farming and fishing. The Hopkins Fishermen Association has 30 members, of which 15 are active traditional fishers, though many are shifting to part- or full-time jobs associated with the growing tourism industry in and around the community. 14 fishers have area-specific licenses as traditional users of GRMR under the Managed Access program.

Recently, there has been an almost exponential growth of low-medium end tourism in the community, and an associated development of foreign-owned resorts catering to medium-high end tourism along the coastline. Tourism has enabled people in Hopkins to develop consistent incomes, with farming and fishing shifting to secondary importance, providing supplementary incomes in the low tourism season for those with only seasonal tourism employment (Morozova, 2016). The establishment of larger resorts has increased the availability of employment, opening up opportunities, particularly for women in the community, with a demand for service-related staff (housekeeping, cooking, reception etc.). It has also improved opportunities for employment as tour guides. Many of the larger resorts are willing to invest in capacity building for their staff, and retain them at the same rates during the low season, reducing their need to return to fishing. However, many also select their staff based on skills and experience, not necessarily through a wish to provide local employment - it is estimated that between 50 and 80% of employment is of local residents (Hopkins or Sittee River) (Morozova, 2016).

The increasing interest in Hopkins, not just a tourism destination but also for recreational and retirement homes for foreign investors, has led to the sale of seafront properties, providing short-term economic gain for those selling, but reducing the potential for local community members to maximize long term development opportunities.

Small businesses identify marketing as one of their biggest barriers, with insufficient funds available for large scale promotion. Those wanting to enter the tourism industry as tour guides either fund themselves or are trained on the job when working at one of the resorts.

SARTENEJA

Sarteneja, established in the 1850's by refugees of the Caste War, has a population estimated at 2,300, and is the largest fishing village in Belize. It is accessible by road from Orange Walk and Corozal (via Copper Bank), though roads are unpaved, poorly maintained, and can become flooded during storm events, preventing access for up to 2 months. It is also accessible by water, with daily water taxis connecting it to San Pedro and Corozal.

The majority (69.6%) of households in the Sarteneja community consider themselves dependent on the traditional harvesting of marine products (lobster, conch and fin-fish), and more recently also reef-based tourism, throughout the coastal waters of Belize (SACD data, 2014). 37 fishers are licensed for the Glover's Reef Managed Access area (35% of the fishers using the area). The reliance on fishing creates a strong relationship between the state of the resource and the needs of the community. With the decline in both the conch and the lobster fisheries, and the collapse of some of the key fin-fish spawning aggregation sites, there has been a significant impact on the livelihoods of the community. 86.1% of respondents consider their income to be the same (33.3%; n=72) or less (52.8%; n=72) than 10 years ago, with only 13.9% reporting an increase in income (SACD data, 2014).

Against a background of limited education (95.3% of interviewees in Sarteneja had not progressed beyond primary level education), limited communication skills (97.6% of respondents are Spanish speaking as their first language, and many have limited English skills), limited access to financial capital to start new initiatives and lack of training in alternative skills, it is challenging for the fishers of this stakeholder community to move into other livelihoods, especially with the poor quality of agricultural soils, few local employment opportunities and lack of alternative industries in the area. The key perceived barriers to development are limited employment opportunities (34% of respondents) and the state of the roads (28%) (SACD data, 2014).

Whilst the area is not good for agriculture, Sarteneja benefits from the aesthetic beauty of its scenic waterfront, and from the rich traditional and cultural aspects of this fishing community, opening up opportunities for tourism. The Corozal Bay Wildlife Sanctuary offers opportunities for boat excursions based on the natural resources, including opportunities to see manatees, dolphins and birds, and the community has a cohort of newly graduated tour guides that are building their capacity for Sarteneja-based tours.

STAKEHOLDER ANALYSIS

A basic stakeholder analysis identifies stakeholder interests and impacts (Tables 9 and 10), to assist in defining specific strategies for communication and engagement.

Stakeholder	Role
Fisheries Department	Government authority responsible for Glover's Reef Marine Reserve. Responsible for enforcement of Fisheries legislation, implementation of Managed Access, towards achieving maximum sustainable yield. Also responsible for protection of sea turtles
Wildlife Conservation Society	A long term partner, providing technical support to Fisheries Department for science and piloting of Managed Access
Forest Department	Government authority responsible for enforcement of mangrove legislation and protection of manatees, crocodiles, and dolphins
Department of the Environment	Government authority responsible for regulation of coastal and caye development activities, and of large scale agricultural and industrial activities in the watersheds
Geology and Petroleum Department	Government authority responsible for regulation of dredging and oil exploration / extraction activities
Belize Tourism Board	Provide training, certification and licensing framework for tour guides, tour operators and hotels. Promote tourism development and regulation of tourism use of the protected area
Tour Guides	Have livelihoods based on the marine resources of the area. Provide interpretation for tourists, and guide visitor behavior
Traditional Fishermen	Have livelihoods based on the marine resources of the area – primarily conch, lobster and fin-fish.
Fishing Cooperatives	Promote and encourage increased extraction of marine product. Link fishermen with the export market
Coastal and Caye Developers	Have cleared terrestrial ecosystems and mangroves to build on cayes of GRMR in the past, with the potential to impact the environment further. May also be willing to use best environmental practices in their development
Tourism Services – hotels, resorts, restaurants	Rely on the aesthetic beauty of GRMR for attracting guests to the area. Provide employment and training in the tourism industry, and the services to build capacity of Stann Creek communities as environmentally sound tourism destinations. Provide interpretation activities for visitors.
Research Organizations	Use the WCS base for scientific research at GRMR, contributing to knowledge for improved management
Student Study Organizations	Use GRMR as an educational study site
Belize Coast Guard	Responsible for security to life and property

TABLE 9: KEY STAKEHOLDERS OF GLOVER'S REEF MARINE RESERVE

TABLE 10: STAKEHOLDER ANALYSIS FOR GLOVER'S REEF MARINE RESERVE

Stakeholder	Influence or Impact of Glover's Reef Marine Reserve on Stakeholder		Influence or Impact of Stakeholder on Glover's Reef Marine Reserve	
Community Stakeholder Sarteneja, Dangriga, Hopkins,	▪ Protection of fish, lobster and conch resources within the Conservation and Preservation Zones ensuring continued viability of fishery	+	▪ Some cooperating with Managed Access regime and improving stewardship	+
	▪ Protection of important mangrove nursery sites, ensuring continued viability of fishery	+	▪ Some have low level of cooperation or openly antagonistic towards protected area	-
	▪ Protection of traditional fisher rights through Managed Access	+	▪ Illegal fishing within the replenishment zones	-
	▪ Exclusion from traditional fishing areas	-	▪ Unsustainable / illegal fishing practices (undersized / out of season / restricted species)	-
			▪ Fishing impacts within protected areas (including damage to coral)	-
			▪ Anchor damage to reef	-
Tour Guides (including tour boat captains)	▪ Benefit from having Glover's Reef Marine Reserve as a major venue for snorkeling, dive- and kayak-associated tourism	+	▪ Support the conservation goals of Glover's Reef Marine Reserve	+
	▪ Employment in reef-based tourism initiatives and related tourism sector businesses	+	▪ Provide interpretation for visitors, facilitating overall visitor appreciation	+
	▪ Income from using Glover's Reef Marine Reserve for tourism	+	▪ If well trained, assist with visitor management within the protected areas through in-depth briefings	+
			▪ If poorly trained, can result in poor visitor management and increased impact on corals and associated fauna, anchor damage etc.	-
			▪ Impact behavior of fish through poor tourism practices such as chumming	-
Local / National Tour Operators	▪ Benefit from having Glover's Reef Marine Reserve as a major venue for snorkeling, dive- and kayak-associated tourism	+	▪ Provide marketing at a national level, and send visitors to Glover's Reef Marine Reserve, increasing sustainability	+
	▪ Income from using Glover's Reef Marine Reserve as a tourism destination	+	▪ Support the conservation goals of Glover's Reef Marine Reserve	+
			▪ Increase the potential for exceeding the carrying capacity of the protected area	-

TABLE 10: STAKEHOLDER ANALYSIS FOR GLOVER'S REEF MARINE RESERVE /2

Stakeholder	Influence or Impact of Glover's Reef Marine Reserve on Stakeholder		Influence or Impact of Stakeholder on Glover's Reef Marine Reserve	
Caye-based Tourism Initiatives	▪ Marketing benefits from being located in part of Belize's World Heritage Site	+	▪ Support the conservation goals of Glover's Reef Marine Reserve	+
	▪ Benefit from having Glover's Reef Marine Reserve as a major venue for snorkeling, dive-, kayak- and fly-fishing associated tourism	+	▪ Provide marketing of Glover's Reef Reserve at both national and international level	+
	▪ Income from using Glover's Reef Marine Reserve as a tourism destination	+	▪ Provide interpretation for visitors, facilitating overall visitor appreciation.	+
			▪ Potential impacts from pesticide / herbicide use	-
			▪ Potential impacts from dredging activities	-
			▪ Potential impacts on fish populations through mangrove clearance	-
			▪ Potential impacts of run-off following caye clearance, and associated sedimentation impacts on seagrass and reef	-
			▪ Potential impacts of inadequate sewage disposal, grey water and detergents	-
			▪ Beach use impacts on turtle nesting	-
BTIA	▪ Benefit from having Glover's Reef Marine Reserve as a tourism venue, and World Heritage Site, attracting visitors to Belize and to the area	+	▪ Provide national and international marketing of Glover's Reef Marine Reserve	+
			▪ Support the conservation goals of Glover's Reef Marine Reserve	+
General Belize Public (excluding primary stakeholder communities)	▪ Maintenance of access to fish, lobster and conch as part of the Belize diet	+	▪ Support of the general public will strengthen the position of protected area	+
	▪ Environmental services	+	▪ Lack of support may increase chances of dereservation	-
	▪ Cultural and aesthetic appreciation	+		
	▪ Increased awareness of marine resources through education	+		

TABLE 10: STAKEHOLDER ANALYSIS FOR GLOVER'S REEF MARINE RESERVE /3

Stakeholder	Influence or Impact of Glover's Reef Marine Reserve on Stakeholder	Influence or Impact of Stakeholder on Glover's Reef Marine Reserve
Visitors: Tourists	▪ Enjoy Glover's Reef Marine Reserve as a tourism destination + ▪ Benefit from education and awareness opportunities +	▪ Entrance fee contributes towards the goal of financial sustainability + ▪ Provide marketing nationally and internationally by word of mouth, if happy with level of product + ▪ Presence deters fishing (and other illegal activities) within protected area + ▪ Negatively impact marine and terrestrial environments through poor tourism practices -
Visitors: Researchers	▪ Benefit from being linked to Glover's Reef Marine Reserve + ▪ Benefit from WCS facilities on Middle Caye + ▪ Benefit from access to a near-pristine reef environment + ▪ Benefit from historic baseline information on past research activities within protected areas +	▪ Conservation management benefits from data gathered, greater knowledge of marine and terrestrial environments and species within area + ▪ Possible impact of research activities on marine environments -
Visitors: Student Groups	▪ Benefit from access to a near-pristine reef environment + ▪ Benefit from the presence of the WCS field station on Middle Caye +	▪ Provide revenue for the marine reserve and support of WCS field station + ▪ Large groups of students have potential to increase the visitor impact on the reef, if poorly supervised - ▪ Possible impact of poorly supervised / vetted student research activities on marine environments -
Sailboat Charter Companies	▪ Benefit from protection of Glover's Reef Marine Reserve as a major destination, and its value as a tourist attraction + ▪ Benefit from tourism infrastructure – mooring buoys, resorts / restaurants, visitor center +	▪ Support the conservation goals of Glover's Reef Marine Reserve + ▪ Impacts of sewage and detergent, bilge water. grey water and oil - ▪ Anchor damage on mooring sites - ▪ Potential for grounding on the reef -

TABLE 10: STAKEHOLDER ANALYSIS FOR GLOVER'S REEF MARINE RESERVE /4		
Stakeholder	**Influence or Impact of Glover's Reef Marine Reserve on Stakeholder**	**Influence or Impact of Stakeholder on Glover's Reef Marine Reserve**
International Tour Operators	▪ Benefit from having Glover's Reef Marine Reserve as a major venue for reef-associated tourism + ▪ Benefit from having Glover's Reef Marine Reserve as a World Heritage Site destination – global recognition for effective marketing + ▪ Income from using the GRMR for tours +	▪ Provide marketing at an international level, and send visitors to the protected area, increasing sustainability + ▪ Support the conservation goals of Glover's Reef Marine Reserve +
Government of Belize	▪ Provides fisheries management for fishing Industry + ▪ Provides environmental services + ▪ Glover's Reef Marine Reserve is included in the National Protected Areas System Plan – effective management contributes towards fulfilling Belize Government's commitment to the conservation of natural resources, CCAD, CBD, and national World Heritage sites + ▪ Income generation of foreign revenue + ▪ Provides employment opportunities in stakeholder communities +	▪ Political support (currently being strengthened through the NPAPSP) + ▪ Can regulate caye development through the EIA process + ▪ Can regulate mangrove clearance through revised the Mangrove regulations + ▪ Can overturn decisions on oil exploration and sale of national cayes -

TABLE 10: STAKEHOLDER ANALYSIS FOR GLOVER'S REEF MARINE RESERVE

1.4 Physical Characteristics

1.4.1 CLIMATE

Wind Systems: Belize is affected by three very distinct seasonal weather systems: trade winds, northers and tropical storms. All three have an influence on the rainfall and temperature patterns, on the sea level, and on the currents of Glover's Reef Marine Reserve. The predominant winds are the ***Trade Winds***, blowing from the east and north-east from April to October, interspersed by tropical storms. ***Northers*** - high-pressure fronts moving down from the north - occur between October and April, bringing cooler weather.

Rainfall: Glover's Reef Marine Reserve lies within the second lowest rainfall belt, with between approximately 1,500 and 2,000 mm (approximately 60" to 80") of rain per year (Figure 5). There is a pronounced dry season stretching from January through to May, with only 32 mm recorded in April, the driest month. This is followed by a wetter season (June to October) with total monthly rainfalls during that period of between 210 and 234 mm, generally associated with passing tropical waves and storms, particularly between September and November.

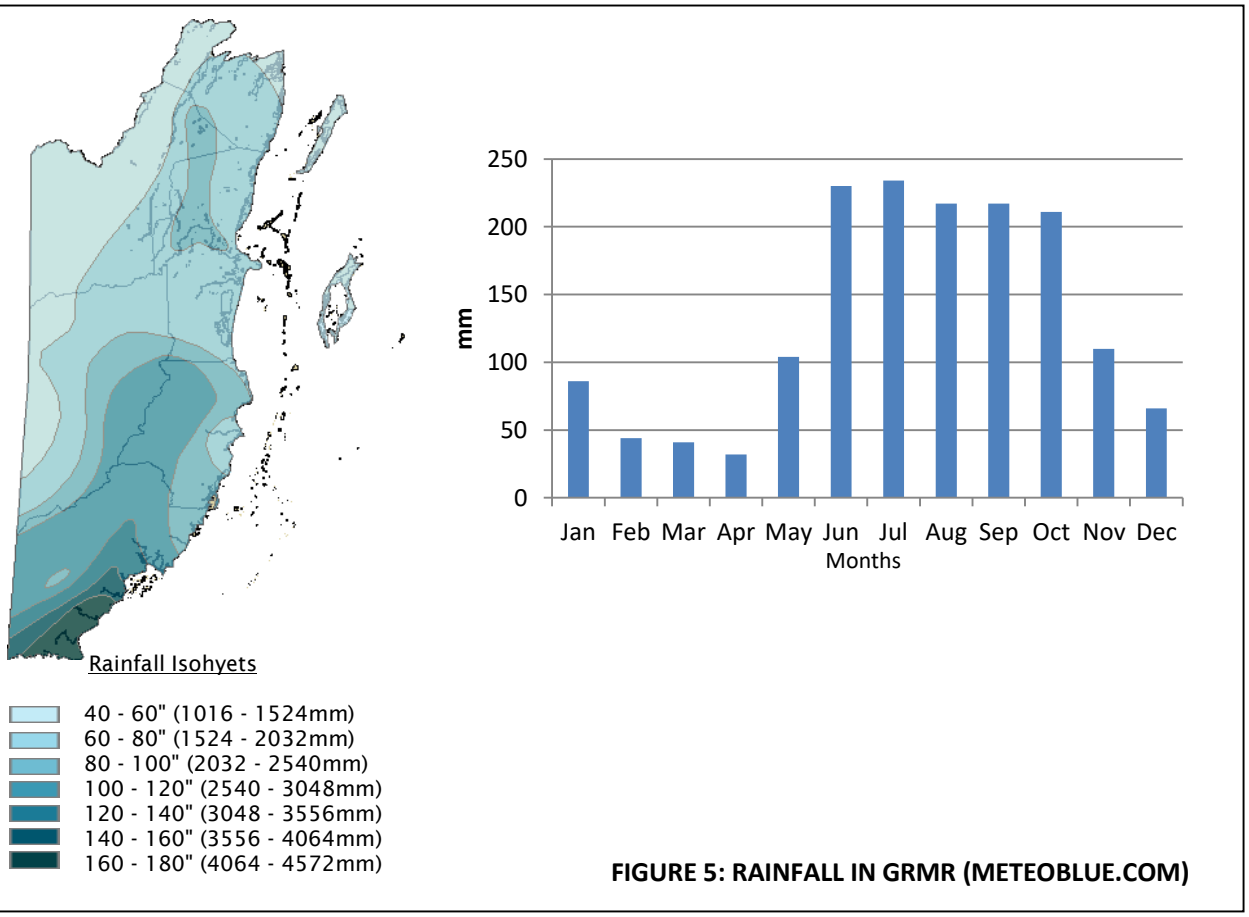


FIGURE 5: RAINFALL IN GRMR (METEOBLUE.COM)

Temperature: The annual mean temperature in the GRMR area is 23.6°C, fluctuating throughout the year from a minimum monthly average of 22°C in January, during the cold fronts, and a maximum in June - August of 25.0°C (Figure 6). Daily low and high temperatures range from 18.0°C to 31.0°C

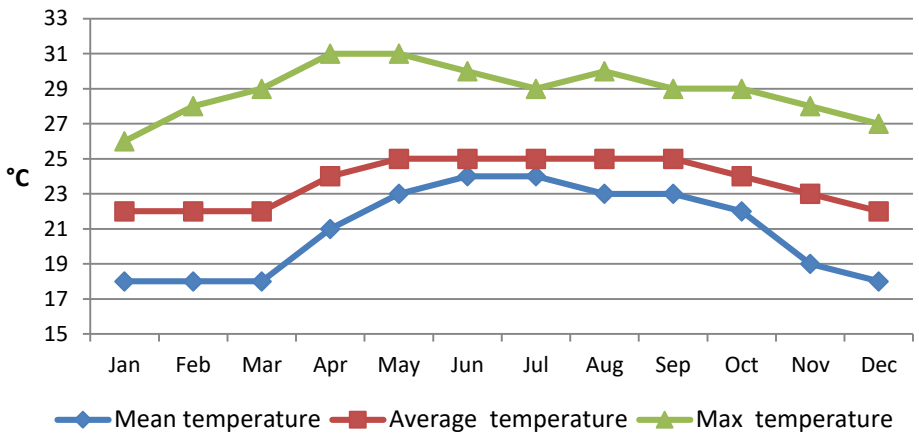


FIGURE 6: MAXIMUM, MINIMUM AND MEAN TEMPERATURE AVERAGE PER MONTH (METEOBLUE.COM)

Tropical Storms: Tropical storms affect Belize every year between the beginning of June and end of November, with potential for landfall being particularly high in northern Belize. Originating in the Atlantic Ocean over warm, tropical waters, these storms are non-frontal, developing highly organized circulations, and ranging in scale from tropical depressions and tropical storms (with sustained wind speed < 74 mph) to hurricanes (with sustained wind speed > 74 mph). These storms move westward towards the Caribbean and Central American coastline, gathering strength until they hit land. They generally bring extreme weather conditions – heavy rains, destructive winds.

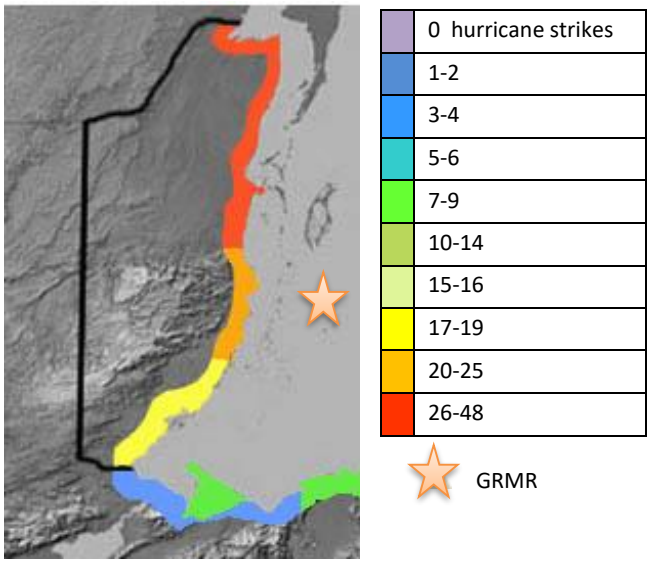


FIGURE 7: TOTAL HURRICANE STRIKES 1851 – 2009, AFTER ANDERSON, 2016

Whilst many hurricanes have very focused paths of destruction, their effects are wide ranging, particularly in the marine and coastal environments. GRMR has been affected on an almost annual basis by tropical storms, some of these reaching hurricane strength (Figure 7). Tropical storm impacts include mechanical damage to the reef and siltation of the corals, affecting habitat quality for reef organisms. Mangroves, whilst known for their resilience to hurricane damage, will lose their leaves and suffer from increased mortality in major hurricanes. The storm surge, a local rise in sea level of several feet that washes over the cayes, has the potential to remove vegetation cover, with salt contamination of ground water and soils. The severity of the impacts from tidal surges depends on the strength of the surge, and the duration of inundation. Tropical storms and hurricanes also have the potential to impact life and property on the Atoll and in the stakeholder communities on the mainland to the west. All tropical storms, even tropical depressions, can bring increased rainfall, causing extensive

flooding of the mainland, and increased water flow into the rivers and coastal waters, increasing the turbidity of the water as far out as GRMR.

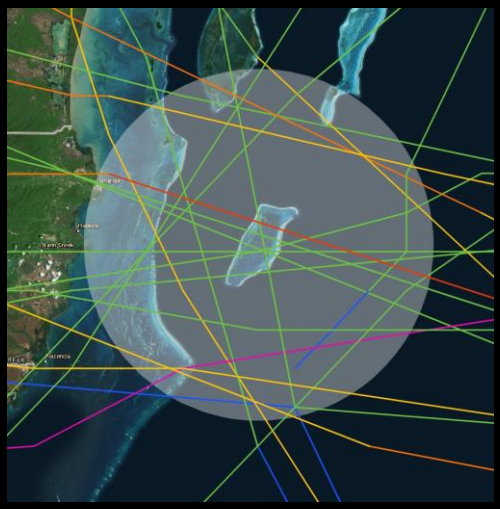


FIGURE 8: HURRICANES AND TROPICAL STORM PATHS PASSING THROUGH OR WITHIN 50KM OF GRMR (WWW.COAST.NOAA.GOV, 2018)

Hurricanes can also bring cooler water to the reef shelf, stirred up from deeper Caribbean Sea, reducing the surface water temperatures, and therefore the potential for coral bleaching. They can cause major changes to the shapes and sizes of cayes and sandbars within the Atoll, as well as causing damage to infrastructure on the cayes. Whilst many hurricanes have very focused paths of destruction, their effects are wide ranging, particularly at sea.

Historical records identify 20 tropical storms / hurricanes that have impacted GRMR between 1900 and 2016, either passing directly across the Marine Reserve, or coming within a 50 km radius of the area. This includes 12 tropical storms, 5 Category One hurricanes, 1 Category Two, 1 Category Three, and 1 Category Four (NOAA, 2018). Five additional hurricanes (Hurricane Earl (H1, 2016), Mitch (H5, 1998), Fifi (H2, 1974), Francelia (H2, 1969) and an unnamed storm (H4, 1931) passed beyond the 50km used to define storm influence, but still strong had strong impacts on the area (Figures 8 and 9; Table 11). As well as the physical and mechanical damage to the coral, hurricanes also stir up the water, increasing turbidity and can reduce water clarity for a significant time after the storm event itself. Water clarity can be further reduced following tropical storms by the associated heavy rainfall, which can exacerbate erosion and increase sediment transport from the mainland via the rivers.

Name	Cat.	Date Passed <50km of GRMR	Name	Cat.	Date Passed <50km of GRMR
Harvey	TS	Aug 19, 2011	Unnamed	TS	Aug 3, 1942
Richard	H1	Oct 24, 2010	Unnamed	TS	Sept 22,1942
Iris	H4	Oct 9, 2001	Unnamed	TS	Oct 11, 1938
Kyle	TS	Oct 12, 1996	Unnamed	TS	Jun 5 and 8, 1934
Gert	TS	Sept 17, 1993	Unnamed	TS	Sep 11, 1933
Greta	H3	Sep 18, 1978	Unnamed	TS	Sep 25, 1932
Edith	H1	Sept 10, 1971	Unnamed	TS	Aug 15, 1931
Laura	TS	Nov 20, 1971	Unnamed	H1	Oct 13, 1906
Anna	H1	Jul 24, 1961	Unnamed	H2	Oct 12, 1892
Abby	H1	Jul 14, 1960			
Gilda	TS	Sep 26, 1954			
Other large storms affecting the area (>50km away from GRMR)					
Earl	H1	Aug 4, 2016	Francelia	H2	Sep 3, 1969
Mitch	H5	Oct 27, 1998	Unnamed	H4	Sep 10, 1931
Fifi	H2	Sep 19, 1974			

TABLE 11: HURRICANES PASSING WITHIN 50KM OF GRMR (WWW.COAST.NOAA.GOV)

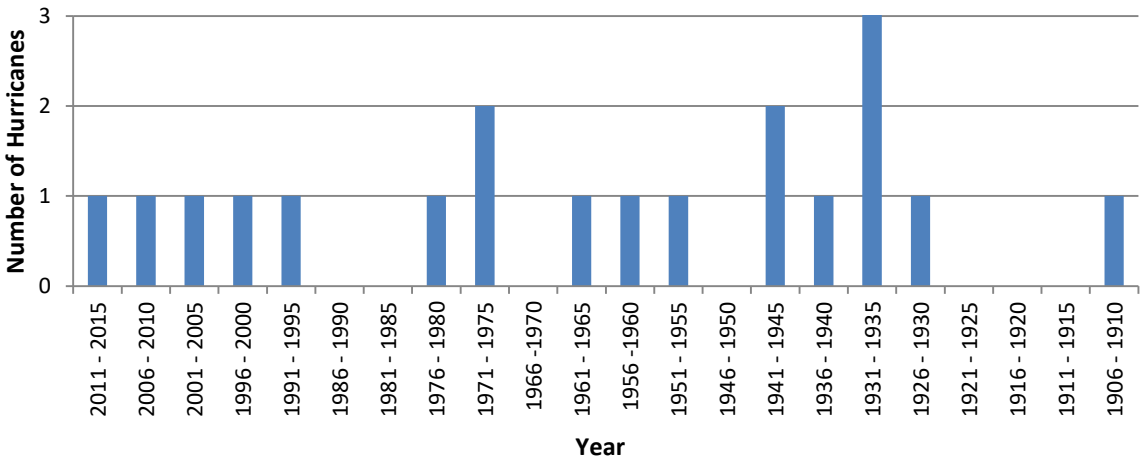


FIGURE 9: FREQUENCY OF HURRICANE EVENTS PASSING WITHIN 50KM OF GRMR 1906 - 2016 (TROPICAL STORMS / HURRICANES); WWW.COAST.NOAA.GOV)

1.4.2 GEOLOGY

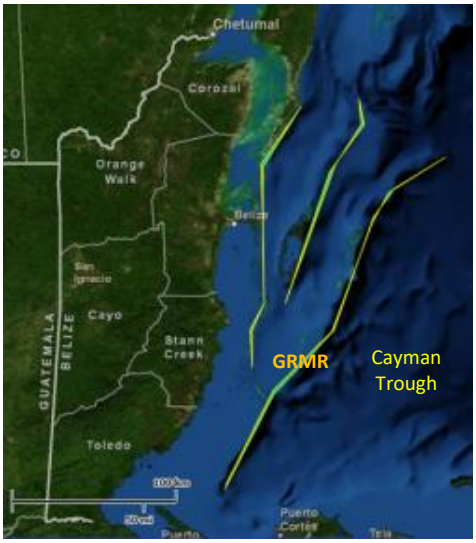


FIGURE 10: FAULT LINES / ESCARPMENTS RUNNING PARALLEL TO THE BELIZE COASTLINE, FORMING THE BASE OF THE BARRIER REEF AND ATOLLS (BASED ON PURDEY ET AL., 2003)

The continental shelf underlies the entire coastline of Belize and extends seaward 15-40 km from the coast. It is a complex underwater platform of Pleistocene limestone rock - a series of tilted fault blocks caused as a result of the eastward subsidence of the Cayman (or Bartlett) Trough during the Pliocene, about seven million years ago (Schafersman 1972) (Figure 10). This has resulted in the development of three offshore atolls – two of these (Lighthouse Reef and Glover's Reef) are located on the third, most easterly escarpment furthest from the mainland.

Glover's Reef Atoll is the most southerly of the three atolls of Belize, covering approximately 200km² (35km long and up to 7.5km wide). The Atoll sits on metamorphic rock, at a depth of between 777 m and 959 m below the reef. This base rock is overlain with approximately 250m of calcareous siltstone of Late Cretaceous age (100 million years ago), and 560 m of Tertiary reef accumulation (64 million years ago to the present). It is thought to have been formed in areas where limestone build-up has been at a rate equal to, or greater than, the subsidence caused by the movement on the faults, resulting in the formation of carbonate platforms surrounded by water that gets progressively deeper to the east, reaching 4000m. The reef platform itself

is thought to be a wave-cut reef of the last interglacial age on which the the overall physiography of the Aoll, including the rim, lagoon, patch reefs, and channels, have developed following rising sea levels.

Soils / Sediments: Sediments from reef and fore reef are comprised of fragments of coral, red algae and *Halimeda*. In contrast, sediments of the back reef area contain more mollusk fragments and have lower percentages of *Halimeda* (Gischler 1994). Sediments associated with the patch reefs are poorly sorted coarse-grained carbonates, composed primarily of *Halimeda*, coral, coralline algae, mollusk and other skeletal particles. The lagoon floor is muddy, composed of fine-grained carbonate sand, with the sand fraction rich in *Halimeda*, mollusk and foraminifer grains (James & Ginsburg 1979).

The Atoll's six cayes are composed mainly of coral rubble on the windward side, deposited by hurricanes over time. The five larger cayes have depressions in the middle, which often contain standing water in the rainy season. On the lagoon side, the cayes have fine sand and coral (Stoddart 1962).

1.4.3 BATHYMETRY

Glover's Reef Atoll lies on a limestone platform stretching north-south, formed by slumping of the escarpment ridge during tectonic activity. The water depths on the platform range from 0 to 500m. On the outer north and east facing margins of the Atoll, and the northern portion of the west margin, the water depth increases rapidly to between 500 and 2900m. A recent assessment under the Ocean Exploration Trust's E/V Nautilus program used a multibeam sonar system to collect data on the deep-water bathymetry on the east facing side of the Atoll. The project provided data for the mapping of deep-water canyons, considered important geomorphic features that impact sediment transport, ocean currents, benthic ecosystems and deep water ecology (Figures 11 and 12; Ktona et al., 2015; Hiers et al., 2016).

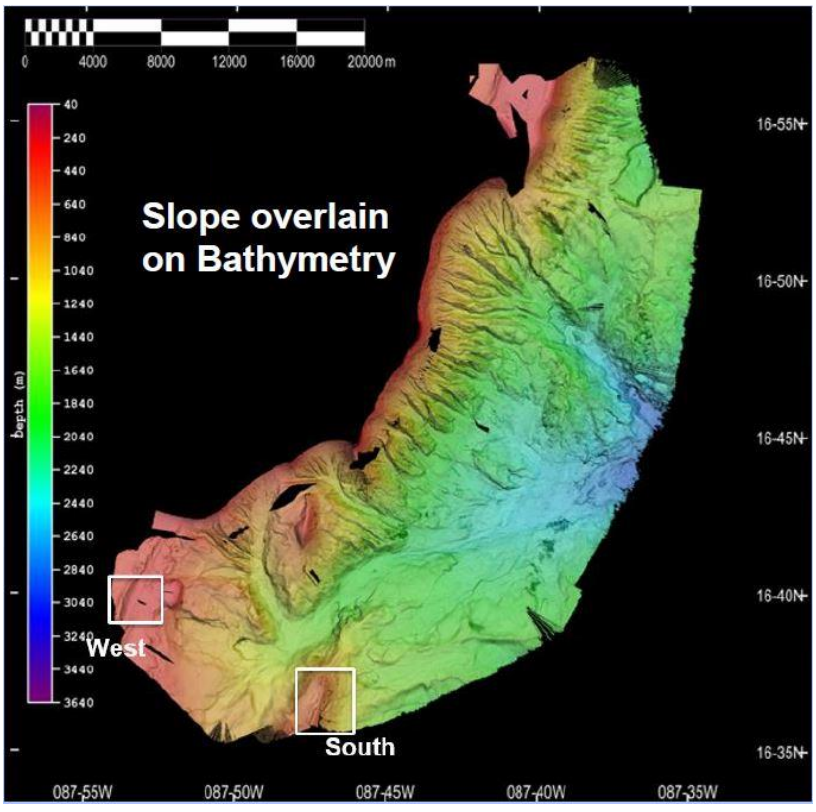


FIGURE 11: BATHYMETRY OF EAST FACING SLOPE OF GLOVER'S REEF ATOLL (Ktona et al., 2015)

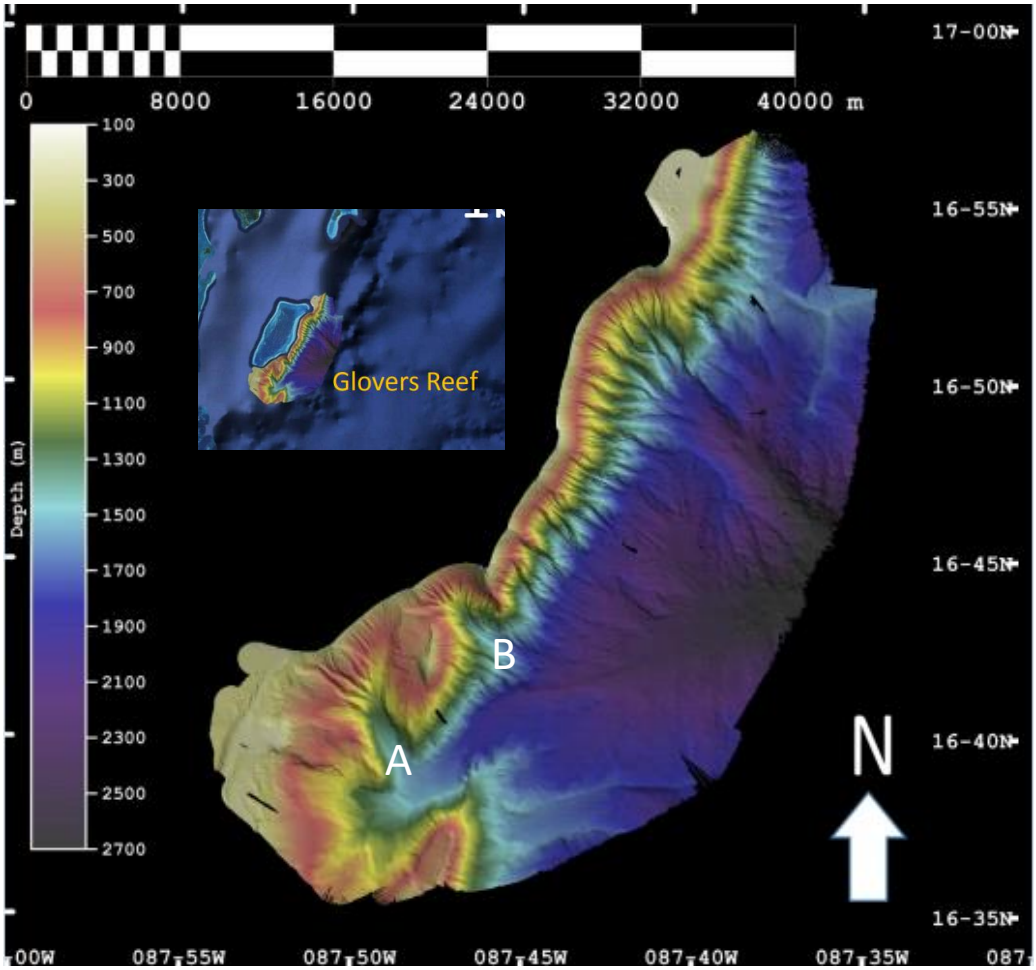
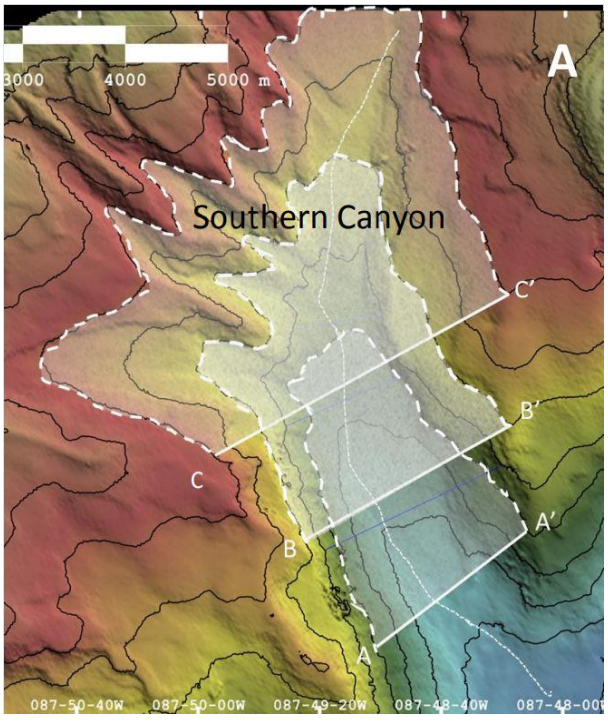
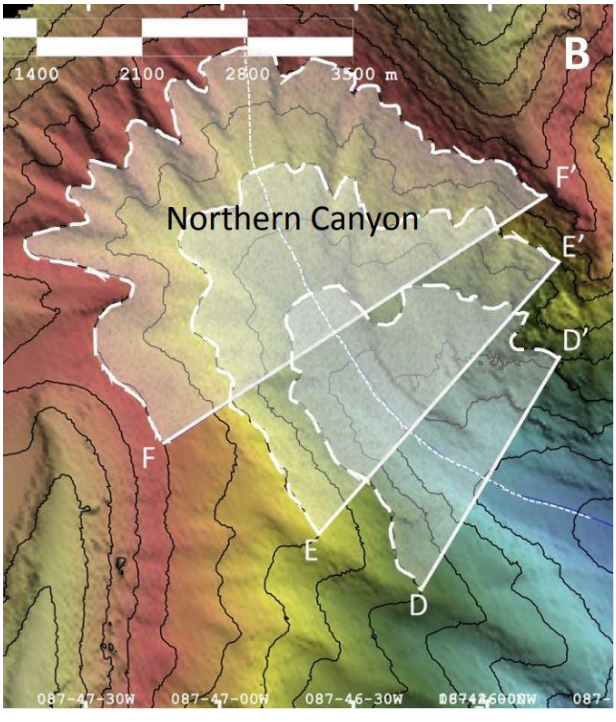


FIGURE 12: BATHYMETRY OF EAST FACING SLOPE OF GLOVER'S REEF ATOLL (HIERS ET AL., 2016)





The lagoon of Glover's Reef Atoll is much deeper than the lagoons of Lighthouse Reef and Turneffe, and is studded with about 850 patch reefs (Gischler 1994), many of which rise very close to the surface. Water depth in the inner lagoon averages 6 – 8 m deep. The platform slopes steeply from the lagoon ridge to the lagoon floor, which is basin-shaped. Two areas, one in the north and one in the south of the lagoon, are up to 18 m deep, separated by a higher area known as "Broken Ground" (Figure 13; Gishler & Lomando 1999).

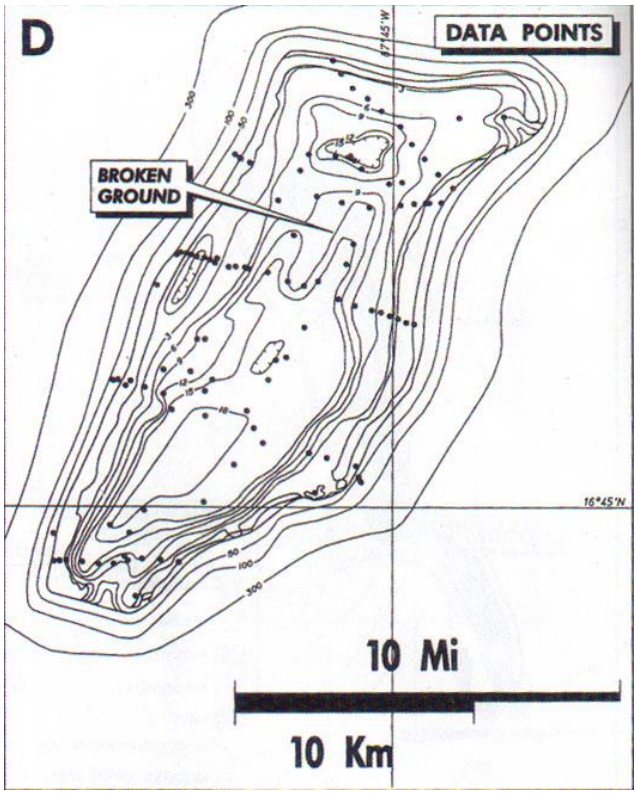


FIGURE 13: MAP SHOWING THE DEPTH CONTOURS WITHIN THE ATOLL'S LAGOON (GISHLER & LOMANDO. 1999)

1.4.4 TIDES AND WATER MOVEMENT

Knowledge of currents is essential in determining the transport of larvae, nutrients and pollutants. Water currents can also result in the spread of diseases, as was demonstrated by the decimation of *Diadema antillarum* populations throughout the Caribbean region, and of invasive species.

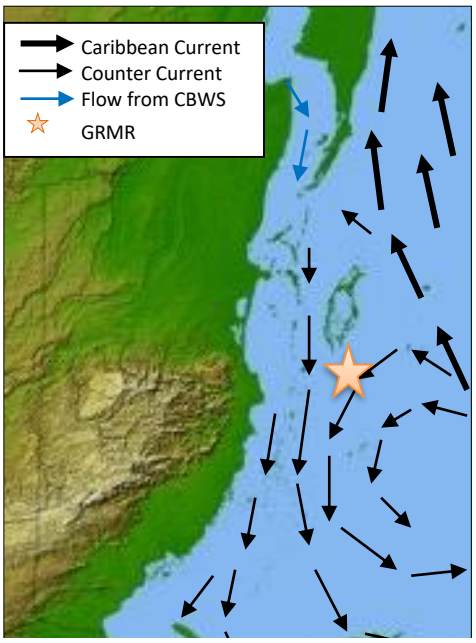


FIGURE 14: OCEANIC CURRENTS OF MESOAMERICAN REEF THAT INFLUENCE BELIZE

On a regional scale, the main oceanic current, the warm-water Caribbean Current, flows westwards from the Lesser Antilles then northwards through the Yucatan Channel, with an average flow rate of between 38 to 43 cm (15 to 17 inches) per second, and with localized gyres and counter-currents. One such counter current is created within the Yucatan Basin / Gulf of Honduras area, throughout Belizean coastal waters, where a counter-current is created, influenced by the Caribbean Current, flowing southwards past the Belize coastline (Figure 14; Stoddart, 1962). This creates a low-flow area between the atolls and the shore, with circulation being predominantly wind-driven by the easterly trade winds for much of the year, resulting in a south west / south circulation in the shelf lagoon and offshore basins (Purdy et al., 1975). Strong northerly winds frequently occur during the winter months, and are associated with cold air masses from the north, shifting currents to a more southerly direction.

