



Management Plan
Half Moon Caye Natural Monument
and
Blue Hole Natural Monument

2017 - 2021





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**Half Moon Caye Natural Monument
Blue Hole Natural Monument
Management Plan 2017 - 2021**

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Introduction

Background and Context

Lighthouse Reef Atoll lies approximately 80km east of the coast of mainland Belize. It is one of four unique atolls in the Mesoamerican Caribbean Reef system, and considered exceptional for its diversity and reef health. Two of Belize's most famous marine protected areas – the Blue Hole Natural Monument and Half Moon Caye Natural Monument - are located on the Atoll. Famed for their scenic beauty, geological features and the rich diversity of marine life they protect, they are important for Belize's economy, providing important tourism destinations that draw international divers and nature-lovers to Belize, whilst also providing replenishment zones that support the traditional fishermen using the adjacent waters of the Atoll. Both are considered important components of not only Belize's marine protected areas system, but also global conservation efforts. This is recognized in their designation as two of seven protected areas that, together, form the Belize Barrier Reef Reserve System – World Heritage Site (UNESCO, 1996), based on their high biological importance and unique geological formations.

Located at UTM 442999 East; 1902099 North, Half Moon Caye Natural Monument consists of both terrestrial and marine components within a total reserve

HALF MOON CAYE NATURAL MONUMENT

Size: 9,771 acres (3,954 ha)

Statutory Instrument: SI 30 of 1982

Spawning Aggregation Site: SI 162 of 2003

IUCN Category: II

Management Authority: Forest Department

Co-management Partner: Belize Audubon Society (BAS)



Location: Half Moon Caye Natural Monument lies on the south eastern point of Lighthouse Reef Atoll, the most easterly of Belize's three Atolls

Uses: Non-extractive – tourism, education and research

Facilities (2015): Ranger's Station, pier, research accommodation, gift shop, visitor centre picnic tables, bathrooms, showers, camping area, kitchen

Visitation (2015): 13860 visitors

On-site Staff (2015): 1 Senior Site Manager, 1 Assistant Site Manager, 3 rangers, 1 coxswain, 1 Assistant Biologist, supported by technical and administrative staff in the BAS office in Belize City

BLUE HOLE NATURAL MONUMENT

Size: 1,023 acres (414 ha)

Statutory Instrument: SI 96 of 1996

IUCN Category: III

Management Authority: Forest Department

Co-management Partner: Belize Audubon Society (BAS)

Location: Blue Hole Natural Monument lies on the Lighthouse Reef Atoll platform, the most easterly of Belize's three Atolls

Uses: Non-extractive – tourism, education and research

Facilities (2009): Mooring buoys. Supported by Half Moon Caye facilities

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area of approximately 9,700 acres (3,926 hectares). The caye itself (41.5 acres / 16.8 hectares in size) was first declared as a protected area in 1928 in recognition of its importance for the nesting colony of white-phase red-footed boobies, along with a large number of magnificent frigatebirds. The caye is also important for representation of littoral forest, one of the most threatened ecosystems in Belize. The south-east facing beach on Half Moon Caye is important for sea turtles - loggerhead, green and hawksbill turtles have all been recorded nesting here. The reef, including the spectacular Half Moon Caye wall (where the Atoll walls drop away into the deeper water), is highlighted for the density and diversity of both corals and fish, leading to its identification as one of Belize's most highly valued dive sites (Tour guide consultations, 2015). Where the wall changes direction, forming an 'elbow', environmental conditions promote the occurrence of one of Belize's regionally important fish spawning aggregation sites.

Eight miles to the north, at UTM 443519; 1914493 lies the 1,023 acre (414 hectare) Blue Hole Natural Monument. Designated in 1996 to protect the geological formations found within the sinkhole – the Blue Hole attracts divers from all over the world to Belize for the opportunity to explore the unique features.

Between them, Half Moon Caye and Blue Hole Natural Monuments provide protection for at least forty eight species of concern under the IUCN Redlist program (Rated as Critically Endangered, Endangered or Vulnerable).

With its distance from the mainland, Lighthouse Reef Atoll has been recognized in the past for having some of the least impacted reef areas in the region. Despite this, coral reef health has been increasingly impacted by rising water temperatures, coral disease, increased macroalgal cover, unsustainable fishing practices and invasive lionfish.

Half Moon Caye and Blue Hole Natural Monuments are both designated as Natural Monuments under the National Parks System Act (1981) (revised as the National Protected Systems Act, 2015), based on their role in...

..protecting and preserving natural resources and nationally significant natural features of special interest and unique characteristics to provide opportunities for interpretation, education, research and public appreciation for the benefit of current and future generations, within a functional conservation area.

The two protected areas each have their own co-management agreements between Belize Audubon Society and the Forest Department of the Government of Belize, but are managed as a single unit, with a single management plan This management plan has been developed for Belize Audubon Society, as the co-management body, to guide management activities for the next five years (2017 – 2021).

Broad management objectives for Blue Hole and Half Moon Caye Natural Monuments, in the Lighthouse Reef seascape

Protection of Biodiversity

- Building capacity in stakeholders for participation in management, through education, public awareness and collaboration
- Providing protection for the littoral forest and the red-footed booby colony of Half Moon Caye
- Providing protection for nesting marine turtles
- Protecting the unique geological karst features of the Blue Hole, an underwater sinkhole
- Providing opportunities for scientific research in near-pristine reef conditions

Maintenance of Commercial Fish Stocks

- Providing commercial marine species of Lighthouse Reef with a refuge from harvesting activities through the continued designation of both protected areas as non-extractive replenishment zones
- Enhancing local and regional fish stocks and protection of marine habitats critical to lifecycle stages such as spawning, juvenile rearing and feeding, promoting increased recruitment and spill over of adults and juveniles into adjacent areas,
- Protecting an important spawning aggregation site, to enhance reproductive capacity, particularly of commercial fish species

Building Stakeholder Support and Benefits

- Providing two well-managed tourism resources – two of the most popular dive destinations in Belize, for the benefit of Belize’s tour guides and tourism industry

Purpose and Scope of Management Plan

This Management Plan, the second for these two sites, has been developed by Belize Audubon Society, the co-management partner, in compliance with the co-management agreement with the Belize Forest Department, the management authority. It is designed to guide Belize Audubon Society through the next five years, providing a framework for both broad management activities as well as more specific research and monitoring activities. The planning process for the revision of the management plan also required a widened scope, assessing issues not only in the Natural Monuments, but across the Atoll, in recognition of connectivity across protected area boundaries, in the larger seascape.

The Plan includes information on the physical and biological attributes of the two Natural Monuments, based on past and current research conducted in the area, ranging from the original descriptive analysis of the Lighthouse Atoll (Stoddart, 1962) to the recent megafauna assessments by MAR Alliance (Graham, 2015). It documents the legislative framework, current uses, summarises outputs of the conservation planning revision process, and integrates the climate change assessment outputs. It identifies the management challenges, as well as defining the goals and objectives of management. It also outlines specific management programs, sets in place the means for measuring management effectiveness, and recommends an implementation schedule.

In line with the National Protected Areas Policy and System Plan, this Plan reflects the participatory approach to management being adopted in Belize today. This has been achieved with the input of key stakeholders of the Atoll, through focal group meetings, interviews with a wide variety of individuals (including key fishing and tourism stakeholders), HMCNM-BHNM staff (both at management and field level), focused questionnaires targeted at the fishermen using Lighthouse Reef (particularly of Copper Bank, Chunox and Sarteneja), and input from the Lighthouse Reef Advisory Committee.

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.



Section One

Current Status

1. Current Status

1.1 Location

Both Half Moon Caye and Blue Hole Natural Monuments are located within Lighthouse Reef Atoll, the furthest of three atolls from the mainland coast of the Central American country of Belize. Lighthouse Reef Atoll is approximately 80 kilometers east-south-east of Belize City (Maps 1, 2 and 3). Whilst separated from the main portion of the Belize Barrier Reef, these two protected areas are considered part of this important natural feature.



Map 1: The three atolls of the Belize Barrier Reef (Google Earth)

Access to both protected areas is by sea, though there is a small private airstrip on Northern Two Caye, to the north of the Atoll. Private helicopter transfer is also available from the mainland.

The main stakeholders of the Atoll are the tourism industry, based primarily from the mainland, San Pedro and Caye Caulker, and the fishing industry, based from the northern fishing communities of Copper Bank, Chunox and Sarteneja. Whilst there are no communities on the Atoll, there are three tourism developments on Long Caye - Itza Lodge Resort, Huracan Diving Lodge and Calypso Beach Retreat – focusing on diving, snorkeling and, to a lesser extent, sport fishing. These resorts support a small

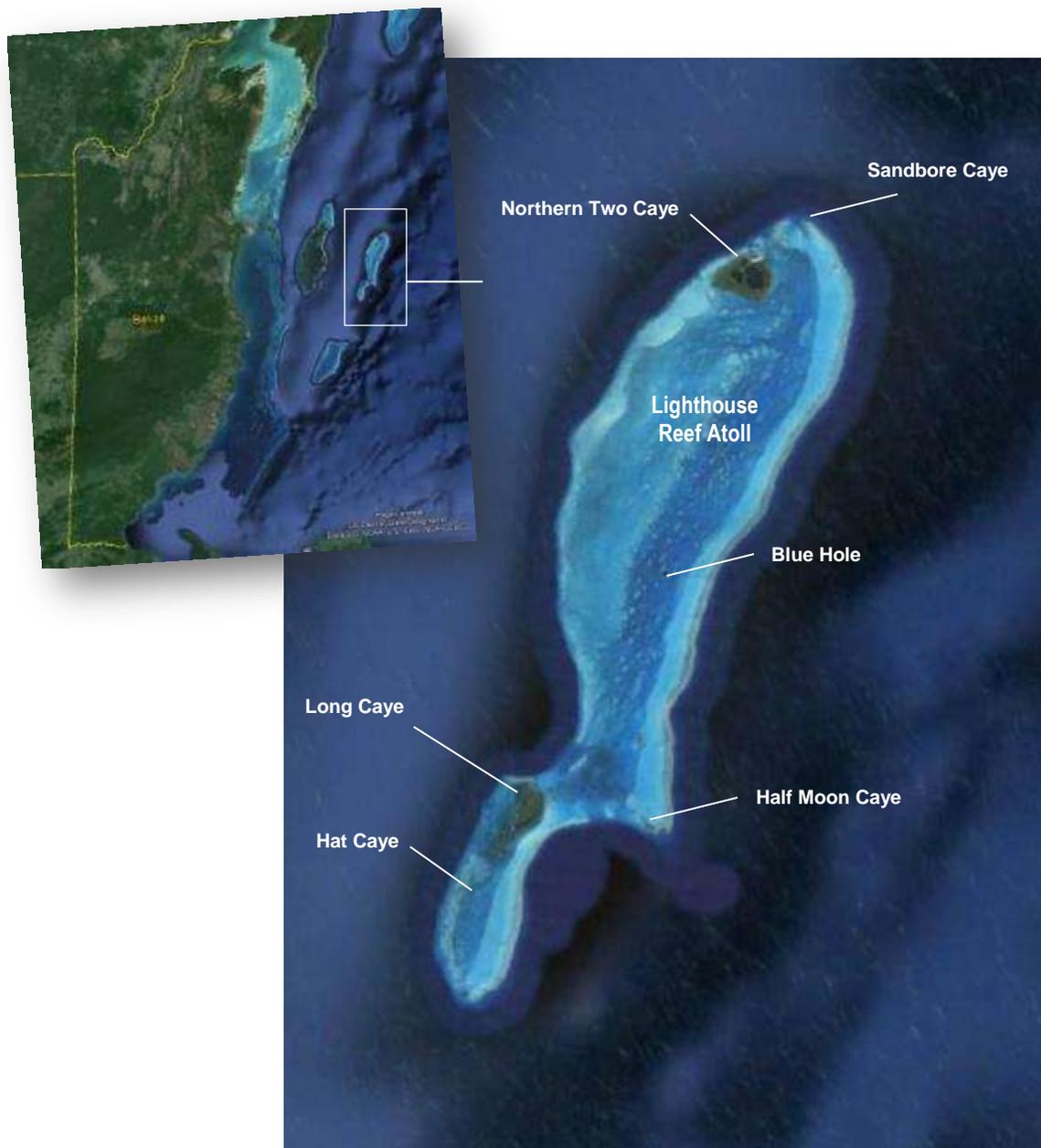
number of resident employees. Private house lots are also situated on the cayes.

The Belize Audubon Society base on Half Moon Caye accommodates 6 staff members, and provides a seasonal base for Island Expeditions - a tented camp of up to 20 visitors and staff. The

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caye is a key focus of the majority of tourism activities - generally day trips from Caye Caulker or San Pedro, with additional tour operations based out of some of the other cayes, Turneffe Atoll, Belize City, and Placencia. The Atoll is also visited by live-aboard dive boats.

Two lighthouses provide warnings for ships in the adjacent shipping lane, preventing groundings on the reef. Both are supported by the Belize Port Authority, though day to day maintenance of the first, on Half Moon Caye, is now the responsibility of the Belize Audubon Society. The second, on Sandbore Caye, is to the north of the Atoll, and is managed by two resident lighthouse keepers employed directly by the Belize Port Authority.



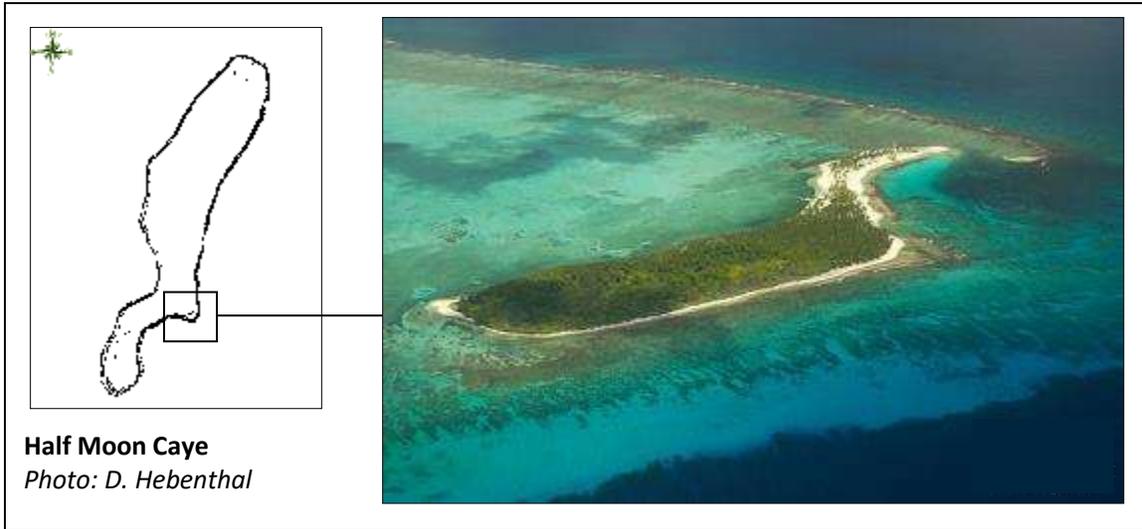
Map 2: Location of Lighthouse Reef and Associated Cayes (Google Earth, 2015)

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Map 3: Location of Half Moon Caye and Blue Hole Natural Monuments, and spawning aggregation sites on Lighthouse Reef (NPAS, 2014; Google Earth, 2015)

1.1.1 Half Moon Caye Natural Monument



The location of Half Moon Caye Natural Monument within Belize is defined by Statutory Instrument 30 of 1982:

ALL THAT PIECE or parcel of land and sea lying and being part of Light House Reef and the Caribbean Sea and containing Half Moon Caye in the country of Belize and bounded on the North by another portion of Light House Reef and the Caribbean Sea, on the East by the Caribbean Sea, on the South by the Caribbean Sea, on the West by the said Caribbean Sea and another portion of Light House Reef and containing approximately 9,700 acres

Boundaries as defined by the Half Moon Caye Natural Monument Statutory Instrument 30 of 1982				
Location	Latitude Longitude		UTM	
North West Corner	17° 14'	87° 34'	439740	1905300
North East Corner	17° 14'	87° 30'	446840	1905300
South East Corner	17° 11'	87° 30'	446840	1899800
South West Corner	17° 11'	87° 34'	439740	1899800

Table 1: Boundaries as defined by the Half Moon Caye Natural Monument Statutory Instrument 30 of 1982

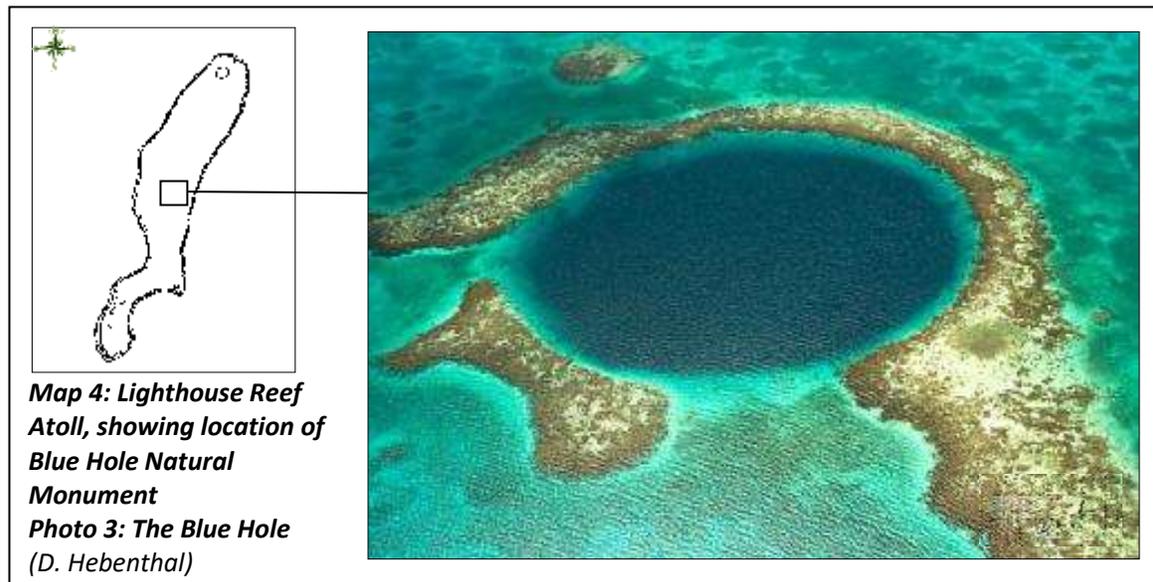
A survey of the literature and geo-spatial data shows some confusion as to the location of both the protected area and Half Moon Caye itself, dependent on the data set used. Therefore, for the purposes of this management plan, the reference points for the protected area have been replotted from the original definitions within the 1982 Statutory Instrument. A new shape file

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for the caye itself was also generated, during the 2008 management planning process. However, this is still to be lodged with the Lands Information Centre (LIC, 2015).

Half Moon Caye acts as the operational headquarters for management of both Half Moon Caye and the Blue Hole, with new facilities for housing wardens, research accommodation, visitors' center, picnic area, bathroom facilities and campground. There are also docking facilities for the visiting dive boats, and permanent mooring buoys at the main dive sites along Half Moon Wall.