The surface currents around the Atoll vary throughout the year. During February and March the currents are mainly northward at a rate of about 1.5 knots, with a reversal in April and May. From June to August currents remain northward at the same rate, increasing to 2 knots during September and October (Stoddart 1962; Wallace 1975). Throughout Belize, the northerly winds are known to depress the water level by as much as a foot, for several days at a time during the early part of the year – this is true on the atolls as well, and is thought to have a greater influence on shallow water and reef crest biodiversity than the regular tides, which average less than 0.3m (Stoddart, 1962; Smithsonian Caribbean Coral Ecosystems Program data, 2018). During February and March, currents flow northwards, with a reversal in April and May. Flow returns towards the north between June and October, at a rate of 1.5 knots in June / July, increasing to 2 knots in September / October (Stoddart, 1962).

Within the Atoll lagoon, surface currents generally flow southwesterly, driven by the trade winds. The east reef acts as a barrier to the oceanic waves, and has a constant strong current, estimated at 2 to 3 knots, flowing westwards into the Atoll. A strong west flowing current has also been observed occasionally between Lighthouse Reef and Glover's Reef (Stoddart, 1962).

Three reef channels are located on the windward side of the Atoll, connecting the lagoon waters directly with the open ocean. These are the North East Channel (1,400 yds wide), the Southwest Channel (approximately 1 mile wide) and the channel between Long Caye and Northeast Caye (about ¼ mile wide). These breaks in the reef are important tidal exchange channels, though even with these openings facilitating water flow into and out of the Atoll, the tidal range is only about 26 cm (Stoddart 1962). Flow is strongest in the major channels through the reef, and weakest on the lee of islands.

1.4.5 WATER PARAMETERS

As the Atoll lagoon is relatively open to the sea, normal marine salinities prevail, with surface water salinities ranged from 35.7 - 36.7 ppt (James & Ginsburg 1979; Gibson and Hoare, 2006). With the higher evaporation rate of water from inside the Atoll, the salinity is, on average, 1 ppt higher than the surrounding ocean, (generally 36 ppt, as opposed to the 35 ppt) (Gibson and Hoare, 2006).

Water temperatures range from between 27 – 28°C, to a depth of 50 m, though during still weather in August / September, temperatures can rise to 32°C in some areas on the atoll, resulting in mass bleaching of corals down to 30 m (Bright, 1999). These high temperature peaks are becoming more frequent as a result of climate change.

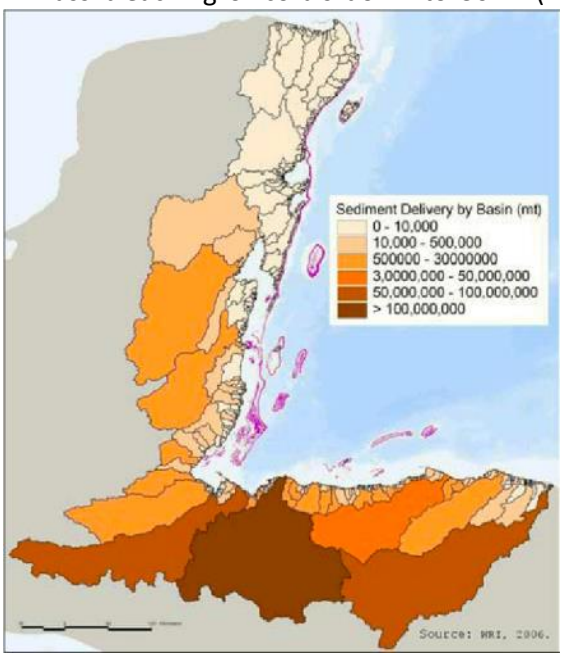


FIGURE 15: SEDIMENT DELIVERY BY WATERSHED BASIN (BURKE ET AL. 2006)

The waters outside the Atoll can be exceptionally clear, with visibility as high as 40 m at a depth of 10 m. Inside the Atoll, water is often turbid (James & Ginsburg 1979). Measures of visibility in 2005 showed some variation between March 2005, with visibility at between 4.5 and 24 m, and May, with variation from 6 to 30 m. March is generally characterized by stronger currents and winds, resulting in rough seas and increased turbidity, whilst May is characterized by calmer weather and correspondingly higher visibility Figure 15; Gibson and Hoare, 2006)

Tropical storms will have a temporary impact on water parameters. Following the passage of Hurricane Mitch in October 1998, Seawifs ocean colour images showed that large river plumes from Honduras extended out to the atoll (Andrefouet et al. 2002) with a significant increase in turbidity. Sedimentation and agrochemical contamination from mainland watersheds have been highlighted as perhaps one of the greatest impacts on the Belize reef, after climate change. Glover's Reef Marine Reserve lies east of six watersheds, which drain some of the principal banana growing areas of southern Belize. Following storm events, the increased sediment load of these rivers is also accompanied by an increased pesticide load, as rain washes agrochemicals from the watersheds into the rivers, and from there into the sea (Figure 16).

This is overshadowed by the watersheds emptying into the Gulf of Honduras from Guatemala and Honduras (particularly the Ulua, Motagua, Patuca and Aguan) where land use change has removed much of the natural vegetation from the formerly forested slopes (Burke et al., 2006). A significant increase in turbidity was also reported after Hurricane Mitch, with impacts from both Honduras and the Belize mainland.

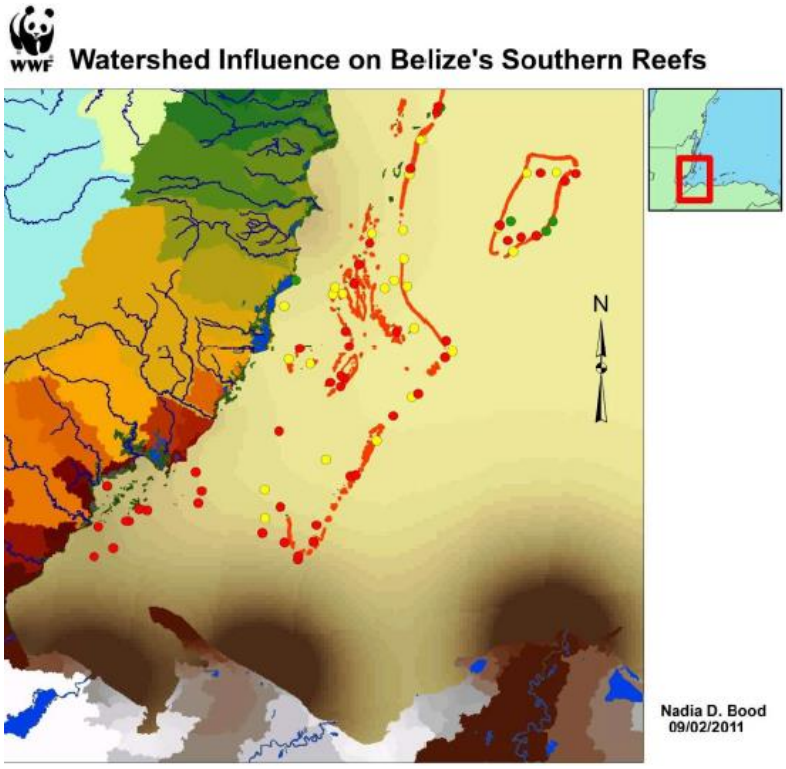


FIGURE 16: WATERSHED INFLUENCES ON BELIZE'S SOUTHERN REEFS (BOOD / WWF, 2011)

Data Source: Plume datasets (WRI, 2006) and coral reef datasets (WWF, 2006)

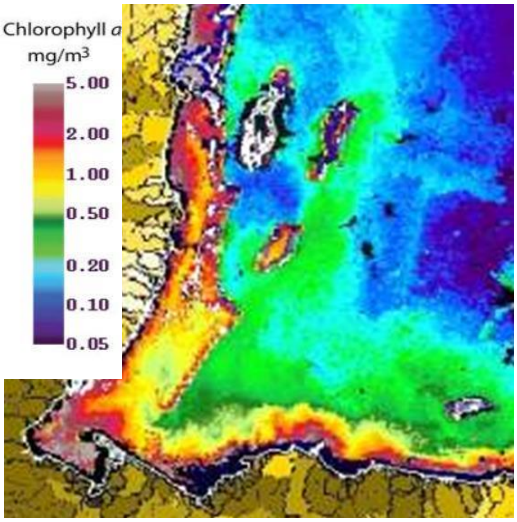


FIGURE 17: SEAWIFS CHLOROPHYLL A. AFTER SHANK ET AL. 2010/ SOTO ET AL. 2009

Sediment core analysis of two sites within the Belize reef system (Turneffe Atoll and Sapodilla Cayes), indicate that watershed runoff onto the reef has increased relatively steadily over time, consistent with historical and current land use trends. Sediment supply to the reef is greater in the south, with greater urgency for action to reduce runoff impacts (Carilli et al., 2009).

SeaWifs ocean colour images also shows that a large pulse of river water extends from the Guatemalan and Honduran rivers, stretching out as far as Glover's Reef Atoll, during these storm events (Figure 17; Soto et al., 2009; WRI/ICRAN, 2006; Andrefouet et al., 2002). Connectivity was tracked using the proxy of weekly mean chlorophyll-a concentrations, derived from satellite imagery over a nine-year period. These studies indicated that Honduran river plumes, particularly that of the Ulu´a River, reached the southern part of the Belize Reef 61% of the time.

- More than 80% of sediment, and more than half of all nutrients (both nitrogen and phosphorous) entering the Mesoamerican Reef originate in Honduras

- Guatemala was identified as a source of about one-sixth of all sediments and about one-quarter of all nitrogen and phosphorous entering coastal waters.

- Compared to the other countries, relatively minor percentages of the regional sediment load come from Belize 10 to 15%) and the Yucatan Peninsula in Mexico (5%) of the nutrients from all modeled watersheds.

- Of the 400 watersheds in the region, the Ulu'a watershed in Honduras was found to be the largest contributor of sediment, nitrogen, and phosphorous. Other significant contributors are the Patuca (in Honduras), Motagua (in Guatemala and Honduras), Aguan (in Honduras), Dulce (in Guatemala), Belize (in Belize), and Tinto o Negro (in Honduras).

Adapted from **"Human-caused Pollution Damaging Prized Central American Reefs; WRI analysis maps sources in Belize, Guatemala, Honduras, Mexico"** WRI, 2006

1.5. BIODIVERSITY OF MANAGEMENT AREA

Significant biological information has been accumulated about Glover's Reef Marine Reserve since the establishment of the Glover's Reef Research Station at Middle Caye in 1996, and the implementation of ongoing reef health and fish stock monitoring programs. This section provides a brief summary of the information on the area – drawn from Fisheries Department reports, published papers, monitoring reports and consultations during the management planning process.

1.5.1 ECOSYSTEMS

Whilst national ecosystem mapping (Meerman, 2004, revised 2017) gives an overview of the eight broad ecosystems to be found on Glover's Reef Atoll (Map 6; Meerman, 2004), more intensive studies have provided a finer detail more useful for management planning (Map 7; Mumby and Harborne, 1999; WCS, 2005). Mumby and Harborne developed a classification scheme that identified seventeen different ecosystem categories within the Atoll, whilst the WCS mapping defined twenty-one as part of their Living Seascape initiative.

Glover's Reef Atoll is considered the best developed of the four atolls of the Mesoamerican Barrier Reef System (MBRS), the longest Barrier reef system in the Western hemisphere. Stretching from the Yucatan to the south of Belize, the Mesoamerican Barrier Reef is recognized as one of 233 ecoregions with biodiversity and representational values considered outstanding on a global scale, and recommended as a priority area for conservation (Olson & Dinerstein, 1998) and a "highest priority" Ecoregional Biodiversity Priority Area (Kramer and Kramer, 2002). Belize has an estimated 1,420 km² of reef within its waters - 5.5% of the reefs of the Wider Caribbean (World Resources Institute, 2005).

ATOLL STRUCTURE

The Atoll is surrounded on all sides by a sharply defined reef (Stoddart, 1962), with an interior lagoon that is highlighted for the high number and density of patch reefs. The windward reef wall is very well developed, with many of the shallow spurs bare of living coral and encrusted with coralline algae (Stoddart 1962). The leeward reef wall is narrower, and the spurs and grooves are not as well developed (James & Ginsburg 1979). The reef crest forms a ridge of living coral separating the reef front from the reef flat. The reef flat, which is not more than 4 m deep, is covered with white coarse-grained sand stabilized locally by sea grass. Directly in the lee of the reef crest is a pavement zone about 10 to 100 m wide comprised of cemented reef rubble with some scattered coral growth (James & Ginsburg, 1979).

A baseline assessment in 1962 classified the peripheral reefs of Glover's Reef into four main groups (Stoddart, 1962):

1. The northern reef, with a reef flat about 500 m wide

2. The eastern reef, stretching from Northern Entrance to Northeast Caye, with a very wide reef flat of about 500 –1400 m
3. The southeast reef, from Long Caye to the Southwest Cayes with a narrower reef flat with a width of about 200 – 500 m
4. The leeward reef, with a reef flat 400 – 500 m wide in the north, increasing to 700m in the south.

MARINE ECOSYSTEMS

The marine ecosystems can be defined by the zones within which they exist:

- Epipelagic Zone
- Mesopelagic Zone
- Bathyal Zone

Epipelagic Zone (0 m – 200 m)

The Epipelagic Zone ranges from 0 to 200 m, and includes the shallow waters of the Atoll lagoon and the deeper waters of the fore reef. Within this zone there are an array of ecosystems that have evolved in response to the degree of exposure and impact of wave action, current direction and intensity, light intensity and light spectra, and are defined by their species composition, formation and substrate characteristics. Five broad ecosystems have been identified and mapped – for this management plan, mangroves have been integrated into the terrestrial ecosystem description (Map 6; Table 12;):

- Fore-reef (upper and lower reef slopes, including spur and grove topography)
- Reef crest and reef flats
- Back reef (with patch reefs)
- Seagrass
- Sparse algae / sand

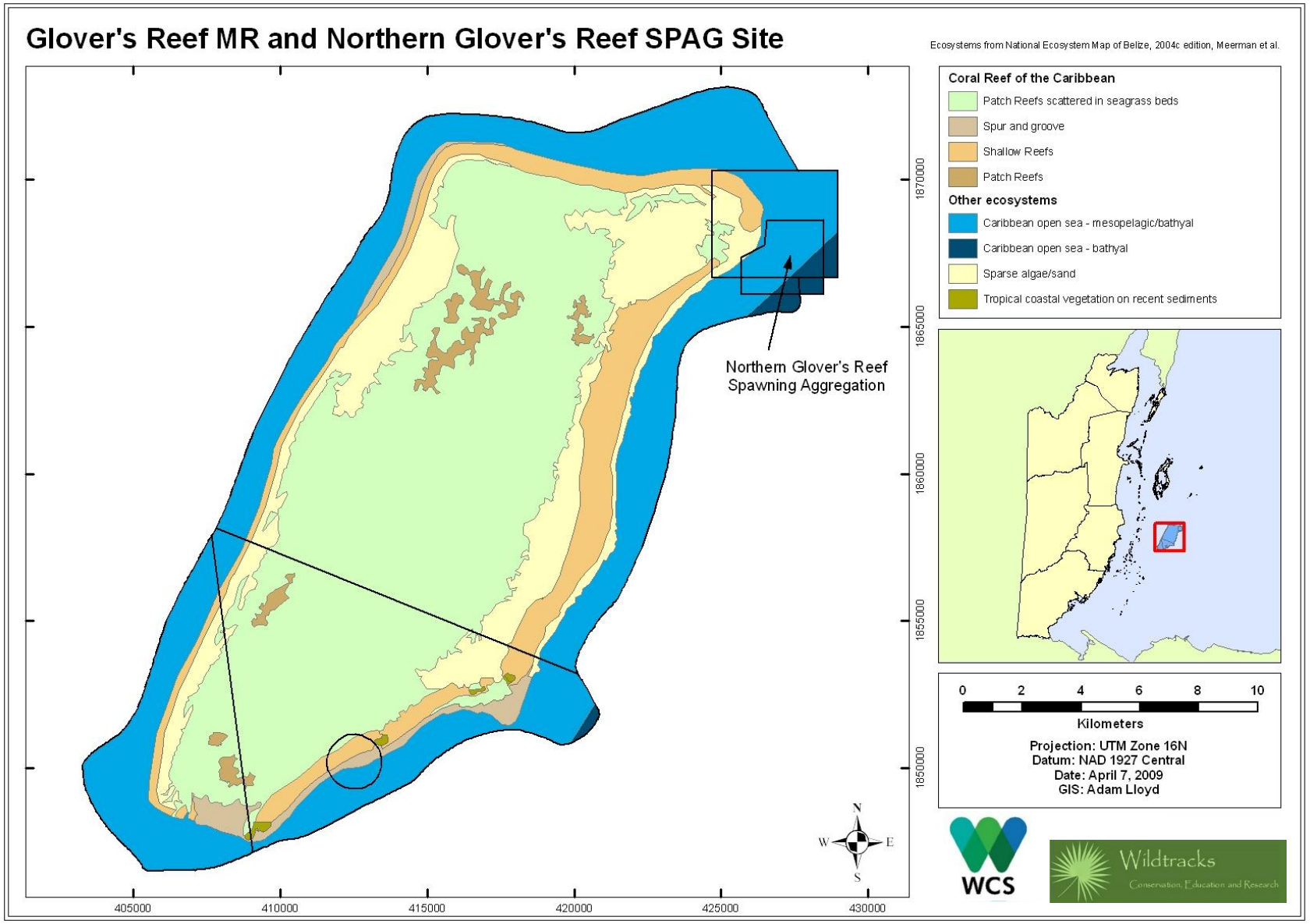
Fore Reef

In general, a gradually sloping fore-reef lies on the seaward side of the Atoll wall running perpendicular on the north and east windward sides of the Atoll, along the length of the fringing reef. It includes the upper and lower reef slopes, with an incline of between 0° and 45° on a substratum dominated by bedrock and sand, and extends from approximately 400m to 1.5 km wide, to the drop-off. The edge of the drop-off lies at a depth of between 15-25 m.

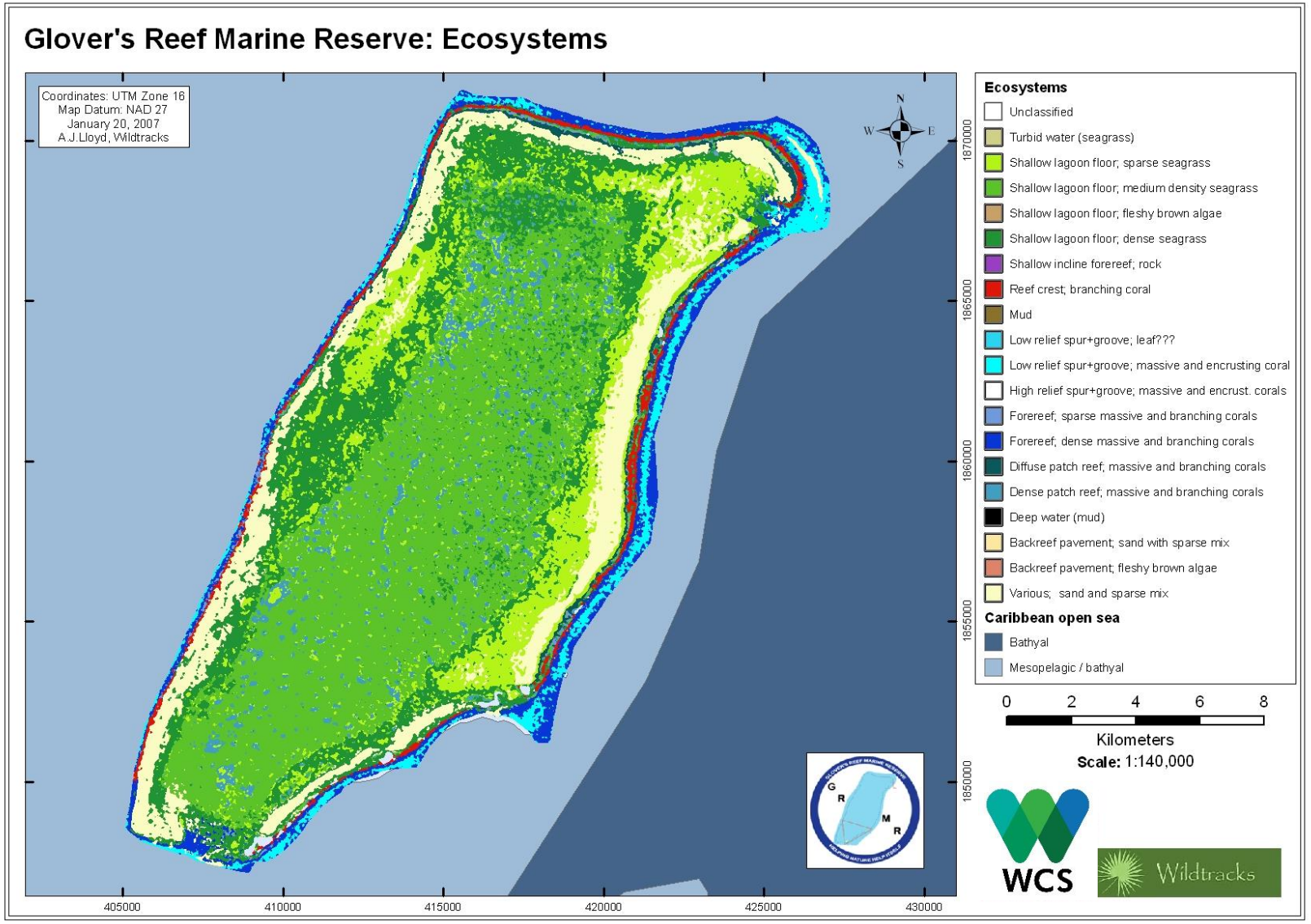
The fore-reef Immediately seaward of the reef crest is low relief spurs (with a height less than 5 m) in shallow water, usually formed by accreting hard corals and calcified algae. The grooves usually contain sand or bare bedrock. Wave energy can be high. This upper fore reef then extends out to a depth of 14-

Meerman, 2017	WCS LIVING LANDSCAPES, 2006	Mumby and Harborne, 1999
Coral Reef		
Reef: Shallow coral Reef	Forereef: Sparse massive and branching corals	Fore Reef: Sparse massive and encrusting coral
	Forereef: Dense massive and branching corals	Fore Reef: Dense massive and encrusting coral
	Shallow incline fore reef: Rock	
	Reef crest / branching coral	Other Reef: Reef crest
	Low relief spur and groove	Other Reef: Low relief spur and groove
	Low relief spur and groove: Massive and encrusting coral	
	High relief spur and groove: Massive and encrusting coral	
	Reef crest / branching coral	Other Reef: Reef crest
Patch reef	Dense patch reef: Massive and branching corals	Patch Reef: Dense patch reef
	Diffuse patch reef: Massive and branching corals	Patch Reef: Diffuse patch reef
Seagrass		
Seagrass Beds	Shallow lagoon floor: Sparse seagrass	Shallow Lagoon Floor: Sparse seagrass
	Shallow lagoon floor: Medium density seagrass	Shallow lagoon floor: Medium density seagrass
	Shallow lagoon floor: Dense seagrass	Shallow lagoon floor: Dense seagrass
	Turbid water (seagrass)	
Caribbean Inner Lagoon / Sparse Algae		
Fleshy brown algae / gorgonians	Shallow lagoon floor: Fleshy brown algae	Shallow lagoon floor: Fleshy brown algae / gorgonians
	Backreef pavement: Fleshy brown algae	
Sparse algae /sand	Backreef pavement: Sand with sparse mix	
	Various: Sand and sparse mix	Rubble and sparse algae
		Sand with sparse algae
	Mud	Mud / Bedrock
Caribbean Open Sea		
Bathyal	Bathyal	
Mesopelagic	Mesopelagic	

TABLE 12: MARINE ECOSYSTEMS OF GLOVER'S REEF ATOLL (Meerman, 2017; WCS, 2006; Mumby et al., 1999)



MAP 6: ECOSYSTEMS OF GLOVER'S REEF MARINE RESERVE (MEERMAN, 2004, REVISED 2017)



MAP 7: ECOSYSTEMS OF GLOVER'S REEF MARINE RESERVE (LIVING SEASCAPES, WCS, 2006)

22 m, and is characterized by impressive spur and groove formations, a major tourism resource that attracts divers from around the world. The tops of these spurs are carpeted with a variety of corals and other invertebrates, with the large surface area provided by the canyon sides and currents that pass through the 'grooves' (or surge channels) providing ideal living conditions for a multitude of marine organisms. In 1999, this was described as a diverse community of species, the most common being *Orbicella annularis, M. cavernosa, Siderastrea siderea, Dichocoenia stokesii, Undaria agaricites, Porites spp. Diploria spp.* and *Millepora alcicornis.* Soft corals such as *Pseudoplexura spp.* and *Pseudopterogorgia spp.* were common, and fleshy brown algae, red branching algae and green calcified algae were abundant (Mumby and Harborne, 1999).

The windward fore reef is very well developed, with many of the shallow spurs bare of living coral. In 1962, before the current impacts on reef health, it was described as being characterized by first a *Porites* zone, followed by an *Annularis* zone, a *Porites-Lithothamnion* zone, then the reef crest of dead reef-rock encrusted with *A. agaricites, P. porites, Millepora*, and finally a well-defined spur-and-groove zone primarily of massive *A. palmata* colonies on the outer slope. and encrusted with coralline algae. (Stoddart, 1962). The leeward wall is narrower, and the spur and groove structure are not as well developed. Historical reports describe this leeward reef as comprised of a mixed *Cervicornis* zone, a mixed *Palmata* zone, followed by an *Annularis* zone to depths of 5 to 10 m with taller colonies in deeper water, and then long buttresses of *M. annularis* and pillars of *D. cylindrus* (Stoddart 1962).

The spur and groove formations give way to the lower reef slope, with an angle < 45°, associated with the drop off wall of the Atoll. With coral diversity and density decreasing in correlation with decreasing light intensity. The deepest-growing hermatypic coral observed was a small *Agaricia fragilis* at 102 m on the eastern side of Glover's Reef Atoll (James and Ginsburg, 1979).

Reef Crest and Back Reef

The reef crest and reef flats lie behind the fore-reef, and are considered typical of high energy surf zones around the Caribbean. Coral species inhabiting these areas are hardy enough to be able to withstand the breaking waves, constant strong current, exposure at low tide, and high light intensity.

The reef crest forms a relatively unbroken barrier along the Atoll margin, separating the fore reef from the back reef and protecting the lagoon from the wave action. It is the shallowest part of the reef, is often emergent, absorbing much of the wave energy, and is particularly important for maintaining the structure of the cayes within the Atoll. Where the reef crest is absent, breaks or 'cuts' occur. Three of these reef channels occur on the windward side of the Atoll, connecting the lagoon waters directly with the open ocean - the North East Channel (1,400 yds wide), the Southwest Channel (approximately 1 mile wide) and the channel between Long Caye and Northeast Caye (about ¼ mile wide).

The reef flats behind the reef crest are not more than a maximum of 4 m deep, and are covered with white coarse-grained sand stabilized locally by seagrass. The shallowest areas of the reef flats, just behind the reef crest, provide high quality sport fishing, especially for bonefish, but concerns have been expressed over the potential tourism impacts caused by sport fishermen and others walking in the shallow waters of the reef crest and reef flats.

Beyond the reef flats is a continuum of habitats from the algae-encrusted coral rubble pavement zone of between 10 and 100 m wide, consisting of cemented reef rubble with some scattered coral growth (James et al., 1979), to the sandy muds of the *Thalassia* meadows and scattered patch reefs, in waters ranging from 0 to 4 m deep, and sheltered by the fringing reef. The sheltered waters of the Atoll lagoon promote the growth of patch reefs of varying size and density, distributed across a lagoon benthos dominated by seagrass meadows, and often surrounded by a halo of sand. Although patch reefs are usually formed by hard corals, this category is also used for patches where the coral has died and another organism now dominates (such as the macroalgal dominated patch reefs). Two categories of patch reef have been defined in the lagoon:

- Diffuse Patch Reef: Dispersed coral formations in the lagoon covering less than 30% of the benthos, surrounded either by seagrass, sand or algae. Although patch reefs are usually formed by hard corals, this category is also used for patches where the coral has died and another organism now dominates (such as the macroalgal dominated patch reefs.

- Dense Patch Reef: Aggregated coral formations in the lagoon covering more than 70% of the benthos, surrounded either by seagrass, sand or algae.

Early assessments showed that the majority of the more than 850 patch reefs within the Atoll's lagoon were distributed randomly with the exception of those in the western and northeast portions of the Atoll where they were aligned along NNE-striking trends. They ranged in size from about 10 m to a few hundred meters (Wallace, 1975), and consisted of massive corals such as *Montastrea, Diploria, Siderastrea* and *Porites,* with occasional thickets of *Agaricia* and *Acropora cervicornis,* and an 80% hard coral cover with 20% algae cover. Where there was dead coral, sea fans and brown algae were abundant (McClanahan & Muthiga 1998).

A more recent assessment in 1998 also focused on the composition of the Atoll's patch reefs, and show that they had undergone a major change in their ecology, experiencing a 75% reduction in coral cover (with *M. annularis* showing the least loss), a 99% loss in cover of *Acropora* spp., and a 315% increase in algae cover, particularly of the erect brown algae *Lobophora* (McClanahan & Muthiga 1998).

The cause for the dramatic change from 80% hard coral cover with 20% algae cover to 20% coral cover and 80% algae cover over the past 25 years is complex, and due to several inter-related

factors, including hurricane impacts, increasing sea temperatures, reduced herbivory, increased level of nutrients, and disease.

Lagoon Floor

The lagoon ranges in depth from 6 to 18 m, with a benthic composition comprised of predominantly fine sand and mud sized carbonate sediment. It supports seagrass meadows, categorized into three types, dependent on density (Table 13). Some deeper areas of the lagoon are almost completely barren of vegetation, though echinoderms and other invertebrates are common.

SEAGRASS	
Sparse seagrass	Seagrass cover < 30%; Depth < 12m; Angle of slope ≤ 45°. This benthic class is dominated by sand and mud, with seagrass from the genera *Halodule, Halophila* and *Syringodium,* with low densities of *Thalassia.* Corals are usually absent, but algae of the genera *Batophora, Laurencia, Halimeda, Penicillus, Avrainvillea, Udotea* and *Cymopolia* are likely to be present
Medium seagrass	Seagrass cover: 30 - 70%; Depth < 12m; Angle of slope ≤ 45°. Dominated by a sand or mud substrate, with seagrass from the genera *Syringodium* and *Thalassia.* Some corals may be present (*Manicina areolata, Siderastrea radians* and *Porites spp.*), and gorgonians from the genera *Pseudopterogorgia.* Algae of the genera *Laurencia, Halimeda, Penicillus, Avrainvillea, Udotea* and *Cymopolia* are likely to be present.
Dense seagrass	Seagrass cover: > 70%; Depth < 12m; Angle of slope ≤ 45°. This benthic class is dominated by a sand or mud substrate, with seagrass from the genera *Syringodium* and *Thalassia.* Algae of the genera *Laurencia, Halimeda, Penicillus, Avrainvillea, Udotea* and *Cymopolia* are likely to be present.

TABLE 13: SEAGRASS ECOSYSTEMS OF GLOVER'S REEF MARINE RESERVE (Mumby et al., 1999)

Mesopelagic / Bathypelagic Zone (200 m to 2000 m)

The Mesopelagic and Bathypelagic Zones include the deeper waters that surround the Atoll. The Mesopelagic Zone extends from a depth of 200 m downwards, merging into the Bathypelagic Zone continues from 200 m to 2,000 m, beginning at the edge of the continental slope and extending beyond into the deeper water. Whilst little is known of the marine life that exists here, whale sharks and other oceanic species are known to travel parallel to the reef,

passing inside the eastern boundaries of Glover's Reef Marine Reserve. There is increasing interest in access to fish stocks in these zones, with several pilot projects proposed.

REEF HEALTH

Regional Reef Health: Reef health across the region has experienced a massive decline over the last five decades. More than 75% of Caribbean coral reefs are considered threatened, a figure expected to increase to 90% by 2030, and 100% by 2050 (Burke et al., 2011).

From having a vibrant Mesoamerican Reef with a mean percentage live coral cover of 38.9% before 1984 (and with some areas as high as 70% live cover in some fore reef areas before the decline of *Acropora cervicornis*) (Jackson et al., 2014), the regional live coral cover was reported to have declined to approximately 10% in 2006. It has improved since then, stabilizing at 18% (HRI, 2017). Reef health in the Mesoamerican region in 2017 was rated as Fair, with a Reef Health Index (RHI) score of 2.8 out of a possible 5.0. This represents an increase since the previous assessment in 2015, with an RHI of 2.5, and a rating of Poor (HRI, 2015).

Whilst this is encouraging, the parallel increases in fleshy macroalgal cover reducing coral recruitment sites and overshadowing living corals, the limited *Diadema* urchin recovery, continued fishing pressure on the herbivorous fish required to keep the algae under control, and poor water quality from activities in the regional watersheds are thought to be limiting coral recovery (HRI, 2015).

Coral Bleaching: Anthropogenically-induced global warming is widely believed to be responsible for increases in global sea surface temperature. Corals are highly sensitive to changes in water temperature - increases of only 1°C can have potentially lethal effects. High water temperature events in the MAR region have resulted in several large-scale bleaching events (e.g., in 1995, 1998 and 2005) causing significant coral mortality in some areas.

Diseases: Coral disease outbreaks are one of the single most devastating disturbances to coral reefs in the Caribbean and Mesoamerican Reef in the recent past.

Disease has always been a natural process in regulating populations, but the recent increased magnitude of disease and resultant mortality may be unique in the last several thousand years. Diseased organisms tend to thrive in higher temperatures, and some may also benefit from increased ultraviolet (UV) radiation. Both stressors (temperature and UV) may render host organisms more vulnerable to disease.

Diseases have also been linked to elevated nutrients (especially from sewage), sedimentation and runoff. Corals seem to be more prone to disease when affected by other stressors.

Healthy Reefs for Healthy People Initiative, 2007

Reef Health in Belize: The Belize Barrier Reef experienced mass coral bleaching for the first time in 1995 (McField, 1999; McField et al., 2007), affecting hard corals at a national level, including

the reefs of Glover's Reef Marine Reserve. Surveys were conducted at GRMR in November 1995, representing patch reef, back reef and fore reef, demonstrating that 44%, 27%, and 61% of the reefs affected, respectively. The greatest impact was on the critical reef building species - *Montastraea annularis, Agaricia agaricites, Agaricia tenuifolia, Madracis* spp., and *Porites porites* (McField, 2000). Extensive bleaching of *Agaricia lamarcki*, *A. grahamae*, *Siderastrea siderea*, and *Diploria labyrinthiformis* was also reported. When these sites were re-surveyed in May 1996, the degree of bleaching had decreased to 6%, 7% and 12%, respectively, indicating that when conditions are favorable, recovery is possible (McField, 2001).

Belize's reefs were again significantly impacted in 1998 by a combined blow from a second, more severe mass bleaching event followed closely by Hurricane Mitch, a Category 5 hurricane with winds of 290 km/hr, which passed approximately 120 miles southeast of Glover's Reef during the last days of October 1998. Since then, bleaching events have been recorded in Belize with increasing frequency, and are thought to be exacerbated by increased acidification resulting from higher CO_2 levels (Anthony et al., 2008) (Table 14). The intensity and frequency of tropical storms has also increased.

Event	Year	Scale of Event
Hurricane Earl	2016	Mechanical damage to corals, reduced water clarity
Coral bleaching event	2015	Significant bleaching
Phytoplankton bloom	2011	Southern and central Belize coastal waters
Ban on fishing for herbivorous fish	2009	
Earthquake	2009	Catastrophic slope failure in 50% of surveyed reef sites in SWCMR
Lionfish first reported in Belize	2008	Impacting juvenile reef fish
Coral bleaching event	2008	Some coral bleaching
Coral bleaching event	2005	Significant bleaching
Hurricane Iris	2001	Category 5 hurricane – mechanical damage to corals, increased sedimentation on reef
Hurricane Keith	2000	Localized coral mortality
Hurricane Mitch	1998	Category 5 hurricane – mechanical damage to corals, increased sedimentation on reef
Coral bleaching event	1998	Catastrophic bleaching – approximately 50% decline in coral cover
Coral bleaching event	1995	Small scale bleaching
White band disease on Acroporid corals	Since late 1980s	Major Caribbean wide die-off Acroporid corals
Viral epidemic in urchin *Diadema antillarum* population	1983	Major Caribbean wide die-off of *Diadema antillarum*

TABLE 14: EVENTS AFFECTING THE BELIZE REEF

59% of Belize's coral reef sites are currently rated as in Poor or Critical health, 29% are rated as Fair, and only 12% considered in Good health, with 0% in Very Good health, based on a survey of 94 sites across the country, based on assessments at 94 sites (HRI, 2017).

Reef Health at Glover's Reef Atoll

Glover's Reef Atoll has followed the national trends in reef health, but with shallow reef (1–3 m) and deep fore reef sites (8 –17 m) on Glover's experiencing the most disturbance of Belize's three atolls, showing higher levels of coral mortality in the late 1990's than the other two atolls in Belize (Kramer et al., 2000). The reefs have been impacted by a number of severe coral bleaching events, the first recorded in 1995 (McField, 2001). Three sites were surveyed on the Atoll in October and November 1995, representing patch reef, back reef and fore reef. They showed that 44%, 27%, and 61% of the reefs affected, respectively. When these sites were re-surveyed in May 1996, the degree of bleaching had decreased to 6%, 7% and 12%, respectively, indicating that when conditions are favorable, recovery is possible (McField, 2001).

Glover's reef was significantly impacted again in 1998 by a combined blow from mass bleaching event and Hurricane Mitch, the fourth strongest storm documented this century with winds of 290 km/hr, which passed approximately 120 miles southeast of Glover's Reef during the last days of October 1998. Assessments at two shallow windward reef sites showed that they suffered severe hurricane damage and coral mortality, while bleaching and diseases were more prevalent on the leeward reefs. Reports described extensive structural damage to the windward eastern and northern fore-reefs, affecting both branching and massive corals down to a depth of 10 m. Many of the corals remaining were severely abraded, with little living tissue remaining, and coral mortality was estimated to be 60 – 70% (Bright 1999). The east facing shallow reef sites sustained the greatest damage, with the Northeast Glover's site reported as having the highest degree of damage in the entire Mesoamerican region. In addition, exposed deep fore reef sites on Glover's had higher than average damage, consisting primarily of knocked over or broken corals, and with coral recruitment reduced by 80% (Mumby, 1999).

Glover's fore reefs also demonstrated a consistently high incidence of coral disease compared to other fore reef sites surveyed in Belize. This was especially so for the East Glovers site, located on the fore reef near Middle Caye, with live coral cover declining over the two-year period from 14.6% to 6.4%, a decline also reflected at the site at the southeast end of the Atoll, which decreased from 23.6% to 11.1% (McField, 2001). Species diversity also declined at both sites. These reefs still displayed remnant signs of bleaching up to 10 months after the mass-bleaching event recorded in September, 1998. These changes were attributed to the combined impacts of the bleaching event and Hurricane Mitch in 1998.

The most recent Healthy Reefs assessment surveyed twelve sites at Glover's Reef. Three were rated as Fair (between 10% and <20% live coral cover), eight as Poor (between 5 and <10% live

coral cover) and one as Critical (< 5% live coral cover). The Atoll had an average live coral cover of 16%, but has a macroalgal cover of 18%, 2% lower than the regional average. Overall, reef health is considered to have improved over the two years since the 2015 assessment (Mcfield et al., 2018).

The history of change in Glover's Reef Marine Reserve is similar to that of other reefs in the region. It has experienced the same large-scale threats, including hurricanes, loss of herbivorous urchins and parrotfish, unsustainable fishing, coral disease and mass coral bleaching triggered by prolonged high sea surface temperatures. All of these impacts have contributed towards the extensive loss of key reef-building *Acropora* species, as well as *Agaricia, Millepora, Diploria spp.* and *Montastraea spp*.

Global climate change (with increasing sea temperatures, UV levels, and associated ocean acidification), has been identified as the biggest contributing factor in reef health decline (Aronson et al., 2006). The increasing sea surface temperatures results in coral bleaching, and the breakdown of the partnership between corals and zooxanthellae. This reduces the resilience of corals, leaving them more vulnerable to disease and infection until sea temperatures fall, and the symbiotic relationship can be re-established (Marshall et al., 2006). As high sea temperature events increase, bleaching is predicted to rise significantly (Westmacott et al., 2000), with an associated increase in coral mortality and macroalgal growth. This has significant economic implications for the fisheries and tourism sectors, and overlies and adds to other stressors, including coral diseases (black, white and yellow band diseases and white plague), unsustainable fishing of herbivorous fish, the population crash of the herbivorous long-spined sea urchin *Diadema antillarum* and other environmental stressors such as sedimentation and pollution (Liddell et al, 1986; Aronson et al, 1998).

Resilience Characteristics of GRMR corals

- Includes reef drop off, with increased shelf / oceanic water interchange, reducing risk of higher water temperatures
- Channels through reef barrier with strong flow and water exchange (though limited to three channels)
- Shaded west facing slope of the Glovers Reef Atoll shades corals, reducing damaging UV radiation
- Reef relief and environmental gradient - fore reef, reef crest, back reef and lagoon with reef patches – increasing potential for coral tolerance to different temperature regimes
- Reduced water contamination from land-based sources with increased distance from shore

All these shifts – in fish populations, in coral species dominance, algal growth and water parameters - lead to concerns for the future viability of the coral reef ecosystem, from a biodiversity point of view, as well as in its role as an economically important fishing and tourism resource in Belize and as a protective barrier to increasingly intense tropical storm events.

There are, however, positive changes over recent years, with an increase in % live coral cover that includes the important reef-building corals. Whilst coral bleaching has continued, with seven large-scale bleaching events since 1995, there hasn't been a large scale mortality event in the last two years. The moratorium on fishing of herbivorous fish is resulting in an increase in parrotfish biomass, and first indications of a slight decline in macroalgal cover (Mcfield et al., 2018).

TERRESTRIAL ECOSYSTEMS

The six cayes, all located on the southeast side of atoll, are aligned more or less along a NE – SW axis, with the exception of Southwest II Caye which is aligned almost north-south. Terrestrial ecosystems represented on the cayes are either *Tropical coastal vegetation on recent sediments* (a continuum ranging from sand beaches with herbaceous beach vegetation to well-structured littoral forest) and mangroves (Tables 15 and 16).