1.1.2 Blue Hole Natural Monument



The location of the Blue Hole Natural Monument within Belize is defined by Statutory Instrument SI 96 of 1996:

ALL THAT portion of the Caribbean Sea comprising approximately 1,023 acres and situate within the Lighthouse Reef Atoll being part thereof...

which defines the boundaries as follows:

Boundaries as defined by the Blue Hole Natural Monument SI 96 of 1996		
Location	UTM Coordinates	
North West Corner	442 350 E	1915 425 N
North East Corner	444 650 E	1915 425 N
South East Corner	444 650 E	1913 625 N
South West Corner	442 350 E	1913 625 N

Table 2: Boundaries as defined by the Blue Hole Natural Monument Statutory Instrument 96 of 1996

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Blue Hole Natural Monument includes no land and has no visitor facilities other than the mooring buoys provided for the dive boats. The primary focus is on diving the sinkhole. Visitors generally include both Blue Hole and Half Moon Caye within their itineraries, with Half Moon Caye providing basic visitor facilities.



- 1. Ranger Station
- 2. Interpretive Centre
- 3. Dock
- 4. Bathroom Facilities
- 5. Kitchen Facilities
- 6. Camping Area
- 7. Bird Platform

Facilities at Half Moon Caye Natural Monument

1.2 Regional and International Context

Half Moon Caye and Blue Hole Natural Monuments are both considered important components of the Mesoamerican Reef (MAR), the second largest barrier reef system on Earth, and an assemblage of ecosystems of remarkable biodiversity and beauty, as well as great scientific and economic value. The MAR stretches from the southern Yucatan in Mexico to the Bay Islands in Honduras, stabilizing and protecting coastal landscapes, maintaining coastal water quality, sustaining species of commercial importance, and providing opportunities for employment in the fishing and tourism industries for nearly two million people living in coastal areas (Global Environment Facility, 2001; Healthy Reefs, 2015). This reef system is included on a global list of 18 richest centers of endemism and has been highlighted as one of the areas most threatened by human impacts (Roberts et al., 2002). It is also important for many species of global conservation concern, among them the critically endangered hawksbill turtle (*Eretmochelys imbricata*) and goliath grouper (*Epinephelus itajara*), as well as the endangered green and loggerhead turtles (*Chelonia mydas* and *Caretta caretta*).

Belize has an estimated 1,668 km² of the Mesoamerican Reef within its waters (GCRMN, 2013), and at one point was recognized for having the lowest average incidence of coral disease in the region (Wilkinson, 2002). Studies have shown that nearly two-thirds of coral reefs are threatened by human activities (World Resources Institute, 2004). Belize, with its small population and relatively low coastal development rate, has always been highlighted as having the lowest human impacts in the region – particularly for the offshore Atolls, reflected by a relatively high percentage of live coral cover (BAS, 2016). However, impacts are increasing - quantitative data on fish populations comparing 2002 and 2008 observations on the main Belize reef, for example, indicate a staggering decline in populations and sizes of larger reef fish such as grouper, snapper, and triggerfish (Mumby, 2009). More recent studies show that this trend has continued. In the past fifty years, there has been a greater than 50% decline in living corals throughout the Wider Caribbean (GCRMN, 2013), including Belize. Whilst Lighthouse Reef has seen similar declines in coral health to coastal areas, its isolation from many of the stresses associated with proximity to the mainland, facing the majority of other reefs in the area, makes it less vulnerable and more resilient, increasing its importance in the maintenance of regional reef biodiversity, increasing the importance of protection of the two Natural Monuments, with effective management in place.

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 has a commitment to ensuring it has measures in place to protect biodiversity, with promotion of sustainable use, contributing to the 2011 – 2020 CBD strategic goals of the Convention. In 1983, Belize signed the **Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region** (the 'Cartagena

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Convention’), with the primary objective of protecting the ecosystems of the marine environment, based on the regional importance of the Mesoamerican Reef System.

Under the **Convention Concerning the Protection of the World Cultural and Natural Heritage**, Half Moon Caye and Blue Hole are two of a serial nomination of seven sites that were designated in 1996 as components of the Belize Barrier Reef Reserve System - World Heritage Site (Table 3). These seven sites are seen as representative of the Belize Barrier Reef under criteria (iii), based on the classic examples of fringing, barrier and atoll reef types, and in recognition of their global value.

In 2009, however, 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 protected areas of 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 status was upheld at the recent sitting of the WHS Committee (2016), as Belize is still to comply with the required actions for reducing threats to the reef.

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.

From: Belize Statement of Outstanding Value, BBRRS World Heritage Site (Draft), 2011

The Protected Areas of the Belize Barrier Reef Reserve System World Heritage Site	
Site	IUCN Category
Bacalar Chico National Park and Marine Reserve	II (National Park)
Laughing Bird Caye National Park	II (National Park)
Half Moon Caye Natural Monument	II (Natural Monument)
Blue Hole Natural Monument	III (Natural Monument)
Glover’s Reef Marine Reserve	IV (Habitat/Species Management Area)
South Water Caye Marine Reserve	IV (Habitat/Species Management Area)
Sapodilla Cayes Marine Reserve	IV (Habitat/Species Management Area)

Table 3: The Seven Protected Areas of the Belize Barrier Reef Reserve System World Heritage Site

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International Conventions and Agreements of Relevance to Blue Hole Natural Monument and Half Moon Caye Natural Monument	
<p>Convention on Biological Diversity (Rio de Janeiro, 1992) Ratified in 1993</p>	<p>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</p> <p><i>Blue Hole and Half Moon Caye Natural Monuments are both important components of Belize’s National Protected Areas System. This revised management plan seeks to ensure better protection of threatened biodiversity, as per Belize’s commitment under the CBD.</i></p> <p><i>The spawning aggregation site of Half Moon Caye is important as an integral part of the National Protected Areas System, managed under an effect management regime. Half Moon Caye Natural Monument</i></p>
<p>Alliance for the Sustainable Development of Central America (ALIDES) (1994)</p>	<p>Regional alliance supporting sustainable development initiatives.</p> <p><i>BAS initiatives within the buffer zone communities of HMCNM-BHNM are targeted at stimulating sustainable economic and environmental development</i></p>
<p>Central American Commission for Environment and Development (CCAD) (1989)</p>	<p>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.</p> <p><i>Belize is working with other ALIDES members towards the implementation of MAR2R, focusing on integrated watershed management for protection of the reef</i></p>
<p>Convention Concerning the Protection of the World Cultural and Natural Heritage (Paris, 1972)</p>	<p>The World Heritage Convention requires parties to take steps to identify, protect and conserve the cultural and natural heritage within their territories.</p> <p><i>Half Moon Caye and the Blue Hole have been accepted as two of seven sites that together comprise Belize’s World Heritage Site under the Convention, based on their unique and exceptional values.</i></p>
<p>International Convention for the Protection and Conservation of Sea Turtles for the Western Hemisphere (December 21st, 1997)</p>	<p>To protected and conserve sea turtle species of the Western Hemisphere</p> <p><i>HMCNM protects one of the few turtle nesting beaches largely unimpacted by human development.</i></p>
<p>The UN Convention on the Law of the Sea (1982)</p>	<p>Establishes a comprehensive framework for issues related to the sea and directly interacts with the Convention on Biodiversity in relation to the Marine Environment.</p> <p><i>Lighthouse Reef Atoll is the eastern-most location in Belize, and is therefore is more affected by oceanic interactions than many other areas of coastal Belize</i></p>

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International Conventions and Agreements of Relevance to Blue Hole Natural Monument and Half Moon Caye Natural Monument	
<p>Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention Cartagena de Indias, Colombia, 1983)</p> <ul style="list-style-type: none"> ▪ 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 (SPA) 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). 	<p>Regional convention with the objective of protecting the marine environment of the Wider Caribbean through promoting sustainable development and preventing pollution. <i>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 the planning and environmental impact assessments of important development projects in order to prevent or reduce harmful impacts within coastal waters. This is achieved through the Integrated Coastal Zone Management Plan (particularly the Lighthouse Reef section), the National Sustainable Tourism Master Plan, enforcement of relevant legislation and the EIA / ECP process.</i></p>

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 MBRS) committed to the development of a 15-year Action Plan – the **Mesoamerican Barrier Reef System Project** - for the conservation and sustainable use of this ecosystem, through the **Tulum Declaration (1997)**. 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.

The role of spawning aggregations adjacent to the atoll are further evidence of the regional importance of Half Moon Caye as breeding areas for commercial fin fish species such as grouper and snapper. Half Moon Caye itself provides a nesting site for marine turtles, important to the

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survival of these marine reptiles within the region. The deeper waters of the “drop off” also provides important habitat for pelagic and migratory species like marlin, sailfish, wahoo, kingfish, tuna (bonito, yellowfin), mackerel, jack (amber, horse-eye, crevalle), and shark.

Reefs in the region have also been affected by several large-scale natural disturbances – the Caribbean-wide die-off of the long-spined sea urchin (*Diadema antillarum*) and near-extinction of the reef-building staghorn and elkhorn corals in 1983. More recently, in 1998, a catastrophic coral bleaching event throughout the region was reported in 2002, caused by increasing surface water temperatures, with subsequent bleaching. Whilst Lighthouse Reef has been affected by these regional issues, its isolation from many of the stresses associated with proximity to the mainland makes it less vulnerable and more resilient, increasing its importance in the maintenance of reef biodiversity. However, even on Lighthouse Reef Atoll, development is occurring on the cayes, and pressure from commercial fishing of fin fish species, lobster and conch is negatively affecting natural population levels.

Half Moon Caye has historically been important for its role as a conch nursery area, with conch and lobster fishing being important extractive activities on the atoll, outside of the protected areas. As a signatory of the **Convention for the Regulation of International Trade of Endangered Species (CITES)**, Belize is obligated to follow the CITES permitting procedures, with a permit required for every individual export of conch (*Strombus gigas*), validated by Customs Department, in order for Belize to ship this product internationally. The Belize Fisheries Department has developed a sustainable use strategy for this species, in order to maintain its export market. However, current reports suggest that much of the conch harvested is undersized, with a need for strengthening of enforcement and increased management of the area, to ensure that conch delivered for export are within the conch extraction size limits. This is being achieved through the roll-out of Managed Access.

Belize is also a signatory to the regional **Treaty of Chaguaramas**, which establishes the Caribbean Community (CARICOM) and the Caribbean Community Single Market and Economy (CSME). Whilst this treaty seeks to open opportunities to all members of CARICOM, amendments exempt its application to the fisheries regime, preserving the status quo of the Fisheries Act, with the fisheries sector limited to access by Belizean nationals only (Edeson et al., 2010). Regional fishery initiatives currently seek to standardize the size limits for lobster across countries, and the timing of open / closed seasons, though this is still an ongoing process.

1.3 National Context

As well as the regional and global importance of ensuring the presence of two effective conservation management areas within possibly one of the most pristine reef areas remaining in the Mesoamerican and Caribbean reef system, Half Moon Caye and Blue Hole Natural Monuments are also important at the national level for their value as a tourism destination –

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they are considered two of the most popular dive sites within Belize, attracting thousands of divers a year to the area, and providing a sustainability mechanism for maintaining not only these two protected areas, but also others under Belize Audubon Society management.

1.3.1 National Planning Strategies

The national goals and objectives for conservation are currently being revised, and revolve around the sustainable use, conservation and protection of Belize's natural resources within the context of sustainable human development. These objectives are implemented through the **National Biodiversity Strategy and Action Plan** (2016), which recognizes the need to mainstream biodiversity across all sectors in Belize, improve integration of biodiversity 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 in 2015) guides system-level and individual protected area management efforts. There is a strong focus on co-management partnerships between the Forest Department and NGO co-management partners, including Belize Audubon Society. The NPAPSP centres on the following policy statement, 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

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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.

Both the National Biodiversity Strategy and Action Plan and the National Protected Areas Policy and System Plan support Belize's Growth and Sustainable Development Plan (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.

Belize's National Protected Areas System

A key goal of the National Protected Areas Policy and System Plan is 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). In the marine environment, in particular, Belize falls short of the CBD targets for ecosystem representation. The greatest gaps are under the various categories of Caribbean Open Sea:

- Caribbean Open Sea – Abyssal is not yet represented within the national ecosystem coverage
- Two other deep water ecosystems (Bathyal and Mesopelagic) have limited coverage, 0.3% and 3.1% respectively. This decreases to 0.2% and 2.9% respectively when including only those areas in replenishment zones (No Take Zones) in the assessment
- Coastal forests (littoral forests) and beach vegetation (Tropical coastal vegetation on very recent sediments, moderately drained), are also under-represented (under the 10% target), and are considered highly vulnerable, lying in areas targeted by tourism development.

Half Moon Caye Natural Monument provides important representation of both deep water and littoral forest ecosystems, and as such is an important component of the National Protected Areas System (NPAS). The Blue Hole Natural Monument, too, provides representation of unique geologic features.

The overall goals of both the National Biodiversity Strategy and the NPAPSP reflect the national objectives - ecological and economic sustainability over the long term, with the development of human and institutional capacity to effectively manage the biodiversity resources within Belize. There are also moves towards decentralisation of the management of these resources, with a strong focus on co-management partnerships, community-based participation and equitable benefit from conservation efforts.

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The **Coastal Zone Management Authority and Institute** was established under the Coastal Zone Management Act for ensuring conservation of the Barrier Reef and other coastal resources, and the planning, management and sustainable development of resources within the coastal zone. The Act does not provide any enforcement capacity (this being through more specific agencies – the Fisheries Dept. (Fisheries Act), the Forest Department (Mangrove Regulations), Department of the Environment (Development regulations) and Geology and Petroleum Department (dredging and oil exploration), but for monitoring, planning and coordination to ensure that activities within the coastal zone are sustainable.

A number of objectives have been identified under **the Integrated Coastal Zone Management Plan** for the Lighthouse Reef Atoll. Whilst this plan focuses on a larger scope than just the two protected areas, it provides the context in which the protected areas operate:

“The management of the Lighthouse Reef Atoll region’s coastal zone must be linked to the goals and aspirations of the people of Belize, particularly the stakeholders of the Lighthouse Reef Atoll. Consequently, it must be intrinsically tied to the socio-economic, cultural and other basic needs of the people of Belize, and their use and demand for land and marine resources. “

The key objectives of the Lighthouse Reef Atoll region guidelines (CZMAI, 2015) are summarized as follows:

1. Protecting the fishing resources and traditional fishing rights, especially for the fisher folk that fish within the region.
2. Promoting orderly and sustainable development, based on suitable land use planning, and with effective development guidelines that will meet the needs of current and future generations
3. Maintaining and protecting on-going and future conservation, recreational and tourism areas and uses
4. Preventing inappropriate high-impact, unsustainable developments that are incompatible with community needs
5. Protecting and preserving significant national and international natural features and ecological biodiversity of special interest or uniqueness that define the character and scientific importance of the Lighthouse Reef Atoll marine ecosystem.
6. Preserving the social and cultural values of the people and communities of the region that are connected to the environment

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7. Fostering and supporting a continued partnership among stakeholders for managing the coastal resources
8. Establishing a framework for regulating the development and use of resource of the region through the continuation of CZMAI’s coastal planning program activities and coastal advisory committee process

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

Principle 1: *Recognition that the Lighthouse Reef Atoll needs special protection and management because of its 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 region by ensuring that proposed development activities do not exceed the carrying capacity of the region*

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*

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 quality of the environment and the need to conserve these qualities is recognised in the MasterPlan, with the sustainable development program providing the framework that will “ensure the NSTMP maintains a balance of 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. For the Lighthouse Reef region, it seeks to constrain development and encourage investment in consolidation of existing tourism resources.

1.3.2 Legal Framework

Both Half Moon Caye and Blue Hole Natural Monuments were created under the National Parks System Act (1981; recently revised as the National Protected Areas System Act), and are two of the four Natural Monuments in Belize, both managed by Belize Audubon Society under a co-management agreement with the Forest Department.

Six key laws have been enacted to protect ecosystems, ecosystem services and biodiversity, contributing to the conservation framework of Belize. The Forest Department is the administration agency for the **National Protected Areas System Act (2015)**, **Forest Act (1927)**, and the **Wildlife Protection Act (1981)**. These three focus on the protection of the environment and natural resources. Both Half Moon Caye and Blue Hole Natural Monuments are designated under the National Parks System Act. The **Wildlife Protection Act (1982)** also falls under the Forest Department, and provides protection for marine turtles, whales and dolphins, with the prohibition of hunting and commercial extraction. This Act is scheduled for revision and significant strengthening in 2016.

The **Fisheries Act (1948)**, 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 requires that artisanal fishers and fishing vessels using the Atoll are licensed annually in order to fish for commercial purposes. This is being further strengthened through the national roll out of Managed Access – a rights based fisheries management regime. The Fisheries Act is currently being revised and updated as the Fisheries Resource Bill. The Belize Fisheries Department, whilst not the authority responsible for Half Moon Caye and Blue Hole Natural Monuments, does provide support to the co-managers, especially in the enforcement of the no-take regulations of the protected areas. Belize Audubon Society is partnering with Fisheries

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 to regulate the fishing industry, and is directly concerned with maintaining sustainable fish stocks and protecting the marine and freshwater environments.

The Wildlife Protection Act (1981)

Provides for the conservation, restoration and development of wildlife and regulation of its use.

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.

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.

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

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Department, providing surveillance and enforcement presence on the remote Atoll and taking an active role in ensuring a smooth roll out for the Managed Access program.

The **Environmental Protection Act (1992)** was enacted under the Department of the Environment with the aim of ensuring that development initiatives within Belize are planned for minimum environmental impact – in the context of Half Moon Caye and Blue Hole Natural Monuments this is particularly important when ensuring that the impacts from development taking place on other cayes within the Lighthouse Reef Atoll are minimized.

The Port Authority is mandated to ensure the safety of navigational channels through navigational aids and has jurisdiction over the lighthouse at Half Moon Caye (**Belize Port Authority Act, revised, 2000**). More recently, its role in the monitoring and maintenance of vessels using navigational channels and the removal of wrecks from the reef has come to the forefront, following the grounding of a cargo vessel on the eastern Lighthouse Reef Atoll reef crest, north of Half Moon Caye, and the downing of a Tropic Air small aircraft. BAS has an MOU with the BPA to monitor and maintain the Lighthouse on Half Moon Caye, boarding of foreign vessels, collection of port dues, and issuance of temporary Boat Master Licenses, to facilitate management of watercraft at Lighthouse Reef.

Whilst the above are the legislative acts most relevant to the Blue Hole and Half Moon Caye Natural Monuments, 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 - including the exploration and extraction of all non-renewable resources, including activities such as dredging for landfill and oil exploration / extraction.

Financial sustainability for protected area and natural resource management is partially addressed at Government level through the development of the Protected Areas Conservation Trust (**PACT Act, 1996; revised 2015**), through a 'conservation tax' of Bz\$7.50 levied on non-residents as they leave the country. This provides a funding mechanism to assist in management and development activities within protected areas.

Regulations, such as the **Forests (Protection of Mangroves) Regulations (1989)** provide for specific protection for mangroves. Marine turtles have been given some protection since the original Fisheries Ordinance in 1940, which provides protection for both the turtles and nest sites. 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)**). Eleven spawning aggregation sites have legislated protection under a serial designation (**SI 161 of 2003**), and are considered vital for the maintenance of Belize's commercial finfish stocks. 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, which can only be caught using 'catch and release' best

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practices. These regulations, however, do not extend to protecting nursery areas or adult habitat – only to the sport fish species themselves. In 2002 a closed season was introduced for the Nassau grouper, during its spawning season in Belize (1st December – 31st March), and Nassau grouper and parrotfish also have greater protection under the **Fisheries (Nassau Grouper and Species Protection) Regulations (S.I. 49 of 2009)**.

Site level legislation: Blue Hole and Half Moon Caye are both Natural Monuments, declared under the National Parks System Act, under the mandate of the Forest Department (Ministry of Forestry, Fisheries and sustainable Development; Table 4).

Protected Areas Categories in Belize		
Category	Purpose	Activities Permitted
Nature Reserve	To protect biological communities or species, and maintain natural processes in an undisturbed state	Research, education
National Park	To protect and preserve natural and scenic values of national significance for the benefit and enjoyment of the general public	Research, education, tourism
Natural Monument	To protect and preserve natural features of national significance.	Research, education, tourism
Wildlife Sanctuary (1)	To protect nationally significant species, biotic communities or physical features.	Research, education, tourism
Wildlife Sanctuary (1)	To protect nationally significant species, biotic communities or physical features, and allow for traditional, sustainable extraction of natural resources	Research, education, tourism, traditional sustainable natural resource extraction
Forest Reserve	To protect forests for management of timber extraction and/or the conservation of soils, watersheds and wildlife resources	Sustainable extraction (timber / NTFP), research, education, tourism
Marine Reserve	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.	Commercial fishing, research, education, tourism
Private Protected Area	To complement the national lands through provision of connectivity, priority species protection, and improved ecosystem representation.	Research, education, tourism, sustainable extraction
Archaeological Reserve	To protect cultural heritage	Research, education, tourism,
Spawning Aggregation Site	To protect spawning aggregation sites	Research, education, tourism,
Special Management Area	To protect biological corridors, critical nesting, roosting or congregation areas requiring active management	Research, education, tourism

Table 4: Protected Area Categories in Belize (NPAPSP. 2015)

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Management policies for the two Natural Monuments are guided by the NPAS Act, which stipulates the type of use permitted in the protected area – in this case, both protected areas are non-extractive, contributing towards the national no-take zones of Belize, and allow for only non-extractive activities – research, education and tourism.

Blue Hole and Half Moon Caye Natural Monuments are two of fourteen marine protected areas within the National Protected Areas System (Table 5). Nine of these are designated under the Fisheries Department (**Fisheries Act, 1948**) as Marine Reserves, the remaining five, including the two Natural Monuments, are administered under Forest Department.

Marine Protected Areas in Belize				
Protected Area	Mgmt. / Co-mgmt	IUCN Category (2012)	SI	Area (Acres)
Bacalar Chico National Park & Marine Reserve	Forest Department Fisheries Dept.	VI	89 of 1986 88 of 1996	11,145.2 15,765.8
Blue Hole Natural Monument	Forest Dept. / BAS	III	96 of 1996	1,023
Caye Caulker Marine Reserve	Fisheries Dept. / FAMRACC	VI	35 of 1998	9,670.2
Corozal Bay Wildlife Sanctuary	Forest Dept. / SACD	VI	48 of 1998	180,508.5
Gladden Spit Marine Reserve	Fisheries Dept. / SEA	VI	95 of 2003	25,978.3
Glover's Reef Marine Reserve	Fisheries Dept.	VI	70 of 1996	86,653
Half Moon Caye Natural Monument	Forest Dept. / BAS	II	30 of 1982	9,771
Hol Chan Marine Reserve and extension	Fisheries Dept.	VI	57 of 1987 18 of 2015	102,400
Laughing Bird Caye National Park	Forest Dept. / SEA	II	94 of 1996	10,119
Port Honduras Marine Reserve	Fisheries Dept. / TIDE	VI	9 of 2000	100,000
Sapodilla Caye Marine Reserve	Fisheries Dept / SEA	VI	117 of 1996	38,594
South Water Caye Marine Reserve	Fisheries Dept.	VI	118 of 1996	117,875
Swallow Caye Wildlife Sanctuary	Forest Dept. / FOSC	IV	102 of 2002	8,972
Turneffe Atoll Marine Reserve	Fisheries Dept / TASA	VI	111 of 2012	325,000

Table 5: Marine Protected Areas of Belize

Two of the eleven Spawning Aggregation Sites known in Belize are protected under SI 161 of 2003 – Sandbore and Half Moon Caye Lighthouse. A third, Northern Two Cayes, has seasonal

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protection for Nassau Grouper (SI 162 of 2003). There is provision for continued fishing by traditional fishermen under special license in some of these sites.

1.3.3 Land Tenure

Half Moon Caye and Blue Hole Natural Monuments are both national protected areas, legally established under the National Parks System Act. Whilst there is no terrestrial component to Blue Hole Natural Monument, Half Moon Caye Natural Monument includes Half Moon Caye itself. Historically, this Caye was divided into a number of privately owned parcels until 1928, when the area supporting the red-footed booby colony was declared a Crown Reserve (Table 6). Over time (and with the encouragement and support of BAS), the majority of the parcels on the caye were incorporated into the protected area through purchase or the cancellation of leases. The lighthouse and the land immediately surrounding it are owned by the Port Authority (Port Authority, pers. com., 2006).

Historical Land Tenure of Half Moon Caye		
Year	Event	Legislation
1928	Red-footed Booby colony declared a Crown Reserve (Lots no. 14,15, and 16 reserved)	
1973	GoB buys lots adjoining Crown Reserve - 11, 12, 13 and 17 from H. Grey-Wilson (but does not reserve them)	
1978	GoB reserves lots 11, 12, 13 and 17	Notice No. 655, Gazetted 19 June, 1978
1978	Lot. 18 leased by H. Grey-Wilson incorporated into Crown Reserve	Notice No. 768, Gazetted 15 July, 1978
1978	Lots 7, 8, 9 and 10, leased by Austin Miller, reserved by GoB	Notice No. 828, Gazetted 5 August, 1978
1979	BAS and GoB purchase and reserve remaining privately held lots 2, 3, 4, 5 and 6 from H. Grey-Wilson for Bz\$30,000 (each sharing 50% the cost). Lot 1 remains with Port Authority	Notice No. 1097, Gazetted 20 October, 1979
1982	Half Moon Caye Natural Monument established – the first protected area in Belize, and the first marine protected area in Central America (BAS, 1997). BAS appointed as co-managers	SI 30 of 1982

Table 6: Historical Land Tenure of Half Moon Caye

Whilst not within the protected areas, the land tenure of the other cayes on the Atoll also has an impact on management of the protected areas, as extensive clearance of the natural vegetation – particularly mangrove – will remove critical habitat for marine species such as parrotfish, and forest vegetation important for resident and migratory birds. With the exception of Half Moon Caye, all the cayes on Lighthouse Reef Atoll are privately owned (Table 7), and the landowners' rights to develop need to be recognized, but also regulated to ensure minimized

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impacts (CZMAI, 2015). This is particularly important in view of the isolated nature of the Atoll, and the critical importance of mangrove ecosystems to the long term health of the reef.

Name of Caye	National		Property		Total Acreage
	Size (Acres)	%	Size (Acres)	%	
Sandbore Caye	0	0	12.0	100	12.0
Hat Caye	NA	0	0.5	100	0.5
Half Moon Caye	45	100	NA	0	45.0
Long Caye	NA	0	620.0	100	620.0
Northern Two Caye	0	0	1100.0	100	1100.0
TOTAL	45		1732.5		1777.5

Table 7: Proportional Land Tenure Status for LHR cayes (CZMAI, 2015)

Sandbore Caye: Sandbore lies in the northwest of the Atoll surrounded by patch reefs and seagrass beds and is considered unstable, experiencing natural shifts in size. Whilst it is privately owned, it is now not considered suitable for future development.

Northern Two Caye: The largest of the Atoll cayes, with an area of 1,100 acres (445 ha). The north-eastern and north-western fringes of the caye are slightly elevated above sea level, and are considered more suited for low impact development. However, the lower areas of lagoons and mangrove marshes play an important role in maintaining the marine biodiversity and reef health of the Atoll, and need to be taken into consideration during the assessment of any EIA for the caye. Lighthouse Reef Resort was once located here.

Long Caye: The northeastern part of Long Caye is able to sustain low-impact development, and the current three resorts are operating under the principles of eco-friendly tourism and environmental best practices. The lagoon area to the south of the caye, however, is critical for the long term maintenance of the Atoll environment.

Hat Caye: A small caye that lies in the south west of the Atoll, Hat Caye is the only caye that remains available for use by fishermen as a fishing camp. The near environment is patch reef, making access difficult, with an environmental sensitivity that would be impacted by even small scale development.

Based on Lighthouse Reef Atoll Coastal Zone Management Guidelines, CZMAI, 2015

1.3.4 Evaluation of Importance

Both Half Moon Caye and Blue Hole Natural Monuments have been designated as components of the Belize Barrier Reef Reserve System - World Heritage Site, in recognition of the uniqueness of their contribution to Belize's reef system, the largest, and possibly the least impacted reef complex in the Atlantic-Caribbean area.

Also highlighted is the remarkable biodiversity and beauty of the two protected areas, and their value as a scientific resource, importance in protecting threatened species, and in providing a management tool for ensuring the continued viability of commercial marine fisheries (WWF, 2002).

Lighthouse Reef Atoll

One of the best-developed coral atolls in Caribbean. A well-developed coral barrier and interior lagoon patch reefs provide habitat for a diverse assemblage of reef fish, lobster, conch, and sportfish (bonefish, permit). Open oceanic influences contribute to fish diversity and presence of pelagic species. Two fish spawning aggregations are present. Unique blue hole provides habitat for sharks and possible unique assemblage of endemic and cryptic species. The whitelined toadfish, a rare and cryptic fish, has been observed here. At least 289 reef fish species are present. Half Moon Caye and Blue Hole Natural Monuments provide no-take replenishment zones.

WWF Ecoregional Conservation Planning for the

Half Moon Caye Natural Monument

Half Moon Caye Natural Monument consists of both terrestrial and marine components, important for not only the threatened species it protects, but also for its contribution towards sustaining commercial fish species - particularly conch stocks, and for its attraction as a tourism destination. The terrestrial component, a 41.5 acre (16.8 ha) sand and rubble cay, supports possibly the only viable breeding colony of white-phase red-footed boobies in the western Caribbean (Jones, pers. com. (2007)). The marine component, approximately 9,727 acres, includes a portion of the

Key Features of Half Moon Caye Natural Monument

- Designated as part of Belize's World Heritage Site
- Important tourism destination
- Furthest Atoll from the coast
- Includes reef wall that drops to 1,000 m – considered to be one of Belize's best dive sites
- Includes a regionally important spawning aggregation site
- Representative littoral forest
- South-east facing beach is important for sea turtles - loggerhead, green and hawksbill turtles
- An important way-point for Neotropical migrants and nesting structure for resident birds, including red footed booby and magnificent frigatebird colony

edge of the Atoll, a reef wall dropping to over 3,000 feet. Being far from the impacts of sedimentation from coastal development, the water clarity is exceptional, attracting many divers from around the world, who come to explore the atoll – particularly the section known as the Half Moon Wall, in the south of the protected area. Here, spur-and-groove, patch and reef

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crest coral formations harbor over 280 species of fish (Kramer and Kramer, 2002), and provide habitats for five critically endangered IUCN red-listed species - staghorn and elkhorn coral, loggerhead and hawksbill turtles, and the goliath grouper.

The sandy beach of the caye itself is an important nesting site for three species of marine turtle – loggerhead, green and the hawksbill turtle. The Atoll drop-off provides ideal conditions for the formation of three large spawning aggregations – one of which (South Point) is within the protected area.

The inclusion in Half Moon Caye Natural Monument of deeper water ecosystems (Bathyal and Mesopelagic) beyond the Atoll shelf, with their limited representation within the NPAS, increases the importance of its contribution to the National Protected Areas System. However, whilst the Bathyal ecosystem covers 58.8% of the protected area, it still only accounts for 0.2% of national representation. The National Replenishment Zone Expansion initiative currently under public consultation, seeks to increase coverage of these under-represented ecosystems through expansion of Half Moon Caye Natural Monument by a provisional further 32.334 ha (TNC, pers. com.). This would fill an important ecosystem gap within the current protected area system, but would also place greater burden on BAS, as the co-management agency. Inclusion of this area within the management scope of the Lighthouse

Threatened Species of Lighthouse Reef Atoll

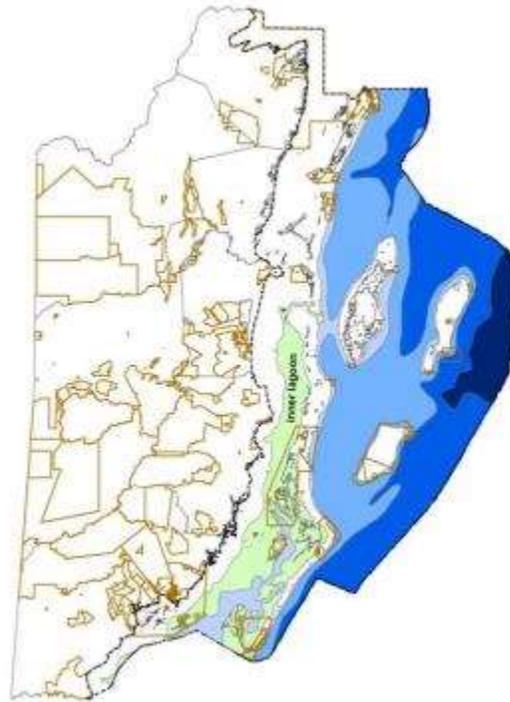
Critically Endangered

Staghorn Coral	<i>Acropora cervicornis</i>
Elkhorn Coral	<i>Acropora palmata</i>
Leatherback Turtle	<i>Dermochelys coriacea</i>
Hawksbill Turtle	<i>Eretmochelys imbricata</i>
Goliath Grouper	<i>Epinephelus itajara</i>

Endangered:

Loggerhead Turtle	<i>Caretta caretta</i>
Green Turtle	<i>Chelonia mydas</i>
Nassau Grouper	<i>Epinephelus striatus</i>
Fire Coral	<i>Millepora striata</i>
Whale Shark	<i>Rhincodon typus</i>
Boulder Star Coral	<i>Montastraea annularis</i>
Star Coral	<i>Montastraea faveolata</i>
Belize Leaf-tailed Gecko	<i>Phyllodactylus insularis</i>
Great Hammerhead	<i>Sphyrna mokarran</i>
Scalloped Hammerhead	<i>Sphyrna lewini</i>

IUCN Red List (2015)



Caribbean Open Sea Ecosystem Representation	% in NPAS	% in RZ	% in HMCNM
Abyssal	0.0%	0.0%	0.0%
Bathyal	0.3%	0.2%	0.2%
Mesopelagic	12.8%	2.9%	0.2%
Coastal shelf	33.0%	7.8%	0.2%

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Reef conservation areas would require revision of the existing management plan as an adaptive management requirement.

The littoral forest is recognized as a critically under represented ecosystem in the NPAPSP gap analysis (Meerman, 2005) and most recently under the NPAPSP Rationalization exercise (Walker et al., 2013). 8.5% lies within the marine protected areas system, but only 2.7% lies within non-extractive zones, the rest being predominantly on privately owned cayes. Littoral forest provides not only nesting sites for the red-footed booby and magnificent frigatebird colony, the original reason for the establishment of the Half Moon Caye Natural Monument, but also for white-crowned pigeons and cinnamon hummingbirds. It also provides an important waypoint for migratory birds. The forest is an important habitat for the endangered Belize leaf-toed gecko, as well as Allison’s anole, two lizard species with very restricted distributions.

Blue Hole Natural Monument

The Blue Hole Natural Monument is known for the large, circular sinkhole, some 300m (1,000 ft) in diameter and 125m (412 ft) in depth, formed an estimated 15,000 years ago in the Pleistocene Era (Jones et. al. 2002). With vertical

Key Features of Blue Hole Natural Monument

- Designated as part of Belize’s World Heritage Site
- Important tourism destination
- Important geological feature - marine sink hole
- Presence of sharks

cliffs and overhanging shelves supporting stalactites, the Blue Hole is considered a global “must dive” necessity for any committed diver, and is one of the best known tourism destinations within Belize, bringing divers from all over the world.

Whilst nowhere near as vibrant as the Half Moon Caye Wall, the shallow water reef that creates the rim of the collapsed cave system, and the adjacent seagrass, support fish and other marine life as a no-take zone, contributing towards the conservation of commercial species such as conch and lobster.

Blue Hole Natural monument also has added scientific value as a huge sediment trap, providing data on past geological events that can be captured through sediment core analysis – rising and falling sea levels, hurricanes, long-term climate change, mercury and arsenic fluctuations and deposition events from African dust clouds (US Geological Survey, 2001).

It has also been highlighted within the WWF Ecoregional planning for the possibility of harboring a “unique assemblage of endemic and cryptic species” within the Blue Hole itself (WWF, 2004).

Environmental Services of the Protected Areas

Whilst the two protected areas themselves are small in size, and therefore limited in the environmental services they provide, they are part of the larger Lighthouse Reef Atoll, with mangrove cayes, coral reefs and seagrass providing key interconnected ecosystems critical to the long term viability of marine resources of the area. The close connectivity of mangroves, whilst not within the protected areas themselves, is vital to maintaining the productivity of the coral reefs and seagrass beds of the central lagoon and Atoll wall. The Atoll provides a number of environmental services, supporting livelihoods and protecting lives:

-
- | | |
|------------------------------------|---|
| Regulation | <ul style="list-style-type: none">▪ First line of protection for Turneffe Atoll and the Belize coastline from storm surges and waves from the east▪ Protection of the barrier reef from oceanic waves, promoting the growth of and maintaining the structural integrity of the central Belize Barrier Reef▪ The reefs of the Atoll produce coral sand and fragments, a major component in the formation of beaches and cayes▪ The prop roots of red mangroves protect the cayes from erosion▪ Seagrass plays an important role in stabilizing the substrate and settling turbidity in the water |
| Recruitment | <ul style="list-style-type: none">▪ The coral reefs provide structure to ensure that there are viable populations of commercial species for subsistence 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▪ At least three spawning aggregation sites lie on the east-facing Atoll wall, important for recruitment of many commercial species (especially grouper and snapper) |
| Cultural and Socio-Economic | <ul style="list-style-type: none">▪ The Atoll has been an important, traditional commercial fishing ground for the Belize capture fisheries industry – particularly for conch▪ Blue Hole and Half Moon Caye are both important resources for tourism and recreation, helping to support Belize’s tourism industry▪ Aesthetic appreciation of the scenic beauty |
| Support | <ul style="list-style-type: none">▪ Coral reefs, seagrass and mangroves play an important role in the cycling of nutrients▪ Coral reefs, seagrass beds and mangroves within the Atoll provide ecosystems necessary for different life stages of commercial and non-commercial species▪ Coral reefs are among the most productive habitats, producing 2,000 decagrams of carbon per square meter per year▪ Seagrass is effective as a CO₂ sink▪ Mangroves provide nesting structure for several bird nesting colonies, as well as the osprey, an important top predator▪ Littoral forest provides important stop-over habitat for migratory bird species |

Ecosystem Services of Lighthouse Reef Atoll (Adapted from UNEP-WCMC, 2006)

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An evaluation of the reef system demonstrated the economic value of Belize’s reef and mangrove to the country (Cooper et. al, 2008). Based on the coastal protection provided by the barrier reef, atolls and mangroves, the support of the fisheries industry and the contribution towards tourism income, the overall value of the reef and mangroves in Belize was estimated at Bz\$790 – \$1,118 million a year (US\$395 - \$559 million a year). Reefs and mangroves also protect coastal properties from erosion and wave-induced damage, providing an estimated US\$231 to US\$347 million in avoided damages per year. In total, reef- and mangrove-associated fisheries are estimated to have a direct economic impact of US\$14 to \$16 million per year (Cooper et. al., 2008). The protective annual value of Turneffe Atoll, to the west, has been estimated at US\$38.3 million, based on the damages avoided from tropical storms though the presence of coral reef and mangrove (Fedler, 2011).