TERRESTRIAL ECOSYSTEMS	
MANGROVE	
Coastal Fringe Mangrove	*Rhizophora mangle* extends out from the shoreline of Middle Caye and Southwest Cayes, and *Avicennia germinans* is found on the western portion of Northeast Caye.
HERBACEOUS BEACH COMMUNITY	
Rubble Beach	Located primarily on the windward side of the cayes, with coral rubble deposits forming ridge or rampart of broken coral , which may be as much as 5ft high.
Sandy Beaches	These gently sloping, coral/algal fine sand beaches are located on the leeward side of the cayes.
Littoral Forest	Characterized by species such as sea grape (*Coccoloba uvifera*), ziricote (*Cordia sebestena*) and gumbolimbo (*Bursera simaruba*), this forest type is found on the southeast side of Northeast Caye, with a small stand also being located on Middle Caye, interspersed with grassland, This ecosystem, whilst not occurring within the Marine Reserve itself, is highlighted as under-represented within the National Protected Areas System, and at great threat from coastal development.
Brackish Pond	Middle Caye, Northeast Caye and Southwest I Caye have small depressions in the central portion of the caye that fill with brackish water during the rainy season.
Coconut Palm	The littoral forest on the majority of the cayes has already been cleared, and the area planted with coconuts (originally the Panamanian tall variety, but with the onset of 'lethal yellow', many landowners have replanted with the more resistant Maypan variety – a hybrid between the Malaysian dwarf and the Panamanian tall coconut varieties. In some places, such as Northeast Caye, these form dense thickets.

TABLE 15 TERRESTRIAL ECOSYSTEMS OF GLOVER'S REEF ATOLL (Meerman, 2017; WCS, 2006; Mumby et al., 1999)

Meerman, 2017	WCS LIVING LANDSCAPES, 2006	Mumby and Harborne, 1999
Tropical coastal vegetation on recent sediments	Mangrove	Coastal Mangrove Fringe
	Rubble beach	Rubble Beach
	Sandy beach	Sandy Beach
	Sandy beach and palm	
	Littoral forest	Littoral Forest
	Brackish Pond	Brackish Pond
	Palms and buildings	Coconut
	Brush and grass	

TABLE 16: TERRESTRIAL ECOSYSTEMS OF GLOVER'S REEF ATOLL (Meerman, 2017; WCS, 2006; Mumby et al., 1999)

The following descriptions of the cayes is taken mainly from Stoddart (1962) and Stoddart *et al.* (1982), updated by recent observations, and the Wildlife Conservation Society Living Landscape mapping initiative (2006) (Figure 18).

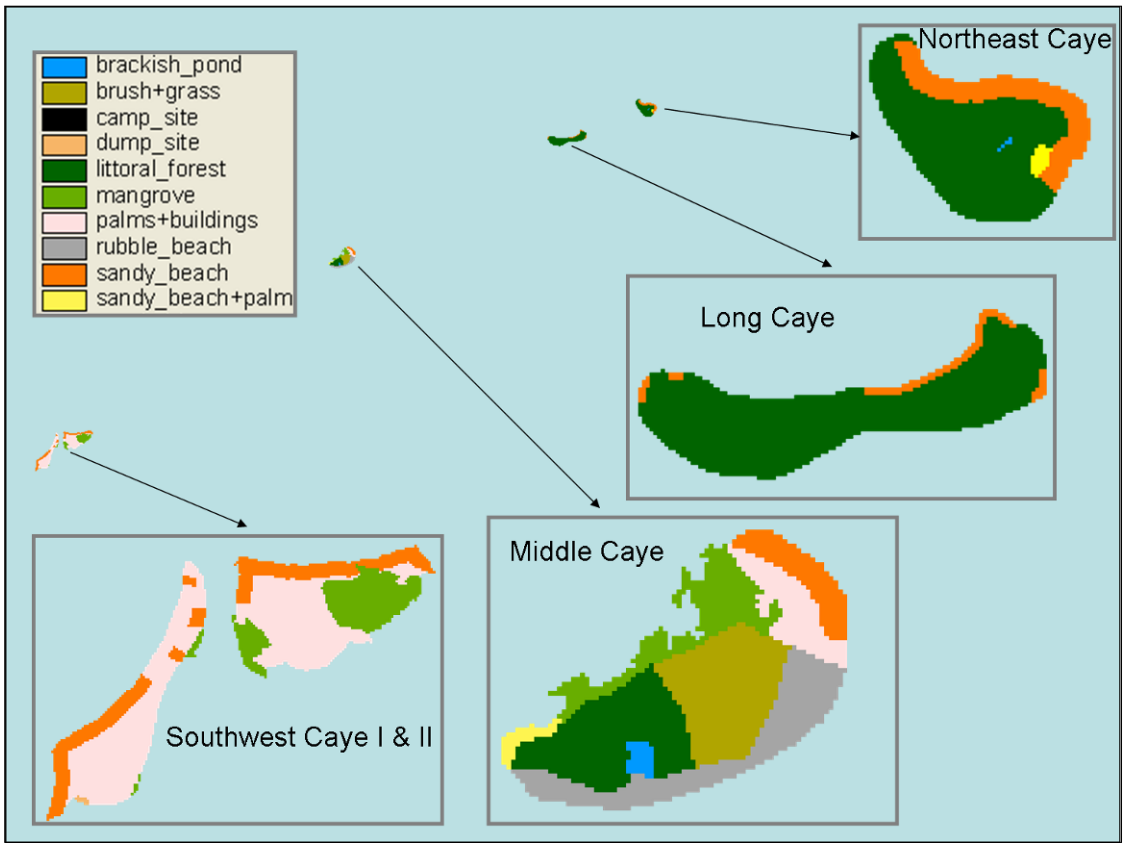


FIGURE 18: ECOSYSTEMS OF THE CAYES (LIVING SEASCAPES, WCS, 2006)

Northeast Caye: Northeast Caye, the northernmost of the cayes, is located to the north of the eastern channel leading into the atoll. It is semicircular in shape, with an area of approximately 4.5 ha. The windward side has a high rubble/shingle beach. The caye retains much of its natural cover, though also supports a tourism resort.

A total of 40 species of plants were recorded on the island (Stoddart 1962; Linhart 1980; Stoddart *et al.* 1982). Presently, a tall broadleaf littoral forest grows on the southeast side of the caye, and is characterized by sea grape *(Coccoloba uvifera*) and gumbo limbo (*Bursera simarubra*), with *Ficus citrifolia, Pouteria campehiana* and *Cordia sebestena*. A patch of black mangrove (*Avicennia germinans*) lies on the western half of the caye, whilst a dense, unmanaged coconut grove dominates the center (Walker, 2007).

A multi-species herbaceous flora to the northwest extends towards a rich beach flora that has established on coral rubble deposited by Hurricane Mitch. A small brackish pond lies in the center of the caye.

Long Caye North (Lamont Caye): This small shingle caye or islet, also owned by the Lamonts, has developed on a patch reef located in the main channel between Northeast Caye and Long Caye island. Whilst originally having an area of about 0.5 ha, it was heavily impacted and eroded by Hurricane Mitch in 1998, which completely destroyed the building located on the caye. Originally, the caye was covered by coastal scrub, with a total of 22 plant species identified by Stoddart (1962), Linhart (1980) and Stoddart *et al*. (1982). The islet is now an almost completely bare sand caye, with very little vegetation.

Long Caye: Long Caye is a long, narrow island with an area of approximately 6 ha, with two well-developed, parallel shingle ramparts formed by successive storms. Beachrock is found at its southeast corner, and the reef rock is exposed at low tide, forming pools. To the north is a low peninsula that is intermittently connected to the caye.

Most of the island is covered with coconut plantation, with 28 other plant species recorded (Stoddart 1962, Linhart 1980, Stoddart et al. 1982). In 1994, a survey of the western side of the caye only identified 25 plant species (Meerman, 1995), including chit palms (*Thrinax radiata*), on the southern part of the island, and ziricote (*Cordia sebestena*), on the coral ridge. The black torch (*Erithalis fruticosa*) and the passionflower (*Passiflora suberosa*) were the two most frequently observed species, forming dense tangles on the southern end of the island. Whilst mangrove was present, it was very limited in its distribution (Walker, 2007).

In 1997, the coconut trees on the island were infected by the lethal yellowing disease, with dying palms recorded on all parts of the caye, the most severely affected area being the southern point (Berlin & Quiroz, 1998). The owners of Slickrock and Off the Wall Dive Shop on the northern half of the caye have been treating some of the coconut trees and replanting with the resistant Maypan hybrid. More recent work indicates that, with the exception of the beachfront area operated by Slick Rock, the condition of the native flora has improved in condition in recent years – subsequent to the loss of much of the coconut cover (Walker, 2007). Littoral forest and herbaceous beach community plant species are re-establishing across much of the island, and have been successfully incorporated into the landscaping around the Off-the-Wall Dive Shop facilities.

Middle Caye: Middle Caye, with an area of about 6 ha, is situated near the center of the unbroken southeast reef tract. It has beachrock on the seaward shore and a swampy area on the southwestern end, with a brackish water pond located in the center.

In the past, most of the caye was covered with coconut thicket, with a total of 42 plants species recorded in the past by Stoddart (1962), Linhart (1980) and Stoddart et al. (1982) and 30 species in 1998 by Meadows (Bright 1999). Meadows noted that no black mangroves were present on the caye during the 1998 survey, though it has become re-established on the north-eastern tip of the island – almost certainly

as the result of less aggressive beach clearance activities (Walker, 2007). In the late 1990's the island's coconut trees were decimated by lethal yellowing disease (Berlin & Quiroz 1998), and a total of 150 hybrid Maypan disease-resistant coconut trees were subsequently planted to replace some of those that had died, near the facilities. On the remaining area of the island, the untreated trees died rapidly and many were removed (Bright 1999).

A non-exhaustive survey of the flora of Middle Caye (Walker, 2007) demonstrated that, in the absence of the coconuts, the native flora and vegetation assemblages are re-establishing very well, with native species assemblages being established over much of the island, greatly increasing the extent and condition of natural vegetation, and enhancing habitat quality for the fauna. A total of 31 species of plant were identified in the survey, not including most of the grasses, and not including at least one more unidentified herbaceous species. Species richness is evidently increasing as a direct result of the reduction of the coconut abundance, and as a result of more environmentally-friendly management. It would appear that overall species richness is rapidly returning to natural levels, though it can be expected that habitat structure will continue to change significantly over coming years as woody shrubs and trees extend the current limits of the littoral forest into some of the areas currently dominated by herbaceous beach flora. Current management (pruning of taller growth, to maintain a vista) of a significant portion of the northern portion of the island has provided a competitive advantage to two semi-woody shrubs: *Ernodea littoralis* and *Erythralis fruticosa*, the berries of the latter being an extremely attractive food source to the resident white-crowned pigeons, to the migrant birds passing through the Atoll in significant numbers, and to the healthy population of black iguanas. Tall red mangrove provides important habitat on the western side of the caye.

Top: *Ernodea littoralis*
Bottom: *Erithralis fruticosa*

WCS owns the caye and has established a research facility the Glover's Reef Research Station, on the cleared northern end of the island. This includes a dormitory for researchers, a laboratory, kitchen, manager's house, staff quarters, showers and composting toilets, workshop, solar panels and back-up diesel generators, air compressor for filling SCUBA tanks, and a dock. WCS has also provided a location in this area for the headquarters of the marine reserve, administered by the Fisheries Dept. This includes accommodation for reserve staff, a kitchen, and an area allocated for a small visitor center.

Southwest I Caye: The Southwest Cayes are located at the southern end of the Atoll, immediately east of the broad southern entrance to the atoll's lagoon. Although it has been reported that the cayes were originally one large island, which was spilt in half during the 1931 hurricane (Gibson 1988), Stoddart (1962) records suggest that they have existed in their present state for at least two centuries. The sheltered bay between the two cayes forms a natural protected nursery area, though there are concerns that, following Hurricane Mitch and the closure of the reef cut by coral rubble, reducing the water flow through the area, sedimentation is reducing the depth of the channel.

Southwest Caye I is the larger and more easterly of the two cayes, with an area of 9 ha. It is comprised of coral rubble on its seaward shore, sand on the leeward shore, and an area of natural vegetation in the interior that has been maintained (Maaz, 2015). The vegetation is primarily coconuts and mangroves, though 40 plant species were recorded in the past by Stoddart (1962), Linhart (1980) and Stoddart *et al.* (1982). The island, however, was heavily impacted by Hurricane Iris in 2001, and some of the vegetation was affected. Significant mangrove clearance has been implemented by Isla Marisol. In addition the coconuts have suffered severely from lethal yellowing. The affected area has been replanted with resistant hybrid coconuts. Tourism development of Southwest Caye has been towards the clearance of white sandy beaches and the re-establishment of coconuts, with Malathion being used to keep biting insects at bay.

Southwest II Caye: This caye is the most southerly on Glover's Reef and, unlike the other islands, it is mainly sandy with no swampy areas. It was once entirely covered with coconut woodland, with 40 species of plants recorded by Stoddart (1962), Linhart (1980) and Stoddart et al. (1982). The northern portion of the caye supports a healthy mangrove area, though the mangroves have been cleared from almost all other parts of the caye (Maaz, 2015) Resort development has reduced the natural vegetation, with

clearance for bare sand with coconut trees. The southern part of the 6-hectare island, owned by Port Authority, is the location of the lighthouse, operated by the Port Authority.


J. Maaz

1.5.2 FLORA

A total of 34 naturally occurring native species of plant, representing 22 families, have been reliably identified as currently occurring within the littoral forest and herbaceous beach community of the cayes of Glover's Reef Atoll (Walker, 2007). Whilst earlier surveys recorded up to 40 species, past anthropogenic impacts have had huge impacts upon the flora of the cayes – and the introduced coconut palm continues to have a very major impact.

There is a diverse species assemblage for this ecosystem type, especially in view of the distance of Glover's Reef Atoll from other island and mainland populations. The flora of island ecosystems is dynamic in species occurrence and stature – changes often reflecting both natural cycles and anthropogenic impacts (Stoddart, 1962)

Species of the littoral forest and of the herbaceous beach community play critical roles in the stabilization of the cayes, and in providing habitat for the fauna – including species that are endangered and / or have very limited distributions. National populations of several of the plant species found on the cayes of the Atoll have undergone significant decline in recent years, as coastal beaches are cleared and developed for coconut plantations, tourism and residential use. Those cayes with significant areas of littoral forest and herbaceous beach communities, such as Middle Caye and Northeast Caye, in particular, play a crucial role in the continued survival of these ecosystems

1.5.3 FAUNA

THREATENED AND ENDANGERED SPECIES

Several species of global concern are present in Glover's Reef Marine Reserve, including four 'Critically Endangered' species – the Nassau grouper (*Epinephelus striatus*) (one of several grouper species that utilize the spawning aggregation sites of Belize), the hawksbill turtle (*Eretmochelys imbricata*), which uses the Atoll for both nesting and feeding, and two species of coral. Eight 'Endangered' and twenty-eight 'Vulnerable' species have also been recorded on the Atoll.

INVERTEBRATES

Glover's Reef Marine Reserve has long been recognized for its rich and diverse fauna. The Atoll lagoon, patch reefs and spur and groove formations are known for their high diversity, attracting increasing numbers of tourists each year. With water depths ranging from the shallow reef flats and reef crest to the open sea, and a series of interconnected complex ecosystems - mangrove, seagrass, sand and reef - the Marine Reserve has the heterogenerity for high biodiversity. Five species of coral present within the Marine Reserve are considered to be critically endangered or endangered on the global scale (IUCN, 2019; Table 17).

Glover's Reef Marine Reserve Coral Species of international Concern	
Critically Endangered	
Staghorn Coral	*Acropora cervicornis*
Elkhorn Coral	*Acropora palmata*
Endangered	
Fire Coral	*Millipora striata*
Boulder Star Coral	*Montastraea annularis*
Star Coral	*Montastraea faveolata*
Vulnerable	
Lamarck's Sheet coral	*Agarica lamarcki*
Pillar Coral	*Dendrogyra cylindrus*
Elliptical Star Coral	*Dichocoenia stokesii*
Boulder Star Coral	*Montastraea franksi*
Rough Cactus coral	*Mycetophyllia ferox*

TABLE 17: CORAL SPECIES OF INTERNATIONAL CONCERN (IUCN, 2019)

A recent assessment surveyed eight sites covering patch reef and fore-reef. A total of 35 species of hard coral were identified, with a maximum of 23 species identified at any individual site. 20 common species accounted for greater than 92% of species at all locations, with *Orbicella annularis* the dominant species at all but Southern locations where *Undaria agaricites* was most abundant and *Montastrea annularis* was ranked fourth. *Siderastrea siderea* also ranked highly, though less so at western sites. *Porites asteroides* was the species at patch reef sites (Tewfik, 2014). Coral cover was found to be highest on sites on the east of the Atoll, whilst those on the western side showed the lowest. Soft coral covers were generally higher at eastern sites, with strong current, oceanic waters providing suitable environment. Highest sponge cover was noted at the western side. Macroalgaal growth was highest in the lagoon, which may favor these species with shelter from physical disturbance and potentially retained nutrients. Fire coral (i.e. *Millepora* spp.), thought to be indicative of disturbance by high energy waves, or of areas with poor water quality in the lagoon, was most abundant on the lagoon patch reefs, and lowest on the west reefs (Tewfik, 2014).

CORAL SPECIES OF GRMR (Bright and Tilley, 2013)	
SCLERACTINIA Stony corals order (using classification proposed by Budd et al., 2012)	
Acropora cervicornis	Staghorn coral
Acropora palmata	Elkhorn coral
Acropora prolifera	Fused staghorn coral
Acroporidae	
Agaricia agaricites	Lettuce coral
Agaricia fragilis	Fragile saucer coral
Agaricia grahamae	Dimpled sheet coral
Agaricia lamarcki	Whitestar sheet coral
Agaricia tenuifolia	Thin leaf lettuce coral
Agariciidae	
Astrocoeniidae	
Cladocora arbuscula	Tube coral
Colpophyllia natans	Boulder brain coral
Dendrogyra cylindrus	Pillar coral
Dichocoenia stokesi	Domed star coral
Diploria labyrinthiformis	Grooved brain coral
Eusmilia fastigiata	Smooth flower coral
Favia fragum	Golfball coral
Faviinae (formerly Family Faviidae, *in part*)	
Helioseris cucullata	Sunray lettuce coral
Isophyllia rigida	Rough star coral
Isophyllia sinuosa	Sinuous cactus coral
Madracis auretenra	Yellow pencil coral
Madracis decactis	Ten-ray star coral
Manicina areolata	Rose coral
Meandrina danae	Butterprint rose coral
Meandrina meandrites	Maze coral
Meandrinidae	
Merulinidae	
Montastraea cavernosa	Great star coral
Montastraeidae	
Mussa angulosa	Spiny flower coral

TABLE 18: CORAL SPECIES OF GRMR (Bright and Tilley, 2013)

CORAL SPECIES OF GRMR / 2	
Mussidae	
Mussinae	
Mycetophyllia aliciae	Knobby cactus coral
Mycetophyllia ferox	Rough cactus coral
Mycetophyllia lamarckiana	Ridged cactus coral
Mycetophyllia reesi	Ridgeless cactus coral
Oculinidae	
Orbicella annularis	Lobed star coral
Orbicella faveolata	Mountainous star coral
Orbicella franksi	Boulder star coral
Pocilloporidae	
Porites astreoides	Mustard hill coral
Porites divaricata	Thin finger coral
Porites furcata	Branched finger coral
Porites porites	Club tip finger coral
Poritidae	
Pseudodiploria clivosa	Knobby brain coral
Pseudodiploria strigosa	Symmetrical brain coral
Scolymia cubensis	Artichoke coral
Scolymia lacera	Atlantic mushroom coral
Siderastrea radians	Lesser starlet coral
Siderastrea siderea	Massive starlet coral
Siderastreidae	
Solenastrea bournoni	Smooth star coral
Stephanocoenia intersepta	Blushing star coral
OCTOCORALLIA subclass	
ALCYONACEA Soft corals, Sea fans, Sea whips order	
Briaridae	
Briareum asbestinum	Corky sea finger
Gorgoniidae	
Gorgonia ventalina	Common sea fan
Pseudopterogorgia bipinnata	Bipinnate sea plume
Plexauridae	
Eunicea mammosa	Swollen-knob candelabrum
Plexaura homomalla	Black sea rod
Plexaurella sp.	
Pseudoplexaura sp.	

TABLE 18: CORAL SPECIES OF GRMR (Bright and Tilley, 2013)

FISH

Of the more than 300 fish species included in the current species list, four are considered to be globally threatened (Critically Endangered or Endangered), including the critically endangered Nassau grouper (*Epinephelus striatus*) and endangered Goliath grouper (*Epinephelus itajara*) (Table 19). Both of these species have been targeted commercially in the past, with the Nassau grouper declining nationally by more than 80% since the late 1970's, attributed primarily to fishing pressure, particularly at the spawning aggregation sites where it is most vulnerable. The Nassau Grouper is perhaps the most vulnerable of the species known to congregate at the Northeast Point spawning aggregation site on Glover's Reef Atoll. This site is also important as a multi-species spawning aggregation site, with three other species - Black Grouper (*Mycteroperca bonaci*), Tiger Grouper (*M. tigris*) and Yellowfin Grouper (*M. venenosa;* IUCN: Near Threatened) - recorded using the location for spawning activities over the course of the year (FiD / Chicas, 2018; Heyman and Requena, 2002).

Glover's Reef Marine Reserve Fish Species of international Concern	
Critically Endangered	
Nassau Grouper	*Epinephelus striatus*
Endangered	
Goliath Grouper	*Epinephelus itajara*
Whale Shark	*Rhincodon typus*
Great Hammerhead	*Sphyrna mokarran*
Vulnerable	
Gray Triggerfish	*Balistes capriscus*
Dusky Shark	*Carcharhinus obscurus*
Pallid Goby	*Coryphopterus eidolon*
Glass Goby	*Coryphopterus hyalinus*

TABLE 19: FISH SPECIES OF INTERNATIONAL CONCERN (IUCN, 2019)

GRMR SPAWNING AGGREGATION SITE

Herbivorous fish such as the parrotfish, important charismatic species of tourism value, are demonstrating recovery following a ban on extraction. Assessment in 2017 demonstrated a biomass of 2,173 g/100m^2 (Mcfield et al., 2018). These herbivores are critical for maintaining the health of the reef, in their role as grazers, removing algae, clearing surfaces that can act as settling sites for corals.

A LAMP assessment in 2015 recorded a total of 46 species, 16 families and 6 trophic groups across the 18 fore-reef sites surveyed. Herbivores, including Acanthurids and Scarids, composed the largest proportion of fish on fore-reef sites. The Haemulids, composed the next most abundant trophic group with all other groups in relatively low abundance Commercially important snappers (Lutjanidae) and groupers (Serranidae) appeared to be in low abundance with very few large individuals (Tewfik, 2016). Nassau grouper and Stoplight parrotfish were observed on patch reefs, with Scarids, made up the largest

proportion of fish. Commercially important snappers (Lutjanidae) and groupers (Serranidae), however, appeared to be in very low abundance. Whilst a high level of species diversity exists at FRMR, it was recognized that the levels of fish biomass, especially commercial snappers and groupers, was well below conservation targets and even below levels that which could sustain ongoing fisheries for those species in future (Tewfik, 2016).

Sharks and rays have been studied extensively on the Atoll. The great hammerhead (*Sphyrna mokarran*) is also still fished within Belize, despite its globally Endangered status. The more common nurse shark and the Endangered whale shark (*Rhincodon typus*) are also protected under the Fisheries Act, with no fishing, or even touching, permitted. A 5-year survey (July 2000 to May 2004) of the elasmobranch fauna of Glover's Reef Marine Reserve documented the use of this oceanic atoll by at least 12 elasmobranch species, including nurse sharks *Ginglymostoma cirratum*, Caribbean reef sharks *Carcharhinus perezi*, lemon sharks *Negaprion brevirostris*, and southern stingrays *Dasyatis americana* (Institute of Conservation Science). The study showed that elasmobranch abundance did not change from year to year, but was significantly higher inside the lagoon than on the ocean reef outside the atoll. *G. cirratum* dominated both shallow and deep lagoon catches, with smaller individuals more prevalent in the shallow lagoon. *C. perezi* of all size classes dominated the ocean reef, but small juveniles of this species were also common in the deep lagoon (Chapman et al., 2005; Chapman et al., 2007). A large juvenile Galápagos shark, *C. galapagensis*, was collected on the ocean reef, extending the range of this species into the Western Caribbean (Pikitch et al., 2005).

The Belize Fisheries Department is developing a National Plan of Action for the shark fishery following the guidelines of the International Plan of Action for the Conservation and Management of Sharks (IPOA – Sharks) The plan is designed to achieve the conservation and sustainable use of shark species through the protection of the marine environment (ecosystems and biodiversity), with the minimization of by-catch, waste and discard, and through the adoption of selective and environmentally safe fishing practices.

MAMMALS

Four species of dolphin have been reported from within the Glover's Reef Marine Reserve (Table 20). The Atlantic bottlenose dolphin (*Tursiops truncatus*) and the Atlantic spotted dolphin (*Stenella frontalis*) are both seen commonly inside the Belize Barrier Reef (Ramos et al., 2016). The less commonly sighted deeper-water rough-toothed dolphin (*Steno bredanensis*) and Fraser's Dolphin (*Lagenodelphis hosei*) have also been reported. Sperm whale (*Physeter microcephalus*) have passed close to the west side of Glover's Reef.

Glover's Reef Marine Reserve Mammal Species of international Concern	
Endangered	
Antillean Manatee	*Trichechus manatus*
Vulnerable	
Sperm Whale	*Physeter macrocephalus*

TABLE 20: MAMMAL SPECIES OF INTERNATIONAL CONCERN (2018)

Other species known to use the deep waters between the Atolls and the barrier reef, though not recorded specifically for Glover's Reef, include clymne and spinner dolphins (*S. clymene, S. longirostris*), pods of killer whales and false killer whales (*Orcinus orca, Pseudorca crassidens*), as well as sort-finned pilot whales (*Globicephala macrorhynchus*) (Ramos et al., 2016).

Antillean manatees (*Trichechus manatus manatus*), a sub-species of the West Indian manatee, have been reported occasionally from Glover's Reef. The Belize coast is home to the largest population of Antillean manatee in the Caribbean (Morales-Vela *et al*, 2000), with a population estimated at between 800 and 1,000 individuals (Auil, pers. com.). This species is considered threatened throughout its range, with the Antillean sub-species rated as 'Endangered' (IUCN, 2017).

BIRDS

The first recorded bird survey of the Atoll was conducted by Salvin in 1862. In 1998 Meadows also carried out a bird survey of Middle Caye (Bright, 1999), and a more recent visit to the Atoll (Balderamas, pers. com. 2007) produced a complimentary species list, bringing the total number of species recorded for the Atoll to 84. These last two surveys, both coinciding with the autumn and spring migrations, emphasized the importance of the cayes for monitoring the movements of these migratory species, and protecting the caye vegetation on which they rely for food. Only a few species, such as brown pelicans (*Pelecanus occidentalis*), kingfishers, herons and ospreys (*Pandion haliaetus*), are resident on the caye, as is the near-threatened white-crowned pigeon (*Columba leucocephala*). Ospreys nest both on the island and artificial nesting platforms (Gibson 1988, Bright 1999). Least terns were reported as nesting on the ground on Long Caye North during April and May, though this small caye has been heavily eroded by Hurricane Mitch, and it is uncertain whether it is still utilized by the terns. Southwest Caye II was once the only known nesting site in Belize for the white-capped brown noddy (*Anous stolidus*), with hundreds of pairs nesting at the turn of the century. Only eight were known to have nested in 1988 and none are believed to nest there now (Bright 1999), the caye being heavily impacted by tourism development.

As with the other atolls of Belize, Glover's Reef is considered important as a migratory bird stopover refueling point. Many thousands of migrants that have meandered off course end up on the Atoll cayes every spring and fall. Some migrants that would normally follow the mainland coast may end up on Glover's Reef after being blown offshore by shifting winds, as has been seen particularly with night-flying migrants, and may well be drawn to the lighthouse in large numbers, when it is working. Others may use Glover's Reef as part of a straight line migration path down the Yucatan Peninsula coastline, through Ambergris Caye and then to Lighthouse Reef, Glover's Reef, and Sapodilla Cayes, and from there to Guatemala and Honduras, where they again hook up with the mainland and its "infinite" resources.

The species composition of Glover's Reef is very comparable with that of Half Moon Caye, on Lighthouse Reef Atoll (Walker et al., 2005), - a comparison of the migratory species on these Atolls with those of surveys on the remote San Andres Island, offshore of Columbia shows an approximately 87% overlap of migratory species. Of these, the blue-winged, golden-winged, yellow, blackburninan, cerulean, magnolia, prothonatory, worm-eating, Swainson's and hooded warblers are largely believed to fly trans-gulf, relying

WAXWING FEEDING ON *ERYTHRALIS FRUTICOSA*

on making landfall on the Yucatan Peninsula (N. Bayly, pers. com.). If they do wander off course, cayes such as those of Glover's Reef and the more southerly San Andres Island may be very important in allowing them to store up enough fat reserves to survive the next leg of their migration. An interesting addition to the list of migrants making a stopover on the island is the cedar waxwing, with a flock of approximately 80 individuals observed feeding on the fruit of *Erythralis fruticosa*, an important food source for many of the migratory birds passing through (Walker, 2007). Other migrants that might occur on the caye but have not yet been recorded include the American kestrel, black-necked stilt, common tern, least tern, alder and least flycatcher, gray kingbird, and Lincoln's sparrow (L. Jones, pers. com.). Middle Caye has been the focus of several recent field trips by professional birders, with a generated list of 75 species (Table 21).

BIRDS OF GRMR		
Pelicans Brown Pelican **Herons, Ibis, and Allies** Great Blue Heron Great Egret Snowy Egret Little Blue Heron Tricolored Heron Cattle Egret Green Heron Yellow-crowned Night-Heron White Ibis **Pigeons and Doves** White-crowned Pigeon Ruddy Quail-Dove White-winged Dove **Cuckoos** Yellow-billed Cuckoo **Nightjars** Common Nighthawk nighthawk sp. **Hummingbirds** Green-breasted Mango hummingbird sp. **Rails, Gallinules, and Allies** Rufous-necked Wood-Rail **Shorebirds** Ruddy Turnstone Sanderling Least Sandpiper Spotted Sandpiper Willet **Gulls, Terns, and Skimmers** Laughing Gull Royal Tern Sandwich Tern **Frigatebirds, Boobies, and Gannets** Magnificent Frigatebird Brown Booby **Cormorants and Anhingas** Double-crested Cormorant	**Vultures, Hawks, and Allies** Osprey **Kingfishers** Belted Kingfisher **Falcons and Caracaras** American Kestrel Merlin Peregrine Falcon **Tyrant Flycatchers: Pewees, Kingbirds, and Allies** Olive-sided Flycatcher Eastern Wood-Pewee Eastern Kingbird Gray Kingbird **Vireos** Philadelphia Vireo **Martins and Swallows** Northern Rough-winged Swallow Bank Swallow Barn Swallow **Thrushes** Gray-cheeked Thrush Swainson's Thrush **Catbirds, Mockingbirds, and Thrashers** Gray Catbird Tropical Mockingbird **Blackbirds** Orchard Oriole Baltimore Oriole Great-tailed Grackle	**Wood-Warblers** Ovenbird Northern Waterthrush Black-and-white Warbler Tennessee Warbler Mourning Warbler Common Yellowthroat Hooded Warbler American Redstart Cape May Warbler Northern Parula Magnolia Warbler Bay-breasted Warbler Blackburnian Warbler Yellow Warbler Chestnut-sided Warbler Blackpoll Warbler Black-throated Blue Warbler Palm Warbler Yellow-rumped Warbler Yellow-throated Warbler Prairie Warbler **Cardinals, Grosbeaks, and Allies** Summer Tanager Scarlet Tanager Rose-breasted Grosbeak Blue Grosbeak Indigo Bunting Dickcissel **Middle Caye E-bird checklist** Philip Balderamas (2019) James Telford (2017) Jane Crawford (2017) Lee Jones (2004, 2010) Brendan Galvin (2013) **Note:** All e-bird reports have to be verified by the country representatives (P. Balderamas, R. Martinez) to be included on the list

TABLE 21: BIRDS OF GRMR (E-bird – P. Balderamas, R. Martinez, J. Crawford, L. Jones, J. Telford)

REPTILES OF GLOVER'S REEF ATOLL

The herpetofauna of Glover's Reef Atoll is comprised entirely of reptile species. No amphibians have been recorded there, as the saline conditions, absence of freshwater sources, and distance from the mainland are the main determinants precluding their presence.

Glover's Reef Marine Reserve Reptile Species of international Concern	
Critically Endangered	
Hawksbill Turtle	*Eretmochelys imbricata*
Endangered	
Green Turtle	*Chelonia mydas*
Vulnerable	
Loggerhead Turtle	*Caretta caretta*
American Crocodile	*Crocodylus acutus*
Leatherback Turtle	*Dermochelys coriacea*

TABLE 23: CORAL SPECIES OF INTERNATIONAL CONCERN (2019)

Seven reptile species have been recorded from Glover's Reef, four terrestrial (residents of the littoral forest), and the three marine turtles (loggerhead, green and hawksbill). The three marine turtles are all rated as globally threatened, the hawksbill being listed as 'critically endangered', and the green and loggerhead being 'endangered' (Table 23; IUCN, 2019). Additionally, the island leaf-toed gecko is rated as Near Threatened on Belize's National List of Critical Species (Meerman, 2005). A crocodile, presumed to be the American Crocodile (*C. acutus*), has been observed on the Atoll - it is believed that fishermen brought a juvenile crocodile there from Turneffe Islands sometime during the period 1993 -1995 (M. Paz, pers. com). Recent reports suggest that it has possibly been killed.

All three marine turtles - **loggerhead** *(Caretta caretta),* **green** *(Chelonia mydas),* and **hawksbill turtles** (*Eretmochelys imbricata*) - are found in the waters of Glover's Reef Atoll, and nest on the cayes. The decline in the number of turtles nesting on the cayes of Glover's Reef follows regional (and global) trends of decreasing marine turtle populations, leading to these species being globally threatened (Critically Endangered / Endangered / Vulnerable; IUCN, 2019). Clearance of beach vegetation associated with tourism development, coral rubble washed onto beaches during storm events, and accumulated washed up garbage can impact turtle nesting behavior or result in the nesting beaches being inaccessible (Smith, et. al., 1992). No successful turtle nest of any species were recorded during turtle monitoring activities in 2004, 2005 or 2006, though there were anecdotal reports of eggshells and sighting of a hatchling turtle during this period (Glover's Reef Annual Reports, 2004, 2005 and 2006). Turtle nests have, however, been recorded between 2007 (K. Schofield, pers. com.) and 2017 (Glover's Reef Annual

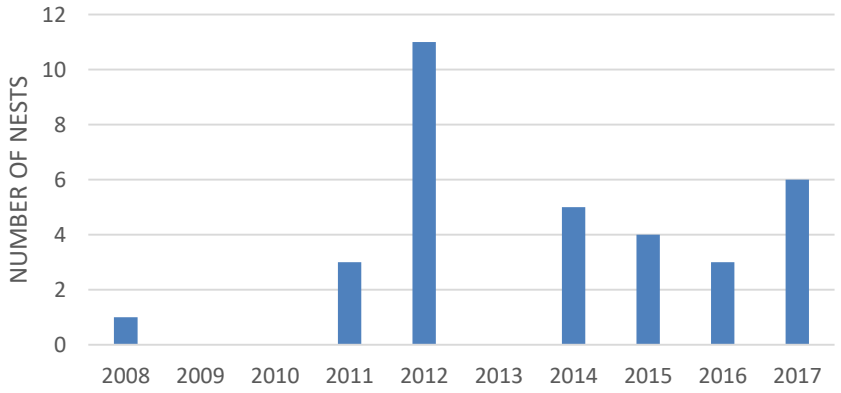


FIGURE 19: GRMR TURTLE NESTS, 2008 – 2017 (FiD / CHICAS, 2017)

Report, 2017), with a maximum of 11 in 2012 (Figure 19). All nests were identified as Hawksbills.

The **hawksbill turtle** (*Eretmochelys imbricata*) is considered Critically Endangered (IUCN, 2019), and is generally restricted to shallow waters of tropical portions of the Atlantic, Pacific and Indian oceans, including Glover's Reef Atoll lagoon, where it feeds primarily upon marine sponges and invertebrates. This species has a protracted nesting season of 6 months or more – peaking in June and July, with the period between nesting seasons generally being 2-4 years (but may be as long as 10 years) (Chacon, D., 2004). In 2017, nesting was reported from Long Caye (2 nests), Middle Caye (1 nest), South West Caye (2 nests) and North East Caye (2 nests), with a total of 816 eggs laid (an average of 116 eggs per nest), and an 88.9% hatch success rate (Note: There is a discrepancy in the data as 7 nests were listed, but only 6 were included in Figure 19). Nesting occurs at night, generally at high tide, with nests generally concealed in beach vegetation and, except for a faint asymmetrical crawl (ca. 0.7 m wide) leading to and from the ocean, seldom any obvious evidence of the visit. Clutch size is between of 50-200 eggs. The individuals nesting on a particular beach form a distinct population – with feeding ranges overlapping with other nesting populations, but with virtually no cross-nesting recruitment (Chacon, 2004). Once a nesting-beach population has crashed, there is therefore very little likelihood of it being recolonized by females from another nesting area.

Three hawksbills have been tracked as part of WCS' turtle monitoring activities, with one sub-adult showing high site fidelity, returning consistently to the area where it was tagged, and only venturing out of the Atoll lagoon a few times, with the greatest distance travelled from the Atoll was recorded as 3 km (Figure 20; Burns Perez, 2015). The other two hawksbills tagged showed similar patterns of site fidelity, returning to their points of capture.

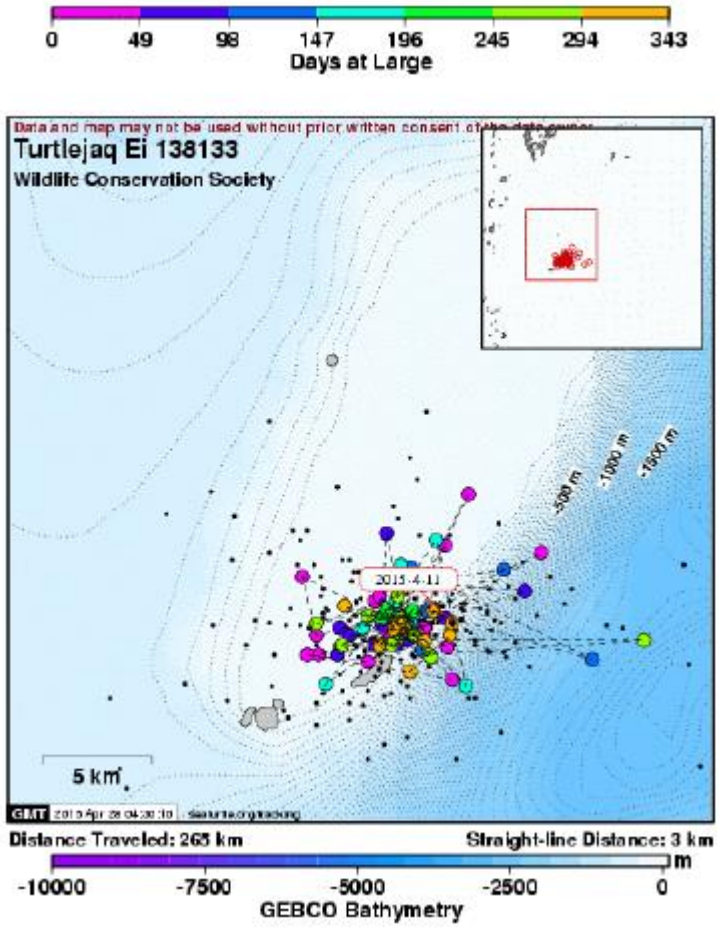


FIGURE 20: SATELLITE TRACKING OF SUB-ADULT HAWKSBILL, 13 MAY, 2014 to 11th APRIL, 2015 (WCS, 2015)

Green turtles *(Chelonia mydas)* are primarily a tropical species ranging throughout the Atlantic, Pacific and Indian oceans, though they are known to range into temperate seas at times. They are mostly herbivorous, feeding on sea grasses and seaweeds. Females normally breed every 2-3 years, but may lay several clutches in a single season, excavating nests on sandy beaches above high-water mark, and laying clutches of 100-150 eggs. Females were reported nesting on the western beach of Middle Caye (Gibson 1988), and traditionally on Long Caye North, though the erosion of the beach following Hurricane Mitch may have removed this caye as a nesting site. It is estimated that an average of 19 females nested in Belize annually from 1979-1982 (Smith et al, 1992) - the species is considerably rarer today than in the past when cayes such as Half Moon Caye at Lighthouse Reef apparently hosted hundreds of nests per year into the early twentieth century.

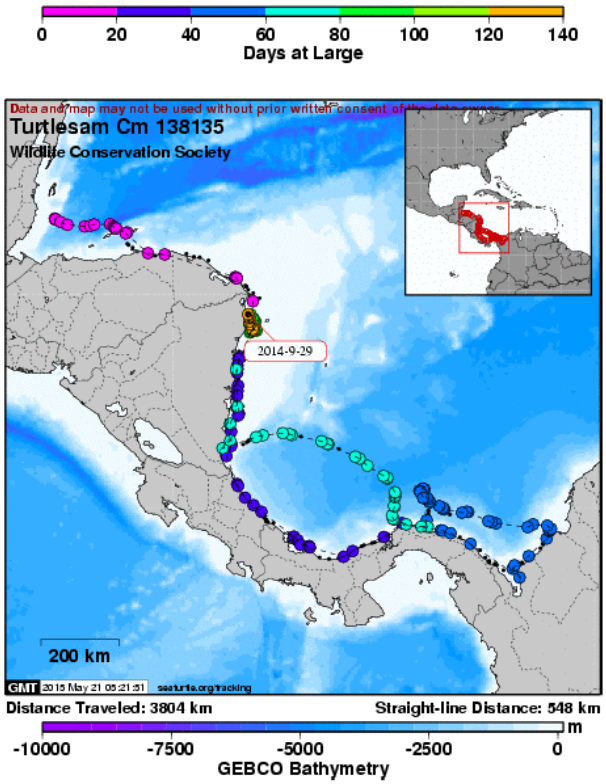


FIGURE 21: SATELLITE TRACKING OF SUB-ADULT GREEN TURTLE, 14TH MAY – 30TH SEPTEMBER, 2014 (WCS, 2015)

No nests were reported in 2017, but individuals were observed during the in-water surveys (Glover's Reef Annual Report, 2017). One tagged individual left GRMR for the coast of Nicaragua, heading south along the coastline to Columbia, and then returning north towards Nicaragua once again, travelling a total of 3,804 km (Figure 21; Burns Perez, 2015).

The **Loggerhead turtle** *(Caretta caretta)* is classified as vulnerable (IUCN, 2019). This species occurs throughout tropical, subtropical and temperate seas around the world. It is omnivorous, feeding on a wide range of marine invertebrates, seaweeds and turtle grass. Loggerheads are seen mating March through May along the outer reef and subsequently nest at Ambergris Caye, Glover's Reef, Lighthouse Reef, and at scattered locations throughout the offshore cayes from May through August. Nesting occurs at night, and usually at high tide. Females excavate nests on sandy beaches above high-water mark, and lay clutches of 60-200 eggs. A single female may lay several clutches during a single season. It is estimated that fewer than 40 loggerheads nest annually in Belize. Nesting is known to have occurred in the past on the north beach of Northeast Caye and on the eastern and western beaches of Long Caye, where in 1999, 30 nests were recorded, with hatchlings appearing in December (though both Loggerhead and Hawksbill are recorded as nesting in these areas, and there is no record of which species was observed hatching). In 2002, several nests and possible false crawls were observed in late October (pers. com K. Schofield), though again these may equally be Hawksbill. Loggerheads were reported nesting on Long Caye in 2007 (J. Gibson, pers. com., from report by K. Schofield). During eight years of surveys (2007 – 2015),

loggerheads were the least common of the three species observed at GRMR, with only one loggerhead being seen during the 2015 in-water survey. All loggerheads seen were > 60 cm straight carapace length in size (Burns Perez, 2015).

THE ISLAND LEAF-TOED GECKO (*PHYLLODACTYLUS INSULARIS*)

ST. GEORGE'S ISLAND GECKO (*ARISTELLIGER GEORGEENSIS*)

The island leaf-toed gecko (*Phyllodactylus insularis*) and **St. George's island gecko** (*Aristelliger georgeensis*). The island leaf-toed gecko is Belize's only endemic reptile (records of its presence on the Bay Islands and from Isla Guanaja of Honduras (Lee, J., 1996, 2000) are apparently erroneous (Wilson, L.D., pers. com.) as those specimens are attributed to *Pyllodactylus palmeus*). Its endemism is the justification for its inclusion on Belize's National List of Critical Species (Meerman, 2005). It has been recorded from Middle Caye and Long Caye (Meerman, 1995, Walker, 2007). Whilst the adults appear to be principally active at night on tree trunks 1-3m above ground, juveniles are commonly observed climbing on the foliage of herbaceous and shrubby plants less than 1m above the ground. Its known range in Belize is extending as further surveys are conducted on more islands - to date in addition to the population on the cayes of Glovers Reef Atoll, this species is also recorded from Half Moon Caye, and more recently from several cayes off the coast of southern Belize (Crawl Caye, False Caye, Lagoon Caye, Peter Douglas Caye and West Snake Caye; Boback, 2005). There is little doubt that the distribution and abundance of this nocturnal gecko in Belize is significantly greater than previously reported. It is quite possible that the population of this species has fallen significantly with the loss of the bulk of the coconut trees, and adults now appear to be largely confined to the littoral forest at the southern end of Middle Caye. As the *Thrinax* palm continues to re-establish on the island, habitat conditions for *Phyllodactylus* will improve, and the population may be expected to then recover.

A second gecko species, **St. George's island gecko** (*Aristelliger georgeensis*), was recorded on Middle Caye for the first time (Walker, 2007), and was found to be significantly more abundant than the endemic *Phyllodactylus insularis. Aristelliger georgeensis* is considered to be a human commensal (Lee, 2000), but it is unclear whether it is a recent colonizer on the island, or whether females and sub-adults had previously been mistaken for *Phyllodactylus insularis.*

The **Brown anole** (*Anolis sagrei*) is abundant on the cayes, and is principally active on the ground and up to 2m elevation on vegetation. This species is widely distributed throughout the western Caribbean.

Whilst generally considered a human commensal, it does occur throughout the littoral forest of Northeast and Middle cayes – and indeed on numerous uninhabited coastal islands. It would appear that these ecosystems are the natural habitat for the brown anole, and that its range has extended alongside that of the human population along the coastal plain.

Black iguanas (*Ctenosaura similis*) are common on the cayes of Glover's Reef, and are considered part of the natural fauna.

1.5.4 ECONOMICALLY IMPORTANT SPECIES

Nationally, the annual economic benefits from reef and mangrove-dependent fisheries is estimated at between US$14–16 million (Cooper et. al, 2008). More recent trade figures demonstrate the national fishing industry which provides direct employment for over 2,640 fishers (Belize Fisheries Department, 2017) and supports an estimated 15,000 Belizeans from 20 communities, with a further 1,000 people involved indirectly in processing and export (Belize Fisheries Department, 2013). In 2015, the capture fishery produced over 97,500 tonnes of product – primarily lobster and conch for the export market (FAO, 2017). In 2016, lobster exports (tail and meat) were approximately Bz$18,259,380. Conch and other mollusk exports were valued of Bz$10,522,230 (Table 24; SIB, 2017).

TRADITIONAL CONCH FISHING

The fishery at Glover's Reef Marine Reserve focuses on Caribbean spiny lobster (*Panulirus argus*), Queen conch (*Lobatus (Strombus) gigas*), two invertebrate species of commercial importance, and a variety of fin-fish – particularly snapper and grouper.

Product	*2016 (lbs)*	*2017 (lbs)*
Lobster Tail	432,013	546,788
Lobster Meat	40,367	47,841
Whole lobster	447,874	405,270
Conch	849,475	564,760
King Crab	1,713	3,919
Whole Fish	170,496	33,720
Fish Fillet	300	5,135
Sea cucumber	87,407	-
Shark	24,383	41,000
Total	***2,054,028***	***1,648,433***

TABLE 24: NATIONAL FISH PRODUCTION (SIB, 2017)

Conch and lobster have both declined since the early 1980's, when the industry was at its peak. It is significant to note that the general trend of total national lobster production over the period from 1981 to 2008 is a decline of almost 77% - national lobster landings peaked in 1981 at 2,204,622 lbs, but fell to 457,680 lbs in 2006, when it stabilized, with 511,389 lbs exported in 2009 (tails and head meat combined - with a market value of Bz$13.8 million (Ministry of Agriculture and Fisheries, 2009)). 90% of the lobster and conch is exported through the two fishing cooperatives, the remaining 10%, and the majority of the finfish, are sold for local consumption.

884,092 pounds for market clean conch meat was reported for the 2017 national conch season (Belize Fisheries Department, 2017). Regional concerns on the state of the Queen conch is being addressed through listing of the species in Appendix II by the Convention on International Trade in Endangered Species (CITES) in 1992. Belize has been placed in the Category (ii) list of countries, as an expression of concern as to the viability of the national conch fishery, and instigating a rigid requirement for implementation of an assessment and monitoring procedure. Each year, pre and post season surveys are conducted to assess the conch population, and to set a national quota – this was set at – 884,092 pounds for market clean conch meat for the 2017 – 2018 conch season (FiD, 2017). Glover's Reef Marine Reserve is an important site for conch – CPUE data for the Marine Reserve indicates that Queen conch represented 58.1% of the total catch weight for GRMR in 2017 (Table 25; Figure 22; FiD / Chicas, 2018).

GRMR CATCH PER UNIT EFFORT DATA 2017

Queen Conch	62,269 lbs
Whole Fish	24,453 lbs
Lobster Tail	19,261 lbs
Fish Fillet	1,196 lbs

TABLE 25: FiD / CHICAS, 2018

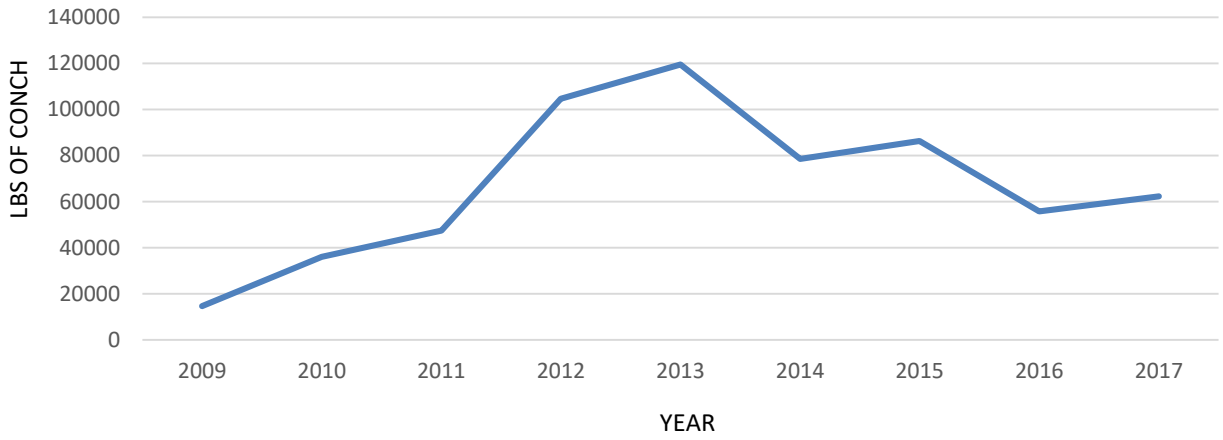


FIGURE 22: CONCH CATCH PER UNIT EFFORT DATA FOR GRMR, 2009 – 2017 (FiD / CHICAS, 2018)

Monitoring from 2004 to 2011 under the Long-term Atoll Monitoring Program (LAMP) surveyed 33 sample sites in the three management zones (General Use, Conservation and Wilderness). The results demonstrated that GRMR was shown to have healthy populations of juvenile conch in both the Conservation and General Use Zones, with each zone having mean densities of 160 conch per ha over all sampling periods. The mean density of adult conch on sand algal flats and seagrass beds was also high with mean densities of 90.3 conch per ha in the CZ and 43.4 conch per ha in the GUZ. falling within the healthy population target range of 50 – 300 conch per ha recommended by the Healthy Reefs for Healthy People Initiative (WCS, 2012; McField et al., 2007). Trend data from post season surveys from 2010 to 2017, however, based on surveys of 12 sites, demonstrates an overall downward trend since the 2012 report (FiD /Chicas, 2018), though with some signs of recovery since the implementation of Managed Access in 2015 (Figure 23).

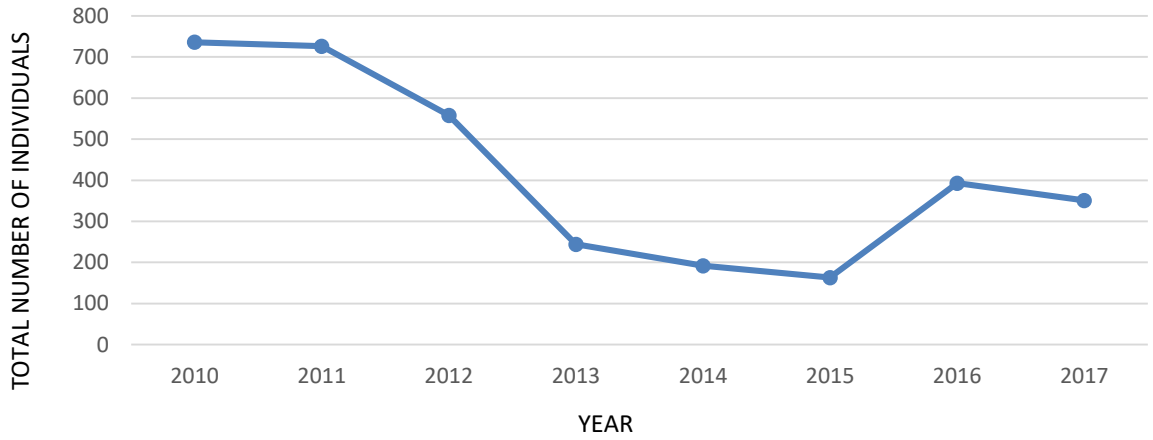


FIGURE 23: CONCH POST-SEASON SURVEY COUNTS, 2010 – 2017 (FiD /WCS DATA) BASED ON 12 SURVEY SITES – 6 IN CZ AND 6 in GUZ

In the 2017 survey, conch densities were demonstrated to be higher in the Conservation and General Use Zones, (0.09 per m^2) compared with 0.05 per m^2 in the General Use Zone. Conch density in the Conservation Zone appears to be increasing, whereas density in the General Use Zone is decreasing. Average shell length also differs between the two zones, with conch in the Conservation Zone having an average shell length of 145.8 mm, compared with the smaller average of 139.6 mm in the General Use Zone (FiD / Chicas, 2018).

Conch in the Conservation Zone also have higher average lip thickness (9.19 mm) as opposed to 5.35 mm in conch in the General Use Zone), suggesting that conch in the Conservation Zone are, on average, larger and more mature (FiD / Chicas, 2018). These results suggest that whilst the conch populations have not yet recovered, the Conservation Zone is working. It should be noted, though, that consultations with GRMR fishers indicate that there has been illegal fishing activity within the Conservation Zone.

Spiny lobster is the other key targeted species, and is only fished by free diving (neither shades nor drums are allowed at GRMR). Post-season surveys of a total of 99 individual lobster over a total of 14 sites (7 in the conservation Zone / 7 in the General Use Zone) show that the mean carapace length is higher in the Conservation Zone, at 118.0 mm as opposed to 110.4 mm in the General Use Zone. The density is also higher, with 12.9 lobsters observed per hour in the Conservation Zone, and 6.67 in the General Use Zone – 65% of all individuals recorded being in the Conservation Zone (FiD / Chicas, 2018). Both pre and post season surveys demonstrate that lobster numbers, whilst fluctuating, show a general upwards trend between 2011 and 2017 (Figure 24; FiD / Chicas, 2018).

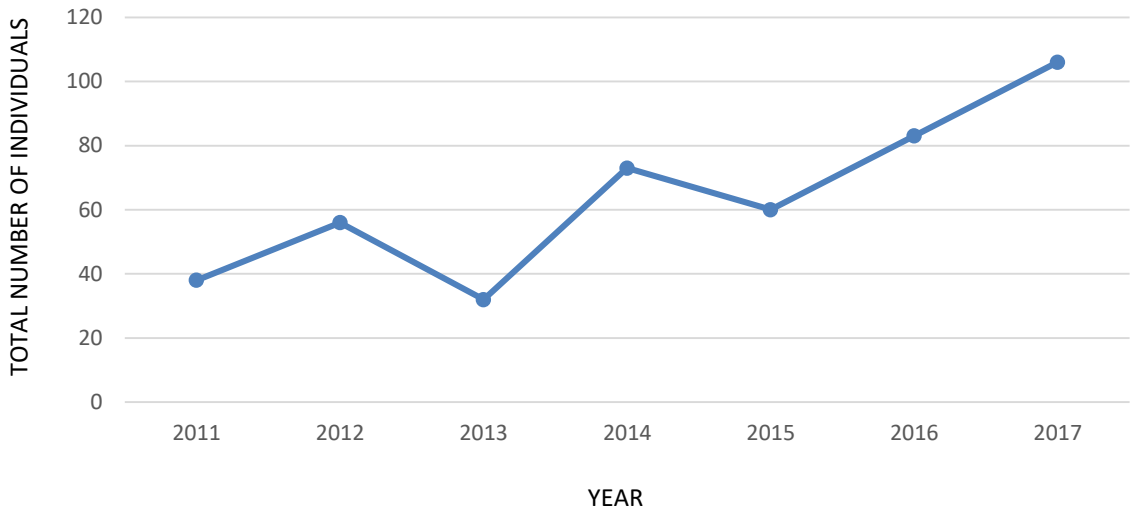


FIGURE 24: LOBSTER POST-SEASON SURVEY COUNTS, 2010 – 2017 (FiD /WCS DATA) BASED ON 14 SURVEY SITES – 7 IN CZ AND 7 in GUZ

Lobster CPUE data for GRMR demonstrates a gradual increase in catch, through data collection hasn't been consistent over the last nine years (Figure 25; FiD/ Chicas, 2018)

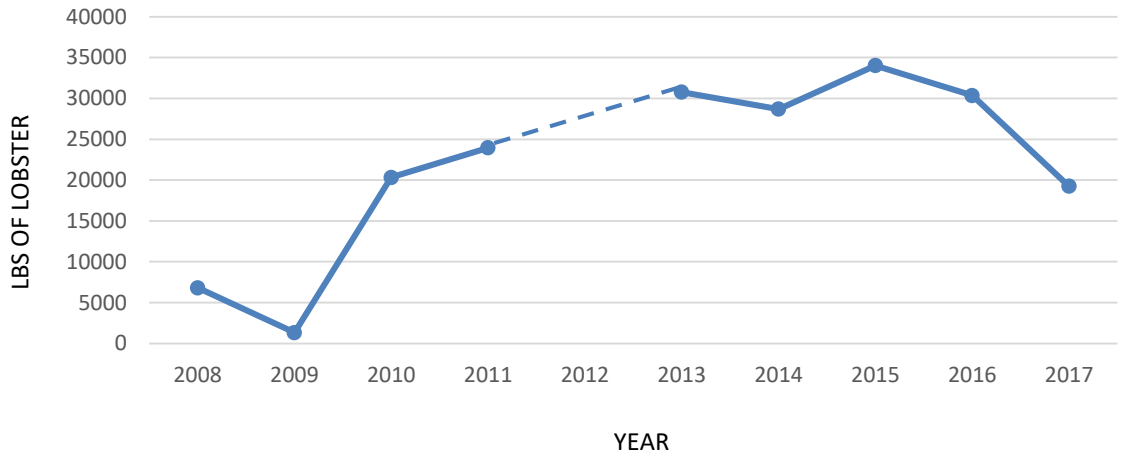


FIGURE 25: LOBSTER CATCH PER UNIT EFFORT DATA FOR GRMR, 2009 – 2017 (FiD / CHICAS, 2018)

National lobster landings peaked in 1981 at 2,204,622 lbs, but fell to 457,680 lbs in 2006, when it stabilized, with 511,389 lbs exported in 2009 (tails and head meat combined - with a market value of Bz$13.8 million (Ministry of Agriculture and Fisheries, 2009)). Current production figures show that lobster landings (combined tails, meat and whole lobster) have increased to almost 1,000,000 lbs (SIB, 2017), though still haven't recovered to the 1981 levels.

90% of the lobster and conch is exported through the two fishing cooperatives, the remaining 10% is sold for local consumption (Staff consultations, 2017).

Fin-fish are also extracted from the marine protected area, and provide an important component of the commercial catch – most are fished using spear guns and hand lines. Much of this catch is sold in local markets and directly to hotels rather than through the co-operatives, though some is marketed for export. The targeted export species include groupers (*Epinephelus* sp. and *Mycteroperca* sp.), snappers (*Lutjanus* sp. and *Ocyurus* sp.), the hogfish (*Lachnolaimus maximus*), king mackerel (*Scomberomorus cavalla*), great barracuda (*Syhyraena barracuda*), and jacks (*Alectis* sp., *Caranx* sp. and *Trachinotus* sp.). Snappers are reported to make up the largest single family of fish that are exported, with whole fish and fish fillet exports totaling 113,500 lbs in 2001, dropping to 52,316 lbs in 2006 (Belize Fisheries Dept. 2002; Ministry of Agriculture and Fisheries, 2007). Production dropped further to 33,720 lbs for whole fish in 2017, and 5,135 lbs for filleted fish.

The Long Term Atoll Monitoring Program has demonstrated a significant decline in fin-fish densities in both the Conservation and General Use Zones. This is thought to be related to substantial changes in the structure of the fish community as a result of unsustainable fishing levels. In 2017, commercial fish biomass for GRMR was 363 g/100m^2, lower than other atolls (Turneffe: 585 g/100m$^{2;}$ Lighthouse Reef: 1,746 g/100m^2) (HRI, 2018).

The Nassau Grouper (*Epinephelus striatus*) (IUCN status: Critically Endangered), is perhaps the most vulnerable of the species known to congregate at the Northeast Point spawning aggregation site on Glover's Reef Atoll. This species is considered one of the top predators, assisting in maintaining the system and buffering against fluctuations caused by other factors such as increasing sea temperatures and pollution. The decline of these top predators results in the system becoming less stable and more unpredictable. The spawning site is being monitored by WCS and Fisheries Department, and has always been considered important for this large species (Heyman and Requena, 2002). The Nassau Grouper has declined nationally by more than 80% sites, where it is most vulnerable. The Northeast site has been identified as one of only two viable sites remaining for the Nassau Grouper, of nine originally known locations (Paz and Grimshaw, 2001). In 2001, it was estimated to contain over 2000 individuals (Paz and Grimshaw 2001), with over 4,000 to 6,000 individuals counted at peak spawning time in 2002 (Table 17; Heyman and Requena, 2002).

Since the 1970's, fishermen from Dangriga traditionally fished the spawning bank, but have reported significant declines in numbers over the last fifteen years, describing congregations of between 20,000 and 30,000 spawning individuals in the 1980's. After the mid 1980's there was a shift in resource utilization to fishermen from Hopkins, using hand lines. Results from the Northeast site for the 2006 monitoring program reported over 3,000 individuals (FiD / Carballo, 2006). Since then, however, numbers have shown a sharp decline, with only a maximum of 450 individuals recorded in 2017 (Figure 26).

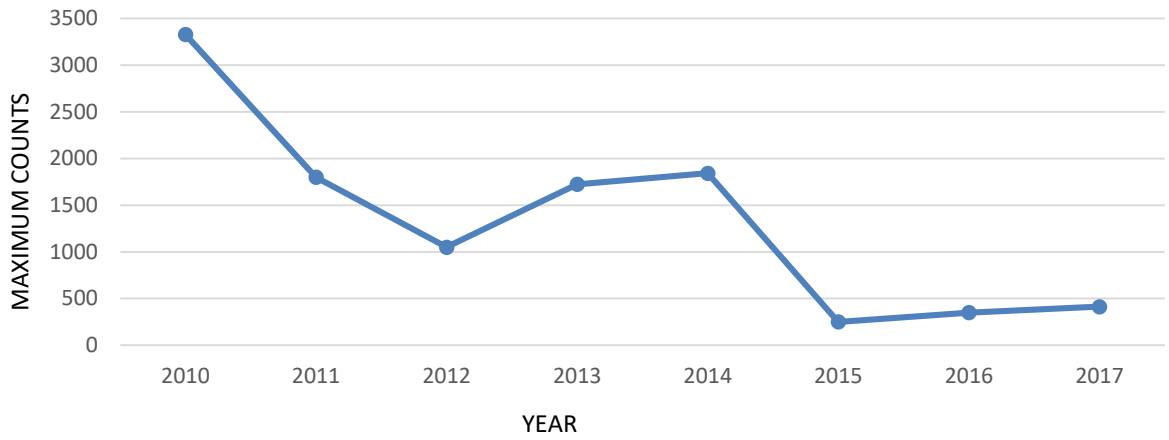


FIGURE 26: NASSAU GROUPER MAXIMUM COUNTS, 2009 – 2017 (FiD /WCS DATA)

The spawning bank is located within the Seasonal Closure Zone of the marine reserve, which according to regulation 7(3) is closed to fishing during the period of 1st December to the 1st March - the extent of most of the spawning season. However, until recently, fishermen from Hopkins have been allowed to fish the banks for part of each season under special permission from the Minister, and under a quota system. With the decline in numbers of spawning groupers, and the increasing fuel costs, the number of fishermen decreased to only 14 during the 2001 season, and fishing the site is now no longer permitted, with the creation of protective legislation in 2002 giving much greater protection to spawning aggregation sites throughout Belize, with the creation of specific 'no-take' Spawning Aggregation Site reserves. In 2016, maximum numbers were closer to 350 (Figure 26; Tewfik, 2016), and Nassau Grouper were rated as POOR during the Conservation Planning process (GRMR Conservation Planning Workshop, 2017). The continuing decrease in observed numbers at peak spawning season may be a reflection of weather conditions at survey times, but may also reflect illegal fishing and transboundary incursions.

It has been estimated recently that one-third of all known Nassau grouper spawning aggregation sites in the Caribbean region have disappeared, and a recent study estimated that under present management conditions, Nassau Grouper (once the second most commonly caught fish in Belize) will disappear from this country by the year 2013 (Paz and Grimshaw, 2001). Whilst Nassau grouper are still present on the reef, more than half of Belize's 13 traditional Nassau grouper spawning sites are already considered to have collapsed, as reproduction-size aggregations no longer form. In 2002 a closed season was introduced for the Nassau grouper, covering its spawning season in Belize, (1st December – 31st March). However, tag studies have shown that most of the groupers that spawn at the bank remain within the atoll, and that more groupers are caught by spear fishing outside the spawning season than by hand lines during the spawning aggregation (Sala et al., 2001), suggesting that this species needs greater protection generally, not just at the spawning site. There is unfortunately no long term data available from before the population crash to be able to determine trends in the spawning population.

Sea cucumbers have been over-fished on the Atoll, with only 6 individuals encountered during surveys of 36 sites in 2017 – a density of 0.0008 sea cucumbers per m^2 (FiD / Chicas, 2018).

1.5.5 PAST AND PRESENT RESEARCH

Stoddart (1962) described the early research conducted on the Atoll. The earliest known investigation was recorded in the notes of Captain Richard Owen who visited in 1830, and which were compiled by Bird Allen. These notes formed the basis for the information on the Atoll included in Darwin's "Structure and Distribution of Coral Reefs," published in 1842. Later that century, in 1862, the ornithologist Salvin visited Glover's Reef. The marine fauna was studied in 1925 by the Pawnee Expedition. Schmidt recorded the visit of the Mandel Caribbean Expedition in 1940, which made collections of mollusks and reptiles.

Stoddart (1962) then described the reefs and caye vegetation during a visit made in 1961, and later re-surveyed the Atoll in 1971 (Stoddart 1982). In 1971 the Atoll was also visited by a team of 40 scientists as part of the Comparative Investigations of Tropical Reef Ecosystems (CITRE) Workshop held on Long Caye, with the Smithsonian Institution publishing several scientific papers on the Atoll as a result of this meeting.

Several other studies were carried out during the 1970's: James and Ginsburg (1972) investigated the deeper reefs using the Nekton submersible, a study of the caye flora was carried out in 1973 (Linhart 1980); Schafersman (1972) studied the patch reefs, a sedimentology and ecology study was conducted by Wallace (1974), as was a study of deep water species on the margin of the Atoll (Colin, 1974). An inventory of the marine benthic plants of the atoll was also completed (Tsuda & Dawes 1974), and a series of icthyological research studies were conducted by Greenfield (1972, 1975 and 1979), Greenfield and Greenfield (1973) and Greenfield and Johnson (1981).

In 1992, a preliminary assessment of coral cover and lobster and conch population densities was conducted by the Fisheries Department at two sites, prior to the implementation of reserve protection (Young et al. 1993). A study was also initiated to investigate the effectiveness of the reserve in enhancing fish catches (Carter 1993).

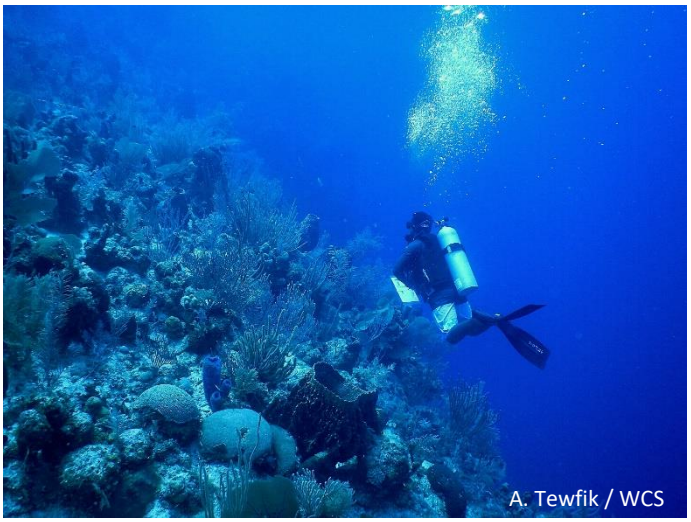
The construction of the Wildlife Conservation Society research station in 1996 supported and promoted further research on the Atoll, with a continually greater focus on applied and management related research. Since opening in 1997, particular emphasis has been placed on investigation of the following objectives:

- The status and trends in biological communities at Glovers Reef Atoll
- The effect of marine reserve protection on various components of the system
- The abundance, spawning site fidelity, rate of return, and fishing mortality of reproductive groupers at the spawning aggregations at Glovers Reed Atoll
- The importance of the atoll as habitat for a broad diversity of marine animals

Studies have investigated the grouper spawning aggregation in the northeast corner of the Atoll (Sala *et al*. 2001; Sala & Ballesteros 2000), the effectiveness of the Conservation Zone in conserving stocks of commercial species such as spiny lobster and queen conch (Acosta 1998, Acosta & Robertson 2001), the abundance and distribution of sharks (Pikitch et al. 2005), the phase shift from coral to algal dominance on the patch reefs (McClanahan & Muthiga 1998), and the effect of algal dominance on the ecology of the reefs (McClanahan et al. 2000). Other research conducted includes studies on coral recruitment, grazing pressure, and the effects of nutrient enrichment on coral populations (Mumby 1998; Mumby 1999; McClanahan et al. 2002). A baseline survey of the fauna and flora of the patch reefs was also carried out and a GIS database developed (Thoney, 2000), currently accessible through the WCS website – http://programs.wcs.org/gloversreef .

A survey of 13 reef sites was carried out on Glover's following the mass bleaching event and passage of hurricane Mitch in 1998 (Kramer & Kramer 2000). McField (2001) also surveyed two sites on the fore reef at Glover's in 1997 and 1999 and thus recorded observations prior to and following the massive bleaching event and hurricane Mitch in 1998, reporting on the changes that occurred during this period of major ecological disturbance. Many of these studies are ongoing as part of long-term research programs.

Several monitoring programs have been initiated on the atoll. The WCS Research Station has introduced a Long-term Atoll Monitoring Program (LAMP) (Acosta, 2001). The Program uses the CARICOMP methodology, which includes meteorological and oceanographic parameters, and productivity measurements of corals, sea grasses and mangroves. In addition, the LAMP monitoring includes plankton sampling and surveys of major fishery species (lobster, conch, and five fin-fish species), both inside and outside the Conservation Zone. WCS scientists are conducting the program along with reserve personnel, in particular with the Reserve Biologist.



REEF ASSESSMENT, LONG-TERM ATOLL MONITORING PROGRAM (LAMP)

Glover's Reef was one of three sites in Belize for the coral reef monitoring component of the CPACC (Caribbean Planning for Adaptation to Climate Change) project. The site was chosen as it was considered representative of areas that are minimally impacted by human disturbances. The monitoring site is located within the reserve's Conservation Zone, on the fore-reef east of Middle Caye at a depth of 50 – 54 feet, in an area consisting of low relief spur and groove formations (Bood, 2001). In addition, reserve staff members initiated a coral reef monitoring program using the point intercept and video transect methods.

The Atoll is also included in the national survey and monitoring program to assess the sites of fish spawning aggregations. Apart from the Nassau grouper spawning site on the northeast corner of the atoll being monitored by WCS (Sala and Ballesteros 2000), two additional sites have been surveyed for spawning aggregations. These include a site off Middle Caye, and one near the South West Cayes. Heyman and Requena (2002) have discovered that these sites are important for black grouper and smooth trunkfish. On the terrestrial side, recent work included an assessment of the extent of the lethal yellowing disease of coconut trees, which struck several of the islands in 1998 (Berlin & Quiroz 1998). In addition, bird and flora surveys were carried out on Middle Caye (Bright 1999; Meadows 1998), and on birds, flora and reptiles of western Long Caye (Meerman, 1995). More recent work includes AGRRA and the MBRS Synoptic Monitoring program.

TABLE 26: RESEARCH STUDIES AT GLOVER'S REEF

Name of Researcher	Research Topic or Species	Year
McClanahan and Muthiga	Ecological shift in a remote coral atoll Belize over 25 years.	1998
McClanahan	Predation and the control of the sea urchin *Echinometra viridis* and fleshy algae in the patch reefs	1999
McClanahan, Aronson, Precht, and Muthiga	Fleshy algae domination of remote coral reefs of Belize	1999
Acosta	Survey of lobster & conch populations	2001
Sala	Nassau grouper – acoustic study	2001
Ihde	PhD study on tagging of 5 commercial fin-fish species to deduce fishing intensity & migration between different zones	2001
Mumby	Monitoring of coral damage & recovery; fish behavior	2001
Baker	Study on regeneration of zooxanthellae through transplanting corals from deep to shallow water, and *vice versa*	2001
McClanahan	Algal growth and fish herbivory	2001
Pikitch	Survey of shark distribution & abundance	2001
Purcell	Coral reef fish larval dispersal and recruitment in relation to MPAs	2000
REEF	Distribution & abundance of coral, fish, etc.	2001
Rosenthal	Comparison of function of fish colour on the Caribbean and Pacific sides of the Central American isthmus	2001
Richards & Cummings	Biology of hogfish; survey of MPA methodology	2001
McClanahan	Sea urchins – predation and mortality rates	2001
Semsar	Sex change in the Bluehead wrasse	2002
Acosta, McClanahan & Mumby	LAMP Project	2002
Acosta	Inventory of species of Glover's Reef Atoll	2002

TABLE 26: RESEARCH STUDIES AT GLOVER'S REEF / 2

Name of Researcher	Research Topic or Species	Year
Acosta, McClanahan & Mumby	LAMP Project	2002
Acosta	Inventory of species of Glover's Reef Atoll	2002
McClanahan	Algal growth and fish herbivory	2002
Pikitch	Shark survey	2002
Purcell	Coral reef fish larval dispersal and recruitment in relation to MPAs	2002
Steneck	Coral recruitment – substrate study	2002
Allsop	PhD study on sex change in species of blenny	
Sala	Nassau grouper – annual assessment of abundance and acoustic study; reef ecology	2002
Acosta & Robertson	Diversity of reef community	2002
Acosta	Dispersal of Caribbean spiny lobster and implications for conservation	2002
Acosta & Robertson	Comparative spatial ecology of fished and non-fished lobster species	2002
Carriero-Silva & McClanahan	Role of inorganic nutrients and herbivory in controlling microbioerosion of carbonate substrate	2003
McClanahan, Sala et. al.	Interactions between nutrients and herbivory in controlling algal communities and coral condition	2003
Mumby, Edwards, Arias-Gonzalez et. al.	Importance of mangroves to reef fish communities	2004
McClanahan, Sala & Mumby	Effects of phosphorus and nitrogen enrichment on macroalgae	2004
Godwin and Marsh	Neuroendocrine changes to the bluehead wrasse	2005
Bood	Recovery and resilience of coral assemblages	2005
Clarke	Blenny habitat	2005
Acosta	Modeling of populations of conch, lobster and fish	2005
Mumby, Foster & Henken	Patch dynamics of coral reef macroalgae	2005
Chapman	Shark survey	2005
Steneck & Arnold	Contribution of fish communities to coral reef resilience	2006
Chapman	Shark survey – habitat use and demographic population structure	2006
Thorrold & Gawarkiewicz	Physical oceanography of Glover's (preliminary work to study on the movements of Nassau grouper larvae)	2006
Mumby	Asexual reproduction in *Montastrea annularis*; effects of *Diadema* at Glover's	2005
Acosta	Modeling of populations of conch, lobster and fish	2006
Steneck & Mumby	Linking herbivory to reef resilience	2006
Godwin and Marsh	Neuroendocrine changes to the bluehead wrasse	2006

TABLE 26: RESEARCH PROJECTS CARRIED OUT THROUGH THE WCS RESEARCH STATION AT MIDDLE CAYE BETWEEN 2001 AND 2006 (WCS & FISHERIES DEPT.)

Several maps of the area have been produced over the years - maps of Glover's Reef atoll are provided by the DOS sheets at a scale of 1:250,000 and also the 1:50,000 series, available from the Lands Department in Belize or the Ordnance Survey in the U.K. Digital, georeferenced copies are also available. The 1:20,000 chart from the Hydrographic Office of the Royal Navy, sheet 1797 (Monkey River to Colson Point; 1992) provides depth soundings of the area. Stoddart (1962) provides a map of the Atoll based on aerial photography, and also published maps of the cayes which he surveyed in 1961 (Stoddart 1962) and re-surveyed in 1971 (Stoddart *et al.* 1982).

In 1988, Dr. Franz Meyer of CEDAM developed a map of the Atoll based on a Landsat image, to be followed by the Coastal Zone Management Authority & Institute (CZMAI), which acquired Landsat TM imagery of the coastal offshore region, including Glover's Reef, for the year 1996 from which it derived a 1:50,000 marine habitat map, using the classifications defined by Mumby *et al.* (1998). During mapping activities under different ecoregional planning initiatives, there are now a series of shape files available delineating the protected area, its management zones, the associated spawning aggregation site, and the marine and terrestrial ecosystems. This is supplemented by more recent data from WCS, which has GIS maps of the Atoll developed from their inventory of the flora and fauna of the patch reefs (Thoney 2000), updated during the Living Seascape initiative. This mapping is on the Wildlife Conservation Society Glover's Reef website.

SeaWifs ocean colour images are available from NASA and have been used for determining temporal and spatial patterns of turbidity in the area of the Atoll after major climatic events such as Hurricane Mitch in 1998 (Andréfouët *et al.* 2002).

Between 2011 and 2012, seven research projects were being implemented, including:

- Belize Shark Conservation Research, D. Chapman and E. Pikitch, Institute for Ocean Conservation Science & School of Marine and Atmospheric Science. Stony Brook University
- Dispersal of *Panulirus argus* (spiny lobster) larvae and how it affects disease transmission. Mark Butler, Old Dominion University
- Applying patterns of natural coral recovery to guide Caribbean coral reef restoration efforts. B. Huntington, NRC Post Doc Fellow NOAA Southeast Fisheries Science Center
- A Hands-on Approach to Marine Science Education: Surveying and comparing the marine habitats of Glover's Reef. C. Williams, J. Kilborn, N. Mendez, B. Hayes and J. Alaniz. SCUBAnauts International, Inc., U.S.A.
- The effect of coral reef degradation on the recruitment of reef fish larvae at Glover's Reef Atoll, Belize. N. Bayani (Master's Thesis) Department of Ecology, Evolution and Environmental Biology, Columbia University
- Sampling Corals along Belize Coast. M. Fine and O. ben-Tzvi. The Future of Reefs in a Changing Environment (FORCE) project. The Interuniversity Institute for Marine Sciences in Eilat, Israel & Bar-Ilan University. Israel.
- Spawning Aggregation Acoustics Research. M. Schärer, Caribbean Coral Reef Institute (CCRI), University of Puerto Rico

More recent research and monitoring under WCS has been focused on supporting the development of the Managed Access program, and evaluating the effectiveness of management strategies, demonstrating the benefits of conservation zones in the long term sustainability of fish stock on the Atoll, and providing a model for other protected areas in Belize, the region and globally (including Babcock et al., 2013, Harford et al., 2016, Karnauskas et al, 2014). Work has also focused on implementation of the Long Term Atoll Monitoring Program, and extending it to cover a wider suite of species, monitoring of catch per unit effort, monitoring of the spawning aggregation site, and in-water and nesting surveys of turtles.

1.6 CULTURAL AND STAKEHOLDER USE OF GLOVER'S REEF MARINE RESERVE

1.6.1 COMMUNITY AND STAKEHOLDER USE

Historically, Glover's Reef was once an important trading post for the indigenous Mayas of Mesoamerica. In more recent times, the Atoll served as a refuge for British buccaneers, the name 'Glover's' being derived from the famous British pirate, John Glovers.

Nowadays, Glover's Reef is renowned for its pristine reef structure of "spectacular walls and coral canyons", its clear, shallow, sheltered waters, the string of cayes that line the eastern edge of the Atoll, and the vibrant marine flora & fauna. Three primary stakeholder uses have been identified for the area – fishing, tourism and research.

TRADITIONAL FISHING

The Atoll is a traditional fishing area for lobster, conch and fin-fish, with the greatest activity occurring during the opening of the lobster and conch seasons. Before the seasonal closure zone, and the subsequent closure of the north east grouper spawning site, heavy fishing pressure on the groupers would also occur during peak spawning times. 105 fishermen are licensed to fish in Glovers Reef Atoll (Managed Access Area 8; FiD data, 2017). The majority of fishermen who visit the area use wooden sailboats up to 30 feet long, equipped with auxiliary outboard engines and ice boxes, originating primarily from Sarteneja. Each will carry between seven and twelve crew members, who free-dive for conch, lobster and occasionally fin-fish. These boats sail from Belize City to spend an average of six to twelve days fishing on the Atoll, before returning to the mainland (Sarteneja fisherman, pers. com.) The skiffs, originating from Dangriga and Hopkins are primarily fishing by hand-line, though also dive for lobster and conch, and spending a much shorter time on the Atoll (an average of three to four days). The majority of fishermen are members of either National or Northern Fisherman Co-operatives.

TOURISM AND RECREATION USE

Tourism is becoming an increasingly important economic activity on Glover's Reef Atoll, though with accessibility far harder than Lighthouse and Turneffe, much of the tourism is based on live aboards, or based from the five resorts currently operating from the cayes within the Atoll. A sixth, Manta Ray Resort, is currently not in operation. Visitors also arrive from other resorts on the mainland and other cayes on a daily basis, such as Hamanasi Adventure and Dive Resort, from the mainland near Hopkins, and from hotels on Tobacco Caye. Sailboats from The Moorings charter yacht business based in Placencia visit the atoll for snorkeling and diving, and other private boats and yachts also visit the reserve, but on a relatively small scale. Dive boats are required to register in order to operate within the reserve.

The Nekton Pilot, a live-aboard dive boat, also brings divers to the Atoll, though several stakeholders have expressed the opinion that current mooring facilities are insufficient for the size of the boat, and there has been friction about the way in which the boat has moored in the past, with damage to both mooring buoys and coral heads.

Activities concentrate on scuba-diving, kayaking, wind surfing, sport fishing and fly fishing, with the impressive reef structures of the reef edge and the sheltered waters of the inner lagoon providing perfect conditions for these activities. A number of popular dive sites have been identified - Emerald Forest Reef and Baking Swash on the leeward reefs, and Southwest Caye Wall, Middle Caye Reefs, Long Caye Wall, and Shark Pt. on the windward reefs (Meyer 1990) all provide opportunities for both diving and snorkeling, considered impressive even on a world scale. The Pinnacles, in the southern portion of Glover's Reef, is a dive site renowned for its particularly rich marine life, being somewhat sheltered from the prevailing currents. Dive guides are required by law to accompany groups of divers, and resorts offering SCUBA activities generally have dive guides resident on-site. In addition, many of the visitors to the Atoll visit the WCS research station on Middle Caye, where they are given informal presentations on the research being carried out.

To prevent damage to the reef, four moorings have been installed at two popular dive sites on the eastern fore reef, and two on patch reefs in the lagoon. There is recognition among the tourism stakeholders, though, that this is insufficient for the current demand, and a series of other sites have also been identified for similar mooring points.

At peak occupancy, there are estimated to be approximately 120 guests on the Atoll in total, though the average occupancy is 50% of that. Residential staff number approximately 38 (these figures do not include Middle Caye, the location of the WCS research station and the Fisheries Department base). With the high costs of transport, the majority of the resorts operate on a weekly itinerary, offering all-in packages with a single arrival / departure day. Two of the companies – Slickrock and Island Expeditions – focus on kayak activities, based from camp facilities, whilst Isla Marisol and Off the Wall have a much greater investment in infrastructure. Most of the resorts close for one to two months of the year, or in some cases longer. Most are open, however, from October to April/May.

Glover's Reef is also known for its fly fishing, attracting many of the pelagic species. Sport fishing is allowed within the Conservation Zone of the reserve, under special license and only on a catch-and-release basis. Sport fishermen are required to apply for a sport fishing license to fish in the marine reserve. The Atoll is particularly well known for its bonefish, found throughout the flats and reefs that surround the cayes on the eastern side. On the west of the Atoll, permit use the seagrass flats to feed, and throughout the inner lagoon, fishermen try for catch-and-release barracuda, jacks, snapper and grouper. Bluewater fishing is also popular beyond the Atoll drop off, for deep sea species such as wahoo, marlin, kingfish, black finned tuna, dolphin and sharks. Whilst increasing the value of Glover's Reef as a tourism destination, activities such as chumming (throwing chopped fish into the water in fish congregation areas such as channels, breaks in the reef and reef elbows) to attract game species is known to alter fish behavior.