1.3.5 Socio-Economic Context

Belize has a low population currently estimated at approximately 368,300 (Table 8; SIB, 2015), with the lowest population density in Central America, at just over 14.6 persons per sq. km., concentrated primarily within the northern plain, southern coastal plain, Belize Valley and Stann Creek Valley. Much of the remaining country is less suited to habitation, with swampy lowlands and steep terrain in the Maya Mountains. It is a country of many cultures, with Mestizo, Creole, Maya and Garifuna forming the major population groups (Figure 1). The indigenous Maya of Belize are descendants of the original Central American civilization, at its height approximately 2,000 years ago. In general, stakeholder communities of Lighthouse Reef Atoll are the northern coastal communities and northern cayes, settled in the 1850s by Mestizo refugees from the Mexican Caste War. These communities can be categorised based on their primary income – Copper Bank, Chunox and Sarteneja are predominantly fisheries-based, whilst San Pedro and Caye Caulker are tourism focused.

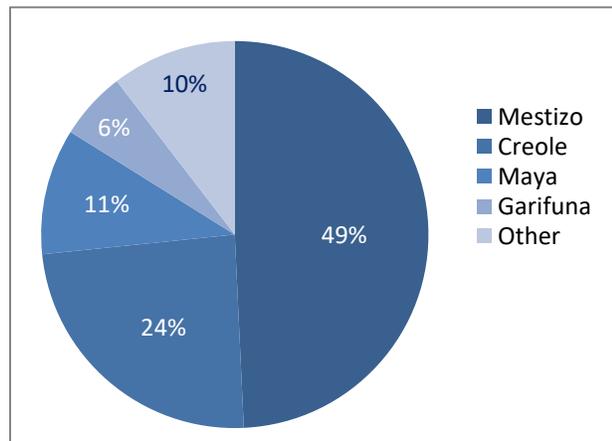


Figure 1: Ethnic Composition of Belize (2010)

Belize Demographic Statistics (Average)	
Population (2015 est.)	368,310
Population density (2015)	14.6/sq. km.
Urban Population (2014)	44.1%
Annual growth rate (2014 est)	1.9%
Life expectancy (2014 est.)	68.5
Below Poverty level	33.5% (2002) 43% (2010)
Death Rate	5.95/ 1,000
Birth Rate (2014 est.)	25.1 / 1,000
Literacy rate (2010)	79.7%
Unemployment rate (2014)	12.1%
GDP (per capita, 2013)	Bz\$8,207.878 per capita
Annual GDP Growth (%)	0.69% (2003)
Ref: UN data, 2010; CIA Factbook, 2015; Ministry of Health Central Bank	

Table 8: Belize Demographic Statistics, (SIB, 2010)

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In 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 2010, 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 – generally those from urban areas who have completed secondary school or have professional training.

The **tourism industry** is the number one foreign exchange earner – an estimated 1,299,100 visitors travelled to Belize in 2015, and whilst approximately 73% of visitors arrived through cruise ship visitation, over 326,000 were overnight visitors (BTB, 2016). 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. Direct tourism expenditure in Belize exceeded Bz\$510 million in 2015 – 14.7% of the total GDP. When indirect contributions are taken into account from related support industries, this rises to 38.6% of the GDP (WTTTC, 2016). In 2015, the tourism industry supports over 18,000 direct jobs – 13.1% of total employment, expanding to 34.8% of total employment when related support industries are taken into account (WTTTC, 2016). Blue Hole and Half Moon Caye are both considered key tourism destinations in Belize (Tour guide consultations, 2015).

Whilst the two Natural Monuments are non-extractive, they play a role an important role in in supporting the **fisheries industry** of Lighthouse Reef, part of a traditional industry that provides employment for over 2,750 fishers (Ministry of Agriculture and Fisheries, 2010). Nationally, the fishery supports an estimated 12,500 Belizeans from 20 communities, with a further 1,000 people involved indirectly in processing and export (Belize Fisheries Department, 2013). In 2014, marine products (including farmed shrimp)

Marine Domestic Exports, 2014	
Capture Fisheries	
Product	Value (Bz\$)
Lobster Tail	13,998,780
Conch	8,534,180
Whole fish	558,190
Aquarium Fish	472,430
Lobster Meat	1,614,840
Crab	86,770
Total	Bz\$113,259,230

Table 9: Marine Domestic Exports, 2014
SIB, 2014

provided the greatest contribution towards domestic exports (18.4%), exceeding Petroleum Products for the first time since 2007 (Table 9; SIB, 2014; Central Bank, 2015).

Economic dependence on the traditional, non-mechanised coastal-shelf fishing industry is high, particularly in the northern coastal communities, with limited options for diversification away from the fishing industry. Alternative job opportunities in many of these coastal communities, particularly those of the north, are limited, with many fishermen leaving primary school to go directly into fishing (SACD, 2009).

Six communities on the Belize mainland have been identified as key stakeholders in the Atoll area, directly through tourism and/or commercial fishing (Table 10; Map 4). Whilst there is no

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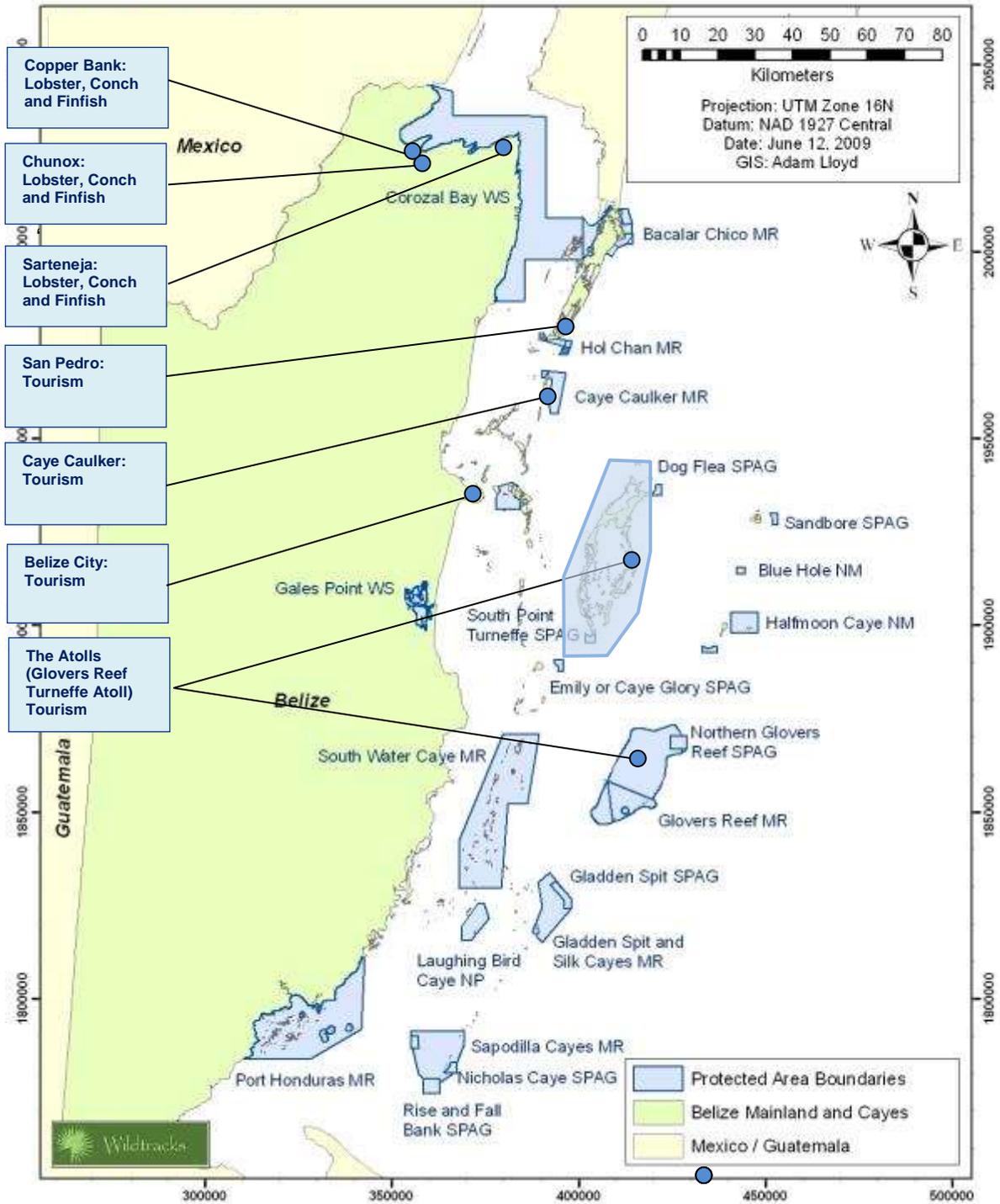
community established on the Atoll itself, there are three all-inclusive resorts operating either seasonally or throughout the year, with residential staff dependent on the overnight tourism visitation.

Stakeholder Communities of Half Moon Caye and Blue Hole Natural Monuments				
Community	Location (UTM) Distance (km)	Population (approx.)	Population components	Comments
Tourism				
San Pedro	E16 0398200 N18 1981250 (Approx. 90 km NW)	11,510	Mestizo	Tourism based economy, embarkation point for majority of visitors to Half Moon caye and Blue Hole Natural Monuments
Caye Caulker	E16 0391450 N18 1961500 (Approx. 80 km NW)	1,800	Mestizo	Tourism based economy, embarkation point for some visitors to Half Moon Caye and Blue Hole Natural Monuments
Belize City	E16 373850 N19 35160 (Approx. 76km NW)	53,532	Multi-cultural	Main port and population center. Tour operators and fishermen using Lighthouse Reef
Fishing				
Chunox	E16 0356500 N18 2023500 (Approx. 149 km NW)	525	Mestizo	Small number of fishing boats, focused on Lighthouse Reef Atoll
Copper Bank	E16 0356700 N18 2026020 (Approx. 151 km NW)	1,400	Mestizo	Small number of fishing boats, focused on Lighthouse Reef Atoll. Largest number of fishermen utilizing natural resources of Lighthouse Reef.
Sarteneja	E16 0378750 N18 2029500 (Approx. 142 km NW)	2,300	Mestizo	Largest fishing community, concentrating on lobster and conch throughout Belize waters

Table 10: Stakeholder Communities of Half Moon Caye and Blue Hole Natural Monuments

Half Moon Caye and Blue Hole Natural Monuments – Management Plan 2017-2021

Primary Stakeholder Communities of Lighthouse Reef



Map 4: Principal Stakeholder Communities of Half Moon Caye and Blue Hole Natural Monuments / Lighthouse Reef

A basic stakeholder analysis identifies respective interests and impacts (Tables 11 and 12).

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Stakeholder	Role
Fisheries Department	Regulates both fishery and spawning aggregation sites towards maximum sustainable yield. Responsible for enforcement of Fisheries legislation, roll out of Managed Access, and protection of sea turtles
Forest Department	Responsible for enforcement of mangrove legislation and protection of American crocodile, dolphins, manatees and whales
Department of the Environment	Responsible for regulation of development activities on the cayes of the Atoll, and the EIA process
Geology and Petroleum Department	Responsible for regulation of dredging and oil exploration / extraction activities
Belize Tourism Board	Uses protected areas – especially marine – to showcase Belize’s natural resources. Encourage visitation
Traditional Fishermen	Have livelihoods based on the marine resources of the area – conch, lobster and finfish.
Fishing Cooperatives	Promote and encourage increased extraction of marine product. Link fishermen with the export market
Caye Developers	Clear terrestrial ecosystems and mangroves to build on cayes of Lighthouse Reef. Clearance of / maintenance of cleared terrestrial ecosystems; some take short cuts that have the potential to impact the environment...including dredging, seawalls, over-water constructions
Tourism Lodges	Provide employment and training in the tourism industry, some follow tourism best practices to variable degrees and provide a venue for environmentally sound interpretation activities for visitors. Clearance of / maintenance of cleared terrestrial ecosystems; some take short cuts that have the potential to impact the environment...including dredging, seawalls, over-water constructions
Tour Guides	Provide interpretation for tourists, and guide visitor behaviour on the reef
Dive operators	Based from Turneffe, Belize City, San Pedro and Caye Caulker. Carry groups to dive, particularly at Blue Hole, Half Moon Caye Wall and the Aquarium. Guide visitor behaviour on the reef
Researchers	Provide information on biodiversity and physical parameters for guiding management. Provide long term monitoring data. Potential impacts on Blue Hole and reef if not following best practices.
Students	Belize and international students learn from field trips to LHR.
Conservation organizations	Lobby for protection of the Atoll, provide technical input and funding
Belize Coast Guard	Responsible for providing security to life and property

Table 11: Key Stakeholders of Lighthouse Reef Atoll

**Half Moon Caye and Blue Hole Natural Monuments – Management Plan
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Table 12: Stakeholder Analysis for Half Moon Caye / Blue Hole Natural Monuments and Lighthouse Reef				
Stakeholder	Influence or Impact of HMCNM-BHNM on Stakeholder		Influence or Impact of Stakeholder on HMCNM-BHNM	
Commercial Fishermen Belize City Sarteneja Chunox Copper Bank	<ul style="list-style-type: none"> ▪ Production of marine products supporting traditional fisheries industry 	+	<ul style="list-style-type: none"> ▪ Some support for effective management of protected area 	+
	<ul style="list-style-type: none"> ▪ Presence of reef and spawning aggregation site for support of local fisheries industry 	+	<ul style="list-style-type: none"> ▪ Low level of cooperation or openly antagonistic towards concept of protected areas 	-
	<ul style="list-style-type: none"> ▪ Potential to conserve marine resources in perpetuity for continued use by future generations 	+	<ul style="list-style-type: none"> ▪ Unsustainable fishing ▪ Illegal fishing within Natural Monuments 	-
	<ul style="list-style-type: none"> ▪ Potential for exclusion from some traditional fishing areas 	-	<ul style="list-style-type: none"> ▪ Anchor damage to reef ▪ Clearance of littoral forest and mangroves for fishing camps ▪ Harvesting of forest products for traps and construction ▪ Poor solid waste management 	-
Tourism Developments on LHR	<ul style="list-style-type: none"> ▪ Presence of Blue Hole, reef, largely intact terrestrial ecosystems and high-value sport fishing resources attract tourism 	+	<ul style="list-style-type: none"> ▪ Generally support the conservation management goals of BAS 	+
	<ul style="list-style-type: none"> ▪ Relatively pristine, wild environment 	+	<ul style="list-style-type: none"> ▪ Generally cooperate and collaborate towards effective management of the area 	+
	<ul style="list-style-type: none"> ▪ Limited development provides ‘exclusivity’ attraction for high end tourism 	+	<ul style="list-style-type: none"> ▪ Provide a potential financial sustainability mechanism for future management of the Atoll 	+
	<ul style="list-style-type: none"> ▪ Several World class diving sites 	+	<ul style="list-style-type: none"> ▪ Potential for negative impacts on environment - clearance of littoral forest and nesting beaches, dredging for access and landfill 	-
	<ul style="list-style-type: none"> ▪ Distance from mainland, deep waters surrounding the Atoll and prevalent currents help maintain high water quality and clarity 	+	<ul style="list-style-type: none"> ▪ Potential for introduction of invasive species (rats / South East Asian house geckos) in building materials and other transported goods 	-
	<ul style="list-style-type: none"> ▪ Environmental qualities of LHR Atoll provide an environment for employment opportunities in tourism 	+	<ul style="list-style-type: none"> ▪ Potential for contamination of ground water and adjacent sea if sewage is not adequately addressed ▪ Potential for increased solid waste if solid waste management is not adequately addressed ▪ Potential for ground water depletion through unsustainable water extraction ▪ Potential to exceed ‘Limits of Acceptable Change’ through poorly regulated levels of visitation 	-

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Table 12: Stakeholder Analysis for Half Moon Caye / Blue Hole Natural Monuments and Lighthouse Reef / 2				
Stakeholder	Influence or Impact of HMCNM-BHNM on Stakeholder		Influence or Impact of Stakeholder on HMCNM-BHNM	
Non-tourism Development on HMCNM-BHNM	<ul style="list-style-type: none"> ▪ Relatively pristine, wild environment ▪ High value real-estate investment potential ▪ Limited development provides ‘exclusivity’ attraction for high end market 	+	<ul style="list-style-type: none"> ▪ Generally support the conservation management goals of LHR Atoll ▪ Cooperation and collaboration towards effective management of the area ▪ Potential for negative impacts on environment - clearance of littoral forest and nesting beaches, dredging for access and landfill ▪ Potential for introduction of invasive species (rats / South East Asian house geckos) in building materials and other transported goods ▪ Potential for contamination of ground water and adjacent sea if sewage is not adequately addressed ▪ Potential for increased solid waste if solid waste management is not adequately addressed 	+
		+		+
		+		-
		+		-
		+		-
		+		-
Tourism Stakeholders (Diving / Snorkeling) Belize City San Pedro LHR resorts	<ul style="list-style-type: none"> ▪ Presence of Blue Hole, reef, spawning aggregation sites and high-value sport fishing resources for tourism and fisheries industries ▪ Income from using HMCNM-BHNM / LHR Atoll for tourism 	+	<ul style="list-style-type: none"> ▪ Support the conservation management goals of BAS ▪ Cooperation and collaboration towards effective management of the area ▪ Adoption of reef tourism Best Practices through awareness and alternative livelihood training ▪ Provide a potential financial sustainability mechanism for future management of the Atoll ▪ If well trained, assist with visitor management within the area through in-depth briefings ▪ If poorly trained, can result in poor visitor management and increased impact on corals and associated fauna, anchor damage etc. ▪ Potential to impact behavior of fish and crocodiles through feeding and other unsustainable / poor tourism practices ▪ Increase the potential for exceeding the carrying capacity ▪ Increased anchor and boat damage to coral and seagrass 	+
		+		+
		+		+
		+		+
		+		+
		+		-
		+		-
		+		-
		+		-
		+		-

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Table 12: Stakeholder Analysis for Half Moon Caye / Blue Hole Natural Monuments and Lighthouse Reef / 3

Stakeholder	Influence or Impact of HMCNM-BHNM on Stakeholder	Influence or Impact of Stakeholder on HMCNM-BHNM
General Belize Public	<ul style="list-style-type: none"> ▪ Production of fish, lobster and conch + ▪ Maintenance of spawning aggregation and commercial fish species + ▪ Protection of Turneffe Atoll and Belize City from storm surges + ▪ Cultural and aesthetic appreciation + ▪ Increased awareness through education + 	<ul style="list-style-type: none"> ▪ Support of the general public will strengthen the position for maintenance as Natural Monuments + ▪ Support of the general public will strengthen the position for reducing development / oil exploration threats in the surrounding seascape + ▪ Lack of support may increase chances for dereservation -
Tourists	<ul style="list-style-type: none"> ▪ Enjoy HMCNM-BHNM / LHR Atoll as a tourism destination + ▪ Benefit from education and awareness opportunities provided by LHR Atoll + 	<ul style="list-style-type: none"> ▪ Entrance fee contributes towards financial sustainability + ▪ Provide marketing nationally and internationally by word of mouth, if happy with level of tourism product + ▪ Presence deters illegal fishing practices within the Atoll + ▪ Potential to increase negative impact on natural values of HMCNM-BHNM / LHR Atoll through poor tourism practices - ▪ Potential to exceed carrying capacity for tourism sites at HMCNM-BHNM / LHR Atoll -
Researchers	<ul style="list-style-type: none"> ▪ Benefit from being based at HMCNM-BHNM / LHR Atoll, at established facilities with access to a virtually pristine reef environment + ▪ Benefit from historic baseline information on past research activities within protected areas + 	<ul style="list-style-type: none"> ▪ Conservation management benefits from data gathered, greater knowledge of marine and terrestrial environments and species within area + ▪ Benefit from increased research activity within area + ▪ Potential impact of research activities on marine environments -
Government of Belize	<ul style="list-style-type: none"> ▪ Provides fish replenishment areas for fishing Industry + ▪ Provides environmental services + ▪ Potential for LHR to be integrated within the National Protected Areas System as a special management area, to facilitate implementation of managed access + ▪ Income generation of significant foreign, tourism based revenue + ▪ Provides tourism and fishery based employment opportunities in stakeholder communities + 	<ul style="list-style-type: none"> ▪ Political support (currently being strengthened through the NPAPSP) + ▪ Limited political support - ▪ Uncertainty of long term future commitment -

1.4 Physical Characteristics

1.4.1 Climate

Weather 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 around Lighthouse Reef Atoll. 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.