RESEARCH USE

Middle Caye is owned by Wildlife Conservation Society, and provides a base for a number of research projects throughout the year, exploring the marine ecosystems of the Atoll, and advancing knowledge of the biodiversity and physical environment of the area. The facilities can house up to 18 researchers at any one time, along with the station manager and staff. Research activities require permission from the Fisheries Department and WCS before going ahead, allowing filtering of inappropriate research activities. Fisheries Department also conducts research in the area, based from the facilities on Middle Caye. Past research has been summarized in Section 2.5.4.

The WCS research station on Middle Caye, opened to scientists since mid-1997, complements the management activities of Fisheries Department, supporting research programs being carried out on the Atoll. There are eight buildings located on the caye, including a boat locker, compressor room, workshop, generator house, ranger station, wet and dry laboratories, kitchen/dining area, dormitory and Station Manager's house.

EDUCATIONAL USE

The GRMR staff has been carrying out an informal education program targeting visitors to the reserve, including fishermen and tourists. This includes sharing information about the reserve and the importance of the atoll's ecosystems. The reserve manager also gives presentations about the work carried out by the Fisheries staff to visiting student and tour groups upon their request. A reserve brochure was printed several years ago, and has recently been updated WCS has also developed a colour brochure that highlights the reserve's zones and their importance to fisheries management. This publication was designed for use in a school outreach program.

The reserve headquarters originally housed a rudimentary visitor centre, which included displays of maps, artifacts found on the caye, etc. However, this needs to be set up once again and educational material developed.

The WCS Station Manager also carries out an informal education program to visitors to Middle Caye, giving a tour of the island and an overview of the research programs being carried out. In the past, student interns from the University of Belize have conducted research projects and have been hosted at the research station. There are plans for WCS to expand its educational program to both local and international student groups.

1.6.2 ARCHAEOLOGICAL SITES

Little is really known about the extent to which the Maya used the cayes of Glover's Reef. Surveys of Middle Caye in 1997 and 1998 showed that these cayes probably served as pre-classic Mayan settlements. Pottery similar in form to that found in Stann Creek indicates tentative dating of the Maya sites to the Late and Terminal Classic periods (Graham, 1999). As Glover's Reef is located along the pre-Columbian trade route between Honduras and the Yucatan, it was probably used more than casually, but whether as a short term fishing station or with longer-term occupation is not yet known. A pre-classic Mayan settlement has been identified on Long Caye.

Pieces of European pottery and porcelain, are also commonly found on Middle Caye and indicate historic use of the island over the late eighteenth and early nineteenth centuries, (Graham, 1999), possibly as shipwrecked crews. The Atoll has a history of use by pirates, and is believed that the name "Glover" is derived from the name of the pirate 'john Glover' who made the atoll his base (Stoddart, 1962), from which he was able to raid Spanish merchant ships. The Atoll is noted for its numerous shipwrecks, including the following:

1. The "Monmouth", an English merchantman wrecked on its way to London in 1751.
2. The "Argyle" and "Polly", an English merchantman and American ship both sank in 1774.
3. An unidentified Scottish ship in 1786.
4. The "Chance", an English merchantman sank in 1793 coming from Jamaica.
5. The "General Don", an English ship en-route from France sank in 1808.
6. The schooner "Susan" was wrecked in 1858 and the crew rescued and taken to Middle Caye where they remained for six months.
7. The 200 ft steel steam ship, the Alps, sank in 1914 (B. Lamont, pers. com.)

Section Two

Conservation Planning

2. CONSERVATION PLANNING

Conservation Action Planning (CAP) is a structured approach to planning, implementing and measuring success for conservation projects at system and site level. During the management planning process, the original seven conservation targets identified in the WCS 2006 Seascape Planning for the area were reviewed and revised, with a shift from a species-orientated approach to one more focused on ecosystems and species assemblages.

ORIGINAL CONSERVATION TARGETS (2008)

- Nassau Grouper
- Conch
- Caribbean Reef Shark
- Hawksbill Turtle
- Osprey
- Black-spined Urchin
- Star Coral

REVISED CONSERVATION TARGETS

- Coral Reefs
- Mangrove
- Seagrass
- Littoral Forest / Sandy Beaches
- Deep Sea Ecosystems
- Commercial Species
- Sharks and Rays
- Sport Fish Species
- Charismatic Megafauna

2.1 IDENTIFICATION OF CONSERVATION TARGETS

Nine **Conservation Targets** were identified during the revision of the conservation planning process, selected to assist in guiding conservation strategies at site level, based on:

- **Representation of the biodiversity and cultural heritage of the site.** The focal targets should represent or capture the array of ecological systems, communities and species of importance of Glover's Reef Marine Reserve, and the multiple scales at which they occur

- **Reflection of ecoregion or other existing conservation goals**. Focal targets are grounded in the reasons for protection – Glover's Reef Marine Reserve's current status of protection as part of the National Protected Areas System Plan, and as one of seven protected areas within Belize's World Heritage Site. Focal targets should also reflect conservation efforts at the regional level, as well as national initiatives including the National Protected Areas Policy and System Plan, and at regional level, the TNC, CI and WWF ecoregional assessments, which identify the Belize Reef as one of the region's key marine areas of ecological, biological and social importance.

- **Viability or at least feasibly restorable**. Viability (or integrity) is a measure of a target's ability to persist for many generations. If a target is on the threshold of collapse, or conserving a target

requires extraordinary human intervention, it may not represent the best use of limited conservation resources.

- **Being highly threatened**. All else being equal, targets should focus on highly threatened species or ecosystems, ensuring that critical threats are identified and addressed through conservation actions.

Ecosystem and species assemblage targets were selected to represent the important conservation features of the Atoll:

Ecosystem Level Targets: Assemblages of ecological communities that occur together, share common ecological processes, and have similar characteristics. Three marine and two caye (terrestrial) ecosystems have been selected:

- ***Coral Reefs***
- ***Seagrass***
- ***Deep Sea Ecosystems***
- ***Littoral Forest***
- ***Mangroves***

Species Assemblages: Four species assemblages were selected - groups of species that share common natural processes or have similar conservation requirements:

- ***Commercial Species***
- ***Sharks and Rays***
- ***Sport Fish Species***
- ***Charismatic Megafauna***

Each of these targets has a series of associated **nested targets –** species or species assemblages considered of particular conservation importance that are represented by the target (Table 27).

Conservation Targets and Nested Targets for Glover's Reef Marine Reserve		
Conservation Target	**Nested Target**	
Coral Reefs	Staghorn coral **CR** Elkhorn coral **CR** Fire coral **EN** Boulder star coral **EN** Star coral **EN** *Diadema*	Parrotfish Reef fish species Endemic reef species Charismatic reef fish of high tourism value
Seagrass	Turtle grass Manatee grass Shoalweed Star grass	Juvenile fish species Parrotfish Conch Black tip sharks (juvenile)
Deep Sea Ecosystem	Deep sea corals Potential commercial fish species	
Littoral Forest / Sandy Beaches	Migratory bird species Island leaf-toed gecko **VU** St. George's island gecko Marine turtles (nesting beaches) Hawksbill turtle **CR** Loggerhead **EN** Green turtle **EN**	Brown anole Green iguanas Black iguana
Mangroves	Juvenile fish species Juvenile lobster Birds (roosting and nesting sites)	American saltwater crocodiles
Commercial species	Lobster Conch Fin-fish Sea cucumber	Grouper and snapper spawning aggregation species Nassau grouper **CR**
Sharks and Rays	Great hammerhead **EN** Scalloped hammerhead **EN** Caribbean reef shark Lemon shark Nurse shark Whale shark **EN**	Southern stingray Spotted eagle ray Caribbean whiptail ray Yellow spotted stingray Black tip sharks (juvenile)
Sport Fishing Species	Bonefish Tarpon Permit	Barracuda Jacks
Charismatic Megafauna	Hawksbill turtle **CR** Green turtle **EN** Loggerhead **VU**	Dolphins American crocodiles

TABLE 27: CONSERVATION TARGETS AND NESTED TARGETS

2.2 ASSESSING BIODIVERSITY VIABILITY

The Viability Assessment conducted under the Conservation Planning process provides:

- A means for determining changes in the status of each focal target over time, to measure success of conservation strategies, compare the status of a specific conservation target with future conditions, and with other projects in Belize / Central America that focus on that target

- A basis for the identification of current and potential threats to a target and identification of past impacts that require mitigation actions

- A basis for strategy design and the foundation for monitoring

The conservation viability outputs have been developed using the TNC / Miradi viability assessment tools with assessment using the following viability ratings:

- **Very Good** – The Indicator is considered to have an ecologically desirable status, requiring little or no intervention for maintenance.

- **Good** – The indicator lies within the acceptable range of variation, though some intervention is required for maintenance.

- **Fair** – The indicator lies outside the acceptable range of variation, and human intervention is required if the viability of the target is to be maintained

- **Poor** – Restoration of the conservation target is increasingly difficult, and impacts may result in extirpation from the conservation area

In some cases, where multiple nested species are assessed, the precautionary principle has been applied, with selection of the lowest rating - sharks and rays, for example, have different ratings (sharks: FAIR, rays: VERY GOOD). The shark rating has been used, as combining the two would downplay the risk to sharks when prioritizing conservation actions. The same has been done for Littoral Forest / Sandy Beaches – the assessment is based on the Littoral Forest.

For Commercial Species, each nested target (lobster, conch, sea cucumber, fin-fish, grouper / snapper aggregations, and other fin-fish aggregations) is assessed individually, with the outputs rolled up to give an overall rating for the Conservation Target.

Conservation Targets	Seascape Context	Condition	Size	Viability Rank
Commercial Species	FAIR	FAIR	FAIR	FAIR
Sharks and Rays	GOOD	FAIR	FAIR	FAIR
Coral Reefs	FAIR	FAIR	GOOD	**FAIR**
Littoral Forest / Sandy Beach	POOR	FAIR	GOOD	**FAIR**
Mangroves	FAIR	VERY GOOD	GOOD	**GOOD**
Charismatic Megafauna	GOOD	GOOD	GOOD	**GOOD**
Sport Fishing Species	GOOD	VERY GOOD	VERY GOOD	**VERY GOOD**
Seagrass	VERY GOOD	VERY GOOD	VERY GOOD	VERY GOOD
Project Biodiversity Health Rank				**GOOD**

TABLE 28: SUMMAY OF GRMR CONSERVATION TARGET VIABILITY OUTPUT

The overall viability rating for Glover's Reef Marine Reserve is **GOOD,** with four targets rating as **FAIR**, two targets rating as **GOOD** and two targets rating as **VERY GOOD** (Table 28). The Deep Sea Ecosystem is currently considered a data gap, and has therefore not been included in the viability assessment. With the extension of the GRMR replenishment zone into the deep sea and the increasing interest in diversification into deep sea fishing, it is recognized, however, that it is an emerging conservation target of increasing importance.

Conservation Target: Littoral Forest / Sandy Beaches		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
SEASCAPE CONTEXT: **POOR** **CONDITION:** **FAIR** **SIZE:** **GOOD** **OVERALL:** **FAIR**	Tropical littoral forests are classified with herbaceous beach communities in the Belize Ecosystem Map as ***Tropical Coastal Vegetation on recent sediments*** (Meerman and Sabido, 2001). This is Belize's most threatened ecosystem, and is highlighted under Belize's National Protected Areas System Plan as being significantly under-represented within the current protected area system, with protected national coverage under protection being only 8.5%, as compared with the national target of 60% for this ecosystem. The lower herbaceous beach vegetation grows along the coastal strand – a combination of low growing shrubs and vines that are considered very important for the stabilization of the beaches, provide structure that binds the sand and prevents erosion, as well as providing optimal nesting conditions for marine turtles. The sandy beaches are constantly shifting, with natural erosion and deposition occurring in response to tide, wind and storm actions. However, this ecosystem is found in areas targeted for residential and tourism development, where it is often subjected to extensive clearance to expose the sandy beaches.	Nested within the Terrestrial Ecosystem target are both **tropical littoral forests** and **herbaceous beach vegetation,** with 34 naturally occurring native species of plant. It provides habitat for the caye specialist lizards - the endemic **island leaf-toed gecko** (*Phyllodactylus insularis*) and **St. George's island gecko** (*Aristelliger georgeensis*), as well as for generalists such as the more ubiquitous **black iguana** (*Ctenosaura similis*) and **brown anole** (*Anolis sagreil*). A number of bird species rely on the littoral forest either as residents, such as the **white crowned pigeon** (*Patagioenas leucocephala*), and provides nesting structure for brown pelicans (*Pelecanus occidentalis*) and **osprey** (*Pandion haliaetus*). Migratory bird species such as the **American redstart** (*Setophaga ruticilla*), **hooded warbler** (*Wilsonia citrine*) and **bay breasted warbler** (*Dendroica castanea*) also rely on the littoral forest for replenishment before continuing their migration. The herbaceous beach vegetation and sandy beaches of cayes across the Atoll provide nesting sites for three species of marine turtle – **hawksbill** (*Eretmochelys imbricata*), **green** (*Chelonia mydas*), and **loggerhead** (*Caretta caretta*).

Conservation Target: Commercial Species

Conservation Target	Justification for Target Selection	Species, Communities or Ecological Systems represented by Target

SEASCAPE CONTEXT:	Glover's Reef is important for supporting 105 fishers and their families (FiD, 2017). The two invertebrate species of highest commercial importance are the **Caribbean Spiny Lobster** (*Panulirus argus*) and **Queen conch** (*Lobatus (Strombus) gigas*), both of which are fished extensively throughout the General Use area of the Atoll. Important export species that help support the national economy, both lobster and conch catches have declined historically over the years, but are showing some signs of improvement at GRMR, with the measures put in place to ensure greater sustainability of the stocks. Fin-fish species are also important to the local economy. Many of the target species, such as black grouper, Nassau grouper, mutton snapper, and hogfish are also top predators - essential in maintaining a healthy reef community.
FAIR	
CONDITION:	
FAIR	
SIZE:	
GOOD	
OVERALL:	
FAIR	

Nested Target	Seascape	Condition	Size
Lobster	FAIR / GOOD	FAIR / GOOD	FAIR / GOOD
Conch	FAIR / GOOD	FAIR	GOOD
Sea Cucumber	POOR	POOR	POOR
Fin-fish	FAIR	GOOD	FAIR
Grouper / snapper aggregation	POOR	FAIR	POOR
Other aggregations	POOR	POOR / FAIR	FAIR

Conservation Target: Coral Reefs		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
SEASCAPE CONTEXT: **FAIR** **CONDITION:** **FAIR** **SIZE:** **GOOD** **OVERALL:** **FAIR**	The reef building corals of Glover's Reef Marine Reserve are critical to the maintenance of local biodiversity, and considered a conservation priority in ecoregional planning initiatives. Coral reefs are one of most diverse ecosystems on this planet, essential to the viability of the majority of fish and marine invertebrates living in the shallow tropical waters of Belize, providing basic structure for shelter, foraging, and reproduction. The coral reef is critical to the maintenance of the local fishing industry, particularly for spiny lobster and fin-fish populations - key commercial species. It is also one of the most important tourism resources Belize has to offer, and supports a significant percentage of overall employment in coastal communities. Reefs at GRMR also provide habitat for a relatively high number of endemic fish species, some of which are globally threatened. Coral reef ecosystems throughout the region, including GRMR, are being impacted by warming seas and increasing ocean acidity, causing coral bleaching and lowering resistance to disease.	The reef ecosystems of GRMR, including fore-reef, back-reef, reef slope, patch reef, are composed of many scleractinian coral species, providing a diverse range of habitats for a multitude of fish species and invertebrates, including commercially important species such as the spiny lobster, snapper and grouper GRMR provides protection for at least eleven IUCN redlist species ranked Critically Endangered or Endangered, including the critically endangered staghorn and elkhorn corals: Staghorn Coral (*Acropora cervicornis*) **CR** Elkhorn Coral (*Acropora palmata*) **CR** Nassau Grouper (*Epinephelus striatus*) **CR** Hawksbill Turtle (*Eretmochelys imbricata*) **CR** Loggerhead Turtle (*Caretta caretta*) **VU** Green Turtle (*Chelonia mydas*) **EN** Goliath Grouper (*Epinephelus itajara*) **EN** *Millepora striata* **EN** *Montastraea annularis* **EN** *Montastraea faveolata* **EN** Great Hammerhead (*Sphyrna mokarran*) **EN**

Conservation Target: Sharks and Rays		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
SEASCAPE CONTEXT: **FAIR** **CONDITION:** **FAIR** **SIZE:** **GOOD** **OVERALL:** **FAIR**	Nineteen shark species have been recorded in GRMR waters, including the world's largest fish, the globally endangered whale shark (*Rincodon typus*), as well as scalloped and great hammerheads, and the vulnerable silky shark. Rays, including the southern stingray, are also represented in the waters of the Atoll. Sharks play an important role as the apex predators of the marine communities, maintaining the natural trophic integrity of the reef and sea ecosystems. Studies demonstrated that the Atoll provides a nursery habitat for early life stages of nurse sharks, Caribbean reef sharks, lemon sharks and southern stingrays. Some species have been shown to have high site fidelity, being present throughout the year, and reliant on the food resources of the Atoll. Sharks are important charismatic species for marine tourism satisfaction – marine tourism is a key contributor to the national economy.	Silky Shark *Carcharhinus falciformes* **VU** Galapagos Shark *Carcharhinus galapagensis* Bull Shark *Carcharhinus leucas* Blacktip Shark *Carcharhinus limbatus* Whitetip Shark *Carcharhinus longimanus* Dusky Shark *Carcharhinus obscurus* Caribbean Reef Shark *Carcharhinus perezi* Sandbar Shark *Carcharhinus plumbeus* Smalltail Shark *Carcharhinus porosus* Tiger Shark *Galeocerdo cuvier* Nurse Shark *Ginglymostoma cirratum* Lemon Shark *Negaprion brevirostris* Blue Shark *Prionace glauca* Caribbean sharpnose shark *Rhizoprionodon pororsus* Scalloped Hammerhead *Sphyrna lewini* **EN** Great Hammerhead *Sphyrna mokarran* **EN** Bonnethead *Sphyrna tiburo* Smooth Hammerhead *Sphyrna zygaena* Whale Shark *Rincodon typus* **EN** Southern stingray *Dasyatis americana*

Conservation Target: Mangroves		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
SEASCAPE CONTEXT: **FAIR** **CONDITION:** **VERY GOOD** **SIZE:** **GOOD** **OVERALL:** **GOOD**	The prop roots of fringing red mangroves are important in their role as a critical fisheries nursery area for commercially valuable species, and considered important in the maintenance of fish and lobster stocks, including Caribbean spiny lobster and several species of grouper and snapper, all dependent on the connectivity between the spawning aggregation sites, coral reef, seagrass and mangrove at different times in their life stages. Parrot fish, too, are considered to have a functional dependency on mangroves as juveniles. Mangroves also play a key role in the maintenance of caye integrity through erosion control. The trees themselves serve as nesting and roosting structure for resident and transitory birds. Migratory birds rely on the shelter and re-provisioning resources of the mangroves as they pass through the Atoll. The complex red mangrove roots provide a structure for a whole ecosystem of tunicates, sponges, algae and mollusks, and sheltering other organisms, protecting them from predators in the open waters beyond the roots. Mangrove leaves provide important nutrients for plankton, contributing towards the base of the food chain. They also provide global services, removing and storing carbon dioxide from the atmosphere.	Red mangrove (*Rhizophora mangle*) Black mangrove (*Avicennia germinans*) White mangrove (*Laguncularia racemose*) Buttonwood (*Conocarpus erectus*) Caribbean spiny lobster (*Panulirus argus*) Nassau grouper (*Epinephelus striatus*) Mutton snapper (*Lutjanus analis*) Schoolmaster (*Lutjanus apodus*) Grey snapper (*Lutjanus griseus*) Mahogany snapper (*Lutjanus mahogoni*) Blue-striped grunt (*Haemulon sciurus*) Black grouper (*Mycteroperca bonaci*) Red-tailed parrotfish (*Sparisoma chrysopterum*) Blue parrotfish (*Scarus coeruleus*) Rainbow parrotfish (*Scarus guacamaia*) White-crowned pigeon (*Columba leucocephala*) Cedar waxwing (*Bombycilla cedrorum*) Golden-winged warbler (*Vermivora chrysoptera*) Tennessee warbler (*Vermivora peregrine*) Northern parula (*Parula americana*) Chestnut-sided warbler (*Dendroica pensylvanica*)

Viability of Conservation Targets: Charismatic Megafauna		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
SEASCAPE CONTEXT: **GOOD** **CONDITION:** **GOOD** **SIZE:** **GOOD** **OVERALL:** **GOOD**	This target includes those large species that are appreciated by both tourists and residents for their beauty and size, and that generally require larger areas than the GRMR, with connectivity to the open oceans. Three species of marine turtles – the critically endangered hawksbill, endangered green, and vulnerable loggerhead turtles frequent the waters of the GRMR for feeding and use the cayes for nesting. American crocodiles and Antillean manatees are both seen occasionally in the area, and larger marine mammals – including sperm whale, orcas and pygmy pilot whales – use the deeper oceanic waters that surround the Atoll. Four species of dolphin have been recorded in the area	**Dolphins** Fraser's Dolphin *Lagenodelphis hosei* Bottle-nosed Dolphin *Tursiops truncatus* Atlantic Spotted Dolphin *Stenella frontalis* Rough-toothed Dolphin *Steno bredanensis* Green Turtle *Caretta caretta* **EN** Hawksbill Turtle *Eretmochelys imbricata* **CR** Loggerhead Turtle *Chelonia mydas* **VU** **Occasional** American Crocodile *Crocodylus acutus* **VU** Antillean manatee *Trichechus manatus manatus* **EN**

Viability of Conservation Targets: Sport Fishing Species		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
SEASCAPE CONTEXT: **GOOD** **CONDITION:** **VERY GOOD** **SIZE:** **VERY GOOD** **OVERALL:** **VERY GOOD**	The back reef flats provide optimal habitat for sport fish species. The presence of permit, tarpon and bonefish in close proximity provide 'Grand Slam' opportunities – catch and release of all three in one day. The deeper waters beyond the drop off also provide challenges for deep-sea sport fishermen. The sport fishing industry based on the resources of the Atoll provides significant employment to local guides, boat captains, resort staff on the cayes, and tour operations based on both the Atoll and the mainland. The seagrass, mangroves and shallow waters of the Atoll provide sheltered juvenile and growing out habitat.	The three primary sport fishing species of the Atoll are **permit** (*Trachinotus falcatus*), **tarpon** (*Megalops atlanticus*) and **bonefish** (*Albula vulpes*), providing the foundation for the successful sport fishing industry. Also sought by sport fishermen are a number of other species from the shallower waters of the Atoll (**great barracuda** (*Sphyraena barracuda*), **snapper and grouper** and from the deeper waters beyond the drop-off (**blue marlin** (*Makaira nigricans*), **white marlin** (*Tetrapterus albidus*)**, sailfish** (*Istiophorus albicans)*, **wahoo** (*Acanthocybium solandri*), **dorado** (*Coryphaena hippurus*) and **king mackerel** (*Scomberomorus cavalla*).

Conservation Target: Seagrass		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
SEASCAPE CONTEXT: **VERY GOOD** **CONDITION:** **VERY GOOD** **SIZE:** **VERY GOOD** **OVERALL:** **VERY GOOD**	Seagrass meadows are essential for maintaining the ecological health of the shallow marine ecosystems of the Atoll, with an important role in nutrient cycling, sediment stabilization and maintenance of water clarity. Seagrass is also a critical ecosystem for many fish and invertebrate species, with an acre of sea grass being shown to support up to 40,000 fish and 50 million small invertebrates (Seagrass Ecosystems Research Laboratory, 2005). Over 90% of the seagrass beds of GRMR are considered to be intact, with only marginal impacts around the cayes, primarily from boat activity. However, recolonization of cleared seagrass patches is considered to be slow (Koltes et. al. 2014). Other potential impacts on the condition and extent of seagrass within GRMR include poor water quality from caye-based pollution and from land-based agrochemical pollution, and increased sediment loads from both Belize and Guatemala, despite its distance from the mainland.	In the shallow waters of the GRMR, these beds are dominated by *Thalassia testudinum,* interspersed with sparse stands of *Syringodium filiforme* and *Halimeda* spp. Nested targets include the marine turtles. These species play a role in the maintenance of the seagrass and increase the productivity of this ecosystem through grazing. Seagrass beds are an essential habitat for the Queen Conch *(Lobatus (Strombus) gigas)*, one of the most important commercial species extracted from the sea. It also harbors juveniles of many commercial fish species and the critical, reef-maintaining, herbivorous parrotfish, which rely on the seagrass beds in part of their juvenile phase.

2.3 THREATS TO BIODIVERSITY

Seven key threats to the biodiversity of Glover's Reef Atoll were identified, with an eighth, climate change identified as an over-arching threat (Table 29).

THREAT	PRIORITY
Illegal Fishing	1
Unsustainable fin-fish fishing	1
Oil pollution	2
Agricultural runoff from watersheds + sewage	3
Direct physical damage to coral (Poor anchoring practices Poor tourism practices (divers etc))	3
Introduced species - lionfish	3
Caye development / sewage and solid waste / Dredging	4

Climate change

TABLE 29: KEY THREATS TO THE BIODIVERSITY OF GRMR (CONSERVATION PLANNING WORKSHOP, 2017)

ILLEGAL FISHING

Type of threat: Historical / Ongoing / Potential

Target: Commercial species, sharks, sport fish, herbivores, turtles

	SCOPE	***SEVERITY***	***IRREVERSIBILTIY***
Lobster / conch	Medium	Medium	Medium
Fin-fish	Medium	Medium	Medium
Nassau grouper	Very High	Very High	Medium

KEY ISSUES

- Illegal gear
- Fishing in no take zones
- Transboundary incursions
- Non-licensed fishers
- Taking parrotfish
- Fishing in spawning aggregation,
- Local scuba fishing / spear fishing
- Taking undersized product (13% of surveyed catch is undersized lobster / conch)
- Taking turtles

IDENTIFIED STRATEGIES

- Strengthen enforcement – increased patrols, staff, night patrols, joint operations with the Belize Coastguard
- Strengthen interagency communication and collaboration through joint security meetings Fisheries Dept., coastguard and WCS
- Ensure patrols are informed and strategic, based on identification of hotspots and times
- Continued engagement of fishers through Managed Access
- Education / awareness campaign focused on the need for sustainable fishing, to improve engagement of communities and stakeholders
- Improved interface between patrols and fishermen
- Capacity building and annual refresher courses for protocols and case files, to improve prosecution rate

UNSUSTAINABLE FISHING PRACTICES

Type of threat: Historical / Ongoing / Potential

Target: Commercial species

	SCOPE	*SEVERITY*	*IRREVERSIBILTIY*
Lobster / conch	High	Medium	Medium
Fin-fish	High / Very High	High	High / Very High
Nassau grouper	Very High	High	High

KEY ISSUES / COMMENTS

- Need to improve best practices for lobster and conch fishing and strengthen lobbying to meet national commitments to the region
- There are few large Nassau Grouper – need to strengthen sustainable management of this species with targeted enforcement focused on the spawning aggregation site in key months
- No strategies /size limits are in place for other fin-fish such as snappers and groupers – this would require new legislation

IDENTIFIED STRATEGIES

- New legislation to support multi-species national management plans
- Collaboration between WCS, EDF, Fisheries Dept. towards development of species specific national management plans that include size range / size limits for snappers and groupers, jacks (possible basket approach) focused on the top 10 target fin-fish species.
- Incorporation of recommended regulations / size limits for fin-fish into the marine reserve regulations
- Gear restriction (gill nets, spear guns) to improve sustainability
- Engagement, education and improved capacity of fishers (especially boat captains and young fishers) for best practices towards a more sustainable fishery and improved awareness of issues of unsustainable fishing
- Support of good fisher stewards in engaging other fishermen
- Education of the consumers (supermarkets and fishmongers) ensuring they are informed of the need for sustainability
- Ensure restaurant / hotels, supermarkets etc. only buy and sell fish with the skin patch
- Certification of restaurants – fish right eat right
- Engagement of markets supplied by the co-operatives.
- Investigate packaging of GRMR fin-fish with certification of fish as sustainable (caught using best practices) to supply restaurant / hotels, supermarkets in San Pedro, Caye Caulker, Belmopan etc.

DIRECT IMPACTS TO STRUCTURE OF REEF

Type of threat: Historical / Ongoing / Potential

Target: Coral Reef	***SCOPE***	***SEVERITY***	***IRREVERSIBILTIY***
Coral Reef	Medium	Medium	Low

KEY ISSUES / COMMENTS

- Improving sustainable tourism would require working with tour guides using the Atoll, providing them with information, engaging them in improving tourism best practices and visitor satisfaction.
- Improving tourism best practices is also an enforcement issue, ensuring the tourism legislation (e.g. guide : visitor ratios) and site level regulations are adhered to.
- Independent travelers (e.g. catamaran / private vessels) are provided with a briefing on arrival.
- There are also issues of chemical use associated with sun tan lotion etc.
- Tourists – snorkelers, divers - risk of reef impacts on the patch reef in the Conservation Zone this is highest with snorkelers, who all go to the same site, resulting in degradation.
- Potential for damage from student use of reefs for research projects
- Structural damage from boat groundings.
- Structural damage from anchor damage.
- Fishermen diving for lobster don't always follow best practices around corals- hold on to the corals, break them to access lobster, throw conch shells on top of coral, tie canoes to corals
- Fishers state that they do not want to purposefully damage the reef as a healthy reef benefits them. However strong winds would require tying the canoes, if they are not to miss a day fishing and consider this a part of the traditional use of the reef for fishing.
- Fishers will generally dump their empty conch shells in non-productive areas. However, the youths are not as selective.
- Good fisher / reef practices also depend on how good the boat captain is.
- Strategies need to focus more training in best practices for both boat captains and youths.

IDENTIFIED STRATEGIES

- Continue to engage fishers in improved best practices around coral reefs
- Improve awareness of resorts and tour guides, as well as tourists, for snorkelling / dive best practices
- Improve knowledge of best practices around reefs for tour guides, and Atoll-based tourism operations
- Ensure all research / student groups are aware of best practices before working on the reef
- Improve surveillance and enforcement against marine tour guide infractions and investigate the potential for a ticketing / fine system
- Improve the capacity of rangers to be able to enforce tourism regulations
- Ensure there are sufficient mooring buoys at the dive site
- Ensure there are sufficient mooring buoys for overnight vessels
- Collaborate with private sector for maintenance of mooring buoys
- Ensure effective marking of shallow areas around channels to prevent boat groundings
- Improve knowledge of best practices around reefs for tour guides, Atoll-based tourism operations, boat captains and fishers

OIL POLLUTION

Type of threat: Historical / Ongoing / Potential

Target: All Targets	***SCOPE***	***SEVERITY***	***IRREVERSIBILTIY***
All Targets	Medium	Medium	N/A

KEY ISSUES / COMMENTS

- Oil exploration and extraction is not permitted in the area
- There are between 20-30 boats that use the Atoll regularly
- Poor boat practices - 2 stroke engine oil discharges, fishermen pouring old fuel/oil mix in the sea, throwing empty oil containers in the sea.
- The risk of a fuel spillage during a boat grounding is high, with significant implications for the adjacent ecosystems and species. The impacts are not very reversible – takes time for impacted ecosystems to recover.
- The risk of leaks from fuel storage tanks on the cayes is considered high, though these are generally not located near the more fragile reef areas
- The level of impact from poorly maintained outboards is rated at low / medium

IDENTIFIED STRATEGIES

- Engage tourism and fishing stakeholders in minimizing oil pollution
- Encourage DoE to conduct an annual inspection of fuel storage tanks on the cayes
- Provide boat captains that use the Atoll on a regular basis with opportunities to improve outboard maintenance
- Discourage use of 2-stroke outboard engines / encourage use of 4-strokes

AGROCHEMICAL POLLUTION IN WATERSHEDS

Type of threat: Historical / Ongoing / Potential

Target: All Targets	***SCOPE***	***SEVERITY***	***IRREVERSIBILTIY***
All Targets	Very High	Medium / High	High

KEY ISSUES / COMMENTS

- Agrochemicals are potentially the single biggest driver in the wrong direction.
- Algal blooms have been observed in the Atoll lagoon, which compounds the issues of coral and fish disease.
- Agrochemicals are both a national and transboundary issue.
- Also of concern is the effectiveness of sewage treatment in large population centres – e.g. Belize City
- There is potentially also a public health issue, with build-up of contaminants such as DDT and mercury through the food chain
- The severity of impacts depends on the level of nutrients and is hard to quantify at this point.
- Macro algae is an issue – 45 – 50% of cover is algae on patch reefs, and macro algae is also present at these high levels on the fore reef.

IDENTIFIED STRATEGIES

- Monitor water quality
- Improved awareness of best practices for sewage, black and grey water management on cayes
- Support of / engage in national and regional ridge to reef projects to reduce agrochemical and sewage impacts
- Support agro-certification schemes
- Lobby for improved sewage management in urban areas
- Improve awareness of the general public of issues of agrochemicals and sewage in the food chain

LIONFISH

Type of threat: Historical / Ongoing / Potential

Target: Commercial Species	***SCOPE***	***SEVERITY***	***IRREVERSIBILTIY***
Grouper / Snapper	Low	Not known	Medium
Small reef fish	High	Not known	Medium
Small shrimps	Medium	Not known	Medium
Parrotfish	Not known	Not known	Medium

KEY ISSUES / COMMENTS

- Management through market demand to control the population

IDENTIFIED STRATEGIES

- Kill on sight to actively suppress lionfish populations
- Encourage opportunistic fishing of lionfish
- Improve local and national market for lionfish
- Encourage the general public to eat lionfish
- Link GRMR fishers with lionfish market at San Pedro / Caye Caulker / Belize City

2.4 PLANNING FOR CLIMATE CHANGE

2.4.1 SITE RESILIENCE ASSESSMENT

When planning management strategies for climate change, it is important to determine areas of resilience and vulnerability. It is also important to identify adaptive strategies that can assist in maintaining the viability of biodiversity whilst increasing resilience at both site and stakeholder community level. This assessment of the predicted implications of climate change has been conducted for Glover's Reef Marine Reserve, based on the ***conservation targets*** identified during conservation planning, and on the ***environmental services*** provided by the protected area in question.

Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems.
Warming of the climate system is unequivocal, and since the 1950's, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen.

IPCC, 2014

The following assessment has been based on Belize's "*Guidelines for Integrating Climate Change Adaptation Strategies into Protected Areas Management Plans*" management planning framework, and provides a mechanism for assessing the implications of climate change through a series of steps:

1. Understanding the resources of GRMR
2. Understanding climate change projections for GRMR
3. Identifying vulnerability factors and resilience features
4. Identifying focal targets threatened by climate change
5. Assessing, rating and prioritizing the threat of climate change for each focal target
6. Situation Analysis and baseline
7. Development of adaptation objectives and strategies

2.4.2 IDENTIFIED RESOURCES OF GLOVER'S REEF MARINE RESERVE

The following resources have been identified as important for Glover's Reef Marine Reserve:

The Fisheries Resources support a traditional capture fisheries focused on lobster, conch and fin-fish. GRMR is important in supporting commercial fishermen from the adjacent and northern coastal communities.

Resource	Comment
▪ Conch, Lobster	GRMR contributes to both national conch and lobster production, providing an important income for traditional fishermen from the northern and central fishing communities.
▪ Snapper / Grouper	The snapper and grouper continue to be important in supporting local fishermen and supplying local markets and the tourism sector (resorts and restaurants)

The Tourism Sector. Glover's Reef Marine Reserve is considered important locally as a tourism resource, generating income and employment for the local economy and foreign exchange for the national economy.

Resource	Comment
▪ Healthy reef	The caye-based resorts have access to patch reefs thriving close to shore in the calm, shallow waters of the Atoll lagoon, and the rich biodiverse fore reefs of the Atoll wall. The vibrant colours and marine life associated with the corals are one of the key attractions for visitors to the area.
▪ Sandy beaches	The sandy beaches of the cayes have led to the development of a number of popular resorts, and add to the touristic appeal of the protected area.
▪ Sport fishing	GRMR is known as a sport fishing destination, contributing to tourism income.
▪ Charismatic Species (sharks, turtles, dolphins)	As well as being key for maintaining ecosystem health, charismatic species are also an important tourism resource, contributing towards high visitor satisfaction.

Ecosystem Services: The ecosystem services provided by GRMR are considered of national importance, supporting a tourism sector that is based on the aesthetic appeal and health of the reef, with associated snorkelling and diving activities. The Marine Reserve also supports the commercial and sport fishing industries by protecting key nursery areas, enhancing fin-fish, conch and lobster populations, and contributing towards the long-term sustainability of these activities.

Ecosystem	Ecosystem Services
Mangroves	The mangrove ecosystem provides a highly productive protected nursery habitat for juvenile commercial species (both extractive species supporting fishermen livelihoods and reef species of touristic appeal). It buffers and protects life and property on the cayes, reducing shore erosion and breaking the strength of storm force winds.
Seagrass	GRMR has extensive seagrass beds, with high connectivity to reef and mangrove, stabilizing the substrate, providing productive nursery habitat for juvenile commercial species, as well as foraging sites for threatened species such as marine turtles, and commercial species such as conch. Seagrass is also recognized for its value in CO_2 absorbing qualities.
Corals	The coral reefs of GRMR are well developed, with reef types ranging from patch reefs in the sheltered lagoon to spur and groove on the fore reef. The reef provides habitat for a vibrant array of reef species as well as for commercial species – lobster and fin-fish.
Coastal vegetation and littoral forest	The cayes of GRMR support small remnants of littoral forest, considered the most threatened ecosystem in Belize. The forest is important for endemic gecko and migratory birds, as well as for nesting birds. The coastal strand vegetation is important for stabilizing turtle nesting beaches, and maintaining the cayes.

2.4.3 IDENTIFICATION OF THE PRIMARY CLIMATE CHANGE ELEMENTS

The primary climate change elements associated with Glover's Reef Marine Reserve are identified as:

- Sea level rise
- Increased sea surface temperature
- Increased intensity of storms
- Ocean acidification
- Decreased precipitation
- Increased air temperature

Current, short term and long term predictions for climate change impacts are identified (Table 30).

TABLE 30: CLIMATE CHANGE PREDICTIONS (B2 SCENARIO) FOR GLOVER'S REEF MARINE RESERVE

Climate Change Impacts	Current Status	25 - 50 yrs	100 yrs
Sea level rise	Increased global average sea level rise rate of 1.8mm per year from 1961 – 2003 (IPCC, 2007). Current average increase in sea level rise in the Mesoamerican region is estimated at 3.1mm per year (IPCC, 2007).	The Hadley Centre's Unified Global Climate Model (GCM), HadGEM2-ES, provides additional data to the IPCC reports (IPCC 2007, 2013) for three Representative Pathways Projection scenarios[1]. In all three, the coastal sea level is projected to exceed 10 cm by the 2030s; 22, 23, and 38 cm respectively are projected for the low, medium and high emission scenarios by 2050 (NCCPSAP 2015).	By the end of the Century, the Hadley Centre's Unified GCM, HadGEM2-ES projects coastal seal level to rise by 34, 56, 120 cm respectively for the low, medium and high emission scenarios (NCCPSAP 2015).
Sea surface temperature rise	Water temperature increased by 0.74˚C between 1906 and 2005 Current levels of increase are estimated at 0.4˚C per decade (Simpson et al., 2009)		Predicted regional increase in temperature by up to 5˚C by 2080, with the greatest warming being experienced in the north-west Caribbean (including Belize) (WWF, 2009).
Increased intensity and frequency of storms	Increased storms from 1999 onwards, with annual fluctuations. More storms during El Nina, fewer during El Nino. Stronger storms >Cat 4 / 5	Extreme precipitation events over most of the mid-latitude land masses and over wet tropical regions predicted to become more intense and more frequent.	Extreme precipitation events over most of the mid-latitude land masses and over wet tropical regions predicted to become more intense and more frequent.
Increased Air Temperature	Mean annual temperature has increased in Belize by 0.45°C since 1960, an average rate of 0.10°C per decade. Average number of 'hot' days per year in Belize (days exceeding 10% of current average temperature) has increased by 18.3% between 1960 and 2003 (NCSP/UNDP).	Warming is predicted to occur throughout Central America, over the next 25 to 50 years; up to 1°C since the mid-1970s (IPCC, 2014). Both seasonal and annual air temperatures are predicted to increase by approximately 2°C.	Temperatures are expected to increase between 1.6°C to 4.0°C by 2100 (IPCC, 2014).

[1] RCP 2.6 (low emission), RCP 4.5 (medium emission), and RCP 8.5 (high emission) scenarios

TABLE 30: CLIMATE CHANGE PREDICTIONS (B2 SCENARIO) FOR GLOVER'S REEF MARINE RESERVE / 2

Climate Change Impacts	Current Status	25 - 50 yrs	100 yrs
Changes in rainfall regime	Mean annual rainfall over Belize has decreased at an average rate of 3.1mm per month, per decade, since 1960 (NCSP/UNDP)	Predictions suggest that 2020/2030 may show a slight increase in the early and late parts of the wet season (May and Oct-Nov). The dry season and the mid-wet season decreases in rainfall (June), on the other hand, will be characterized by further decreases. Between 2030/2040, the entire country will be characterized by reduced precipitation, with exceptions only in early and late parts of the wet season (May and Nov). 2050/2060 projections are for an enhancement of the 2030s pattern of reduced rainfall (-1 to -4 mm/day) in the dry season (December – April). Increased precipitation of 2-7 mm/day is projected during the early and late (Oct May - Nov) parts of the wet season (NCCPSAP 2015). These predictions are based on predictions for the mainland – Stann Creek District. Predicted ecological shifts may alter the catchment functionality important for maintaining rivers in dry season in the south of Belize, and providing nutrients to the reef environment. Increased concentration and seasonality of agrochemical delivery	During the 2070s and 2090s predictions suggest that the Belize landscape is marked by reduced rainfall from December through to September. The largest reduction of up to -7 mm/day is projected in the Stann Creek District during the mid-wet season dip in June. The end of the wet season (Oct - Nov) maintains increased rainfall of 2 – 5 mm/day in the western Toledo, Stann Creek, Orange Walk and Corozal Districts (NCCPSAP 2015)

TABLE 30: CLIMATE CHANGE PREDICTIONS (B2 SCENARIO) FOR GLOVER'S REEF MARINE RESERVE / 3			
Climate Change Impacts	**Current Status**	**25 - 50 yrs**	**100 yrs**
Ocean acidification	Atmospheric CO_2 concentration has increased from 280 parts per million (ppm) in 1880 to 385 ppm in 2008 - 35% increase in hydrogen (Simpson et al., 2009). The global average atmospheric carbon dioxide in 2017 was 405.0 ppm, with a range of uncertainty of plus or minus 0.1 ppm. Carbon dioxide levels today are higher than at any point in at least the past 800,000 years (Blunden et al., 2017). 48% of all atmospheric CO_2 resulting from burning of fossil fuels has been taken up by the ocean (Hartley, 2010)	Predicted atmospheric CO_2 levels of 450 ppm by 2040 (Simpson et al., 2009). Predicted 30% decrease in pH of seawater. Predicted decrease in calcification rate by 20 - 50% by 2050	Some experts predict a 35% reduction in coral growth by 2100 (Simpson et al., 2009) Decrease of between 0.3 and 0.5 units by 2100 (Hartley et. al. 2010).

TABLE 30: CLIMATE CHANGE PREDICTIONS (B2 SCENARIO) FOR GLOVER'S REEF MARINE RESERVE

2.4.4 HYPOTHESES OF CHANGE

TABLE 31: HYPOTHESES OF CHANGE	Ecosystems		
	Coral Reefs	**Seagrass**	**Littoral Forest / Sandy Beaches / Mangroves**
Sea level rise	▪ Coral reef growth may be able to keep up with sea level rise, barring other impacts and dependent on rate of sea level rise. ▪ Change in dispersal / recruitment routes / sources for marine species. ▪ Potential loss of deeper corals, shift in distribution, as light availability decreases with increasing water depth. ▪ Increased sedimentation and reduced light availability due to increased caye and coastal erosion.	▪ Increases in water depths above present meadows will reduce light availability. ▪ Changes in currents may cause erosion and increased turbidity of water column. ▪ Shifts in distribution and extent of seagrass beds.	▪ The lowest lying cayes will become inundated ▪ Salt intrusion of aquifer under cayes may alter terrestrial vegetation cover, with changes in species presence / diversity, favoring more salt resilient species. ▪ Potential loss of low-lying crocodile and turtle nesting beaches. ▪ Inundation of sandy beaches, reducing nesting success of turtles. ▪ Reduction of functional, available fish nursery mangrove habitat.
Sea surface temperature rise	▪ Increased coral bleaching and eventual loss of ecosystem functionality. ▪ Increased coral disease. ▪ Possible impacts from new invasive species and algal blooms. ▪ A shift towards more tolerant species and symbiont types, and more opportunistic species, with reduced diversity. ▪ May alter coral larval dispersion through localized changes in current patterns. ▪ Impact on tourism as a result of reduced coral health.	▪ Temperature stress on seagrass will result in distribution shifts, changes in patterns of sexual reproduction, altered seagrass growth rates, metabolism, and changes in carbon balance. ▪ When temperatures reach the upper thermal limit for individual species, the reduced productivity will cause plants to die (above 35˚C for turtle grass (*T. testudinum*)). ▪ Higher temperatures may increase epiphytic algal growth, reducing availability of sunlight.	▪ Reduced oxygen content in water in mangrove areas. ▪ Loss of barrier reef functionality may reduce protection from erosion and storm events, increasing risk to mangroves and sandy beaches.

TABLE 31: HYPOTHESES OF CHANGE	Ecosystems		
	Coral Reefs	**Seagrass**	**Littoral Forest / Sandy Beaches / Mangroves**
Increased frequency and intensity of storms	▪ Increased mechanical damage to corals. ▪ Increased sedimentation, particularly from watersheds following high rainfall and storm damage to riparian belts, exacerbated by anthropogenic clearance of the riparian belt. ▪ Sediment smothering corals, reducing rugosity and burying lobster and fish habitat. ▪ Removal of macro algae, resulting in more available substrate for recruitment (positive impact). ▪ Fragmentation of coral – dispersal and colonization.	▪ Massive sediment movements that can uproot or bury seagrass. It may also become harder for seagrasses to become re-established. ▪ Would be exacerbated by anthropogenic impacts – primarily dredging and landfill.	▪ Removal of some or all natural vegetation with less time for regeneration between storms - change in forest / mangrove structure / reduced species diversity. ▪ Increased erosion, loss of part or entire cayes, changes in beaches. ▪ Arrival of opportunistic species. ▪ Destruction of bird nesting / roosting sites. ▪ Reduction of functional, available mangrove fish nursery habitat.
Ocean acidification (corals, lobster / conch)	▪ Decreases in coral calcification rates, growth rates and structural strength. Also impacts other invertebrates. ▪ Weakening of reef matrix. ▪ Change in ratio of accretion / dissolution.	▪ Possible positive effect on photosynthesis and growth, as seagrass is carbon limited in some situations. ▪ Higher CO_2 levels may increase the production and biomass of epiphytic algae on leaves, adversely impacting seagrasses by causing shading.	▪ Positive increase in growth. ▪ However, damage to coral reefs may adversely impact mangrove systems that depend on the reefs to provide shelter from wave action. ▪ May affect mangrove root communities – especially invertebrates, such as mollusks.

TABLE 31: HYPOTHESES OF CHANGE	Ecosystems		
	Coral Reefs	**Seagrass**	**Littoral Forest / Sandy Beaches / Mangroves**
Decreased Precipitation	▪ Increased algal blooms may be attributed to reduced precipitation, resulting in decreased water visibility – with potential to be positive, by shading corals from intense UV, or negative by blocking sunlight, depending on light penetration.		▪ Reduction of freshwater lens, affecting carbon uptake and photosynthesis. ▪ Potential change in species composition favouring more heat / saline tolerant species. ▪ Decreased precipitation, with a decrease in productivity, growth, and seedling survival.
Air Temperature			▪ May alter phenological patterns - timing of flowering and fruiting. ▪ Some species show a declining leaf formation rate at temperatures above 25°C (IUCN, 2006). ▪ Thermal stress may affect mangrove root structures and establishment of mangrove seedlings above 35°C. ▪ At leaf temperatures of 38-40°C, almost no photosynthesis occurs (IUCN, 2006). ▪ Possible localized changes in species distribution.

TABLE 31: HYPOTHESES OF CHANGE	Resources		
	Commercial Species	**Turtle Nesting Beaches**	**Large Marine Vertebrates**
Sea level rise	▪ Conch: May experience shift in range or habitat loss linked to changes in critical habitat. ▪ Snapper / grouper / lobster: Shift in range / habitat loss of both adult and juvenile fin-fish and lobster – linked to inundation of mangrove, shift in seagrass distribution, changes in coral reef.	▪ Turtle nesting beaches may become inundated, reducing hatch rate success.	▪ Adults are able to adapt to changing water depth – highly mobile. ▪ Shifts in foraging areas.
Sea surface temperature rise	▪ Reduction in accessibility to commercial marine resources – lobster, conch, snapper, as they move into deeper cooler water, and associated reduction in income for commercial fishing industry. ▪ Conch: Temperature may affect spawning (spawning has been shown to increase as a linear function of bottom water, temperature, but decline once a temperature threshold is reached). ▪ Lobster: Possible effects on larval and adult lobsters and reproduction. ▪ Loss of critical habitat for commercial species. ▪ May affect physiological processes, and disease may become more prevalent. ▪ Possible impacts from new invasive species and algal blooms.		▪ Manatees and sharks are able to adapt to changing water temperatures by moving to cooler areas – highly mobile – as long as other resources are still available (e.g. seagrass / manatees). ▪ Shifts / habitat loss of critical ecosystems.

TABLE 31: HYPOTHESES OF CHANGE	Resources		
	Commercial Species / Fishing	**Turtle Nesting Beaches**	**Large Marine Vertebrates**
Increased frequency and intensity of storms	▪ Reduced availability and degradation of habitats for commercial species with destruction of reef, seagrass and mangrove habitats. ▪ Possible impacts on larval dispersal / survival (potential for wider dispersal of larvae). ▪ Increased frequency of damage / destruction of fishing infrastructure (boats, fish traps) negatively impacting the fishing industry. ▪ Increased mechanical damage to sport fish habitats, reducing tourism potential.	▪ Increased potential for inundation of turtle and crocodile nests during storm events, deposition of corals and boulders over existing beaches, by storm events ▪ Removal or erosion of turtle and crocodile nesting beaches, ▪ Impacts on dispersal / survival of both adults and nestling turtles	▪ Able to move away from storm areas, but can be impacted if caught up in the storms ▪ Small increase in number of manatee deaths / strandings have been reported after large hurricanes
Ocean acidification	▪ Habitat loss (impacts on reef). ▪ Impacts on larval viability and adult growth rates ▪ Weakening shell structures - a decrease in the calcification process by species that build an exoskeleton of $CaCO_3$ (e.g. conch). ▪ Changes in larval fish behavior, based on reduced ability to distinguish chemical and sound cues linked to settlement sites.	▪ Sea turtle olfaction may be impacted reducing their ability to locate food and nesting sites.	▪ Elevated CO_2 may have detrimental effects on sharks by increasing energetic demands, decreasing metabolic efficiency, and reducing their ability to locate food through olfaction.
Decreased Precipitation	▪ Possible changes in salinity impacting larval dispersal.		▪ Manatees require access to relatively freshwater (< 10ppt) every 10 days or so… decreased precipitation may discourage their occasional use of GRMR

TABLE 31: HYPOTHESES OF CHANGE	Resources		
	Commercial Species / Fishing	Turtle Nesting Beaches	Large Marine Vertebrates
Air Temperature	▪ Potential impacts on mangroves as a nursery habitat	▪ Turtles may have a female biased sex ratio >31˚C females; 29 -- 30˚C 50:50; <29˚C males. ▪ Warming of turtle and crocodile nesting beaches, resulting in increased egg mortality, shorter hatching time with smaller average hatching size, reducing survival potential. ▪ Increased disease risk to eggs.	

TABLE 31: HYPOTHESIS OF CHANGE FOR GLOVER'S REEF MARINE RESERVE

2.4.5 PRIORITIZATION OF TARGETS

Each target has been assessed for the impacts of the identified primary climate change elements (increased intensity of storms, decreased precipitation, increased air temperature and increased water temperature and increased acidity), each element being rated on a scale of 0 to 4 (Table 32). Ratings took into consideration factors such as the severity, scope, contribution and irreversibility of each climate change element (Table 33).

Rating		Description
Very High	**4**	The climate change element is (or is predicted to be) the major contributing factor to the reduced viability, or possible local extinction, of the target over the majority of its extent within the project area over the next 50 years, and cannot be reversed.
High	**3**	The climate change element is (or is predicted to be) a significant contributing factor to the reduced viability of the target over a significant part of its extent within the project area over the next 50 years, but can be reversed at high cost or over a long time period.
Medium	**2**	The climate change element is (or is predicted to be) a moderate contributing factor to the reduced viability of the target over part of its extent within the project area over the next 50 years, and can be reversed at moderate cost.
Low	**1**	The climate change element is (or is predicted to be) a minor contributing factor to the reduced viability of the target in localized areas within the project area over the next 50 years, and will reverse naturally or at limited cost.
Positive	**0**	The climate change element is (or is predicted to be) a positive impact on target viability.

TABLE 32: RATINGS FOR SELECTION OF PRIORITY CONSERVATION TARGETS

Predicted climate change element	*Conservation Targets*						
	Coral Reef	*Seagrass*	*Mangroves / Littoral Forest*	*Commercial Species*	*Sharks and Rays*	*Charismatic Species*	*Sport Fish Species*
Increased sea level	High (3)	Low (1)	High (3)	Medium (2)	Low (1)	Low (1)	Medium (2)
Increased sea temperature	Very High (4)	Low (1)	Low (1)	Medium (2)	Low (1)	Low (1)	Medium (2)
Decreased Precipitation	Low (1)	-	Medium (2)	Low (1)	Low (1)	Low(1)	Low (1)
Increased frequency of storms	Medium (2)	High (3)	Very High (4)	High (3)	Medium (2)	Low (1)	High (3)
Ocean acidification	Very High (4)	Positive (0)	-	High (3)	Medium(2)	Medium (2)	High (3)
Increased air temperature	-	-	Medium (2)	Low (1)	Low (1)	Low (1)	Low (1)
Averaged Rating	**2.80**	**1.25**	**2.40**	**2.00**	**1.33**	**1.17**	**2.00**
	Selected		**Selected**	**Selected**			**Selected**

TABLE 33: RATINGS FOR PRIORITIZATION OF CONSERVATION TARGETS

Prioritized Targets:

- ***Coral Reef***
- ***Mangroves / Littoral Forest / Sandy Beaches***
- ***Commercial Species / Sport Fish Species***

NOTE: Many of the requirements and strategies for commercial species and sport fishing species will be similar, so these two are combined

2.4.6 PRIORITISED STRATEGIES PER TARGET AND OBJECTIVE

TABLE 34: PRIORITISED STRATEGIES PER TARGET AND OBJECTIVE

Target	Objective	Strategy	Threat
Commercial Species / Sport Fishing Species	By 2023, ten key commercial fin-fish species have sustainable fishery plans.	Collaborate in the development of sustainable fishery plans for ten key fin-fish species that address the need for size restrictions.	Unsustainable fishing is leading to a reduction in the viability of commercial fin-fish species.
	By 2023, effectively managed sustainable fisheries diversification initiatives are in place that target both traditional and new target species	Collaborate to ensure diversification into new fisheries is guided by sustainable fishery plans informed by research. Monitor each identified species using both fisheries dependent and independent surveys	Using different fishing techniques (e.g. deep sea fishing) without informed guidelines in place.
	By 2020, at least 75% of fishermen consider they are stewards of GRMR and are integrated into decision making	Strengthen Managed Access committee, addressing identified capacity building needs.	Climate change impacts are exacerbated by limited enforcement effectiveness, and limited engagement of fishers.
		Involve fishermen in activities at all levels – boat drivers, community researchers.	
	BY 2023, all sport fishers are following best practices.	Engage sport fishing guides in effective management of sport fishing at GRMR.	Poor sport fishing practices.
	By 2020, 25% of fishermen will have access to training and funding opportunities to diversify into or improve sustainable alternatives, with integration in project planning and implementation.	Assist fishermen in strengthening marketing of sustainable marine products, with increased market value.	Limited capacity /options for successful implementation of long term income diversification options.
		Identify income diversification opportunities for fishers.	
		Invest in education of fisher's children, to ensure they have employment opportunities beyond fishing.	

TABLE 34: PRIORITISED STRATEGIES PER TARGET AND OBJECTIVE

Target	Objective	Strategy	Priority Threat
Coral Reef Communities	By 2023, effectively planned and managed sustainable fisheries diversification initiatives are in place that target both traditional and new target species.	Monitor each identified species using both fisheries dependent and independent surveys.	Diversification results in increased fishing pressure across a wider range of species, increasing impact to coral reef health.
	By 2020, 100% of tourism activities and services follow well defined and accepted best practices standards.	Educate tour guides and tourists regarding best practices and impacts of malpractice to encourage responsible tourism.	Tourism increasing to unsustainable levels in GRMR as a result of degradation in other popular tourist areas.
		Provide incentives for tour operators to abide by established best practices regulations.	
		Effective management of tourism vessels through installation of sufficient mooring and marker buoys in relevant areas.	Mechanical impacts on the reef from poorly anchored boats and boat groundings.
	Strengthen resilience of coral reefs in GRMR through continued planting out of resilient coral fragments	Partnering with Fragments of Hope/ other reef restoration organizations for out planting of resilient coral strains in GRMR.	Sea temperature rise causing increased bleaching and mortality in less resilient corals.
Mangroves / Littoral Forest	Between 2019 and 2023, there will be no reduction of mangrove coverage in GRMR based on current baseline.	Engage caye owners / managers in maintaining mangroves	Tourism developments on the cayes and coastline will potentially face the need to reinforce shorelines and create landfill, or relocate, as sea level rises
		Ensure DoE / FD does not issue permission for mangrove clearance on Glover's Reef Atoll	
		Continue surveillance of development activities to ensure no non-permitted mangrove loss occurs.	
		Continue on-going outreach to promote stewardship of mangroves on the cayes of GRMR.	

Section Three

Management Planning

3. MANAGEMENT PLANNING

3.1 MANAGEMENT GOALS

The overall goal for the management of Glover's Reef Marine Reserve is:

> ***To provide protection for the physical and biological resources of Glover's Reef, in order to maintain and sustain these resources for the benefit of current and future generations***

This goal is supported by four objectives:

1. To provide protection for the physical and biological resources of Glover's Reef
2. To provide an enabling environment for economic opportunities for livelihoods, towards sustainable development
3. To increase awareness and understanding of the natural resource of Glover's Reef through research and education
4. To provide resources for recreation and tourism

3.2 MANAGEMENT AND ORGANIZATIONAL BACKGROUND

Regulatory authority for Glover's Reef Marine Reserve lies with the Fisheries Department (Ministry of Agriculture, Foresty, Fisheries and Sustainable Development), which administers the policies and laws that govern the protected area. The Fisheries Department manages the Marine Reserves in Belize (including Glover's Reef) under the Protected Area Management (Marine Reserve) program of the Ecosystems Management Unit, as part of its Mission…

> *"To provide the country and the people of Belize with the best possible management of aquatic and fisheries resources with a view to optimize the present and future benefits through efficient and sustainable management".*
>
> ***Mission Statement, Fisheries Department***

…with the specific goal of:

> *"holistic ecosystems management of the aquatic resources through a marine reserve network and international commitments".*

Implementation of the management plan is the responsibility of the Ecosystem Management Unit, managed under the Marine Protected Areas Coordinator, and the site management team, under the Reserve Manager (Officer in Command). Site level management at Glover's Reef Marine Reserve is conducted from the staffed Fisheries Base, established on Middle Caye. The Reserve Manager is supported by a Head Ranger (Officer in Charge of Enforcement) a ranger, a marine biologist and a caretaker. These personnel are responsible for the on-site, day-to-day management of the reserve, and for the implementation of the management plan, through effective use of funds, staff and equipment, and supported by centralized activities such as environmental education and outreach, from Belize City. Each staff position is described by a general terms of reference.

The Wildlife Conservation Society provides assistance to the Fisheries Department through collaborative research and monitoring activities, and a location on Middle Caye for the Fisheries Base to operate from in the management of the Glover's Reef Marine Reserve.

An Advisory Committee (the Glover's Reef Advisory Committee (GRAC)) assists Fisheries Department with management recommendations, and is composed of representatives from the major stakeholder sectors.

The Advisory Committee is "responsible for making recommendations on decisions regarding the development of policies and issues affecting the management of the Glover's Reef Marine Reserve", through the following activities:

- Ensure regular revision and review of management plan;
- Comment on and recommend legislation and regulations (e.g. regarding extension of geographic boundaries of the Reserve and zoning);
- Provide advice on all applications for permits (e.g. dredging, mangrove clearance and leases/subdivisions) within the general boundaries of the Reserve;
- Report on activities impacting the reserve and liaise with government enforcement agencies
- Assist in the development of sustainable financing mechanisms for the Reserve;
- Advise on and, where appropriate, assist with administrative matters, publicity, education and interpretive programs and
- Review and advise on research proposals and research permit applications related to the Reserve.

The Committee has gone through a number of changes, and is currently comprised of the following members:

- 3 members from the fishing co-operatives (Northern, National and Placencia)
- 3 representatives of the residents (landowners) of Glover's Reef Atoll
- 2 representatives from Wildlife Conservation Society (Belize City Office and Research Facilities)
- 1 representative from the Fisheries Department
- 1 representative from the Co-operative Department
- 1 representative from the tour guides
- 1 representative from the Belize Audubon Society
- 1 representative from Dangriga Town Council
- 1 representative from Hopkins Town Council
- 1 representative from the fishermen of Sarteneja

The Advisory Committee plays a vital role in the success of the Marine Reserve by providing strategic support to the reserve personnel, leading to improved management on the ground and the ultimate achievement of the Reserve's management objectives. It also acts as a mechanism for strengthening participation of fishermen in the management of the area – in particular in enforcement, training and equipment.

3.3 MANAGEMENT STRATEGIES

This section identifies a number of strategic themes that strengthen management of the Marine Reserve:

- Fisheries Regulations
- Management Zones and Regulations
- Proposed Replenishment Zone Expansion
- Managed Access
- BBRRS-World Heritage Site Strategies
- Caye Development Guidelines
- IUCN Green List Standards

3.3.1 FISHERIES REGULATIONS

Glover's Reef Marine Reserve functions as a component of the national fisheries management tool, providing an area of management focus to improve sustainable use of marine resources. The Fisheries Department regulations for species, size and seasons are implemented in the General Use Zone, where fishing is permitted (Figure 27). Extraction of marine resources is not permitted in the Conservation and Preservation Zones.

The site level regulations are laid out in SI 70 of 1996, and cover the rules and regulations for each of the zones, required licenses, and entrance fees.

LEGISLATED MANAGEMENT REGULATIONS

ESTABLISHMENT OF ZONES AND RULES FOR ZONES

- Establishment of zones.
- Rules for establishment of zones
- Rules for General Use Zone.
- Rules for Conservation Zone.
- Rules for Wilderness Zone.

COMMERCIAL FISHING, RESEARCH, SPORT FISHING LICENSES AND REGISTRATION OF DIVE BOATS

- Commercial Fishing Licenses.
- Research Licenses.
- Sport Fishing Licenses.
- Registration of dive boats.

GENERAL

- Licenses not transferable.
- Duration and renewal of licenses.
- Cancellation of licenses.
- Condition of licenses.
- Duty to report accidents or damage to property.
- Non-liability of Government.
- Application of Fisheries Regulations.
- Opening days of Reserve.
- Admission fees.
- Prohibition of certain acts.
- Fisheries Administrator may designate certain areas.
- Rendering fish catch information to rangers.
- Officers to uphold Regulations.
- Offences and Penalties.

SI 70 of 1996

FISHERIES REGULATIONS

GENERAL

- No person shall set traps outside the reef or within 300 feet of the Barrier Reef
- No spear fishing within marine reserves
- No fishing without a valid fisher folk or fishing vessel license
- No one should fish using compressed air or scuba gear
- No fishing shall be conducted using explosives or chemicals

CONCH (*Lobatus gigas* - formerly *Strombus gigas*)

- Shell length should exceed 7 inches (17.8 cm)
- Market clean weight and fillet weight should exceed 3 ounces (85 g) and 2.75 ounces (78 g) respectively
- No person or establishment shall buy, sell or have in possession diced conch meat except under a special permit issued by the Fisheries Administrator.
- Closed Season: July 1st to September 30th, or when the catch quota has been met

LOBSTER (*Panulirus argus*):

- No person or establishment should have in possession fillet or diced lobster tail.
- It is illegal to have in possession any soft shell (molting) lobster or females with eggs (berried)
- It is illegal to remove from any female lobster any eggs or spawn or the setae or fibre to which any eggs or spawn are or have been attached.
- Minimum carapace length is 3 inches
- Minimum tail weight is 4 ounces
- Closed season: 15th February to 14th June

FISH FILLET

- Every fish, other than Nassau groupers and grazers, caught in Belizean waters and landed as fillet fish should have a skin patch of 2 inches by 1 inch

SEA CUCUMBER

- No person shall engage or attempt to engage or assist a person to engage or attempt to engage in fishing, of any kind, for sea cucumber without a special license from the Fisheries Administrator
- Individuals applying for special license for sea cucumber must have a valid fisherman's license
- No person shall fish for, or harvest, at any time in the waters of Belize, or buy, sell, have in possession, export or attempt to export any sea cucumber between July 1st and Dec 31st (Special license required)

NASSAU GROUPER

- No person shall take in the waters of Belize, buy, sell, or have in his possession any Nassau Grouper (*Epinephelus striatus*) between 1st December and 31st March
- No person shall take, buy, sell, or have in his possession any Nassau Grouper which is less than 20 inches and greater than 30 inches
- All Nassau Grouper are to be landed whole

FIGURE 27: FISHERIES LEGISLATION REGULATIONS

FISHERIES REGULATIONS

SHARKS

- No person shall take, buy, sell, possess, and export shark meat or fins during the period 1st August to 31st October
- No person shall take or kill any shark of Nurse shark (*Ginglymostoma cirratum*) and Whale shark (*Rhincodon typus*) in the waters of Belize
- No person shall engage in shark finning
- Fishing for any other non-protected shark species requires a special license issued by the Fisheries Administrator
- All sharks are to be landed with the fins attached

TARPON, BONEFISH, PERMIT

- These species of fish are designated for the purpose of sport fishing
- Bonefish commonly known as "macabi" Scientific name: *Albula vulpes*
- Permit Scientific name: *Trachinotus falcatus*
- Tarpon: Scientific name: *Megalops atlanticus*
- No person shall have in possession any bonefish, permit fish or tarpon or any of its product forms, save and except in the act of catch and release.
- No establishment shall have in its possession any bonefish, permit fish or tarpon or any of its product forms

NOTE: Catch and Release means the act of catching fish and then releasing them back immediately into the waters of Belize in the same state in which the fish was landed

GRAZERS:

- No person shall take in the waters of Belize, buy, sell, or have in his possession any grazers. Grazers refer to any fish of the parrotfish, angel fish and tangs (Scaridae and Acanthuridae)

CORAL:

- It is Illegal for any person to take, buy, sell or have in his possession any type of coral

An exception is made in the case of Black Coral - this may only be bought, sold or exported with a licence from the Fisheries Administrator

MARINE TURTLES:

- No person should interfere with any turtle nest
- No person should take any species of marine turtle
- No person shall buy, sell, or have in his possession any turtle or articles made of turtle parts

FIGURE 27: FISHERIES LEGISLATION REGULATIONS / 2

TRAWLING

- No person shall engage in trawling

RESEARCH

- Every person who applies for a research permit needs to submit a proposal for vetting and approval
- Bio-prospecting also requires special permission

GEAR RESTRICTIONS – MARINE RESERVES

- Valid licences are required for commercial fishing, sport fishing and recreational fishing in a Marine Reserve
- Fishing activities conducted in Marine Reserves can only be those permitted in accordance to the specific zone regulations.
- The use of beach traps and fish traps is prohibited in Conservation and Preservation Zones
- A license is required for the use of beach traps and fish traps in the General Use Zone.
- Fishing in a Conservation Zone is prohibited without a license
- Fishing, snorkelling and diving are prohibited in a Preservation Zone
- Spearfishing is prohibited in Marine Reserves
- Use of long lines, seine nets and gill nets is not permitted within Marine Reserves
- It will be assumed that anyone with a speargun, polespear, Hawaiian sling, spearfishing mask or powered speargun or sling is attempting to engage in spearfishing

FIGURE 27: FISHERIES LEGISLATION REGULATIONS / 3

3.3.2 MANAGEMENT ZONES

Glover's Reef Marine Reserve has been divided into four zones to allow for the management of resource for sustainability, to ensure the multiple uses of the marine protected area to continue:

- General Use Zone
- Seasonal Closure Zone
- Conservation Zone
- Wilderness (Protection) Zone

There is also a Spawning Aggregation Site, defined under SI 161 of 2003, which overlaps the Seasonal Closure Zone – both zones are designed to protect the spawning aggregation site in the area.

NOTE: The following are the current zones. However, there is an ongoing project to realign the zones for improved management. The proposed new zones are not yet validated, but are presented after the current zones.

GENERAL USE ZONE (GUZ)

The General Use Zone is the largest of the four zones, with an area of 26,170 ha, (74.6% of the marine reserve), and is divided between two areas - the majority of the northern part of the atoll, and a smaller portion in the south (Map 8).

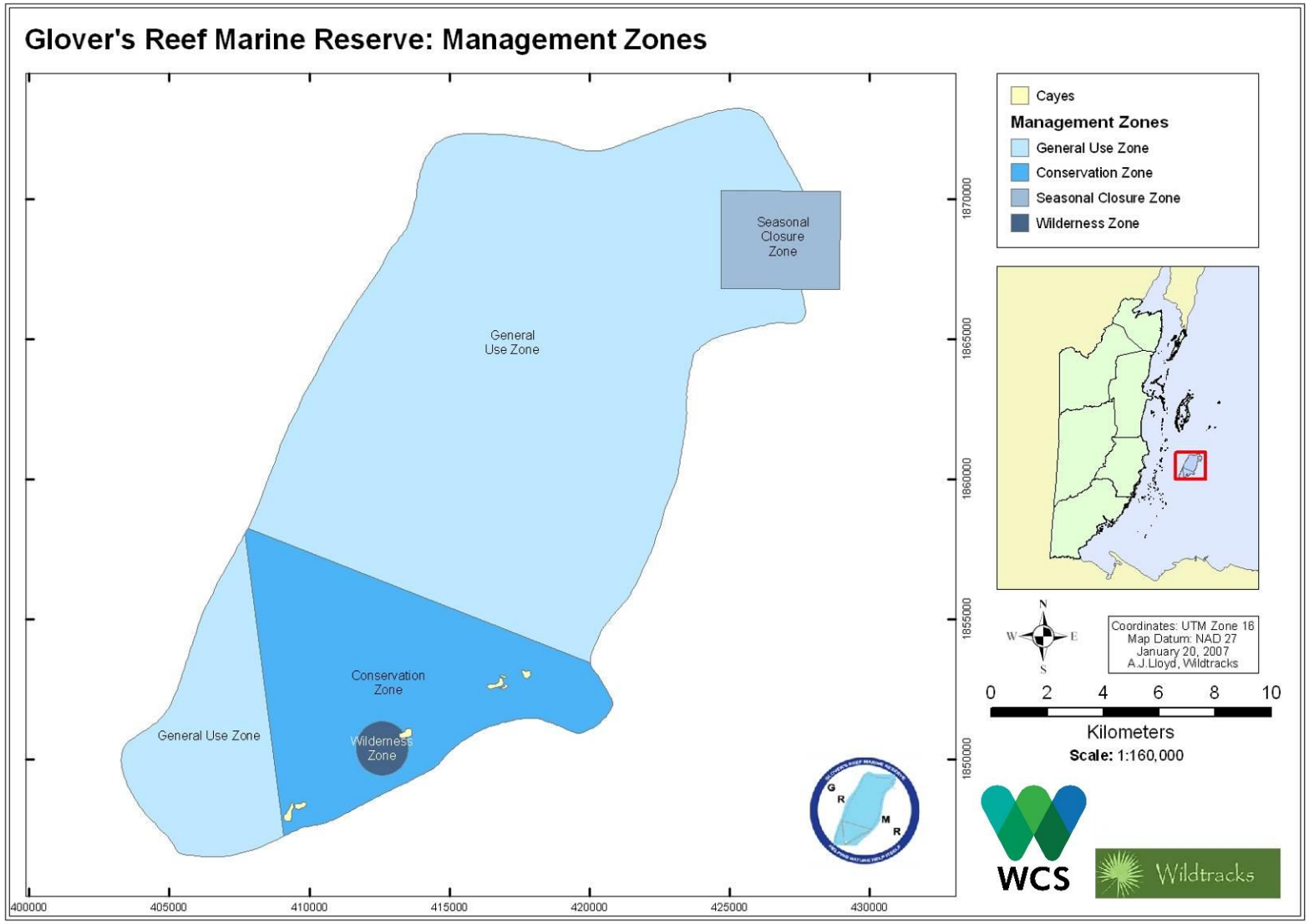
GUZ REGULATIONS

- Fishing is permitted by fishers who have traditionally used the area and have obtained a special fishing license
- No fishing by long lines, traps, nets or spear guns is allowed (NOTE: Hawaiian slings are currently permitted)
- Fishermen using this zone are expected to submit details of their catch as required under the Fisheries Regulations

Fishing is permitted in the General Use Zone - however, it has been recognised at the national level, that with the limited natural resources available, priority should be given to fishermen who have traditionally used the area, leading to the development of the Managed Access program. Under this national framework, Glover's Reef Atoll lies in Area 8, with 105 fishers licensed to use the area for commercial fishing (FiD data, 2017). There are gear restrictions in the General Use Zone, including a ban on the use of fish traps (the term 'fish' being used to include all forms of commercial marine animal), shades, and nets.

Objectives

- To provide opportunities for traditional and sustainable uses and activities to continue under carefully monitored and regulated conditions. These include mainly commercial fishing for lobster, conch and fin-fish
- To provide a study area for close monitoring of fisheries catch in order to demonstrate the potential benefits of 'no take' areas to fisheries production
- To provide an area for water sports such as diving, snorkeling, sailing, kayaking, and sport fishing.



MAP 8: GRMR MANAGEMENT ZONES

CONSERVATION ZONE

The Conservation Zone is the second largest zone, comprising about 7,077 ha or 20.2% of the southern portion of the atoll (Figure 56). Under the current reserve regulations, residents of Glover's Reef can obtain special licenses for subsistence fishing within the Conservation Zone. As this is in contradiction with the objectives of the Conservation Zone, and is causing conflict with traditional fishermen excluded from fishing in this zone, a revision of Marine Reserve regulations will not permit this activity in the future, as the Ecosystems Management Unit seeks to standardise regulations across all marine reserves (Majil, 2007).

CONSERVATION ZONE REGULATIONS

- No extractive uses are allowed, with the exception of subsistence fishing by registered residents of the Atoll (under review), and catch-and-release sport fishing by licensed fishermen
- Spear fishing is not permitted by the subsistence fishers
- Anchors cannot be deployed in areas where moorings are provided
- Divers must register with the Reserve Manager
- Dive boats must obtain a license to operate in the zone

Objectives

- To protect a representative cross section of the Atoll's habitats, including windward and leeward peripheral reefs, the Atoll Lagoon with its patch reefs, and sea grass beds
- To protect at least some of the cuts or passes in the reef, as these are considered ecologically very important in terms of water flow and exchange, for movement of larvae, for species with feeding migrations, and species such as lobsters which migrate back and forth between the lagoon and deeper water for spawning purposes
- To provide an undisturbed area for recruitment of species to adjacent areas, and to protect nursery and spawning areas such as the spawning banks east of Long Caye and Middle Caye.
- To provide an area for recreational diving, sport fishing, boating, and appreciation of the marine environment
- To provide a relatively undisturbed area with representative natural ecosystems that can be used for applied research

WILDERNESS ZONE

This zone, equivalent to a "Preservation Zone", is the smallest of the zones, encompassing an area of only 270 ha. It is located within the Conservation Zone, just south of Middle Caye, lying along the south eastern reef tract.

WILDERNESS ZONE REGULATIONS

- No activities are permitted within this zone and it is closed to visitors except under special permission.
- No boats are permitted to travel in the zone except in cases of emergency

Objectives

- To preserve at least a small representative area free of disturbance from all activities
- To have an undisturbed area to be used as a baseline for research and monitoring purposes

SEASONAL CLOSURE ZONE

This zone encompasses the Nassau grouper spawning bank located on the northeast corner of the atoll. It covers an area of 1,550 ha, including the channel in the reef and extending out to the deep water of the fore reef and drop off (Map 9). It overlaps with the Spawning Aggregation Site, with regulations defined under SI 161 / 2003.

SEASONAL CLOSURE ZONE REGULATIONS

- The zone is closed to fishing from the 1st December to the 1st March. The spawning aggregation site itself is closed to all fishing year round, and overlaps with the Seasonal Closure Zone.

Objectives

- To provide protection for the population of spawning Nassau grouper during their reproductive season
- To monitor the recovery of the spawning population of grouper

SPAWNING AGGREGATION SITE

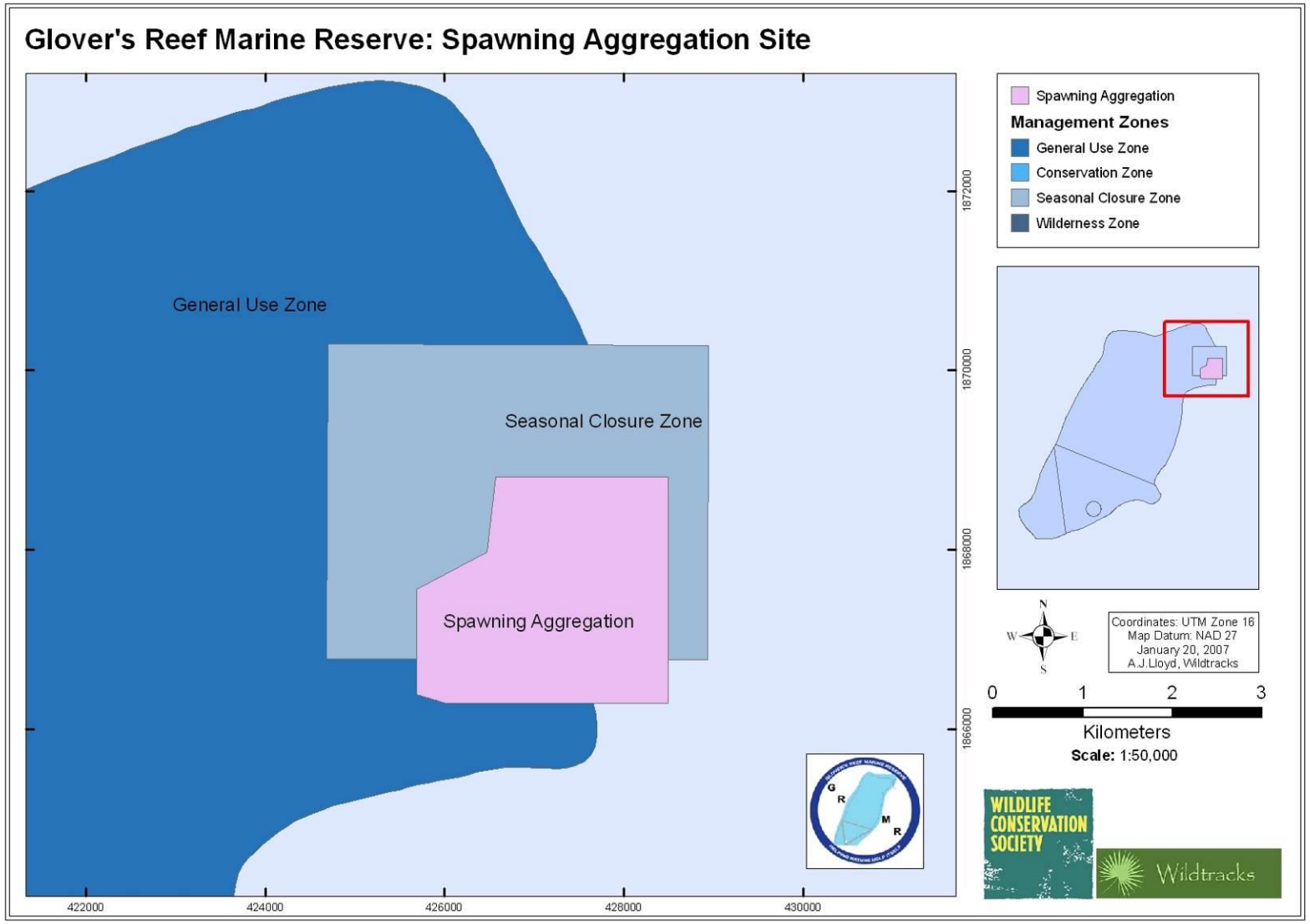
This zone is permanently closed to fishing to protect the spawning aggregation site. It overlaps the Seasonal Closure Zone, but is more specifically linked to the area covered by the Spawning Aggregation Site (Map 9).

SPAWNING AGGREGATION SITE REGULATIONS

The zone is permanently closed to fishing

Objectives

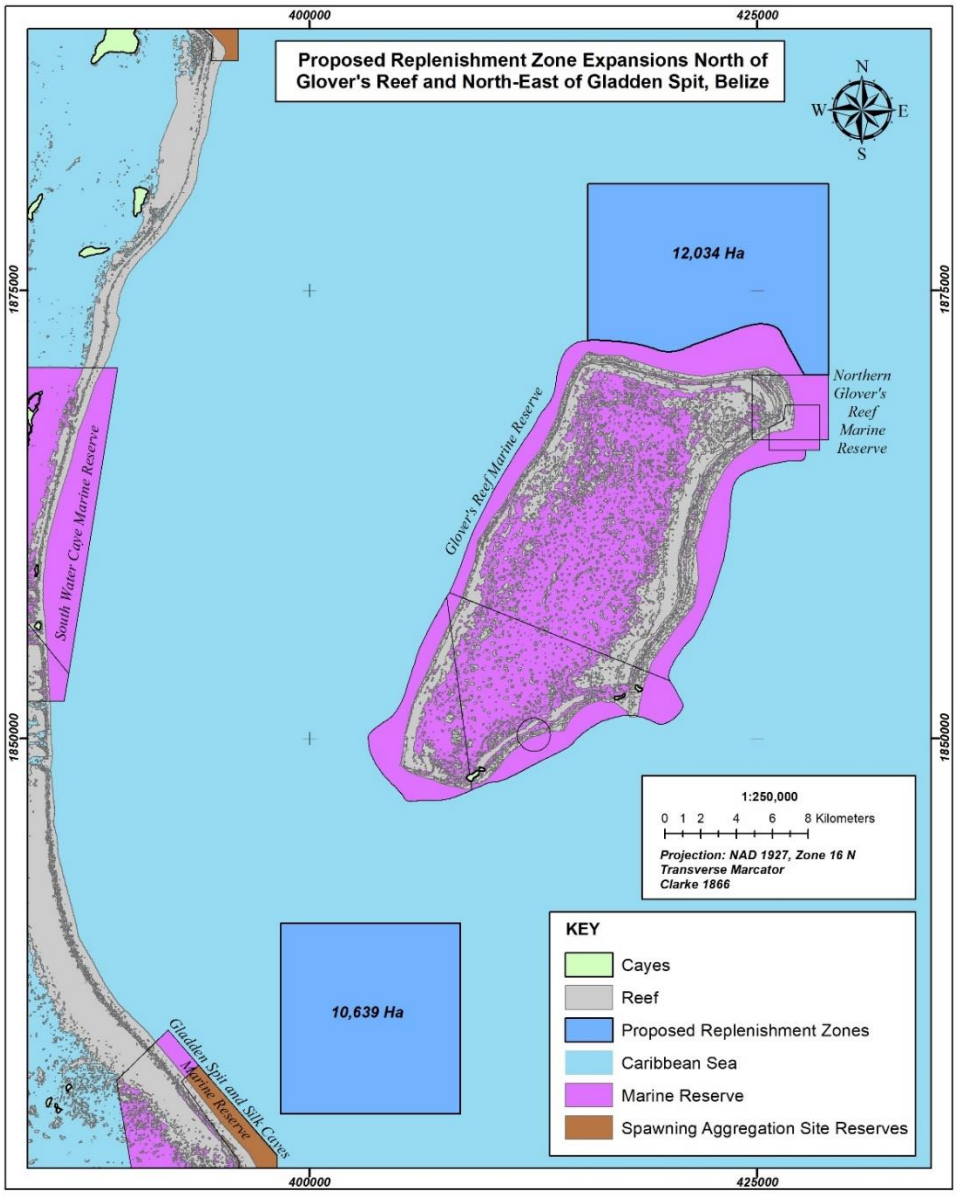
- To provide protection to the population of spawning Nassau grouper during their reproductive season
- To monitor fluctuations in the spawning population of grouper



MAP 9: GRMR SPAWNING AGGREGATION SITE / SEASONAL CLOSURE ZONE

3.3.3 PROPOSED REPLENISHMENT ZONE EXPANSION

A proposed Replenishment Zone Expansion has been approved by Cabinet, adding an addition 12,034 ha of non-extractive oceanic waters to the north of Glover's Reef Marine Reserve, contributing to representation of this ecosystem in the National Protected Areas System, and to the total marine area under full protection. This expansion is still to be finalized, but once established will need additional resources for both surveillance and enforcement and research and monitoring if it is to be managed effectively.



MAP 10: GRMR PROPOSED REPLENISHMENT ZONE EPANSION, WCS, 2019

3.3.4 MANAGED ACCESS

Overview: Until recently, Belize has had an open access fishery with a steady rise in the number of fishermen, increasing fishing pressure and making it harder for each fisherman to make a living - too many fishermen chasing too few fish.

Managed Access is a fisheries management tool that provides 'rights-based' access to customary fishers for their fishing grounds. It focuses on protecting the rights of fishers in their traditional fishing areas, whilst stopping the unsustainable growth in the number of fishers. It achieves this through developing, encouraging and incentivising good stewardship, towards better catches and improved incomes. Identification of customary users is based on validation of Belize residency, and through a transparent, peer review process led by the Community Managed Access Committees, comprised of local fisher representatives, Fisheries Department and co-management partners.