Temperature and Rainfall

Climate data is available from Turneffe Flats, 22 kms to the west, providing a baseline for the year 2010 (Hayes, 2011) that can be extrapolated to also characterize the climate of Lighthouse reef Atoll.

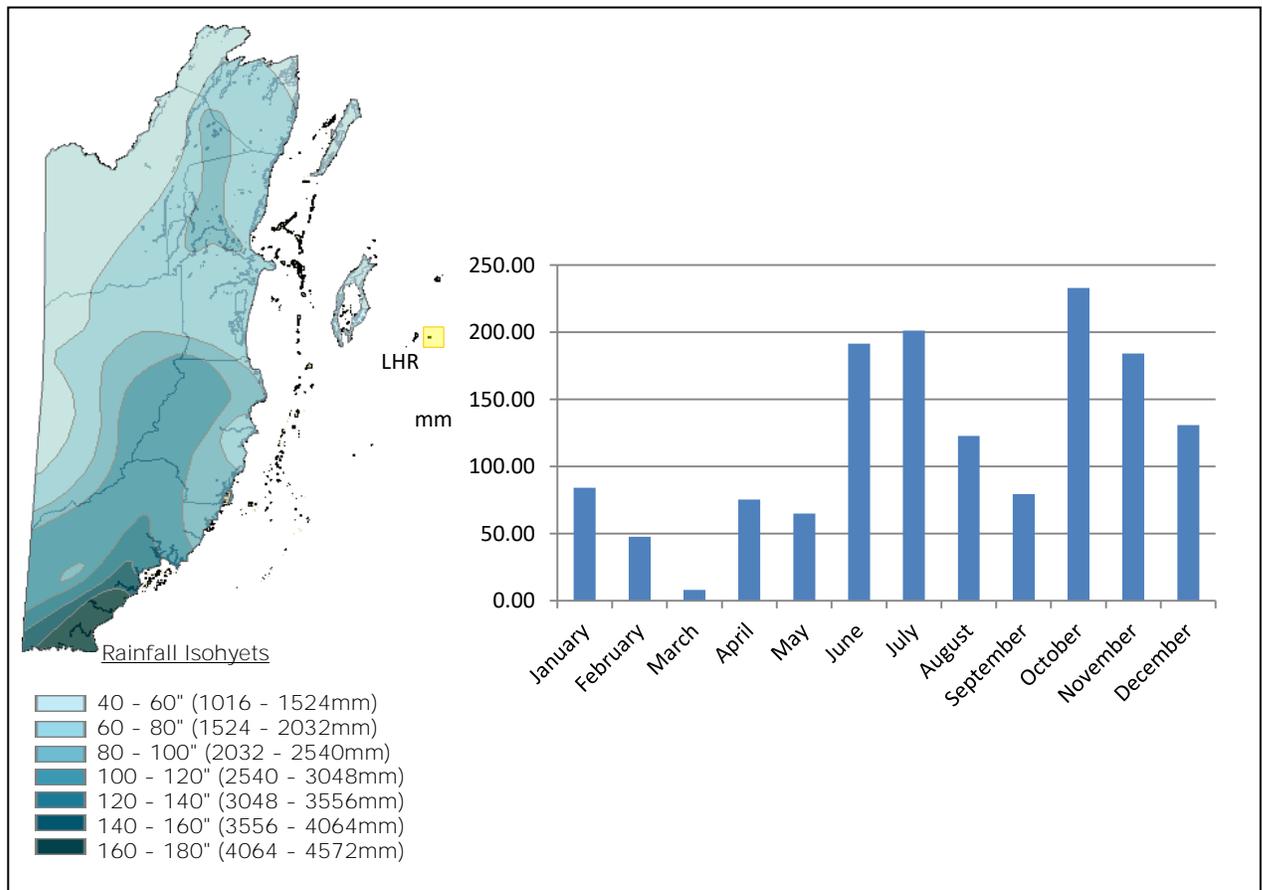


Figure 2: Rainfall in Belize

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As with Turneffe Atoll, Lighthouse Reef Atoll lies within the lowest rainfall belt, with between 100 and 150cm of rain per year (Figure 2). Traditionally, there is a pronounced dry season stretching from January through to the end of May, with total rainfall of 8cm recorded in March, the driest month. This is followed by a wetter season (June to December) with total rainfalls in the region of 200 to 230cm, associated with passing tropical storms, particularly between October and November. This is punctuated by a mini dry season in August / September.

Month	Mean Temperature 2010	Total Rainfall (mm) 2010
January	25.00	84.1
February	25.33	47.8
March	25.39	8.1
April	27.72	75.4
May	28.56	65.0
June	29.39	191.5
July	28.83	201.2
August	29.39	122.7
September	29.33	79.5
October	27.39	232.9
November	26.39	184.2
December	24.39	130.8

Table 13: Mean Temperature and Total Rainfall per month - Turneffe Atoll 2010 (Hayes, 2011)

The annual mean temperature on the adjacent Turneffe Atoll for 2010 is 27.2°C, fluctuating throughout the year from a minimum of 24.4°C in December, during the cold fronts, and maximums in June and August of 29.3°C (Table 13; Hayes, 2011). Whilst these weather patterns have been relatively reliable over many years. They are now changing, with a shift in seasonality, with the dry season extending into June, and the mini-dry, which was traditionally in August, now extending into September.

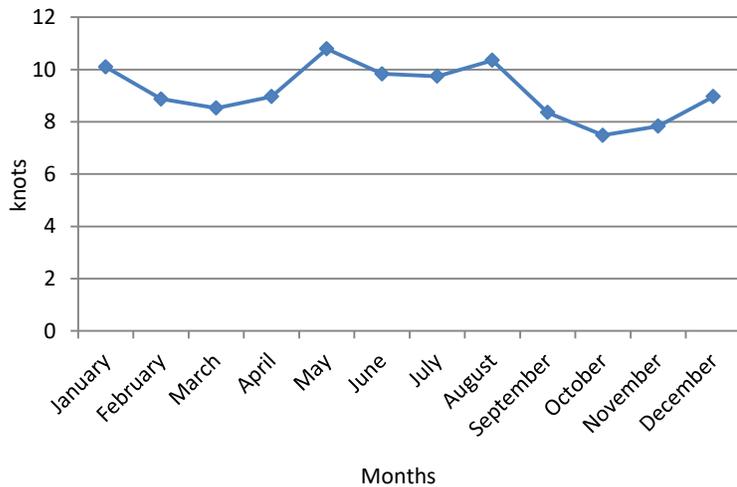
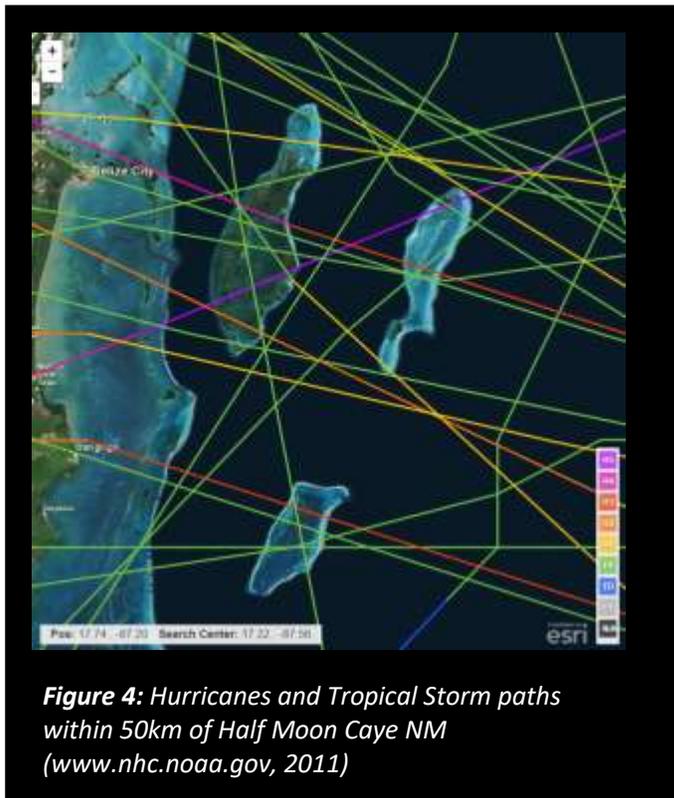


Figure 3: Wind Speed (knots) – Turneffe Atoll 2010 (Hayes, 2011)

Tropical storms affect Belize every year between the beginning of June and end of November, with the effects being felt particularly strongly on the outlying cayes and atolls. 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.



Whilst many hurricanes have very focused paths of destruction, their effects are wide ranging, particularly at sea. Half Moon Caye and Blue Hole Natural Monuments have been affected on an almost annual basis by tropical storms, some of these reaching hurricane strength (Table 11). Of most note are some of the stronger, more recent storms – Hurricane Mitch (1998), Hurricane Keith (2000) and Hurricane Ivan (2004). The destruction of the landing pier during Hurricane Ivan, approximately 900km to the east, and the turbidity experienced after indicates the effects even distant hurricanes can have on the outer atolls.

Historical records identify nine tropical storms / hurricanes that have crossed Lighthouse Reef in the past, as they pass through the Caribbean Sea towards the Yucatan channel. A further fourteen storms / hurricanes came within a 50km radius of Half Moon Caye between 1864 and 2011 (Table 14; NOAA, 2015). A further six hurricanes / tropical storms are identified as having had significant impacts on the Atoll, including Hurricane Mitch in 1998 and Hurricane Iris in 2001, despite not passing within the 50km radius being used in this assessment. Half Moon Caye itself has been shaped and reshaped by hurricanes in the past. Direct effects include the storm surge associated with these events, with a local rise in sea level of several feet washing over the caye, as described for both Hurricanes Abby and Anna (Stoddart, 1962). Depending on the strength of the surge, and the duration of inundation under water, this has the potential to remove vegetation cover, with salt contamination of ground water and soils.

Hurricanes have formed, reshaped and removed the cayes of the Atoll, and had significant impacts on the biodiversity. The bird nesting colony on the more sheltered south facing strand has also suffered from hurricane damage – the colony is reported to have been halved in size after the 1931 hurricane (Cross, 1992), and in 1961, it was almost completely decimated by Hurricane Hattie, the littoral forest average height was reduced from 8m to 4.5m after extensive branch fall, and the littoral forest edge moved back by 23m. 80% or more of the coconut trees were felled (Stoddart, 1963).

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Causing mechanical damage to the coral, hurricanes also stir up the water, reducing 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 of cayes, particularly where mangrove clearance has taken place. The storm will redistribute sand and mud along the reef, filling cavities in the corals, reducing the availability of habitat for reef-living species. Hurricanes can, however, also ameliorate the effects of warming seas, drawing up cooler, deeper water to the surface, and has been shown to reduce water temperatures by as much as 3°C further north, in Florida (Manzello et al., 2007).

Climate Change: Climate change is having a very real impact on the health of the marine environment – with increasing sea temperatures, coral reef health has been declining at an alarming rate, and corals are already at the upper limit of their temperature tolerance, with coral bleaching from elevated water temperatures

rapidly reducing the resilience of the corals. Increasingly strong storms are reshaping cayes, increasing turbidity and impacting reef structure. An assessment of potential climate change impacts is included in Section Two: Conservation Planning.

Name	Cat.	Date Passed <50km of HMC	Proximity / Area hit
Harvey	TS	Aug 21, 2011	35 km south
Richard	H1	Oct 24, 2010	15 km south
Alex	TS	June 26, 2008	Direct (Blue Hole)
Arthur	TS	May 31, 2008	Direct (North tip LHR)
Iris*	H5	Oct 8, 2001	60 km south of LHR
Mitch*	H5	Oct 28, 1998	240km south east
Kyle*	TS	Oct 12, 1996	61 km east of LHR
Hermine	TS	Sept 22, 1980	12km north LHR
Greta	H3	Sept 18,1978	33km south west
Fifi*	H2	Sept 19, 1974	106 km south of LHR
Edith	TS	Sept 11, 1971	Direct (Hat Caye)
Laura	TS	Nov 20, 1971	Direct (Blue Hole)
Hattie	H5	Oct 31, 1961	Direct (North. 2 Cayes)
Anna*	H1	July 24, 1961	82 km south of LHR
Abby*	H1	July 15,1960	70 km south of LHR
Not named	TS	Aug 31, 1945	20 km north
Not named	TS	Oct 23, 1943	10km south of LHR
Not named	TS	Sep 22, 1942	Direct (Mid LHR)
Not named	TS	Sept 20, 1940	6km north west of LHR
Not named	TS	June 8, 1934	20km west
Not named	TS	Sept 30, 1933	45km south of LHR
Not named	TS	Sept 12, 1933	10 km east of LHR
Not named	TS	Sept 10, 1932	7km north of LHR
Not named	TS	Aug 16, 1931	31km south of LHR
Not named	H3	Sept 10, 1931	7km north of LHR
Not named	TS	Sept 16, 1898	12 km north
Not named	H1	July 6, 1893	Direct (north tip LHR)
Not named	H2	Oct 12, 1892	5 km south of LHR
Not named	H1	Aug 31, 1864	4 km north of LHR
TS: Tropical Storm H: Hurricane H1: Category 1: winds > 74 – 95mph H2: Category 2: winds 96 - 110mph H3: Category 3: winds 111 - 130mph, H4: Category 4: winds 131 – 155mph *Whilst these hurricanes did not pass within 50km, they had a huge impact on the reef in the area			

Table 14: Hurricanes Affecting Lighthouse Reef Atoll (<50km)
(www.nhc.noaa.gov, 2011)

1.4.2 Geology

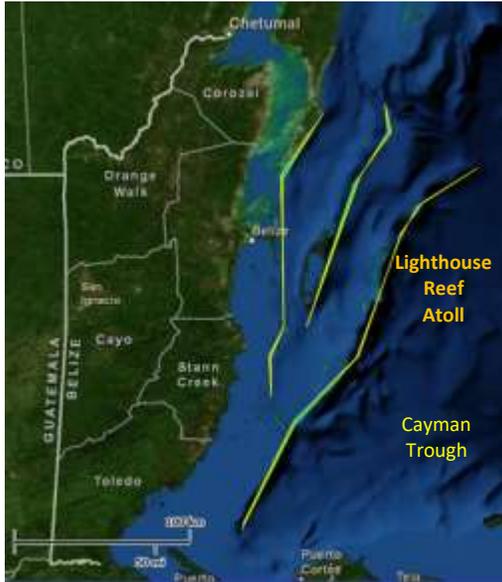


Figure 5: Fault lines / escarpments running parallel to the Belize coastline, forming the base of the barrier reef and atolls (Based on Purdey et al., 2003)

The Belize 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 that ends abruptly on top of the first of three northeast-southwest, tilted escarpments (and associated fault lines) that lie off the coastline. The first escarpment runs parallel to the coast (Figure 5), its ridge supporting an extensive reef system - the Belize Barrier Reef (Rath, 1996). This drops off to the east to a depth of about 1,000 m.

Lighthouse Reef Atoll, the most easterly of the three offshore atolls in Belize, sits on the third of the three tilted submarine escarpments - the furthest from the mainland. This ridge provides the foundation for Lighthouse Reef and Glover's Reef Atolls, and then extends south to eventually intersect the Barrier Reef at Gladden Spit. This

escarpment forms part of the western side of the Cayman Trench (or Bartlett Trough), where it abuts the Central American mainland (Stoddart, 1962). The Trench, which forms part of the tectonic boundary between the North American Plate and the Caribbean Plate, is the deepest part of the Caribbean Sea, with a maximum recorded depth of 7,686m. Lighthouse Reef Atoll is thought to have been formed in an area 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 a carbonate platform surrounded by water that gets progressively deeper to the east, reaching a depth of 4,000m.

Lighthouse Reef Atoll is the smallest of the three off-shore atolls of Belize, covering approximately 200km² (35km long and up to 7.5km wide). It demonstrates typical non-volcanic Atoll formation, with a coral grainstone and coral-red algae-Halimeda grainstone reef crest fringing the Atoll, enclosing the shallow central lagoon, with an area of 112km². 2.9% of the Atoll is land – with six sandy cayes within the lagoon – Northern Two Cayes (Sandbore and Northern Caye), Long, Half Moon, White Pelican and Hat Cayes – of these, only Half Moon Caye has protected status. Charts show the presence of a seventh caye – Saddle Caye (also noted by Stoddart, 1962) – but this no longer exists.

Evidence of the past tectonic activity that gave rise to the major fault blocks can be seen in the north-north-east trend alignment of the two atolls (Lighthouse and Glover's), and of the almost 20km long chain of 'middle reef' patch reefs of the Lighthouse Reef lagoon (Figure 6), which

Half Moon Caye and Blue Hole Natural Monuments – Management Plan 2017-2021

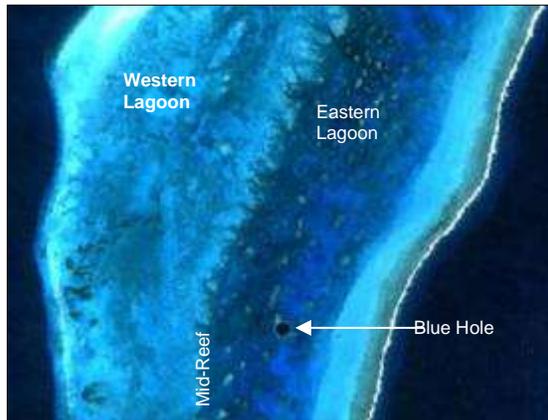


Figure 6: Section of Lighthouse Reef Atoll, showing the Blue Hole, and the linear middle reef separating the western and eastern lagoons

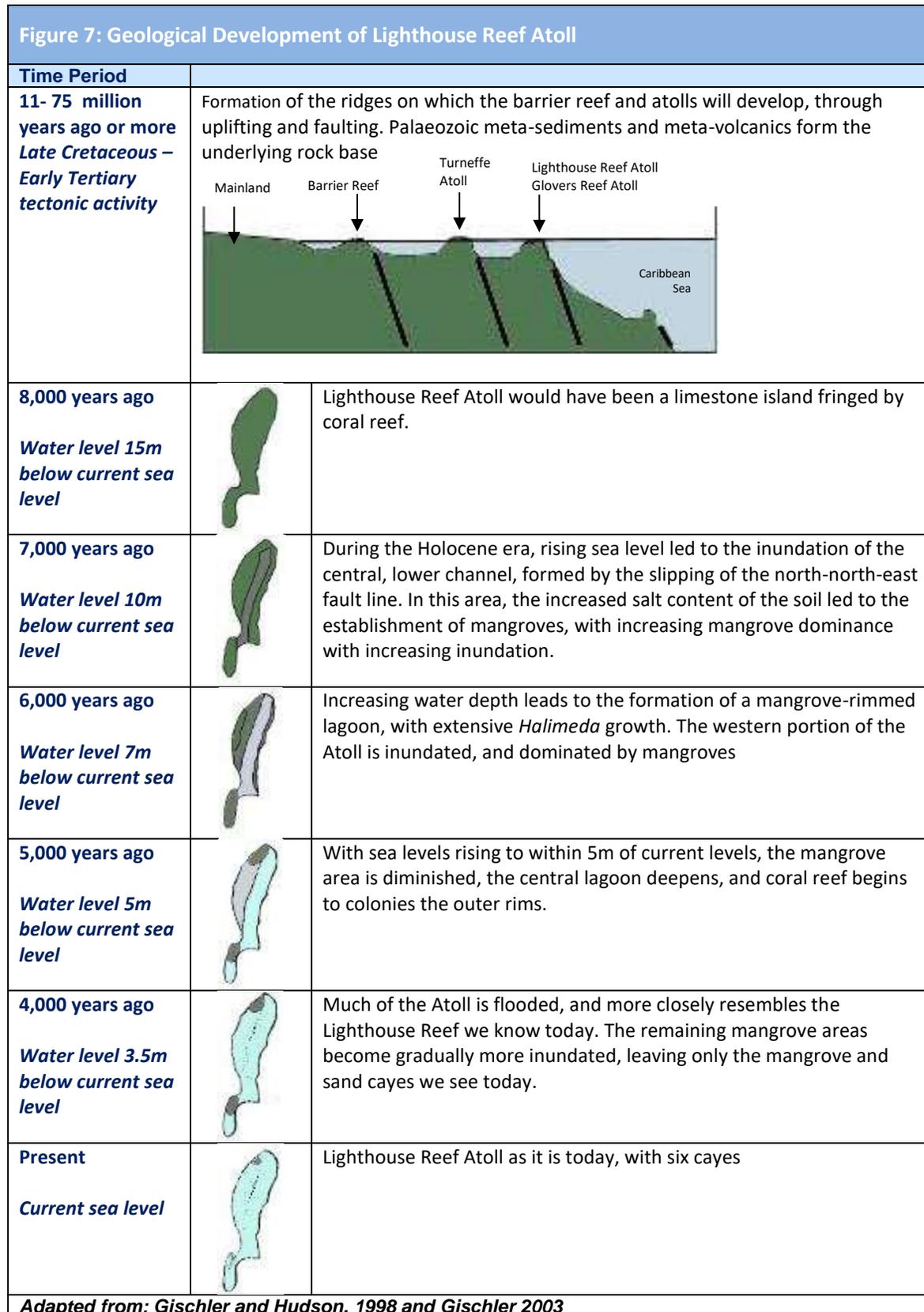
separates the shallow western lagoon (with a maximum depth of 3m) from the deeper eastern lagoon (with a maximum depth of 9m (Jones et. al., 2000)).

The clear water, and the hundreds of patch reefs suggest that the lagoon is well-circulated, sheltered by the spur and groove windward reef, which forms a reef crest – a ridge of living coral separating the reef front from the lagoon.

The leeward rim is discontinuous, with many cuts allowing water circulation and boat passage into the Atoll.

Studies of the development of the Atoll have shown that the surface rock is well cemented Pleistocene limestone karstic bedrock. Underlying this is Late Cretaceous / Early Tertiary rock, with meta-sediments and meta-volcanics, formed over 11 million years ago (Gischler, 2003). Approximately 8,000 years ago, when sea level is thought to have been 15m lower than current levels, evidence suggests that Lighthouse Reef was a limestone island, with a freshwater lens supporting terrestrial vegetation (Figure 7). Development of the Atoll since then has been driven primarily by the rise in sea level.

The Blue Hole has been able to provide a wealth of information on the geological history of the Lighthouse Reef Atoll, supporting theories of changing sea level. The presence of the Blue Hole, with sunken caves in its walls, and the numerous stalactites, a number of stalagmites, and dripstone blankets - structures that form only in the presence of air and percolating freshwater - demonstrate that at one point, this limestone karst rock was at least 125m above sea level (this being the depth of the last recorded karstic feature (Furman and Mattin, 1997). Tectonic activity at one point in the geological history has led to a southward tilting of the formations to an angle of 12° indicated by the spiral patterning and lean on those stalactites formed before this event. More recent stalactites show perpendicular growth form. Concentric rings within the stalactites show a pattern of growth episodes at 153,000, 66,000, 60,000 and 15,000 years ago, tying in with the glacial / interglacial changing sea level cycles. Studies of one of the stalactites collected by the Cousteau team in 1977 show that the most recent transition from exposure to air to submersion in a marine environment took place between 11,500 to 10,200 years ago, with a steady increase in sea level during recent geological time, inundating the Atoll with sea water (Jones et. al., 2000).



Adapted from: Gischler and Hudson, 1998 and Gischler 2003

Soils

Half Moon Caye is the largest simple sand caye on Lighthouse Reef Atoll (and one of the largest in Belize), with a surface of coarse coral-algal sand with a varied, fine coral debris content (Stoddart, 1962). Additional minerals are deposited from sea water spray, and from the organic remains of coral polyps and seaweeds. The eastern section of the island is more or less cleared of natural vegetation, with a sand/humus mix, grading down into pure coral sand, 25 to 30 inches below the soil surface layer, and supporting a low density coconut plantation. The western portion of the island supports littoral forest and beach ground cover, with a soil cover that is much higher in humus content, and with much larger coral debris, forming a higher ridge up to 7 feet above sea level (Stoddart, 1962). Where there is littoral forest cover, the organic content of the soil is higher, especially with the input from guano under the bird colony. However, heavy leaching during rainfall events and the foraging activities by large numbers of hermit crabs has prevented a large build-up of organic material.

Half Moon Caye is susceptible to erosion, particularly during storm events, with the shape and form of beaches changing over time (BAS, 2016). Erosion has occurred mainly on the southeastern part of the caye - the main turtle nesting ground. The strong wave action during hurricanes also results in deposition events – before the 1931 hurricane (even as early as 1775) the southeast facing bay, the location of the marine turtle nesting area, was described as being a sandy beach 20 to 30 yards further seaward than when studied in 1962. There is also documented evidence that the old lighthouse base, built in 1845, was actually constructed on the mid-ridge of the caye (Stoddart, 1962) – more recently, it has been undermined by wave action, with the substantial erosion of the beach, and in 2010, eventually collapsed. Further alteration to the outline of Half Moon Caye occurred in 1998, when the strength of the storm action during Hurricane Mitch, passing to the south, created a new addition to the Caye – Mitch Island – a small pile of coral debris separated from the main body of the Caye by a narrow channel.

1.4.3 Bathymetry

Lighthouse Reef Atoll lies on a limestone platform stretching north-south, formed by slumping of the escarpment ridge during tectonic activity. Depths on the platform range from 0 to 500m. On the 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 1000m. To the south and south west, the ridge continues at a maximum of 500m (Figure 8).

Within the Atoll itself, water depth reaches a maximum of 9m in the deeper eastward lagoon area, and 3m within the shallower westward area. The division between the two is caused by slumping along the north-south mid-axis of the Atoll (Gischler, 2003). Both Blue Hole and Half Moon Caye are situated in the deeper waters of the eastern half of the Atoll.

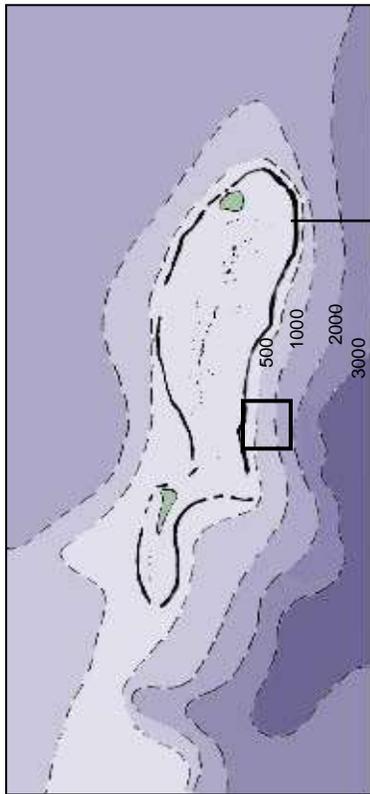


Figure 8: Depth contours (m) adjacent to Lighthouse Reef Atoll. After Gischler, 2003.

Both Natural Monuments have received attention with respect to their bathymetry. A study of the water depth and sea floor topography of the spawning aggregation site at the south east point of Half Moon Caye demonstrates clearly the steep drop off to the south of Half Moon Caye, extending down beyond 1,000m (Figures 8 and 9; Ecochard et.al., 2003).



Figure 9: Bathymetry of spawning aggregation site. Adapted from Ecochard et. al., 2003

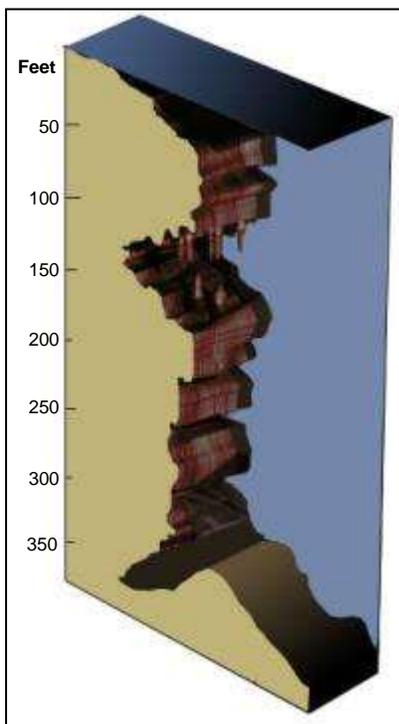


Figure 10: Cross section through Blue Hole, adapted from Furman and Mattin, 1997

The Blue Hole Natural Monument, a natural sink hole with a center depth estimated at 125m (just over 400 feet, has attracted a lot of attention, from the preliminary observations made by Jaques Cousteau in the 1970's to the more in-depth study conducted by the Cambrian Foundation in 1995. This latter study focused on establishing the timeline for rising sea levels during the last ice age, through the analysis of speleotherms and cave formations. Features indicative of past exposure to air, such as flowstone formations, were found down to a depth of 97 meters (320 feet). The bottom of the Blue Hole, is covered in a deep layer of sediment – considered important in geological terms as it is undisturbed by benthic organisms, tides or currents, and therefore provides an uninterrupted history of sediment deposition, with distinct storm layers identified through core analysis (Furman and Mattin, 1997). Near the vertical walls, a ring of higher sediment marks the point where sediment flows in from the edge of the Blue Hole. This slopes steeply towards the wall, where overhanging rock forms a cavern (Figure 10).

The undisturbed, annually layered biogenic carbonate muds sediments and silts at the bottom of the Blue Hole provide a record of events over time. The sedimentation rate has been calculated at an average of 2.5 mm/y, with cores reflecting a history stretching back 1,500 years (Gischler et al., 2008).

1.4.4 Tides and Wave Movement

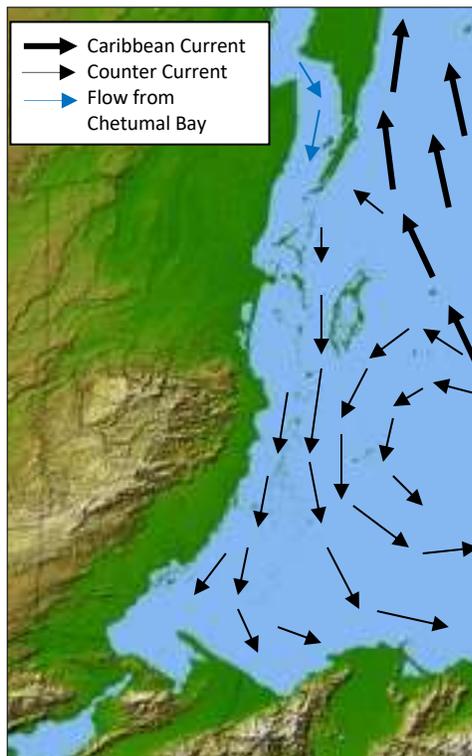


Figure 11: Major Currents of the Belize Reef (after Ezer et al., 2005)

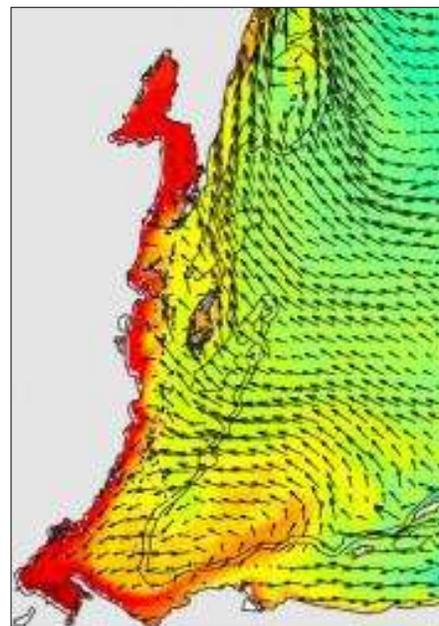


Figure 12: Local Currents of the Belize Reef (Paris et al., 2010)

Knowledge of currents is essential in determining connectivity for larval transport, nutrients and pollutants, as well as for predicting the spread of disease and invasions (demonstrated by the rapid spread of disease in *Diadema antillarum* throughout the Caribbean region in the 1980s). Connectivity through currents has also resulted in the rapid invasion of Belize by lionfish (*Pterois volitans*), which has been increasing in abundance at Lighthouse Reef Atoll, as part of a larger, regional invasion.

On a regional scale, the oceanic, warm-water Caribbean Current forms the main surface circulation in the Caribbean Sea, flowing westwards at an average flow rate of 38 to 43 cm (15 to 17 inches) per second from the Lesser Antilles towards southern Belize. The current then travels northwards offshore, beyond the atolls, and eventually through the Yucatan Channel. This results in a counter clockwise gyre in the Gulf of Honduras area (Figure 11), including much of the coastal waters of Belize, which flows south / southwest, past the Belize coastline and Barrier Reef (Figure 12; Heyman et al., 2000; Stoddart, 1962), in the shelf lagoon and offshore basins (Purdy et al., 1975), with strong currents up to 5 knots in the reef channels especially during low tides.

On a more local scale, and of particular importance for recruitment modelling for coral and fish larvae, the predominant currents around Lighthouse Reef Atoll flow from the east, pushing spawn and larvae from the spawning aggregation sites into the Atoll, with studies suggesting a high level of self-recruitment.

Winds are thought to have a more influential impact on sea level on the Atoll than tides, with wave approach being controlled by the easterly / north-easterly trade winds, from the east-north-east. Within the Atoll lagoon, surface currents generally flow to the southwest, 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 flowing between Lighthouse Reef and Glover’s Reef (Stoddart, 1962).

The surface currents, around the Atoll vary throughout the year, alternating between northerly and easterly, and also often driven by the wind. The north winds produce a south flowing current whilst the easterly winds through much of the rest of the year create a north flowing current. Throughout Belize, the northerly winds are known to depress the water level by as much as a foot for several days at a time – this is true on the atolls as well, and probably has a greater influence on shallow water and reef crest biodiversity than the regular tides, which average less than 0.3m (Stoddart, 1962; Caribbean Coral Ecosystems Program, 2005).

1.4.5 Water Parameters

With water flowing freely between the Atoll and the sea, salinity is thought to be typical of the surrounding marine environment. To date, no formal long term water parameter measurements have taken place within the two protected areas. The most comprehensive water monitoring in adjacent areas in Belize has been conducted by the Caribbean Smithsonian Institute on Carrie Bow Caye. Whilst this field station is 50km south of the southern tip of Lighthouse Reef, it can still be considered the most relevant data set available.

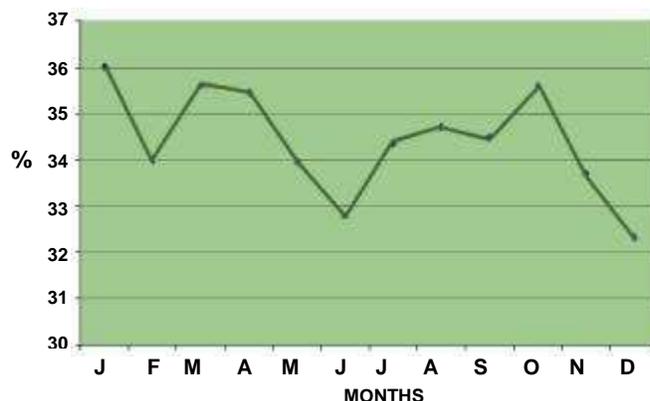


Figure 13: Salinity. Carrie Bow Cay, 2004
Data: Caribbean Coral Reef Ecosystems Program, 2005;
Carrie Bow Cay Meteorological Records, 2002 - 2004

Salinity: Normal seawater salinities of 36‰ (with a variation ranging between 33.0‰ and 37.4‰) have been recorded throughout the Belize continental shelf, including Lighthouse Reef, with slightly lower salinity during the wet season. On the Atoll itself, a series of surface water salinity readings were logged from December 2000 to December 2001, showing that water salinity fluctuated from 37.7‰ to 41.6‰ within the Atoll (Gischler, 2003). This is high, both in levels of maximum salinity and in variation in comparison with readings taken at Glovers Reef Atoll between

October 1966 and May 1967, which ranged from 35.7‰ to 36.1‰ (Gibson, 2003), and Carrie Bow Cay (32.3‰ to 36‰), though this is located closer to shore, and may be influenced by freshwater influx from the mainland (Figure 13).

Water Temperature: Water temperatures logged from December 2000 to December 2001 on the Atoll showed that water temperature fluctuated from 23°C to 31°C. (Gischler, 2003). Readings from Carrie Bow Cay in 2004 show similar fluctuations, ranging from 25.4°C during the north winds in February to 30.3°C in September (Figure 14).