Managed Access is now being rolled out nationally to eight distinct areas, or TURF's, with the open sea considered as the ninth area. Glover's Reef Marine Reserve lies in Fishing Area 8, which encompasses the entire Atoll. Implementation of Managed Access is based on the establishment of area-specific fishing licenses for traditional fishers, and supported by a robust monitoring and enforcement regime. It is also supported by science-based catch limits through a total allowable catch (TAC), to guide sustainable management of the fishery, and by improvements to livelihoods and the fishing industry by linking Belize's sustainable seafood to premium markets.

Belize's Managed Access Strategy is based on the current patterns of fishing, reflecting customary resource use patterns. It establishes user rights for Belizean fishermen, facilitating action against trans-boundary fishing incursions. Each Area has a Managed Access Committee, with representation form traditional fishing communities and fishers using the area.

WHY MANAGED ACCESS?

Managed Access benefits the traditional fishermen. It…

- recognises those fishermen with a long term interest in specific fishing areas
- protects their rights to fish in that area
- protects these areas against incursions by fishermen who are not long-term customary users, and against illegal trans-boundary incursions
- improves fisher compliance through self-enforcement of the rules
- improves collaboration between fishers and area managers, reducing violations
- improves compliance with management interventions that will increase the performance and productivity of the fishing areas
- improves cooperation with managers and scientists to gather and report catch data
- takes advantage of market opportunities to increase revenue
- provides Belize with increased food security - fish are a local, reliable source of protein

3.3.5 STRATEGIES FOR THE BELIZE BARRIER REEF RESERVE SYSTEM – WORLD HERITAGE SITE

Belize's World Heritage Site has recently been removed from the list of sites in danger following the addressing of a number of issues identified for the seven sites, including Glover's Reef Marine Reserve, to the satisfaction of the members of the IUCN World Heritage Convention. These include:

- finalization, endorsement and implementation of the revised Fisheries Act (the Living Aquatic Resource Bill) – in process
- permanent cessation of the sale and lease of lands throughout the WHS through legal instrument

A number of issues have been addressed in response to the WHS concerns and as part of a national initiative to strengthen biodiversity conservation under the Convention on Biological Diversity. These include:

- revision of the Mangrove Protection Act / Regulations
- elimination of all oil concession in and around the WHS, through legislation
- clear definition and strict control of development rights on existing private and leased lands within the WHS through strengthening of the EIA process

Whilst Belize has been able to remove the Belize Barrier Reef Reserve World Heritage Site from the list of sites in danger, maintaining and improving the status of the flagged criteria is considered important.

3.3.6 CAYE DEVELOPMENT GUIDELINES

Development guidelines have been established in the Integrated Coastal Zone Management Plan - South-Northern Region (CZMAI, 2016), which identified recommendations for acceptable development levels on the cayes. It should be remembered, however, that as part of Belize's World Heritage Site, private caye ownership and caye development are issues brought up during the assessment of the site, resulting in its categorization as 'Endangered'. Any new development being considered should therefore be carefully considered before approval is given through the NEAC process.

> *"While some of the cayes are elevated or have high firm land, and their soil profile suggests their suitability for development activity, their ecological sensitivity, protected status, and world heritage designation in the instances of Glovers Reef and South Water Caye, directs that a precautionary approach be applied to future development of the region"* ***CZMP South-Northern Regional, 2016***

The CZMP categorizes land use on the cayes as Residential; Resort and Research/Scientific Station, and Undeveloped. Where lands are held under private ownership:

"*the CZMAI recognizes the right of the landowner to develop their land in any manner they see fit there must be measures in place to steer future development in order to ensure sustained ecosystem services. Therefore, in the case of these lands, if there is no development activity within the first five (5) years of the passage of this planning document then all future development activities, after the time period, MUST follow development standards as outlined within this coastal development guideline."*

Conservation Development: Cayes in the South-Northern Region are not recommended for major development but can accommodate very small scale infrastructure – Research stations, low scale ecotourism lodge, residential/ fisherman's camps with temporary structures.

Cayes assigned Conservation I land use category:

- Middle Caye

Cayes assigned as Existing Low Density Residential:

- Northeast Caye (east side)
- Long Caye (east side)
- Southwest Caye (southern half)

Recommendations (CZMAI, 2016):

1. Increased collaboration among local stakeholders, interest groups and the agencies responsible for land allocation, including the conditions applied to lease approval and the regulation of lot sizes
2. Limit the number of piers per property or caye
3. Prohibit the construction of buildings on piers
4. Preserve remaining crown lands in the region
5. All new developments must be constructed using the standards developed by LUA and CZMAI in the creation of these management guidelines.
6. Although permitted, coastal agriculture and aquaculture activities must be closely monitored and not allowed to occur near important watersheds and lagoons. Relating to this, proper pesticide use and waste water disposal is key to ensuring that the marine

environment is not polluted. Therefore enforcement agencies will be required to conduct regular water testing.

Long Caye and Southwest Caye # II, are located in a coral dominated environment, recognized by the ICZMP as an ecologically sensitive environment. Although no systematic ecological impact survey or carrying capacity studies have been undertaken, the visual and other impacts of development on these cayes have led to strong recommendations that further developments be limited.

3.3.7 IUCN GREEN LIST STANDARDS

Glover's Reef Marine Reserve is well positioned for applying for listing under the IUCN Green List of Protected and Conserved Areas Programme (IUCN Green List Programme). The List aims to encourage, achieve, and promote effective, equitable and successful protected areas in all partner countries and jurisdictions. The IUCN Green List Programme is a Sustainability Standard with global accreditation and application that addresses the social, environmental and economic practices of protected areas. It has been designed and established to increase the number of protected and conserved areas that deliver successful conservation outcomes through effective and equitable governance and management. This is to be achieved through a set of underlying objectives:

1. To ensure that the IUCN Green List of Protected and Conserved Areas Standard provides a suitable measure for strengthening conservation outcomes and improving equitable and effective management of protected and conserved areas

2. To position the IUCN Green List Programme as an accessible channel for conservation capacity development for protected and conserved areas

3. To promote collaboration and investment in implementing effective and equitable conservation management in protected and conserved areas committed to work towards the IUCN Green List of Protected and Conserved Areas Standard.

The revised National Management Effectiveness Tool has recently been aligned to be able to provide guidance for protected areas wishing to apply for listing, with those that are seeking approval under the Green List being assessed for their ability to meet the global standards as part of the National Protected Areas System - Management Effectiveness Evaluation (NPAS-MEE), being conducted in June - July, 2019

3.4 MANAGEMENT PROGRAMS AND OBJECTIVES

Management Programs are a means of grouping management objectives within related areas – for example, those related to natural resource management, or to environmental education. The strength of the combined programs is greater than the sum of the individual Programs, as each supports the others over space and time, with areas of overlap that strengthen the overall management of the protected area. The inclusion of strategies to strengthen communication and collaboration between Program areas is also important, with inter-Program collaboration mechanisms for greater adaptive management effectiveness.

Six Management Programs are identified to provide the framework for management of the marine protected area (Table 35):

A. **Natural Resource Management and Protection**

B. **Research and Monitoring**

C. **Community Development and Outreach**

D. **Tourism and Recreation**

E. **Management and Administration**

F. **Infrastructure, Operations and Maintenance**

The plan identifies intervention strategies for improving conservation target viability and mitigation of threats identified during the planning process – strategies that are incorporated into the management programs, and into the measures of success program for effective management. Also taken into consideration is the protected areas status as part of the World Heritage Site, requiring extra steps to be taken to safeguard its unique values.

Program Areas					
Natural Resource Management and Protection	**Research and Monitoring**	**Community Development and Outreach**	**Tourism and Recreation**	**Management and Administration**	**Infrastructure, Operations and Maintenance**
▪ *Surveillance and Enforcement* ▪ *Zoning and Boundaries* ▪ *Fishery Management* ▪ *Ecosystem and Species Management* ▪ *Addressing Specific Threats*	▪ *Monitoring* ▪ *Research* ▪ *Data Management and Dissemination of results*	▪ *Environmental Education* ▪ *Public Outreach and Information* ▪ *Alternative Livelihoods / Income Diversification* ▪ *Community Capacity Building*	▪ *Visitor Safety and Protection* ▪ *Visitor Education and Interpretation*	▪ *Planning* ▪ *General Management and Administration* ▪ *Financial Management* ▪ *Concessions / Commercial Uses* ▪ *Partnership Relations* ▪ *Information Technology*	▪ *Docking Facilities* ▪ *Administration and Operational Infrastructure* ▪ *Tourism Infrastructure* ▪ *Fleet Operations and Management*

TABLE 35: MANAGEMENT PROGRAMS OF GLOVER'S REEF MARINE RESERVE

3.4.1 NATURAL RESOURCE MANAGEMENT PROGRAM

The Natural Resource Protection Program focuses on ensuring the maintenance of healthy, functional ecosystems, through direct management of the marine environment, surveillance and enforcement and direct biodiversity management interventions. This Program falls under the responsibility of the site manager. Six sub-programs have been identified.

Natural Resource Management and Protection

- *Surveillance and Enforcement*
- *Zoning and Boundaries*
- *Fishing (Marine Resource Extraction)*
- *Habitat and Species Management*
- *Cultural Resource Management*
- *Addressing Specific Threats*

the Resource Protection Program has been strengthened in several ways:

- Use of SMART technology (Spatial Monitoring and Reporting Tool), allowing rangers and managers to plan and implement intelligence-based patrols through collection and analysis of georeferenced data, assisting in identification of hotspots and peak times for illegal activities, for more strategic surveillance and enforcement.
- Partnering with the Belize Coast Guard, providing security for the fishers and staff of GRMR, enabling increased night patrols.
- Roll-out of Managed Access with the support of the Glover's Reef fishers.

PRIORITY STRATEGIES

- Ensuring GRMR has the human resources, equipment and training for effective surveillance and enforcement
- Strengthening collaborative surveillance and enforcement with coastguard
- Continue and strengthen work with fishermen towards effective implementation of Managed Access in GRMR
- Strengthening enforcement of tourism regulations through collaboration with BTB and tourism police

BOAT TO BOAT FISHER COMMUNICATION

STRATEGIES TO ADDRESS SPECIFIC THREATS

Unsustainable Fishing

- Develop national species management plans that establish size range / size limits for the 10 most targeted fin-fish species (snappers and groupers).
- Improved / enforced restriction on use of gears, gill nets, spear guns to improve sustainability.
- Engagement, education and improved capacity of fishers (especially boat captains and young fishers) to improve awareness of issues of unsustainable fishing, and best practices for a sustainable fishery.
- Provide opportunities for fishers demonstrating good stewardship to engage other fishermen.
- Education of consumers with the certification of restaurants – through the "fish right eat right" campaign.
- Ensure restaurant / hotels, supermarkets etc. only buy and sell fish with skin patch, with enforcement of this requirement.
- Investigate packaging of GRMR fin-fish with certification to supply to restaurant / hotels, supermarkets in San Pedro, Caye Caulker, Placencia etc. with fish certified as legal

Direct Impacts on the Coral Reef

- Ensure mooring buoys are installed at dive sites and for overnight vessels, with collaboration with private sector for maintenance
- Improve marking of channels and shallow areas to prevent boat groundings
- Improved capacity of rangers to be able to enforce tourism and boating regulations
- Improved awareness of resorts and tour guides, as well as tourists, of snorkelling / dive best practices and legal requirements that protect coral reef
- Engage and encourage caye owners in following WCS best practices, ICZMP development and WHS guidelines

Agrochemical and Sewage Pollution

- Improve awareness of sewage management on cayes
- Improved awareness of the general public of the issues of agrochemicals and sewage in the marine environment

Lionfish

- Continue suppressing lionfish populations
- Improved local and national markets for lionfish
- Encourage household consumption of lionfish
- Link GRMR fishers with lionfish market in San Pedro / Caye Caulker / Belize City

Natural Resource Management Program		
NRM 1: Surveillance and Enforcement	**Timeframe**	**Measuring Success Indicators**
☐ Ensure surveillance activities are strategic and effective, based on GRMR enforcement data, incidence mapping and identification of hotspots, key times, key offending boats (both tourism and fishing), transboundary, and with integration of SMART technology, supporting Managed Access	1 – 5	▪ # patrols per year ▪ Mapping of patrol routes ▪ Mapping of incursion hotspots ▪ # of warnings given per year
☐ Strengthen cost and time effectiveness of surveillance through use of drones and other technologies	1 - 5	▪ # reported transboundary incursion events ▪ # of cases taken to court
☐ Expand surveillance activities to include caye development and environmental impacts within GRMR, in collaboration with DoE and BTB	1 – 5	▪ # successful convictions ▪ Total annual fines
☐ Strengthen interagency communication and collaboration, through joint security meetings, collaborative partnership with the Belize Coastguard for armed patrols in GRMR, with clearly defined roles and responsibilities	1 - 5	▪ # repeat offenders ▪ # of joint surveillance and enforcement activities with DoE
☐ Strengthen communication and collaboration mechanisms with Forest Department and the Department of the Environment for enforcement of new Mangrove Regulations	1 – 5	▪ # Joint patrols per year with Belize Coastguard ▪ # Patrols conducted in collaboration with Forest Department in response to mangrove issues
☐ Implement effective enforcement of visitor regulations in GRMR, in collaboration with BTB (e.g. tour guide-guest ratios, licenses, visitor qualifications for diving etc.) and enforcement of site-specific zone regulations regarding jet skis, catch and release fishing etc.	1 – 5	▪ # Patrols conducted in collaboration with Department of the Environment in response to caye development issues
☐ Strengthen communication and collaboration mechanisms with the Belize Tourism Board and Department of the Environment for enforcement of laws that impact the Marine Reserve (sewage and other forms of water contamination, poor fuel storage, oil, pesticide use, over-the water structures, dock construction)	1 – 5	▪ # Patrols conducted in collaboration with BTB ▪ # Patrols dedicated to boat to boat fisher engagement
☐ Maintain and strengthen engagement and communication with fishers using a boat to boat approach	1 – 5	▪ % of GRMR fishers who consider Managed Access is working at GRMR
☐ Strengthen Managed Access committee, addressing capacity building needs		▪ # Area 8 MA Committee meetings per year

Natural Resource Management Program		
NRM 1: Surveillance and Enforcement	**Timeframe**	**Measuring Success Indicators**
Awareness of Regulations		▪ % fishers (resident / non-resident) that demonstrate awareness of GRMR regulations ▪ % of tour guides that demonstrate awareness of GRMR regulations ▪ % of resident resort managers demonstrate awareness of GRMR regulations ▪ % of required signage on rules and regulations that are in place ▪ % of visiting live-aboard vessels that have been provided with information on rules and regulations, including Port Authority regulations ▪ # caye residents attending presentation on GRMR zones, rules and regulations per year ▪ # tourism infractions per year ▪ % of staff positions identified as required for effective management of GRMR that are filled ▪ % patrol staff who are considered fully trained for effective patrols ▪ Agreement for long term use of caye / part of Northeast caye for SPAG enforcement
☐ Ensure all tour guides, fishermen and GRMR residents are aware of location, rules and regulations and rationale for the boundaries, zones and expansion through brochures, handouts and other educational material related to regulations	1 - 5	
☐ Increase awareness of visiting live-aboard boats on the rules and regulations of GRMR, mooring sites, zones, bilge water / wastewater, restricted recreational activities and non-extractive designation	1 – 5	
☐ Provide an annual refresher presentation on GRMR zone rules and regulations at each resort for owners / managers / tour guides	1 -5	
☐ Enforce tourism / recreational fishing regulations	1 - 5	
Human Resources and Training		
☐ Ensure protected area staff numbers are sufficient for effective management of the Marine Reserve.	1 – 5	
☐ Seek collaboration with caye owner for short-stay ranger station at Northeast caye for surveillance base for Northeast Point	1 – 2	
☐ Fisheries officers are fully trained for surveillance and enforcement activities, use of SMART, case file preparation, public relations	1 – 5	
☐ Ensure ongoing capacity building for all staff for effective surveillance and enforcement of tourism regulations, in collaboration with BTB	1 – 5	

Natural Resource Management Program		
NRM 1: Surveillance and Enforcement	**Timeframe**	**Measuring Success Indicators**
Human Resources and Training		▪ % of staff that demonstrate an adequate knowledge on the ecosystem services provided by GRMR and the purpose of MPAs ▪ % of court cases with successful outcomes ▪ % of GRMR fishers that consider that they trust the Fisheries Officers ▪ % of boat captains that are trained in navigation of the area ▪ Staff incentive system in place
☐ Ensure staff are aware of the critical role they and the protected areas play in maintenance of fisheries and tourism resources, livelihoods, critical ecosystems / ecosystem services and threatened species	1 – 5	
☐ Collaborate with Forest and Fisheries Departments for provision of awareness materials to magistrates on the legal, national and cultural context for Fisheries and wildlife laws, to strengthen penalties for enforcement issues	1 – 5	
☐ Training for boat captains in navigation of the area for effective enforcement	1 – 5	
☐ Develop staff incentive system to recognize good enforcement	1 - 5	
NRM 2: Boundaries and Zones	**Timeframe**	**Measuring Success Indicators**
☐ Ensure clear zone demarcation and dissemination of information on zones and zone regulations to all fishermen and other users of the Marine Reserve and fair enforcement of zone regulations across all fishermen	1 – 5	▪ % of required buoys that are in place ▪ % of amended zones that are adequately demarcated with marker buoys ▪ % of staff who know the location of boundaries, zone and reasons for establishment ▪ % of fishers using GRMR knowledgeable of the location of boundaries, zone and reasons for establishment ▪ % of tourism sector users who know the location of boundaries, zone and reasons for establishment
☐ Effective demarcation of current zones of GRMR, particularly in key identified areas of conflict	1 – 5	
☐ Maintenance and replacement of boundary and zone marker buoys as needed	1 - 5	

Natural Resource Management Program		
NRM 3: Fisheries Management	**Timeframe**	**Measuring Success Indicators**
☐ Continue implementation of Managed Access at GRMR ☐ Address issue of gill nets and long lines in GRMR through increased awareness of fishers, gear regulations enforcement ☐ Encourage fisher diversification into lionfish ☐ Collaborate with WCS to mainstream vessel monitoring system ☐ Ensure that fisheries management is guided by baseline data and sustainable fishery plans ☐ Ensure impartial enforcement of regulations across all fishers	1 – 5 1 – 5 1 – 5 1 – 2 1 – 5 1 – 5	▪ % of GRMR fishers are considered fully engaged in the implementation of Managed Access ▪ # infractions reported for possession of fillet without skin patches, parrotfish, undersize / out of season lobster / conch, out of season / size grouper, per year ▪ % fishing vessels using GRMR that are part of the vessel monitoring system ▪ Sustainable fishery plans ▪ % GRMR fishers who consider that enforcement is impartial
NRM 4: Ecosystem and Species Management	**Timeframe**	**Measuring Success Indicators**
☐ Maintain surveillance of threats to conservation targets and indicators (e.g. commercial species, coral reef, littoral forest, mangroves, charismatic species) ☐ Ensure those caye owners and developers that can influence turtle nesting success have access to best practices and are engaged in nest protection ☐ Ensure adequate protection of key herbivores to maintain live coral cover and ecological functions ☐ Provide prioritised enforcement for identified resilient coral species and areas within GRMR ☐ Continue to engage land owners, caye developers, residents and users in littoral forest, mangrove, caye and beach vegetation areas in best management practices, protection and restoration	1 – 5 1 – 5 1 – 5 1 – 5 1 - 5	▪ % successful turtle nests per year ▪ # infractions reported for possession of fillet without skin patches, parrotfish, undersize / out of season lobster / conch, out of season / size grouper, per year ▪ Map of more resilient coral areas ▪ # patrols per year that target identified critical coral areas ▪ Extent of mangroves per year ▪ Extent of littoral forest per year ▪ % of cayes considered to be managed under best practices

Natural Resource Management Program		
NRM 5: Addressing Specific Threats	**Timeframe**	**Measuring Success Indicators**
Unsustainable Fishing		
☐ Engagement, education and improved capacity of fishers (especially boat captains and young fishers) to improve awareness of issues of unsustainable fishing, and best practices for a sustainable fishery.	1 – 5	▪ % of fishers demonstrate improved understanding of sustainable fishery best practices
☐ Provide opportunities for fishers demonstrating good stewardship to engage other fishermen.	1 – 5	▪ %of fishers who demonstrate improved stewardship of the fishery
☐ Education of consumers and the certification of restaurants – through the "fish right eat right" campaign.	1 – 5	▪ % fisher who engage other fishers in good stewardship of the GRMR fishery
☐ Ensure restaurant / hotels/ supermarkets etc. only buy and sell fish with skin patch, with enforcement of this requirement.	1 – 5	▪ # restaurants and supermarkets that are certified under "fish right, eat right"
☐ Investigate added-value packaging of GRMR fin-fish with certification to supply to restaurant / hotels, supermarkets in San Pedro, Caye Caulker, Placencia etc. with fish certified as legal	1 – 3	▪ % restaurants and supermarkets checked that have purchased fish without skin patches ▪ Established market for GRMR sustainable fish
Direct Impacts on Corals		▪ % required mooring buoys that are installed
☐ Install and maintain sufficient mooring buoys in critical coral reef locations – key dive sites, safe harbours	1 – 5	▪ % mooring buoys that are maintained on schedule
☐ Ensure navigational routes through reef areas - channels and shallow areas – are adequately marked to prevent boat groundings	1 – 5	▪ % of required marker buoys that have been installed
☐ Ensure all charter boats have the required local guide and to have a protocol in place if there is no guide	1 – 5	▪ % rangers that have the capacity to enforce tourism and boating regulations
☐ Improve capacity of rangers to be able to enforce tourism regulations (diver and snorkeler / guide ratios), in collaboration with BTB	1 – 5	▪ % resorts and tour guides considered to follow best practices
☐ Work closely with Port Authority, Coast Guard and DoE towards ensuring that all boats are seaworthy and captains are licensed	1 – 5	▪ % of new caye development that falls within ICZMP guidelines
☐ Improve awareness of resorts, tour guides, and tourists of snorkelling / dive best practices and legal requirements that protect coral reef	1 – 5	▪ % of caye developments considered to be following environmental best practices

Natural Resource Management Program		
NRM 5: Addressing Specific Threats	**Timeframe**	**Measuring Success Indicators**
Agricultural Runoff		▪ # meetings per year with organizations seeking to address agrochemical contamination in the watersheds west of GRMR ▪ # initiatives addressing agrochemical contamination in the watersheds ▪ % caye residents demonstrate knowledge about pesticide, sewage and plastics management ▪ % coastal town residents demonstrate knowledge about pesticide, sewage and plastics management ▪ Lionfish densities ▪ % of fishers actively catching lionfish ▪ # lionfish fishing events at GRMR ▪ # lbs of lionfish removed from the reef as a result of organized activities ▪ % of households in Dangriga / Hopkins that consume lionfish ▪ % GRMR fishers selling lionfish to San Pedro / Caye Caulker / Belize City ▪ % local restaurants and resorts that serve lionfish ▪ % of caye owners / managers that demonstrate awareness of the issues of releasing non-caye fauna on cayes ▪ % of time lighthouses are operational
☐ Partner with organizations seeking to mitigate agrochemical contamination of waterbodies in the watersheds west of GRMR through better practices for agricultural chemical use	1 – 5	
☐ Collaborate with PCB and the Department of Agriculture to improve information on agrochemical use in the watersheds	1 - 5	
☐ Improved awareness of the general public of the issues of agrochemicals, sewage and plastics in the marine environment	1 – 5	
Lionfish and Other Invasives		
☐ Continue to improve awareness in stakeholders of potential impacts of lionfish	1 – 5	
☐ Encourage use of lionfish as a protein source and sale to local restaurants and resorts	1 – 5	
☐ Encourage household consumption of lionfish	1 – 5	
☐ Provide opportunities for stakeholders to actively participate in removal of lionfish from the reef – under strict guidelines	1 – 5	
☐ Link GRMR fishers with lionfish market in San Pedro / Caye Caulker / Belize City	1 – 5	
☐ Increase awareness in stakeholders of the problems caused by releasing non-caye fauna and flora onto the cayes	1 – 5	
Other		
☐ Collaborate with other stakeholders to ensure lighthouses work, to prevent potential groundings of ships in adjacent shipping lane	1 - 5	

Natural Resource Management Program		
NRM 6: Reporting	**Timeframe**	**Measuring Success Indicators**
☐ Maintain comprehensive patrol reports - number of patrols, zones patrolled, number of boats checked, infractions noted, warnings given, and arrests made - strengthened with integrated use of SMART system ☐ Maintain log of traditional fishermen and boat presence within the Glover's Reef Marine Reserve ☐ Maintain log of tour boats using the Glover's Reef Marine Reserve ☐ Produce quarterly reports, and submit to Fisheries Department and Advisory Committee ☐ Produce annual reports and submit to Fisheries Department and Advisory Committee	1 – 5 1 – 5 1 – 5 1 – 5 1 - 5	▪ Quarterly and annual reports that include patrol data ▪ Annual map of patrol routes / effort ▪ Annual list of traditional fishers and boats using GRMR ▪ Annual list of tourism vessels using GRMR

3.4.2 RESEARCH AND MONITORING PROGRAM

Research and monitoring are essential activities to ensure informed, effective management, and to assess the effectiveness of the Marine Reserve in achieving its objectives of ecosystem and fisheries management. The Research and Monitoring Program comes under the responsibility of the Reserve Biologist, is administered under three sub-programs:

- **Monitoring**
- **Research**
- **Data Management and Dissemination of Results**

Research and Monitoring

- *Fisheries Monitoring and Research*
- *Biodiversity and Environmental Monitoring and Research*
- *Research Permits and Reporting*
- *Dissemination of Results*

Monitoring: Fisheries monitoring targets and activities align with the Fisheries Department monitoring programs (Managed Access catch assessments, in-water pre- and post-season sampling of lobster and conch a part of continuous monitoring of stocks, and Healthy Reef site monitoring of coral reef health). Managed Access fisheries data collection is also conducted to monitor catch per unit effort for commercial species. Monitoring focuses on the fisher catch on the sailboats and skiffs, with recording of date, fisher name, boat, species caught, fishing gear, and total fishing effort (hours fished to 0.5 hr. accuracy) for each fisher's catch.

CATCH MONITORING

Fisheries Department partners with the Wildlife Conservation Society for use of Long-term Atoll Monitoring Program (LAMP II) monitoring protocols at Glover's Reef Marine Reserve with the objective of monitoring and analyzing the viability of exploited populations, as well as habitats set aside in no-take areas, to enhance fished populations, overall biodiversity and ecosystem health. LAMP II extends to an holistic set of species (including but not limited to Queen conch, Caribbean spiny lobster, sea cucumber, five commercially important fin-fish (black grouper, Nassau grouper, hogfish, mutton snapper and Queen triggerfish), parrotfish (six species – stoplight, redtail, yellowtail / redfin, princess, striped and redband), as well as monitoring of critical habitats.

The specific objectives include:

- Gathering data on the number of animals in various size classes including reproductive individuals
- Providing a baseline of habitat quality, beginning with sand flats/seagrass beds
- Comparing populations and habitats between management zones in the reserve
- Providing scientifically credible information for use in future management decisions on size regulations, rules of use and zoning to maintain profitable and sustainable fisheries and non-extractive activities throughout the Glover's Reef Marine Reserve.

Monitoring activities also extend to turtle nesting beaches and the Northeast Point spawning aggregation site. Monitoring targets are also identified in the Conservation Planning / Climate Change Planning section for measuring success, though there is not yet a measures of success monitoring framework at site or national level in Belize.

CORAL BLEACH MONITORING

Monitoring priorities include:

- Continued ongoing monitoring of commercial species, with data guiding management, and dissemination of accessible data outputs to stakeholders.
- Continued monitoring of coral bleaching and coral reef health.
- Reduced duplication of effort through improved synchronization of data collection by Fisheries Department and Wildlife Conservation Society.
- Develop and implement program for Limits of Acceptable Change monitoring for key visitor use areas.
- Implement water quality / contamination monitoring in key sites.
- Develop site-specific monitoring manual and improved on-site data management system to provide a structured process for monitoring continuity regardless of staff change-over.

Research: The majority of the research activities at GRMR are conducted by Wildlife Conservation Society and independent researchers. Research proposals are reviewed by the Fisheries Department, and if approved, a research license is granted on an annual basis. There are a number of long-term research initiatives based within the Marine Reserve.

Research priorities include:

- Assessment of the economic value of the Marine Reserve to the stakeholders and to the economy of the country.
- Promote and support key research that identifies land-based sources of water contamination.
- Investigate the impacts of sport fishing, with particular focus on reef flats bone fishing and associated trampling impacts.
- Continued use of acoustic array in monitoring target species movements
- Studies on grouper and snapper

Use and Dissemination of Results: The Fisheries Department has an ongoing monitoring program to inform management of the key commercial species, with data feeding into CITES permits, decisions on timing for closed seasons and harvesting levels. There is also an increasing need to be able to measure the conservation results of investments into marine protected area management through use of output, outcome and impact indicators, measured as part of the monitoring program. Indicators range from biological indicators (dealt with here, in the biodiversity monitoring sub-program), and socio-economic indicators developed as part of Fisheries Department's Community Engagement Strategy for Dangriga and Hopkins.

The Fisheries Department and its partner, the Wildlife Conservation Society, ensure that the monitoring outputs are successfully disseminated through the production of survey reports and the presentation of data at local, national and international fora. Scientific and technical partners using the WCS station at Middle Caye as a base also produce papers and technical reports, disseminating outputs through their organizations and sharing outputs at scientific symposia and conferences, and through scientific articles and publications.

Research and Monitoring Program		
RMP 1: Monitoring	**Timeframe**	**Measuring Success Indicators**
☐ Continue pre- and post-season in-water surveys of lobster, conch and sea cucumber	1 – 5	▪ Annual GRMR Bio-reports ▪ LAMP II reports
☐ Continue synoptic / LAMP II monitoring programs	1 – 5	▪ CPUE data
☐ Continue monitoring of catch through Managed Access log books	1 – 5	▪ Integration of CPUE data into annual report
☐ Continue boat-based monitoring of catch		▪ % coral bleaching
☐ Continue monitoring for coral bleaching, as part of the National Coral Reef Monitoring Network	1 – 5 1 – 5	▪ % coral mortality linked to bleaching ▪ GRMR data on the CRMN database
☐ Monitor Conservation Action Planning Indicators, including: ○ Total extent of mangrove ecosystem ○ Total extent of littoral forest / sandy beaches ○ Total extent of seagrass ○ % live coral cover ○ Coral bleaching and % coral mortality ○ Parrotfish density ○ Biomass of commercial fish ○ Adult conch density ○ Lobster density	1 - 5	▪ Summary Status of GRMR report on CAP and other indicators (once every 2.5 years) ▪ Output report for SPAG monitoring ▪ Water quality monitoring data ▪ Water Quality monitoring report (once every 2.5 years) ▪ Annual report on WCS monitoring at GRMR
☐ Continue monitoring of turtle nest success and turtle nesting beaches	1 – 5	
☐ Continue monitoring the spawning aggregation site at Northeast Point	1 – 5	
☐ Collaborate with other partners to implement an effective watershed to reef water quality monitoring program	1 – 5	
☐ Prioritize monitoring of agrochemical contamination in water / tissue samples	1 – 5	
☐ Continue ongoing monitoring programs under WCS (e.g. use of acoustic monitoring stations)	1 – 5	
☐ Identify and improve synergies between Fisheries and WCS monitoring	1 - 5	

Research and Monitoring Program		
RMP 1: Monitoring	**Timeframe**	**Measuring Success Indicators**
☐ Monitor threats and impacts: ○ Monitor nutrient levels and relative algal growth on a regular basis to monitor anthropogenic impacts in high visitor-use areas, adjacent to the cayes, mooring buoys and popular dive sites and in control site, using methods such as stable isotope analysis ○ Develop rapid assessment protocols for post-impact assessments for events (boat groundings, hurricanes, earthquakes, oil spills), ○ Monitor presence and density of lionfish population ○ Monitor presence of introduced species – rats, green iguanas, house geckos, tokay geckos (every 2.5 years) ○ Monitor caye land use change using drone mapping (every 2.5 years) ○ Develop Limits of Acceptable Change indicators and monitoring program for monitoring visitor impacts at key use sites	1 – 5	▪ Water Quality monitoring report (once every 2.5 years) ▪ Post-impact assessments ▪ % post-impact assessments completed of impacts requiring action ▪ Lionfish density ▪ % cayes with introduced species ▪ Mapping of caye land use over time ▪ Visitor Use Plan with integrated Limits of Acceptable Change indicators ▪ Maximum % coral bleaching during one year ▪ % coral bleaching ▪ Measures of Success indicator framework
☐ Climate change monitoring: ○ Continue monitoring for coral bleaching, with input into NCRMN ○ Continue to measure success of direct interventions – e.g. promoting higher herbivore densities	1 – 5	▪ Measures of Success report (every 3 to 5 years)
☐ Integrate Conservation Action Planning indicator outputs and outputs of other monitoring programs into a Measures of Success framework that measures conservation outputs, outcomes and impacts	1 - 5	

Research and Monitoring Program		
RMP 1: Monitoring	**Timeframe**	**Measuring Success Indicators**
Socio Economic Monitoring		▪ Socio-economic report on key stakeholder communities ▪ Data on fisher and tour guide income from using GRMR ▪ Visitor Use Plan with Limits of Acceptable Change indicators (including Visitor and Tour Guide Satisfaction) ▪ Status report on cayes (Baseline, Maaz / WCS, 2015)
☐ Collaborate with SWCMR to maintain and update accurate socio-economic data on stakeholder communities (fishers and tour guides) (Every 5 years).	1 – 5	
☐ Maintain and update accurate data on stakeholder benefits of fishers and tour guides using GRMR (Every 5 years).	1 – 5	
☐ Develop Limits of Acceptable Change indicators for key tourism sites and monitor.	1 – 3	
☐ Monitor visitor satisfaction under the Limits of Acceptable Change Program.	1 – 5	
☐ Monitor tour guide satisfaction under the Limits of Acceptable Change Program.		
☐ Update data on number of residents and residential properties occupied or under construction on GRMR cayes, septic systems etc. (Every 5 years).	1 – 5	
RMP 2: Research	**Timeframe**	**Measuring Success Indicators**
☐ Improve communication of research needs to research stakeholders of GRMR to address management questions	1 – 5	▪ List of priority research activities ▪ List of research stakeholders ▪ # research permits per year ▪ % research permit agreements that are fulfilled, with submission of final reports ▪ Research agreement with WCS for continued research and monitoring activities at GRMR ▪ # meetings with Wildlife Conservation Society, Smithsonian Institute, and other research partners per year to discuss research, outputs ▪ # of infractions of GRMR regulations by researchers ▪ Report on deep sea ecosystems and species
☐ Continue and strengthen collaborative relationship with Wildlife Conservation Society	1 – 5	
☐ Ensure all researchers are aware of the rules and regulations of the Marine Reserve, and research regulations under the Fisheries DepartmentDevelop a comprehensive baseline species list of fish, corals and other invertebrates for the protected area	1 – 5	
☐ Continue developing baselines of biodiversity of GRMR	1 – 5	
☐ Improve knowledge of deep sea ecosystems and species	1 - 5	
Research and Monitoring Program		

RMP 3: Data Management and Dissemination of Results	Timeframe	Measuring Success Indicators
☐ Maintain database of GIS data, research and monitoring information for ease of access and to enhance the level of coordination between researchers, help identify gaps in information, and to provide a platform from which the results can be communicated to a wider audience	1 – 5	▪ Database – effective management of GRMR data ▪ Annual bio-reports ▪ % recommendations from Annual Reports that are integrated into annual workplans ▪ Presence of GRMR data in relevant national / regional databases ▪ # presentations given at local, national and international levels on monitoring and research outputs ▪ Improved understanding of research outputs by local stakeholders
☐ Continue presenting monitoring results in annual reports, and integrate into the adaptive management cycle	1 – 5	
☐ Provide data to the National Biodiversity Monitoring Program, Healthy Reefs, and the National Coral Reef Monitoring Network Repatriation / dissemination of research articles	1 – 5	
☐ Use available forums for dissemination of results (eg. workshops, conferences, Advisory Committee meetings etc.)	1 – 5	
☐ Translate research and monitoring outputs into a form that the public understands, and make available to stakeholders	1 - 5	

3.4.3 COMMUNITY DEVELOPMENT AND OUTREACH PROGRAM

Community Development and Outreach

- *Environmental Education*
- *Public Outreach and Information*
- *Alternative Livelihoods / Income Diversification*
- *Community Capacity Building*

Glover's Reef Marine Reserve has a number of mechanisms for ensuring it engages its community stakeholders. There has been an increased focus on engaging traditional fishermen through the piloting and roll out of Managed Access. There are also strategies being implemented by WCS in the key stakeholder communities (Sarteneja, Dangriga and Placencia)

There is also stakeholder representation on the Glover's Reef Advisory Committee (GRAC), which provides a mechanism for stakeholders to input recommendations directly to Fisheries Department towards the management of the protected area.

The central Belize stakeholders of Glover's Reef overlap to some extent with those of South Water Caye Marine Reserve (SWCMR). The SWCMR Community Engagement Strategy (Wildtracks, 2018) provides recommendations for community engagement and empowerment strategies targeted at Dangriga and Hopkins to encourage stakeholder participation in the management and conservation of the natural resources of the Marine Reserve. The report also looks at the enabling environment required for successful engagement of communities, with identification of synergies and areas for strengthening of communication, collaboration and coordination across stakeholders at the local level. This is considered essential for achieving strong, long term, sustainable outcomes with proactive participation of communities in the management of the protected area, and promotion of ownership. A similar engagement strategy has also been developed for the northern communities, including Sarteneja, as a joint initiative by Belize Audubon Society and the Sarteneja Alliance for Conservation and Development (Wildtracks, 2018). Both strategies providing a mechanism for collaboration towards common goals in the communities, improving cost-effectiveness of interventions that synergize with other organizations active in these two areas.

The SWCMR Community Engagement Plan for Dangriga and Hopkins is focused on achieving four outcomes:

TARGET ONE: By 2022, at least 30% of people surveyed in Dangriga and Hopkins recognise the ecosystem values associated with SWCMR and support its conservation and sustainable use

TARGET TWO: By 2022, there has been an increase of 20% in sustained, active support of SWCMR in Dangriga and Hopkins over the 2018 baseline.

TARGET THREE: By 2022, at least 10 local tourism operations have developed strong collaborative partnerships with SWCMR to strengthen management of the Marine Reserve

TARGET FOUR: By 2022, at least 20% of SWCMR fisher households in Dangriga and Hopkins have benefited either directly or indirectly from income diversification strategies, and have demonstrated reduced impacts on the marine protected area over the 2018 baseline

KEY MESSAGES OF THE DRAFT SWCMR COMMUNITY ENGAGEMENT, EDUCATION AND PUBLIC AWARENESS STRATEGY (2018)

Improve knowledge and understanding of:

- Reef, seagrass and mangrove ecosystems and biodiversity, and their local, national, regional and global importance
- Marine conservation and marine protected areas, and their roles in conserving biodiversity and the environment and maintaining a sustainable fishery
- Belize Fisheries policies and regulation
- Management zones of SWCMR and their role in sustainable fishery
- The protected area Management Plan and its components
- The history of the establishment of the protected areas
- Conflicts, threats and challenges that are barriers to effective management of the protected areas
- Ways in which the public can be involved in management and outreach/ opportunities associated with marine protected areas
- Roles of marine protected areas, replenishment zones and regulations
- Ecosystem services
- GRCMR targets and threats
- Threatened Species
- Climate change impacts, adaptation and resilience
- Community involvement in the protection and conservation efforts of marine protected areas

The Strategy identifies the critical need to engage new, supportive stakeholders – the tourism sector and the youths of the community – increasing appreciation and pride in the marine protected area, recognition of benefits and providing mechanisms for active participation in management activities and improved stewardship of the marine resources. The eventual outcome being sought is improved stewardship of the natural resources, whether in and around the communities or at Glover's Reef Marine Reserve. Moving from outreach to engagement for improved stewardship is based on a "desire to encourage community members to adopt and sustain reef-friendly behaviors" (Marshall et al., 2015), and is considered a critical management tool when working with communities towards effective management

Environmental Education: To engage people in conservation of natural resources, there needs to be a basic understanding of the value of those resources to their lives - the ecosystem services they provide that impact the community – the protection from storm events provided by the barrier reef, the economic benefits from tourism and the provision of food and income through traditional fishing activities. Dangriga, in particular, is considered a significant gap in coverage of marine conservation education activities in coastal communities in Belize - ensuring that this gap is filled is particularly important. Building

knowledge and understanding of the role and importance of GRCMR and the services it provides in both Dangriga and Hopkins is therefore considered key to the success of any engagement activities in the communities. A series of three knowledge / understanding pre-conditions – the Key Concepts - were identified during the Theory of Change planning process, essential for ensuring an enabling environment – whilst these are focused on SWCMR, they are equally applicable to GRMR:

- Understanding of the importance of ecosystem services of SWCMR, including climate change adaptation and resilience values
- Understanding of the importance of conservation and sustainable use
- Understanding the role of protected areas, replenishment zones and regulations

The importance of engaging youths through education activities in the schools in Dangriga and Hopkins cannot be over-emphasized, but to date, efforts have been project-based, resulting in limited continuity of presence in the schools, with stops and starts to engagement activities, duplication of effort by organizations and limited cohesive structure or messaging. Marine ecosystem values and good stewardship are not being successfully transferred to youths through the education system. As a result, the majority of students in Dangriga are considered to have a low level of understanding and engagement – not only for support of marine protected areas, but for the marine environment and conservation generally. The key school-based strategy is focused on the development of a structured, collaborative, long-term program that interacts with students at key stages in primary and high school, building knowledge and understanding of the key concepts and identified pre-conditions, engaging students throughout their schooling, and developing conservation leadership skills to improve outcomes. It also integrates a focus on 'learning by doing' through outdoor experience, considered critical as experience has shown that exposure to the marine environment is the most effective way to engage youths and develop a long-term interest in the marine environment and conservation, building a future culture of conservation stewardship in the communities.

Public Outreach and Information: To achieve a change in attitude and behavior in communities, a sustained campaign is required, over a number of years. Key communication strategies focused on GRMR stakeholders are identified in the GRMR management plan, for implementation over a five-year period. Dangriga is traditionally considered a challenging community to engage in marine conservation for a number of reasons, including the limited focus on marine conservation in the education system - youths don't leave school with the basic information necessary to understand and respect the importance of marine protected areas and the ecosystem services they provide to the health, safety and livelihoods of their stakeholders. This limited awareness continues as they become adults. The town is more business-focused than Hopkins, with few people reliant on the marine environment – only a small percentage of the community are either tour guides or fishermen, with few tourism opportunities linked to the reef. This reduces the interest and motivation of many community

members to attend meetings to learn more. The lack of a long-term NGO or co-management partner active in the Dangriga area to implement consistent education / awareness activities has also been a significant challenge to raising awareness. Where organizations are present (e.g. Sarteneja, Punta Gorda, Placencia), communities are considered to have a much better understanding of the roles of the marine protected areas.

Hopkins, however, is more receptive to being informed about the key concepts – the community has largely embraced tourism, with a stronger recognition of the links between tourism, the state of the reef and the state of Hopkin's economy. There is an active BTIA chapter and the Stann Creek Tour Guide Association that are receptive to information on the marine environment and GRMR, for integration into tours. Communication with and engagement of the tourism sector, in general, though, has not been prioritised by GRMR in the past.