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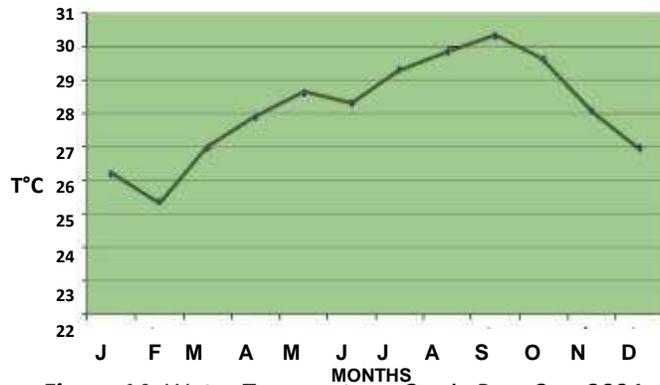


Figure 14: Water Temperature. Carrie Bow Cay, 2004
Data: Caribbean Coral Reef Ecosystems Program, 2005; Carrie Bow Cay Meteorological Records, 2002 - 2004

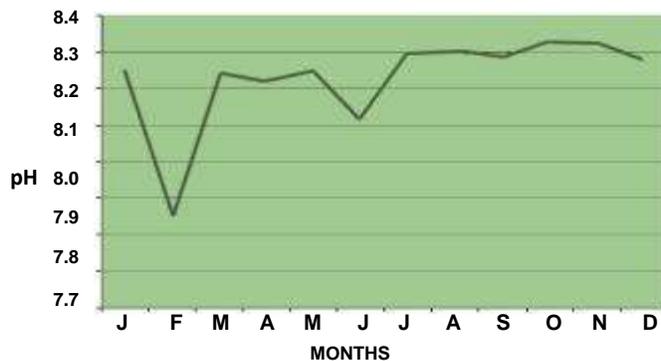


Figure 15: Water pH. Carrie Bow Cay, 2004

Global climate change and the resulting increasing water temperatures are a cause of concern for the continued health of the reef, as predictions suggest that water temperatures will rise in the future. Coral bleaching is thought to be triggered by an increase in water surface temperature of 1.0°C or more above the normal maximum, with a duration of at least two to three days. In September, 2008, Glover’s Reef Atoll reported a temperature high of 32°C, resulting in mass bleaching of corals (Gibson, 2003), an event that extended across the entire Belize reef system, including Lighthouse Reef Atoll.

pH: The pH of water in reef areas in Belize is generally 7.2. The alkaline pH is attributed to the high calcium carbonate saturation along the reef. There is global concern about ocean acidification, with the increasing absorption of carbon dioxide from the atmosphere predicted to inhibit growth of reef builders. Whilst there are natural, annual fluctuations in pH (Figure 15), there is concern that the global increase in acidity due to carbon emissions and

subsequent absorption by the world’s seas will lead to increased stress of the alkali-based coral reef environment. Whilst predictions are not yet considered precise, the process was identified and flagged as long as 40 years ago (Kleypas et al., 2006). Studies in Australia have demonstrated that there has been a 13.3 percent drop in calcification over a twenty year period, (1990 – 2009), an unprecedented decline in the past 400 years (De’ath et al., 2009), and extrapolations suggests that calcification rates may decrease by up to 60% during the 21st century, with ocean pH levels expected to drop by another 0.3 units by 2100.

Turbidity: As Lighthouse Reef Atoll lies far from the mainland, and therefore far from watershed runoff and the associated sediment load, visibility is generally good. The water does get more turbid, however, during ‘northers’ (cold fronts), and can take time to settle after strong tropical storms / hurricanes, as noted by several of the dive boat operators following the effects of Hurricane Ivan.

Sedimentation and agrochemical contamination from mainland watersheds have been highlighted as perhaps one of the greatest impacts on the Belize reef, after climate change. Lighthouse Reef Atoll lies east of three primary watersheds – Northern River, Belize River, Sibun River, and Manatee River, and of the Turneffe Atoll. Following storm events, generally occurring between August and October, the

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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. These events impact water turbidity and quality throughout the coastal waters of Belize, though this seldom extends to Lighthouse Reef Atoll, with its distance from the mainland and the containing effect of the barrier reef (Figure 16; WRI, 2006; Map 7).

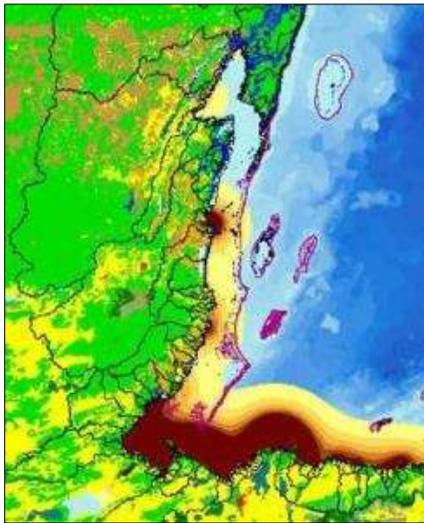


Figure 16: Cherrington, 2011; Based on sediment delivery by watersheds. (Burks and Sugg / WRI, 2006).

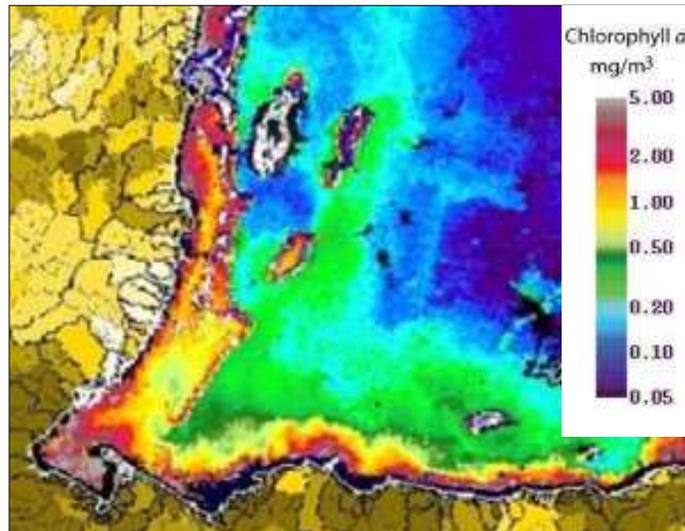


Figure 17: SeaWiFS Chlorophyll α . After Shank et al., 2010/ Soto et al., 2009

Lighthouse Reef is protected from water-borne pollutants from Belize City and the Belize River watershed by the presence of the barrier reef, and can therefore be considered one of the most pristine reefs in Belize, based on water contamination. Sediment core analysis of two sites within the Belize reef system (Turneffe Atoll and Sapodilla Cayes) indicate that sediment and agrochemical runoff onto the reef has increased relatively steadily over time, consistent with historical and current land use trends, though sediment supply to the reef is greater in the south, with its proximity to Honduras. More than 80 percent of sediment, and more than half of all nutrients (both nitrogen and phosphorous) entering the Mesoamerican Reef originate in Honduras (WRI, 2006). An assessment of chlorophyll α (Figure 17; Shank et al., 2010; Soto et al., 2009; WRI/ICRAN, 2006; Andrefouet et al., 2002) demonstrates that a large pulse of river water extends from the Guatemalan and Honduran rivers, stretching to Glover's and Lighthouse Reef Atolls, during major storm events. With the local currents and its location, however, Lighthouse Reef Atoll lies outside the major contamination area except during excessive rainfall.

1.5 Biodiversity

1.5.1 Ecosystems

Lighthouse Reef Atoll is dominated by marine ecosystems – coral reef, seagrass, sparse algae / sand and open sea (Table 15). Five cayes are dotted throughout the Atoll, supporting terrestrial ecosystems with varying levels of human impact. Within the boundaries of the two protected areas, marine ecosystems dominate, with Half Moon Caye being the only representation of terrestrial ecosystems.

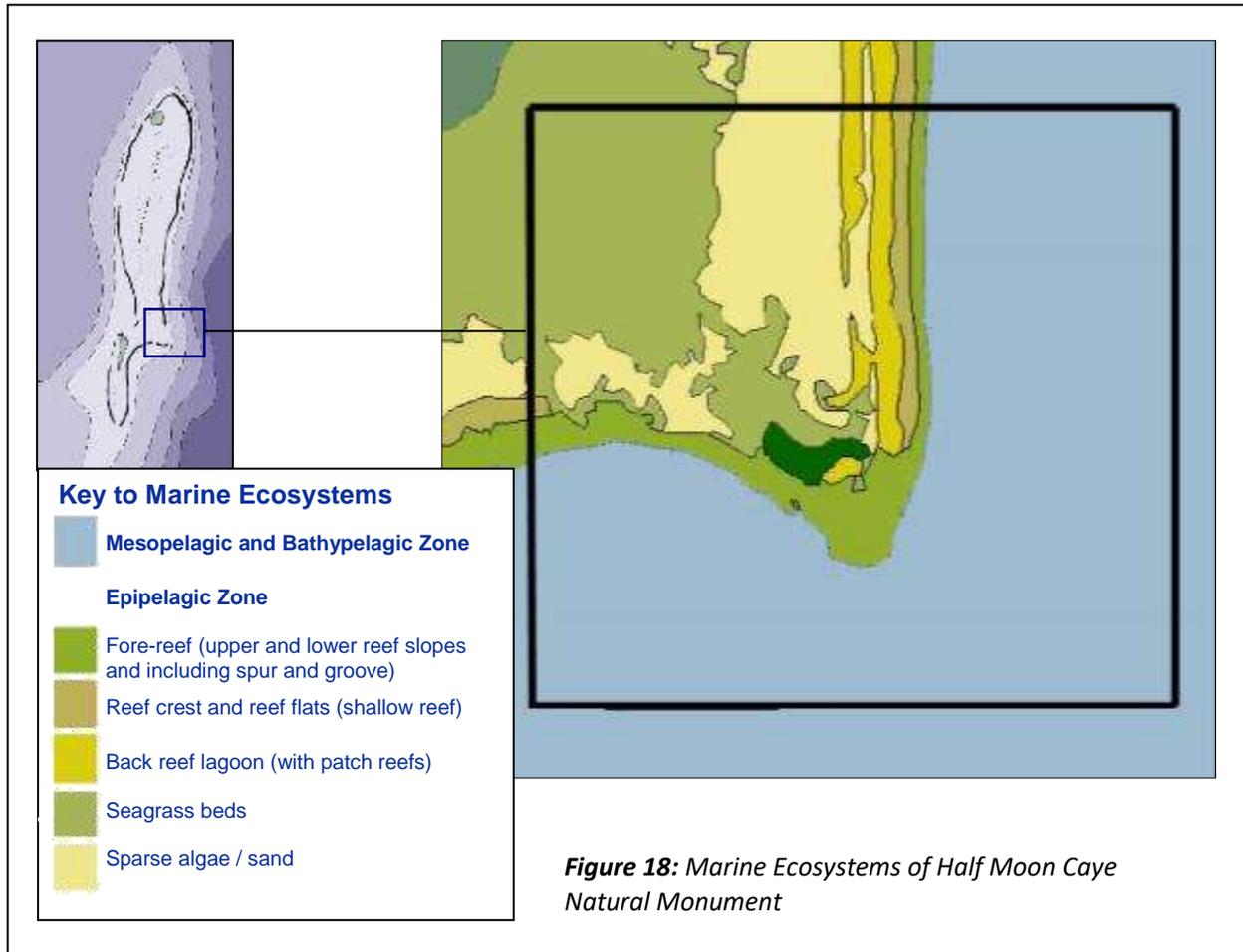
Feature Name	Total ecosystem in Territorial seas (ha)	Area in HMCNM (ha)	Area in BHNM	% of total national ecosystem coverage	% contribution towards national protection of ecosystem in NTZ
Abyssal (>3,000m)	83,558.8	-	-	0.0	0.0
Bathyal (1,000-3,000m)	391,715.5	528	-	0.2	0.3
Mesopelagic (200-1,000m)	469,620.7	1,750	-	2.9	12.8
Coral Reef	60,313.0	226	-	14.3	54.3
Deep water mud	262,250.1	-	-	2.9	22.0
Littoral Forest	16,820.5	31	-	2.7	8.5
Seagrass	379,130.9	2,326	1,023	0.9*	2.7
Sparse Algae and Sea Grass	136,887.2	705	-	0.5	5.2

Table 15: Ecosystems of HMCNM-BHNM (Based on TNC figures, 2015)

Marine Ecosystems

Lighthouse Reef Atoll is part of the Mesoamerican Barrier Reef System (MBRS), the longest Barrier reef system in the Western hemisphere. Stretching over 250km from the Yucatan to the Bay Islands in Honduras (the majority of it within 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 et al., 1998; Roberts, 2001). Lighthouse Reef Atoll, one of four offshore coral atolls associated with the Mesoamerican reef, was created by scleractinian corals, and is comprised of a well-developed fore-reef more than 40 miles in length, enclosing a shallow lagoon, between 1 and 9m in depth containing numerous patch reefs. The Atoll has been identified as a “highest priority” Ecoregional Biodiversity Priority Area, as an example of one of the best developed coral atolls on the Mesoamerican Barrier Reef System (Kramer et al., 2002).

Half Moon Caye Natural Monument



The marine environment of Half Moon Caye Natural Monument spans the range from the Epipelagic to Bathypelagic zones, including not only a part of the Atoll lagoon, but extending beyond the reef crest, best formed on the eastern wall of the lagoon, north of Half Moon Caye. This wall plunges steeply down to the east into the deep, Caribbean waters (Figure 18). A similar profile also occurs to the south of the caye, and is exemplified by the Half Moon Caye Wall, one of the premier reef sites in the World.

Mesopelagic / Bathypelagic Zone (200m and deeper)

The Mesopelagic and Bathypelagic Zones include the deeper waters that lie in the south and east of Half Moon Caye Natural Monument. The mesopelagic zone extends from a depth of 200m downwards, merging into the bathypelagic zone (which begins at the edge of the continental slope and extends beyond into the deeper water). The deep waters to the east of the Atoll provide the geomorphology and oceanographic current conditions required by many species for the formation of spawning aggregations (Heyman et al., 2008). They also attract

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other species known to travel up and down in the deep waters parallel to the reef, including whale sharks, pilot, humpbacked and sperm whales and orcas.

Deep water ecosystems are under-represented within the National Protected Areas System (Walker et al., 2013), increasing the importance of their inclusion within the protected area. A national initiative is investigating the potential for extension of the eastern boundary of HMCNM to include the Mesopelagic and Bathypelagic zones, increasing coverage of these ecosystems within the National Protected Areas System.

Epipelagic Zone (0m – 200m)

The Epipelagic (sunlit) Zone ranges from 0 to 200 m depth, and includes the shallow waters of the lagoon and the deeper waters of the fore reef below 200m. 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:

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

The fore-reef of Half Moon Caye Natural Monument lies in the east and the south of the protected area, on the outer side of the reef crest, facing the sea, and includes the upper and lower reef slopes, where the atoll rim falls away into the ocean (Figure 19).

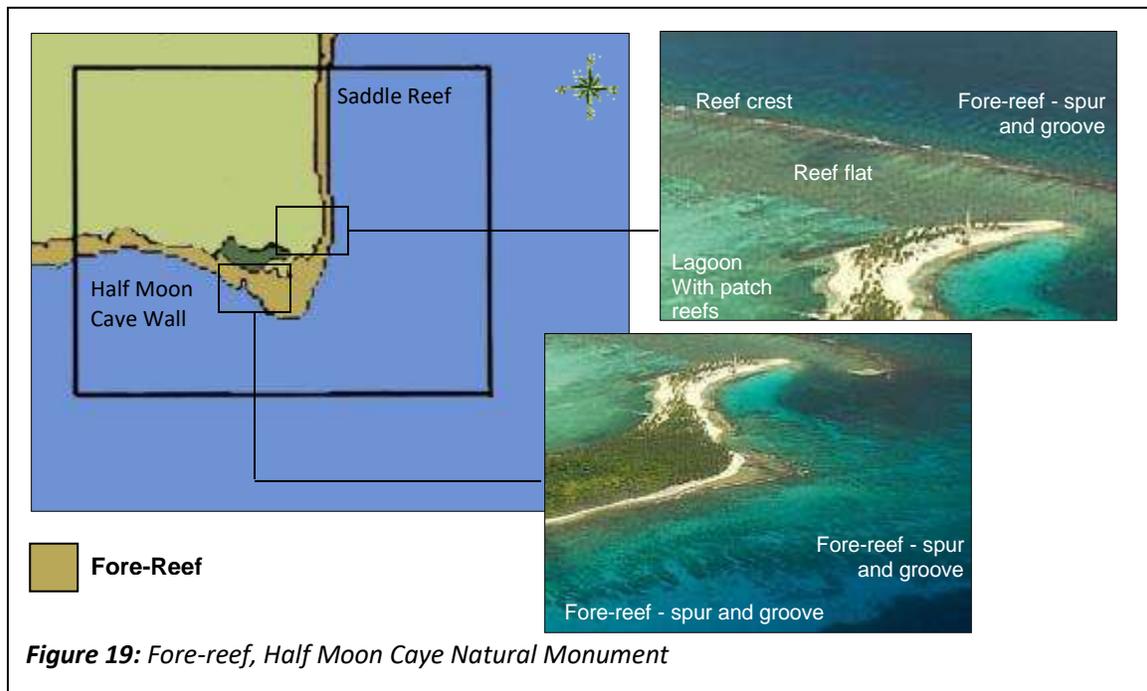


Figure 19: Fore-reef, Half Moon Caye Natural Monument

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Saddle Reef stretches northwards from Half Moon Caye to Harrier Wreck to the east of the lagoon, and is considered to be one of the healthiest examples of reef in Belize. It bears the brunt of the strong waves and currents that continually flow over the reef crest (Stoddart, 1962). The upper slope declines steeply at first to a depth of approximately 6m, then continues less steeply down to approximately 12m, where an underwater ledge slopes gradually towards the drop-off, which starts at between 36 and 42m below sea surface. This drop-off continues vertically down to depths of approximately 800m. As was once typical for the upper reef slope, the ledge has been described in the past as being dominated by:

“ very massively built Acropora palmata....by far the largest specimens seen anywhere on the reefs, forming trees 10 to 20 feet tall. Between the A. palmata there is a carpet of Acropora cervicornis, interrupted here and there by large blocks of dead reef-rock topped with Agaricia agaricites and Millepora complanata. Between the coral colonies the floor is formed of white ripple sand”

Stoddart, (1962)

With the decline of *Acroporas* across the region, including Lighthouse Reef, the flat pavements are no longer dominated by these species (though some stands do still remain), with spur and groove reef formation now being the most prominent feature (Romero, pers. com., 2015). The reef ledge stretches northwards outside the protected area and is an important site for fishermen from the coastal communities (particularly Copper Bank, Chunox and Sarteneja), who fish with handlines for large specimens of various species of grouper (including the critically endangered goliath grouper (*Epinephelus itajara*)).

The lower fish density of Saddle Reef, with its higher, more destructive wave action, is reflective of the lower complexity when compared with the more sheltered Half Moon Caye Wall and West Reef (Romero, pers. com., 2015), to the south-west of Half Moon Caye. In this area, the rim is defined by a well-developed spur and groove formation – as seen at Half Moon Caye Wall to the south of the caye. This is considered one of the best diving sites on the Mesoamerican Barrier Reef System, and an exceptionally well developed example of this type of reef topography, being protected from the waves and currents experienced by the east, windward facing Saddle Reef. The calmer waters have led to this area being favored by divers, with mooring points offshore to allow dive boats minimal impact access.

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CEDAM International mapped this reef in 1989 / 1990 to provide a baseline for subsequent evaluation of diver impact, and identified four zones during their mapping exercise (Figure 20).