The most effective tool for increasing fisher awareness has proved to be boat-to-boat conversations - a strategic outreach tool refined by Belize Audubon Society, providing information to fishers that mirrors the community outreach messages, and reinforcing the key concepts. The boat-to-boat conversations are proving to be a successful mechanism for engaging and communicating with fishers active in the marine protected areas. It has been shown that, for greatest effectiveness, boat-to-boat activities should:

- be led by the Outreach Officer rather than an enforcement officer
- provide the fishers with incentives for participation (generally soft drinks and chips)
- be conducted without the presence of uniformed rangers and coastguard, to ensure easy distinction between outreach and enforcement activities

The fishers in Dangriga have expressed appreciation at having a Fisheries Outreach Officer in the communities that they can approach for information – one not associated with fisheries enforcement (Fisher consultations, 2017 / 2018). Investing in continuing this post is considered a high priority for successful engagement of stakeholders in the Central Belize communities.

The tourism sector has been under-engaged by GRMR, but is identified as a key opportunity for improving support and collaboration for the marine protected area. However, a significant investment in time and effective communication is required towards setting a foundation for future engagement. Unlike the fishing sector, the tourism sector is considered to be more open to being engaged, and has more capacity to be able to support GRMR. It is recommended that they should be brought to the table and fully engaged in management activities. Improved communication is the first step towards achieving the move towards strong partnerships with this private sector.

Alternative Livelihood / Income Diversification: Over the last ten years, there has been a surge in interest by marine conservation organizations in supporting income diversification for fishermen in the coastal communities towards reduced pressure on the marine resources. However, successful outputs have been very limited in terms of scale and long term sustainability. There are many reasons for this, including the independent nature of fishers, their strong cultural ties to the sea, the seasonal nature of fishing, limited education for moving into other occupations, the difficulties of shifting from a known income source to unknown, the impacts of natural disasters…all of these are barriers to successful alternative livelihood and income diversification outcomes.

Despite some advances in the success of income diversification outcomes through initiatives such as seaweed production, the number of fishers and fisher households that have been able to successfully diversify their income base has been minimal. Two key pre-conditions have been identified for facilitating success of income diversification investments:

- Community understanding of projects, funding cycles, project implementation and project reporting
- Consistent support of community groups / projects: Good communication, continuity of presence, mentoring,

The absence of an established conservation organization in Dangriga or Hopkins with the capacity to take on the role of mentoring, improving consistent communication and support of fisher association, coordinating meetings and capacity-building trainings, and monitoring of projects and micro-loans is considered a significant barrier. It is therefore recommended that, should there be continued investment in income diversification projects, the role of oversight and mentoring be filled by a Development Officer, in addition to the Outreach Officer, based in the Fisheries Office, with relevant project development and implementation skills. Also considered key is the recognition of the important role women can play in income diversification for fishing households and the communities as a whole. A review of lessons learnt from past projects highlights the need for consistent communication and mentoring not just during the short term project time frame, but also in the medium term, beyond the life of single projects, if outputs are to be successful in changing lives and reducing dependence on the marine resources.

Community outreach and engagement priorities include:

- Collaborating with BAS / SACD and SWCMR in the implementation of the community engagement and investment strategies for the northern fishing communities and the Central Belize fishing communities.

- Ensuring that messages to fishers are always clear and consistent with other organizations working in the same areas – particularly abut Managed Access and income diversification opportunities.
- Improving communication and building trust with the fishers.
- Demonstrating the benefits of improved management and good stewardship of GRMR to fishers, tour guides and other stakeholders.
- Identifying mechanisms for successfully engaging non-compliant fishers.
- Reaching out to more schools.
- Increasing the focus on fisher families – wives and youths – not just fishers.
- Revision of the GRAC ToR to increase fisher representation.

Community Engagement and Outreach		
CEO 1: Environmental Education	**Timeframe**	**Measuring Success Indicators**
☐ Collaborate with BAS / SACD to implement the Northern Communities Engagement and Investment Strategy	1 – 5	▪ Outreach strategy for northern communities ▪ Outreach strategy for central Belize communities
☐ Collaborate with SWCMR in the implementation of the SWCMR Community Engagement Strategy	1 – 5	
☐ Partner with BAS / SACD in the northern communities and SWCMR in central Belize in the development and implementation of 5-year School Outreach Strategies that engage students in both primary and high schools, to ensure grounding in key concepts.	1 – 5	
CEO 2: Public Outreach and Information	**Timeframe**	**Measuring Success Indicators**
☐ Ensure GRMR Advisory Committee members participate in and are kept informed of reserve activities and management decisions	1 – 5	▪ # GRAC members considered active on committee ▪ % of GRMR fishers who consider that they are well informed about GRMR management decisions and activities ▪ % of GRMR tour guides who consider that they are well informed about GRMR management decisions and activities ▪ % of GRMR resorts that have a copy of the WCS caye best practices guidelines ▪ # Videos, posters, etc. that inform public of ecosystem services of GRMR ▪ # public events attended by GRMR to promote the Marine Reserve ▪ Annual summary flier ▪ Distribution list for annual flier ▪ % of fishers who consider the Managed Access Committee is functioning well ▪ Level of attendance at MA committee meetings
☐ Ensure there are large, clear signs with a map of the Marine Reserve, positioned in key locations including information on fees, zones and regulations	1 – 5	
☐ Provide regular presentations on research and monitoring results, and reserve activities to fishers, tour guides and stakeholder communities	1 – 5	
☐ Reprint and disseminate WCS best practices guidelines for caye-based tourism operations and other residents.	1 -5	
☐ Ensure there is awareness of GRMR and the environmental services and benefits it provides to the communities through use of media opportunities and posters (focusing particularly on biodiversity protection, fisheries production and tourism), displays and exhibits placed at public events such as Sarteneja Regatta, Garifuna Settlement Day, Earth Day, etc.	1 – 5	
☐ Produce an annual summary flier of protected area activities and achievements, to be distributed to residents, tour guides, tour operators and fishers	1 – 5	
Fishing Sector		
☐ Ensure fishers are kept informed of GRMR activities and management decisions affecting them through the Managed Access committee		
☐ Regular boat-to-boat discussions with fishers in GRMR using boat-to-boat protocols		

Community Engagement and Outreach		
CEO 2: Public Outreach and Information	**Timeframe**	**Measuring Success Indicators**
Tourism Sector		▪ % tour guides who consider themselves well informed on GRMR activities ▪ % GRMR resort managers who consider themselves well informed on GRMR activities
☐ Ensure the tourism sector is kept informed of GRMR activities and management decisions affecting them	1 – 5	
☐ Improve knowledge of tourism best practices by GRMR tour guides	1 – 5	
Government and NGO Sector		
☐ Maintain ongoing communication with relevant NGOs and Government agencies on GRMR management activities	1 - 5	
CEO 3: Income Diversification / Alternative Livelihoods	**Timeframe**	**Measuring Success Indicators**
☐ Collaborate with BAS / SACD in the implementation of the Community Engagement and Investment Strategy for the northern fishing communities	1 – 5	▪ % of GRMR fishers benefitting from income diversification strategies ▪ # GRMR entrepreneurs being supported through projects per year ▪ # proposals developed by GRMR fishers ▪ # proposals approved by GRMR fishers ▪ # projects by GRMR fishers successfully implemented ▪ Annual evaluation of Income Diversification partner knowledge and perceptions ▪ Annual evaluation of participant income - % income derived from GRMR fishery ▪ Number of days GRMR fisher participants spend fishing per year ▪ # and % GRMR fishers participating in exchange visits ▪ # and % GRMR tour guides participating in exchange visits
☐ Collaborate with SWCMR in the implementation of the Community Engagement and Development Strategy for Dangriga and Hopkins	1 – 5	
☐ Ensure integration of a conservation / environment component into projects and project agreements	1 – 5	
☐ Identify and support exchange visits and capacity building sessions for potential participants to increase knowledge/ understanding and success rate of income diversification projects	1 – 5	
☐ Follow-on investment to implement lessons learntIdentify and invest in income diversification opportunities for fishers and fisher families based on individual interests, and on a combined grants / loan system	1 - 5	

Community Engagement and Outreach		
CEO 4: Community Engagement and Capacity Building	**Timeframe**	**Measuring Success Indicators**
☐ Strengthen fisher associations for improved representation of fishers, two-way flow of information, and effective organizational, financial and project management, towards improved stewardship of the marine resources	1 – 5	▪ % GRMR fishers who consider that their Fishermen Association is strong
☐ Build capacity of and support an effective Managed Access committee for Area 8	1 – 5	▪ Number of tour guides / tourism sector representatives participating in plastic use reduction
☐ Engage and partner with the local tourism sector and develop an environment of pride and supportive stewardship of the marine protected area, bringing tour guides and resort managers to the table and fully engaging them in management activities	1 – 5 1 – 2	▪ % of fishers who consider the Managed Access Committee is functioning well ▪ lbs of plastic removed
☐ Participatory development of project ideas for reducing plastic use in GRMR	1 – 5	▪ Number of tour guides / tourism sector representatives participating in lionfish removal
☐ Provide opportunities and incentives for lionfish eradication	1 - 5	

3.4.4 TOURISM AND RECREATION PROGRAM

The Tourism and Recreation Program encompasses two primary activity areas: Visitor Safety and Protection, and Visitor Education and Interpretation. Tourism is focused primarily on snorkelling and diving, based from resorts on the GRMR cayes, San Pedro, Caye Caulker or from the mainland.

There is great potential for the Marine Reserve to improve visitation, particularly if the tourism sector can be engaged in playing an active role in marketing at international level. If this is achieved, increasing the financial sustainability of the Marine Reserve, it will also need to be balanced by ensuring that this does not impact the environmental sustainability of the reefs that attract the visitors.

Tourism and Recreation

- *Visitor Safety and Protection*
- *Visitor Education and Interpretation*

Visitor safety and Protection: Ensuring a safe environment for visitors is essential, through information on best practices, infrastructure in key visitor use locations, and enforcement of tourism regulations. There is a need to increase the focus on tourism management, particularly on visitor safety, and to ensure that visitors are well informed, for their own safety and for the protection of the environment.

Under the tourism legislation, visitor management and safety is, to a large extent, the responsibility of the tour guides and tour operators, with regulations covering the need for certified guides and dive instructors, and the requirement for boat captains and dive guides to explain the rules of the Reserve to divers within the Reserve. However it is also recognized that there needs to be greater education of visitors and tour guides of Best Practices for tourism use of the marine resources for sustainability.

PROTECTED AREA REGULATIONS – VISITOR MANAGEMENT

Dive Groups

All divers in the Conservation Zone shall adhere to the following rules:

(a) divers shall register with the Reserve Manager prior to entering the Conservation Zone;
(b) charter dives shall first obtain a license in accordance with these Regulations before operating in the Conservation Zone and all dive boats shall fly the "divers down flag" when they have divers in the water;
(c) only certified scuba divers, or divers undergoing a training course conducted by a recognized instructor shall be allowed to use scuba equipment in the whole of the Reserve;
(d) dive guides shall be required to explain the rules of the Reserve to all divers within the Reserve;
(e) all boats which need to operate in this zone shall first obtain registration from the Fisheries Administrator in accordance with these Regulations

Sport Fishing

(1) Any person who is desirous of conducting sport fishing within the Reserve shall apply to the Fisheries Administrator or the Reserve Manager for a fishing license in the form prescribed as Form IV of the Schedule

(2) The Fisheries Administrator or the Reserve Manager, as the case may be, may grant a fishing license in the form prescribed as Form V of the Schedule.

(3) A fee of Bz$20.00 per month for Belizeans or Bz$50.00 per month for non-Belizeans shall be payable upon receipt of a sport fishing license.

(4) The licensee shall not kill any fish caught under a sport fishing

REGULATIONS. GLOVER'S REEF MARINE RESERVE (SI 70 of 1996)

Visitor Interpretation and Education: The current key mode of information transfer to visitors to GRMR is via the tour guides. Ensuring that tour guides are aware of and using best practices, are well informed about the Marine Reserve and Belize's World Heritage Site, and knowledgeable about the marine life is therefore important for high visitor education and satisfaction.

GOOD ENVIRONMENTAL PRACTICES

SNORKELING

Coral reefs are among the world's most spectacular ecosystems and snorkeling is an excellent way to explore them. As coral reefs face an increasingly uncertain future, snorkelers and other coral reef visitors can play an important role in helping protect these fragile habitats. Follow these simple guidelines to become a "coral friendly" snorkeler.

BEFORE SETTING OUT TO EXPLORE THE REEFS

- For your vacation, choose an environmentally friendly resort or hotel; one that practices energy conservation, recycles, and treats sewage and solid waste in responsible ways.
- Pay user fees or make a donation when visiting coral parks and other marine conservation areas.
- Get the best possible snorkeling instruction you can.
- Practice snorkeling skills away from the reef.
- Make sure your equipment fits properly before you snorkel near corals—it can be very difficult to adjust in the water.
- If you feel uncertain, or are an inexperienced snorkeler, consider wearing a snorkel vest for added buoyancy.
- Learn all you can about coral reefs—they are fascinating and fragile environments.

IN THE WATER

- Never touch corals; even slight contact can harm them. Some corals can sting or cut you.
- Select points of entry and exit to avoid walking on corals.
- Maintain a comfortable distance from the reef, so as to avoid contact.
- Know where your fins are at all times and don't kick up sand.
- Stay horizontal in the water while you're near or above the reef.
- Learn to swim without using your arms.
- Take nothing living or dead out of the water except recent garbage which does not have living organisms on it.
- Move slowly and deliberately in the water—relax as you swim and take your time.
- Avoid using gloves in coral environments.
- Remember, look but don't touch.

Good snorkelers know that the best way to enjoy a reef is to slow down, relax and watch as reef creatures go about their daily lives undisturbed.

Be sure to find out about local laws and regulations as they may differ from these general guidelines.

GOOD ENVIRONMENTAL PRACTICES

SNORKELING

MINIMIZE CONTACT WITH MARINE LIFE

- Never chase, harass or try to ride marine life.
- Never touch or handle marine life.

ON BOATS

- Choose snorkel operations whose boats make use of available moorings —anchors and chains destroy fragile corals.
- Make sure garbage is well stowed, especially light plastic items.
- Be sure to take away everything you brought on board, such as packaging, used batteries and bottles.

SHORESIDE

- Support coral parks and other conservation projects:
  - Visit established coral parks and pay applicable user fees that support marine conservation.
  - Encourage and support the use of boat moorings.
  - Participate in local initiatives to monitor the marine environment.
  - Participate in cleanups.
  - Make a donation or volunteer your skills to support a coral park. For example, you can participate in a reef survey, conduct outreach, or help educate others about reef conservation.
  - Donate used equipment such as cameras, dive gear or reef identification books.
- Avoid purchasing souvenirs made from coral, turtles or other marine life—this is often illegal, and it's never environmentally wise.
- Speak up. Make sure your snorkeling buddies understand these simple but important conservation practices.

The Coral Reef Alliance (CORAL) is a member-supported, non-profit international organization dedicated to keeping coral reefs alive around the world. Visit our website http://www.coral.org

Visit the Project AWARE Foundation website at www.projectaware.org to find out more about protecting the aquatic environment and its resources.

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CORAL RP-105.2002

GOOD ENVIRONMENTAL PRACTICES

DIVING

Divers are some of the strongest and most effective advocates for coral reef conservation. Please follow these simple guidelines to become a "coral friendly" diver.

AS A RESPONSIBLE TOURIST

- For your vacation, choose an environmentally friendly resort or hotel; one that practices energy conservation, recycles, and treats sewage and solid waste in responsible ways.
- Choose coral friendly dive operations that practice reef conservation by:
  - Giving environmental briefings.
  - Holding buoyancy control workshops.
  - Using available moorings.
  - Using available wastewater pump-out facilities.
  - Actively supporting local coral parks.
  - Participating in local conservation projects.
- Pay user fees or make a donation when visiting coral parks and other marine conservation areas.
- Avoid purchasing souvenirs made from coral, turtles or other marine life—this is often illegal, and it's never environmentally wise.
- Learn all you can about coral reefs—they are fascinating and fragile environments.

IN THE WATER

- Never touch corals; even a slight contact can harm them and some corals can sting or cut you.
- Carefully select points of entry and exit to avoid areas of reef.
- Make sure all your equipment is well-secured.
- Make sure you are neutrally buoyant at all times.
- Maintain a comfortable distance from the reef.
- Practice good finning and body control to avoid accidental contact with the reef or stirring up the sediment.
- Stay off the bottom and never stand or rest on corals.
- Avoid using gloves and kneepads in coral environments.
- Take nothing living or dead out of the water, except recent garbage.

Good divers know that the best way to enjoy a reef is to slow down, relax and watch as reef creatures go about their daily lives undisturbed.

Be sure to find out about local laws and regulations as they may differ from these general guidelines.

GOOD ENVIRONMENTAL PRACTICES

DIVING

MINIMIZE CONTACT WITH MARINE LIFE

- Never chase, harass or try to ride marine life.
- Do not touch or handle marine life.

PHOTOGRAPHY & VIDEOGRAPHY

Divers need advanced diving skills to take pictures and video underwater. Photographic and video equipment is cumbersome and affects a diver's buoyancy and mobility in the water. It is all too easy to touch and damage marine life when concentrating on "the perfect shot."

ON DIVE BOATS

- Choose dive operations whose boats make use of available moorings—anchors and chains destroy fragile corals.
- Make sure garbage is well stowed, especially light plastic items and cigarette butts.
- Be sure to take away everything you brought on board, such as packaging, used batteries and bottles.

SHORESIDE

- Support coral parks and other conservation projects:
  - Visit established coral parks and pay applicable user fees that support marine conservation.
  - Encourage and support the use of dive moorings.
  - Participate in local initiatives to monitor the marine environment.
  - Participate in cleanups.
  - Make a donation or volunteer your skills to support a coral park. For example, you can participate in a reef survey, conduct outreach, or help educate others about coral reef conservation.
  - Donate used equipment such as cameras, dive gear or reef identification books.
- Speak up. Make sure your dive buddies understand these simple but important conservation practices.

The Coral Reef Alliance (CORAL) is a member-supported, non-profit international organization dedicated to keeping coral reefs alive around the world. Visit our website http://www.coral.org

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CORAL RP-1042002

Visitor Management Program		
☐ Develop a Visitor Use Plan for GRMR that includes Limits of Acceptable Change, in collaboration with stakeholders	1 - 3	▪ Visitor Use Plan for GRMR with integrated Limits of Acceptable Change
VMP 1: Visitor Safety and Protection	**Timeframe**	**Measuring Success Indicators**
☐ Ensure ongoing capacity building for all staff for effective visitor hospitality and management at GRMR	1 – 5	▪ # Fisheries Officers that have visitor hospitality training
☐ Ensure relevant information on rules and regulations is available for dissemination to tour guides, tourists and other visitors	1 – 5	▪ # tourism infractions reported
☐ Enforce GRMR recreational regulations	1 – 5 1 – 5	▪ % tour guides using GRMR considered to be fully engaged and compliant with BTB and GRMR regulations
☐ Strengthen engagement of and collaboration with tour guides to improve best tourism practices, compliance with BTB laws and GRMR regulations		▪ Accreditation system for tour operators linked to best practices in GRMR
☐ Develop / adopt 'Tourism Best Practices' guide for tour guides, dive leaders and dive boats in collaboration with tourism and reef stakeholders	1 – 5	▪ Tourism best practice guide for tourism sector using GRMR
☐ Support accrediting system for tour companies that show awareness of impact mitigation in their boat handling, mooring, intro. presentations to tourists, and group management	1 – 5	▪ % of required mooring buoys that have been installed in key snorkeling areas ▪ # incidences of significant tourism injury in GRMR
☐ Increase awareness of best practices for tour boats entering the reserve		
☐ Install sufficient mooring buoys in key dive and snorkeling sites	1 – 5 1 - 5	▪ % of required mooring buoys that have been installed at key visitor use sites
☐ Maintain first aid response capability at Middle Caye and written protocols for medical evacuations	1 – 5	▪ % live-aboards and in independent sailboats that have been given information on zones, navigational channels, safe snorkeling areas etc. per year
☐ Ensure visitors on live-aboards and in independent sailboats visiting Glover's Reef Marine Reserve are aware of management zones and rules and regulations, mooring buoy locations and mooring regulations	1 – 5	
☐ Develop and produce laminated poster for distribution to resorts with map of Glover's Reef Marine Reserve highlighting zones, regulations, major dive / snorkeling sites, and dive best practices	1 - 5	▪ Laminated poster of zones and regulations

Visitor Management Program		
VMP 2: Visitor Education and Interpretation	**Timeframe**	**Measuring Success Indicators**
☐ Upgrade Information Centre on Middle Caye, equip with interpretive information designed to raise awareness of the environmental and socio-economic benefits and services of the Marine Reserve, traditional fishing, and its designation as a World Heritage Site	1- 2	▪ Information Centre ▪ Interpretive information ▪ Gift shop ▪ Visitor satisfaction with Visitors' Centre and interpretive information ▪ % fishers who have visited the Information Centre ▪ Annual income from gift shop ▪ GRMR leaflet in English and Spanish ▪ Library containing key GRMR publications (hard copy / digital) ▪ Annual presentation on biodiversity and ecosystem services of GRMR targeting tour guides ▪ % GRMR tour guides that attend presentations
☐ Include information targeted specifically at fishermen, using it as a platform to inform fishermen on results of conch, lobster, coral and other surveys and on ongoing research	1 – 5	
☐ Change displays on a regular basis to ensure there are still items of interest to attract regular visitors	1 – 5	
☐ Include a small gift shop area in the Information Centre, for additional income generation	1 – 5	
☐ Ensure continued production and distribution of brochures Glover's Reef Marine Reserve	1 – 5	
☐ Translate brochure into Spanish for distribution to Spanish speaking fishermen and visitors	1 – 5	
☐ Develop a library of key publications and videos at the Visitors' Centre as a resource for Reserve staff, visitors, and students. Copies of all published work on Glover's Reef Marine Reserve should be available in this library	1 – 5	
☐ Provide annual presentation for tour guides that cover GRMR activities, monitoring outputs, key messages, guest presentations on biodiversity and ecosystem services of the protected area, and ways to reduce tourism impacts	1 - 5	

3.4.5 MANAGEMENT AND ADMINISTRATION

The administration of the Marine Reserve is the responsibility of the Fisheries Department, under the Ecosystems Management Unit. The Reserve Manager reports directly to the Unit's Marine Protected Area Coordinator.

Management and Administration

- *Planning*
- *General Management and Administration*
- *Financial Management*
- *Concessions / Commercial Uses*
- *Partnership Relations*
- *Information Technology*

Planning and general administration (including human resources) are managed both on-site by the Reserve Manager, and from the Belize City Fisheries Department office. The Reserve Manager is responsible for the day to day on-site and financial management of the Marine Reserve, including management of surveillance and enforcement activities, human resource management, site-level annual book keeping, planning and reporting, and collection of visitor fees. Local partnerships with other NGOs, liaising schedules with the Coast Guard for joint patrols, and communication and collaboration with local stakeholders are also managed under the Marine Reserve activities.

In the Belize City office, the Ecosystems Management Unit is responsible for supporting the Reserve Manager, and planning at the system level. Administration, financial and human resource management are scaled up to cover all activities of the Fisheries Department. Larger scale agreements and partnerships with organizations such as WCS are managed by the central office in Belize City, as is the issuing of fishing and research permits.

Re-branding of GRMR and strengthening use of UNESCO branding is proposed to improve the profile of the Marine Reserve, both for community engagement, marketing to local stakeholders and internationally.

Management and Administration Program		
MAP 1: Planning	**Timeframe**	**Measuring Success Indicators**
☐ Preparation of annual workplan / operational plan and budget in October of each year	1 – 5	▪ Annual workplan ▪ Monthly, quarterly and annual reports
☐ Produce monthly, quarterly and annual reports and submit to Ecosystem Management Unit, following Fisheries Department reporting procedures	1 – 5	▪ Annual review report on management plan implementation and outputs (% activities successfully implemented)
☐ Conduct review of management plan strategy implementation and outputs every two years with stakeholder input, and adapt management plan as required, as part of the adaptive management cycle	1, 3, 5	▪ Annual management effectiveness assessment report
☐ Conduct management effectiveness assessment (based on national indicators -Young et al., 2005) annually, and integrate output recommendations into annual workplan /operational plan	1 – 5	▪ Emergency Plan ▪ # staff who are familiar with and trained to implement protocols under the Emergency Plan
☐ Ensure an effective Emergency Plan is in place (to include natural and anthropogenic disasters, medical evacuation etc.), and staff are trained in implementation	1 – 2	▪ # members of Advisory Committee that participate effectively in planning for the Marine Reserve
☐ Build the capacity of the Advisory Committee to be able to participate in planning for the Marine Reserve	1 – 5	▪ # members of Managed Access Committee that participate effectively in meetings
☐ Build the capacity of the Managed Access Committee to be able to participate in planning for the Marine Reserve	1 – 5	▪ Established and active tourism committee
☐ Engage the tourism sector in development of a tourism committee to assist in planning for improved tourism management at GRMR	1 – 5	▪ Tourism Plan for GRMR ▪ Annual review report on tourism plan implementation and outputs (% activities successfully implemented)
☐ Assess and plan for potential liability issues	1 – 2	▪ Liability Issues report
☐ Develop a Measures of Success framework integrating management plan indicators and outcome / impact indicators, and implement every five years	1, 5	▪ Measures of Success Framework ▪ Baseline and 5 yr MoS reports

Management and Administration Program		
MAP 2: General Management and Administration	**Timeframe**	**Measuring Success Indicators**
Human Resources		
☐ Ensure all staff are familiar with Fisheries Department and Reserve management policies, including job descriptions, employee policies, transport policies, and gender issues	1 – 5	▪ % staff demonstrate familiarity with Fisheries Department and GRMR management policies
☐ Ensure the Reserve Manager is trained in marine resource management		▪ Qualifications of the Reserve Manager
☐ Ensure the Reserve Manager has sufficient administrative training for effective general and financial management	1 – 5 1 – 5	▪ Trainings completed successfully by Reserve Manager
☐ Ensure surveillance and enforcement staff have the training required for effective surveillance and enforcement	1 – 5	▪ Relevant trainings completed successfully by surveillance and enforcement staff
☐ Ensure staff are trained in natural resource policies and legislation		▪ % of staff that demonstrate knowledge of natural resource policies and legislation
☐ Ensure relevant staff are trained in operation and maintenance of reserve equipment (boat handling, basic outboard repair etc.)	1 – 5 1 – 5	▪ % of relevant staff trained in operation and maintenance of reserve equipment
☐ Ensure staff are trained in conflict resolution, consensus building and communications skills	1 – 5	▪ % of staff trained in conflict resolution, consensus building and communications skills
☐ Ensure the Biologist is trained in monitoring protocols and data analysis		▪ Relevant qualifications and trainings completed successfully by the Biologist
☐ Ensure staff are trained in CPR, First Aid and use of the oxygen kit	1 – 5	▪ % of staff trained in CPR, First Aid and use of the oxygen kit
☐ Ensure on-site staff have adequate support from Belize City	1 – 5	▪ % of Reserve staff consider they have sufficient support from Belize City office
☐ Conduct an annual evaluation of staff performance with integrated capacity needs assessment of staff and identify and address capacity building requirements on an annual basis	1 – 5 1 – 5	▪ Annual capacity needs assessment outputs ▪ % of capacity needs assessment recommendations implemented by 1 year

Management and Administration Program		
MAP 3: Financial Management	**Timeframe**	**Measuring Success Indicators**
☐ Conduct a financial needs assessment for management of GRMR ☐ Develop and implement a Financial Sustainability plan for the marine reserve that identifies viable financial sustainability mechanisms ☐ Investigate options for reducing operational costs through strategic partnerships in all Programme areas (e.g. with BAS / SACD in implementation of Community Engagement Strategy in northern communities) ☐ Investigate potential for mooring fee to cover maintenance costs ☐ Improve international marketing to the tourism sector in collaboration with BTB	1 – 5 1 – 2 1 – 5 1 – 2 1 - 5	▪ Financial needs assessment for GRMR ▪ Financial Sustainability Plan ▪ % of activities in Financial Sustainability Plan that are successfully implemented ▪ Agreements for strategic partnerships that reduce operational costs ▪ Report on feasibility of charging a mooring fee ▪ Annual investment in marketing GRMR
MAP 4: Commercial Fishing Use	**Timeframe**	**Measuring Success Indicators**
☐ Continue permitting fishers for Managed Access Area 8 based on recommendations from the Area 8 Managed Access Committee	1 - 5	▪ # permits issues for Area 8 fishers ▪ # fishers using GRMR
MAP 5: Partnership Relations	**Timeframe**	**Measuring Success Indicators**
☐ Maintain and strengthen collaborative partnership with Coastguard ☐ Strengthen communication and collaboration with Forest Department and Department of the Environment for effective regulation of development within GRMR ☐ Strengthen engagement with landowners on that Atoll, with weekly meetings ☐ Strengthen partnerships and collaboration with tour companies ☐ Strengthen partnership with BTB for improved marketing of GRMR	1 – 5	▪ £ joint patrols with Coastguard ▪ Strategic plan for effective communication and collaboration with Forest Department and DoE ▪ % of landowners / managers considered informed and engaged ▪ Number of meetings per year with caye owners / managers ▪ % tour companies considered informed and engaged

Management and Administration Program		
MAP 6: Information Technology	**Timeframe**	**Measuring Success Indicators**
☐ Maintain database of surveillance and enforcement information ☐ Maintain database of GIS data, research and monitoring information for ease of access and to enhance the level of coordination between researchers, help identify gaps in information, and to provide a platform from which the results can be communicated to a wider audience	1 – 5 1 - 5	▪ Database of surveillance and enforcement information ▪ Database of research and monitoring information

3.4.6 INFRASTRUCTURE, OPERATIONS AND MAINTENANCE PROGRAM

The Facility Operations and Maintenance Program covers maintenance of present infrastructure such as buildings and docks, construction of new infrastructure, and purchase and maintenance of equipment.

Infrastructure, Operations and Maintenance

- *Administration and Operational Infrastructure*
- *Tourism Infrastructure*
- *Fleet Operations and Management*

During the 5-year management planning period, priorities include:

- Construction of the new GRMR Fisheries Base, with space for equipment storage
- Construction of a floating base for improved surveillance of Northeast Point
- Improved communication – radio and internet
- Construction and equipping of Information Centre, facilitating on-site entrance fee payment, an additional resource for tour guides, improved transfer of information and an on-site gift shop
- Improve in-water tourism infrastructure – marker buoys for demarcating navigational channels and mooring buoys in key visitor use sites
- Ensure all program areas have the equipment for effective operations

Infrastructure, Operations and Maintenance Program		
IOMP 1: Administration and Operational Infrastructure	**Timeframe**	**Measuring Success Indicators**
☐ Construction and maintenance of the new GRMR Headquarters, with office space for Coastguards	1 – 2 1 – 2	▪ Completed GRMR headquarters ▪ Equipped office, kitchen and accommodation
☐ Equipping of Headquarters – office, kitchen, accommodation and store room	1 – 2	
☐ Develop agreement for construction of overnight facilities on Northeast Caye	1 – 3	▪ Agreement for use of north east caye site
☐ Construction and equipping of floating base camp near Northeast Point	1 – 5	▪ Construction of overnight floating base
☐ Ensure GRMR is equipped for effective surveillance and enforcement activities – including but not limited to appropriate boat engine, SMART system, GPS, night patrol lights, first aid kit, freezer	1 – 5	▪ Equipment needs assessment report per program ▪ % of surveillance and enforcement equipment identified in needs assessment that has been acquired
☐ Ensure GRMR is equipped for effective monitoring activities – including but not limited to dive equipment, compressor, water quality monitoring equipment	1 – 5	▪ % of research and monitoring equipment identified in needs assessment that has been acquired
☐ Ensure adequate demarcation of Marine Reserve zones through installation and maintenance of marine reserve marker buoys		▪ % required zone demarcation buoys in place
IOMP 2: Tourism Infrastructure	**Timeframe**	**Measuring Success Indicators**
☐ Ensure key navigational routes are marked clearly by marker buoys	1 – 5	▪ % key navigational routes clearly marked by marker buoys
☐ Ensure safe swimming areas adjacent to cayes identified by tourism sector that are marked by marker buoys	1 – 5 1 – 5	▪ % safe swimming areas clearly marked by marker buoys
☐ Ensure key boat mooring sites have adequate mooring buoys		
☐ Maintenance of buoys	1 – 5	▪ % required mooring buoys installed and maintained
☐ Equip Information Centre at Middle Caye and rotate interpretive displays		
☐ Ensure required signage is in place on cayes	1 – 2 1 - 2	▪ % of Visitor Interpretive information and equipment that is in place / installed ▪ % key signage installed and maintained

Infrastructure, Operations and Maintenance Program		
IOMP 3: Fleet Operation and Maintenance	**Timeframe**	**Measuring Success Indicators**
☐ Maintenance and, when necessary, replacement of patrol vessel ☐ Maintenance and, when necessary, replacement of research and monitoring vessel ☐ Maintenance and, when necessary, replacement of vehicle for outreach and engagement activities ☐ Ensure adequate fuel allocation for effective operations in all program areas	1 – 5 1 – 5 1 – 5 1 - 5	▪ Operational patrol vessel that is adequate for the task ▪ Operational research and monitoring vessel that is adequate for the task ▪ Operational vehicle that is adequate for the task ▪ % Scheduled maintenance activities per vessel and vehicle that have been implemented ▪ % of required fuel for effective operations that has been allocated to GRMR

3.5 MONITORING, EVALUATION AND REVIEW

The Management Program matrices form the basis of an implementation plan, and indicated the time frame for each of the management activities, as well as indicators to guide monitoring and evaluation of plan implementation. In the development of this management plan, the action areas are relatively specific, simplifying the process of monitoring success of implementation, and providing a mechanism for continual tracking of management activities, through annual review by the Fisheries Department.

The management plan should not be considered as static, and the annual review should ensure that strategies and activities are still relevant for the changing socio-economic and climatic contexts. Some management strategies may become obsolete, whilst new management activities may need to be included.

3.5.1 MONITORING, EVALUATION AND REVIEW

Monitoring and review of the management plan and the Annual Work Plans is essential in order to ensure that management is effective in achieving its objectives. This can be achieved through use of a 'measures of success' framework. An annual rapid assessment of management effectiveness should be conducted, with a baseline established ideally just before the first year of management plan implementation, using the national indicators for management effectiveness (Young et al., 2005; revised Walker and Walker, 2009, revised Walker, 2019).

An example of the Monitoring and Evaluation Framework has been developed for the management plan, composed of four tracking matrices, to be used for tracking implementation, outputs outcomes and national impacts of the management programme activities. These matrices have been developed to facilitate the annual review process. Time should be taken to complete each one fully and as accurately as possible at the end of each year, and gaps / further actions identified to improve success. If this is maintained on an annual basis, it will feed directly into the development of Operational Plans and greatly facilitate any management staff transition handover.

Included is an example of the suggested structure for the three Measures of Success matrices (Tables 36, 37, 38 and 39).

Table 36: Natural Resource Management Program - Implementation							
Measure of Success of Implementation							
N.B. It is important to note that the numerical values ascribed to the measures of success are not scores, but indicators of the stage of implementation	**1** No improvement on present status						**Comments:** Justification for Measure of Success score. Problems, concerns. Notes for inclusion in updated Management Plan
	2 Planning has started, but no implementation						
	3 Planning is completed, but no implementation						
	4 Implementation is started, but not yet completed						
	5 Implementation is completed or ongoing (continuous activities), activity has succeeded						
Management Activities	**Measure of Success**						
	Year						
Activity	**1**	**2**	**3**	**4**	**5**	**Desired Status (Outcome and Impact)**	
Surveillance and Enforcement							
Ensure surveillance activities are strategic and effective, based on GRMR enforcement data, incidence mapping and identification of hotspots, key times, key offending boats (both tourism and fishing), transboundary, and with integration of SMART technology, supporting Managed Access						Patrols are effective, targeted, strategic and intelligence-based. Improved integration of informed, improved patrol effort at hotspots with reduced infractions and improved catch	***Current Status:*** Surveillance end enforcement would benefit from strengthening, with further training in use of SMART and more effective analysis of SMART data to identify hotspots. Improved equipment.
Expand surveillance activities to include caye development and environmental impacts within GRMR, in collaboration with DoE and BTB						Caye development is within the ICZMP guidelines and follows best practices	***Current Status:*** Limited surveillance of caye development, but there are weekly meetings with caye owners / managers that keep a two-way flow of information

Table 37: Natural Resource Management Program - OUTPUT								
Measure of Success of Output								
		1 0 – 25% achieved						
		2 26 – 50% achieved						
		3 51 – 75% achieved						
		4 76 – 99% achieved						
		5 100% achieved – completed or ongoing satisfactorily						
Management Activities		**Measure of Success**						**Comments:** Justification for Measure of Success score. Problems, concerns. Notes for inclusion in updated Management Plan
		Year						
		2019	**2020**	**2021**	**2022**	**2023**	**Desired Status (Output)**	
Surveillance and Enforcement								
A1	Ensure surveillance activities are strategic and effective, based on GRMR enforcement data, incidence mapping and identification of hotspots, key times, key offending boats (both tourism and fishing), transboundary, and with integration of SMART technology, supporting Managed Access	4					Patrols are effective, targeted, strategic and intelligence-based. Improved integration of informed, improved patrol effort at hotspots with reduced infractions and improved catch	The majority of the rangers are fully trained for effective surveillance and enforcement. Funding has been located to train the remaining rangers (including newly recruited). Patrols are frequent and information-based guided by mapping of hotspots and use of SMART / drones. Some illegal fishing still occurring, particularly at spawning aggregation sites
A2	Expand surveillance activities to include caye development and environmental impacts within GRMR, in collaboration with DoE and BTB	3					Caye development is within the ICZMP guidelines and follows best practices	A baseline on caye infrastructure was developed in 2015 (Maaz, 2015). Collaborative partnerships are being established with DoE and BTB

Table 38: Natural Resource Management Program - OUTCOME								
Measure of Success of Outcome								
		1 0 – 25% achieved						
		2 26 – 50% achieved						
		3 51 – 75% achieved						
		4 76 – 99% achieved						
		5 100% achieved –or ongoing satisfactorily						
Management Activities			**Measure of Success**					**Comments:** Justification for Measure of Success score. Problems, concerns. Notes for inclusion in updated Management Plan
			Year					
Activity		**Desired Outcome**	**2020**	**2021**	**2022**	**2023**		
Surveillance and Enforcement								
A1	Ensure surveillance activities are strategic and effective, based on GRMR enforcement data, incidence mapping and identification of hotspots, key times, key offending boats (both tourism and fishing), transboundary, and with integration of SMART technology, supporting Managed Access	Increased viability of conservation targets	2					Commercial fish species are rated as FAIR, with a very low biomass. Managed Access is resulting in improved fisher stewardship, but incursions still occur. Minimal monitoring of tourism impacts or enforcement of tourism regulations.
A2	Expand surveillance activities to include caye development and environmental impacts within GRMR, in collaboration with DoE and BTB							Need to improve ability to impact illegal coastal development impacts / collaborate with DoE / BTB.

Table 39: Natural Resource Management Program - IMPACT							
Measure of IMPACT							
	1 No contribution to national NBSAP Targets						
	2 A small contribution to national NBSAP Targets						
	3 A medium-level contribution to national NBSAP Targets						
	4 A significant contribution to national NBSAP Targets						
Management Activities		**Measure of Impact**					**Comments:** Justification for Measure of Success score. Problems, concerns.
		Year					
Activity	**NBSAP TARGET**	**2019**	**2020**	**2021**	**2022**	**2023**	
Surveillance and Enforcement							
Ensure surveillance activities are strategic and effective, based on GRMR enforcement data, incidence mapping and identification of hotspots, key times, key offending boats (both tourism and fishing), transboundary, and with integration of SMART technology, supporting Managed Access	TARGET B1. By 2020 primary extractive natural resource use in terrestrial, freshwater and marine environments is guided by sustainable management plans, with improved biodiversity sustainability	3					Surveillance and enforcement efforts are targeted and somewhat effective in managing the fishery – still need zones for more effective enforcement. **RELEVANT ACTIONS** *B1.1 Strengthen effective management and monitoring of natural resource extraction in the terrestrial, freshwater and marine environments by the regulatory agencies* *B1.2 Strengthen enforcement of natural resource extraction legislation and regulation* *B1.3 Develop /strengthen and implement sustainable natural resource use management plans and permitting systems*
Expand surveillance activities to include caye development and environmental impacts within GRMR, in collaboration with DoE and BTB							

3.6 TIMELINE

The five year timeline provides guidance for implementation of the management plan, but should be considered adaptable, as the management context changes over the years. The timeline also provides a framework against which implementation effectiveness can be measured, to ensure orderly and planned implementation of activities throughout the management plan period (Table 40).

The annual work plan and budget should be developed from the timeline by the Marine Manager at the end of each year, a process that should be in collaboration with the GRMR staff and other Program managers, to ensure that cross-cutting strategies such as Environmental Education and Sustainable Development are aligned with and support the site-specific management activities for GRMR.

Table 40: Example: Natural Resource Management Program						
Management Activity	**Notes**	**Year**				
		1st	**2nd**	**3rd**	**4th**	**5th**
Surveillance and Enforcement						
Ensure surveillance activities are strategic and effective, based on GRMR enforcement data, incidence mapping and identification of hotspots, key times, key offending boats (both tourism and fishing), transboundary, and with integration of SMART technology, supporting Managed Access	**Responsible:** Ecosystem Management Unit Reserve Manager					
Expand surveillance activities to include caye development and environmental impacts within GRMR, in collaboration with DoE and BTB	**Responsible:** Ecosystem Management Unit Reserve Manager					
Maintain and strengthen collaborative partnership with the Belize Coastguard for armed patrols in GRMR, with clearly defined roles and responsibilities	**Responsible:** Ecosystem Management Unit Reserve Manager					
Strengthen communication and collaboration mechanisms with Forest Department and the Department of the Environment for enforcement of new Mangrove Regulations	**Responsible:** Ecosystem Management Unit Reserve Manager					
Implement effective enforcement of visitor regulations in GRMR, in collaboration with BTB (e.g. tour guide-guest ratios, licenses, visitor qualifications for diving etc.) and enforcement of site-specific zone regulations regarding jet skis, catch and release fishing etc.	**Responsible:** Ecosystem Management Unit Reserve Manager					

4. IMPLEMENTING THE PLAN

The following outline presents the first steps towards implementing the management plan.

At the Start of the Management Plan Period

1. Develop the timeline for all programme areas and activities (Table 40)

2. Develop the four Measures of Success tables for all program areas and activities, identifying relevant indicators, to provide a baseline (Tables 36; 37; 38 and 39)

3. Identify those activities scheduled for implementation in the first year and develop the first annual workplan

4. Implement the Annual Workplan

At the End of the First Year…

1. Update the M+E Framework tables for all program areas and activities, and develop a summary report of results and recommendations for integration into the next Annual Workplan and / or adaptation of the management plan

2. Review the workplan, and identify challenges and adaptive strategies, for inclusion in the next workplan (this should be a participatory exercise)

3. Update the status of the indicators and develop a report on the outputs, to be integrated into the Annual Report

4. Identify those activities scheduled for implementation in the second year and develop the second annual workplan, also incorporating adaptive strategies from the workplan review

5. Implement the second Annual Workplan

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