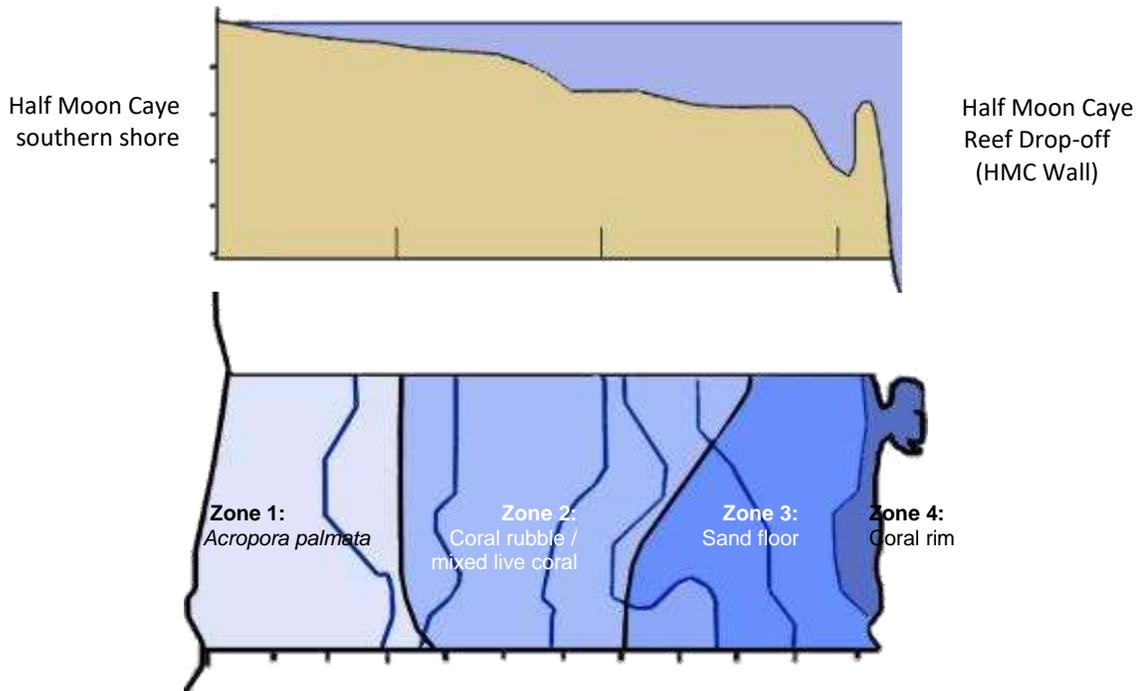


Figure 20: Profile of Fore-reef, south west of Half Moon Caye
(Adapted from CEDAM, 1989)

In the initial survey, an *Acropora palmata* zone, similar to that once seen on the eastern upper reef slope, extended approximately 90m out from the southern shoreline of Half Moon Caye. With increasing water depth, this gave way to a coral rubble / mixed live-coral species assemblage zone stretching to approximately 240m from shore, before transitioning to a barren sand zone, providing a critical ecosystem for queen conch, stingray, benthic shark species and garden eels. Beyond this, at about 350m from shore, and a depth of 9m, a raised coral rim some 15m wide, rises from the sea floor to within 5m of the water surface, before plunging vertically downwards into the open sea (Meyer, in. lit., 1989).

A Rapid Marine Assessment of this fore-reef in 2004 showed that it supported a healthy live coral population, with coral cover ranging from 12% to 43%, and with low levels of disease or bleaching (Graham et al., 2004), though there is evidence of decline when results from 2004 are compared with those of 1997 and 1999 (McField, 2001). 36 species of scleractinian corals were recorded, with *Orbicella annularis* (formerly *Montastrea annularis*) complex dominating the coral community of the fore-reef, with a relative abundance of 39.7%, contributing 12.2% towards coral cover (Graham et. al., 2004). Other species with a significant presence included *Undaria agaricities* (15.9% relative coral composition), *Colpophyllia natans* (8.7% relative coral composition) and *Porites porites* (6.3% relative coral composition) Macroalgae and turf algae were also widely evident on the fore-reef, comprising a combined total of 37% cover. *Acropora*

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cervicornis, with a relative coral composition of 2%, was significantly reduced since the original CEDAM survey, and was the only species to show noticeable recent mortality. *Halimeda*, *Dictyota*, and *Lobophora* were identified as the dominant macroalgae genus on the fore-reef at (Graham et. al., 2004).

The spur and groove formations of this rim show prolific coral growth on the seaward side, with greater coral diversity than other survey sites. Large hard coral formations form a structure rich in hydrozoans, tunicates, sponges and smaller coral species, with a diverse fish and invertebrate species assemblage, and large pelagic species such as the marine turtles, sharks and spotted eagle rays swimming along the seaward cliff face (Graham et. al., 2004).

Blue Hole Natural Monument

Blue Hole Natural Monument lies entirely within the Epipelagic Zone, being within the Atoll lagoon and not extending beyond the Atoll wall. Almost perfectly circular, with a diameter of approximately 320m at the upper rim, and hourglass shape in cross section, and an estimated 124m deep the Blue Hole tells a geological history of eustatic changes in sea level, and inundation cycles of both salt and freshwater (Figure 21; Jones et. al. 2000). The sink hole is surrounded by an almost complete coral rim, which breaks the surface in places. Within the Blue Hole itself the collapsed cave system supports only a limited amount of marine life in comparison to the coral rim - with filamentous algae, boring sponges cornflake algae and isolated gorgonians. Little biological work has been conducted here, and it has been highlighted as having the potential of unique assemblages of cryptic and endemic species (Kramer et al., 2002).

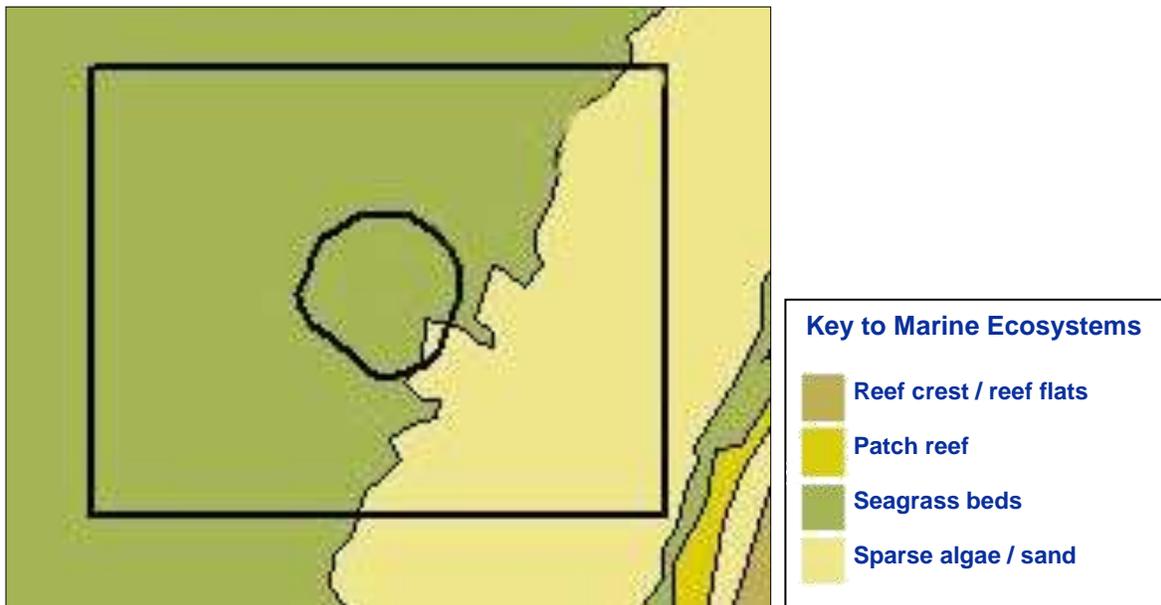


Figure 21: Marine Ecosystems of Blue Hole Natural Monument

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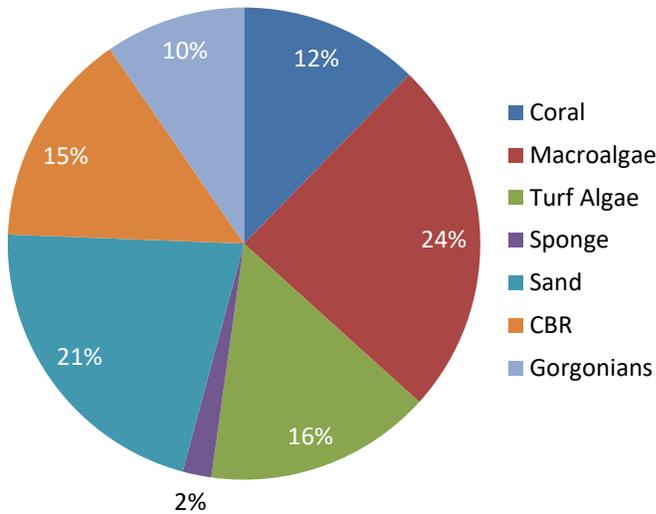


Figure 22: Percentage cover of major reef community categories on the Blue Hole Natural Monument reef (Graham, 2004)

With no previous studies of the corals of BHNM for comparison, the data provided by the 2004 Rapid Marine Assessment forms a baseline for future monitoring. The inner rim of the Blue Hole was surveyed to a depth of 0.6m, with 26 scleractinian coral species recorded. *Montastrea annularis* was the predominant species complex. Coral health was low, with coral cover averaging 12.5%, compared with 40% for macroalgae and turf algae combined (Figure 22). The high macroalgae coverage is thought to be indicative of high diver and snorkeler impacts, though with no data on the status of

the coral before the Blue Hole attracted the current levels of visitation, it is hard to make comparisons. Negative impacts to coral health also result from boat activities, with constant siltation action caused by dive boats maneuvering into and out of the mooring points.



Coral Health

On a regional level, 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). Lighthouse Reef Atoll is no exception. It has experienced the same large-scale threats as other reefs in the region, including hurricanes, loss of herbivorous urchins and parrotfish, unsustainable fishing, coral disease and mass coral bleaching triggered by prolonged high sea surface temperatures. All these impacts have contributed towards the extensive loss of key reef-building *Acropora* species, as well as *Agaricia tenuifolia*, *Millepora complanata*, *Diploria spp.* and *Montastrea spp.* (Kramer et al., 2001).

In 1962 the fore-reef was dominated by Acroporids and *Agaricia* species (Stoddart, 1962). Over the last four decades, however, the structurally complex *Acropora* has been replaced as the dominant coral species, following widespread mortality associated with white band disease, with significant declines also observed in *Agaricia*. These structural corals are particularly important in the maintenance of reef structure, the function as a protective barrier to storms, and as a habitat for commercial species such as lobster and snapper, as well as the touristic reef fish.

Percentage live coral cover at LHR has declined dramatically, with live coral cover on the fore-reef declining from an average of 43.6% to 30.7% between 1997 and 2004 (McField, 2001; Graham et al, 2004), and an average of between 25 and 30% in 2015. By 2004, algae was more prevalent on the fore-reef than live coral cover (Graham et al, 2004). This was particularly true of the vulnerable patch reefs within the Atoll lagoon which experience higher water temperatures, less flushing, less larval transport, greater fishing pressure and a greater range of environmental conditions than the fore-reef. Macroalgal cover on Lighthouse Reef Atoll was shown to have increased from 9.4% in 1997 to 24.68% in 2004 on the fore-reef, and to an average of 68.5% macroalgae coverage on the patch reefs (Graham et. al., 2004). In 2015, macro-algal cover on the BAS survey sites averaged between 10 and 15% (BAS data, 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**

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68% of Belize’s coral reefs are currently rated as in Poor or Critical health, only 4% considered in Good health, and 0% in Very Good health, based on a survey of 94 sites across the country, including Lighthouse Reef Atoll (HRI, 2015). In 2015, Lighthouse Reef rated as Poor on average, with a Reef Health Index of 2.3. BAS is currently conducting a full survey of coral health across the Atoll to provide a more in-depth assessment, however, as there are concerns that this is not representative of the true health of the reef of the Atoll, with a bias towards shallow water survey sites (Romero, pers. com., 2015).

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 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).

Event	Year	Scale of Event
Coral bleaching event	2005	Significant bleaching
Hurricane Ivan	2004	Increased turbidity, coral rubble deposited on southeast beach of Half Moon Caye
Hurricane Iris	2001	Localized coral mortality
Hurricane Keith	2000	Localized coral mortality
Hurricane Mitch	1998	Category 5, direct hit
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
Viral epidemic in urchin <i>Diadema antillarum</i> population	1983	Major Caribbean wide die-off

Table 16: Events affecting the Belize reef

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The Belize Barrier Reef experienced mass coral bleaching for first time in 1995 (McField, 1999; McField et al., 2007), affecting hard corals throughout Belize (including Lighthouse Reef Atoll), impacting *Montastraea annularis*, *Agaricia agaricites*, *Agaricia tenuifolia*, *Madracis* spp., and *Porites porites* (McField, 2000). A second, more severe bleaching episode took place in 1998, followed closely by Hurricane Mitch in the same year, further stressing the corals, with increased coral mortality in key structural species. Since then, major bleaching events have been recorded at Lighthouse Reef with increasing frequency, and are thought to be exacerbated by increased acidification resulting from higher CO₂ levels (Table 16; Anthony et al., 2008).

Elevated water temperatures and associated bleaching generally occur during August – October, with coral recovering as cooler weather reduces sea temperatures in December. Tropical storms may help to reduce or prevent bleaching, drawing cooler, deeper water to the surface, and pushing oceanic waters onto the Atoll, reducing sea temperatures. Based on data from 291 surveys, incidence of coral bleaching in 2011 can be seen to follow this pattern (Figure

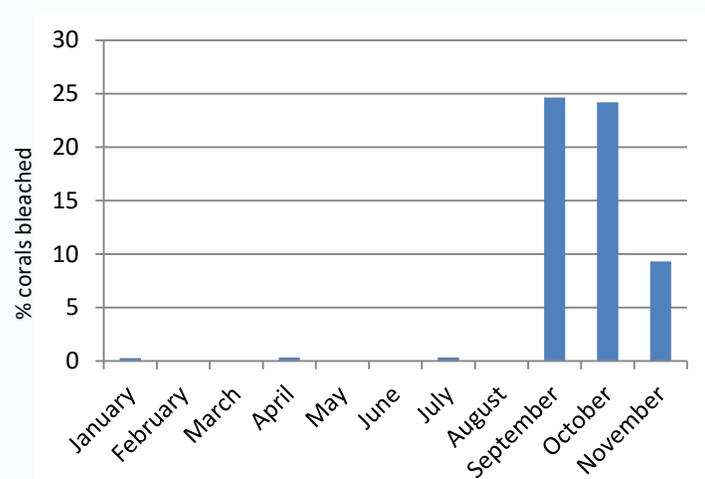


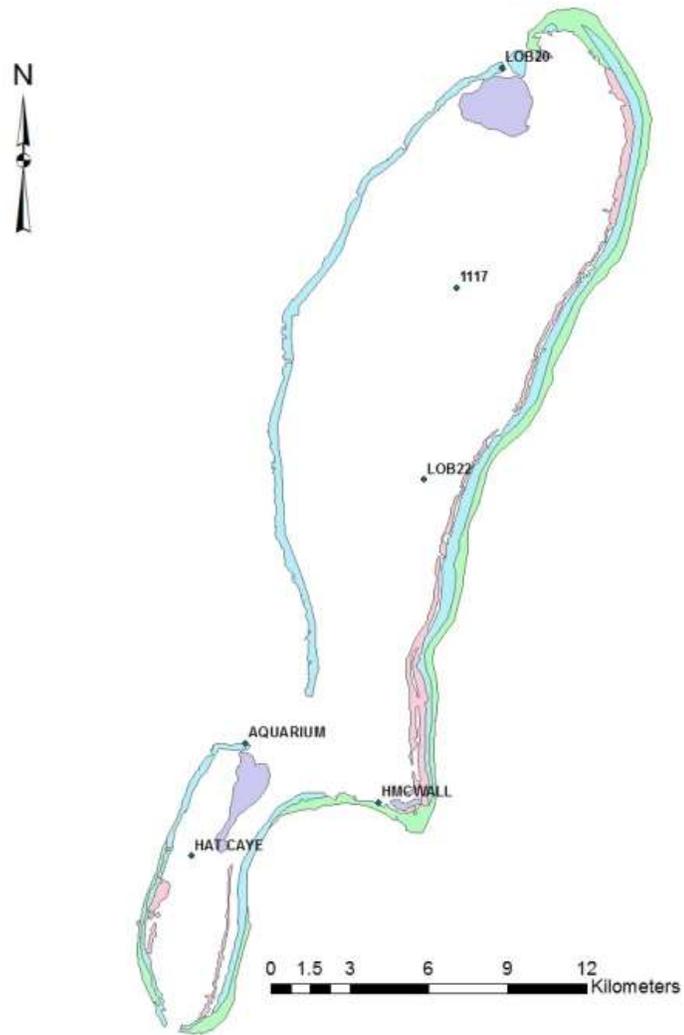
Figure 23: Incidence of coral bleaching, Belize 2011 (NRCMN, 2011)

23: NRCMN, 2011). September was the month with the highest bleaching incidence (24.62%), with 86% (49 out of 57) species monitored showing signs of bleaching (NRCMN, 2011).

The Atoll lies outside the sedimentation plumes emanating from the Belize coastline and whilst the currents draw water northwards from the Gulf of Honduras, it is only during excessive rainfall associated with large tropical storm events that contaminants and sediments may enter the Lighthouse Reef area. Studies have shown that corals in areas with reduced anthropogenic impacts, such as Lighthouse Reef Atoll, tend to be more resilient, recovering faster from bleaching events (Carilli, 2009). The Atoll has the advantages of oceanic upwellings to the east, bringing cooler waters to the Atoll. However, the shallow water environment of the lagoonal patch reefs heats up faster than deeper waters, with faster temperature changes. This can build resilience in some coral species over time, but may also reduce species diversity as the temperature fluctuations become more extreme.

Coral Health

Coral bleaching monitoring is being conducted using belt transects at six sites throughout the Lighthouse Reef Atoll (Table 17; Figure 24), including two of the most popular recreational dive sites – Half Moon Caye Wall and the Aquarium. Two lobster and conch monitoring sites (Lob 20 and Lob 22) and one site (Resilient 1117), where coral bleaching has been documented in the past. One last site, Hat Caye, was selected at random to represent the south end of the atoll.



Sites	Depth (m)	Coordinates WGS 84
HMC Wall	15	16 Q 0441944; 1902346
Aquarium	8	16Q 0435729; 1904645
Hat Caye	2	16 Q 0434851; 1900243
Resilient 1117	1	16 Q 0444933; 1921955
Lob 20	3	16 Q 0446652; 1930312
Lob 22	5	16 Q 0443660; 1914644

Figure 24: Coral Bleaching Monitoring Sites at LHR

Table 17: Coral bleaching monitoring sites at LHR

Benthic Characteristics

The Atoll is encircled by a ring of structural corals, a fringing reef, with a typical fore-reef, reef crest, and back reef structure that protects the more sheltered lagoon. Six sites are sampled by Belize Audubon Society as part of coral bleaching monitoring. The most common coral species at Lighthouse Reef, based on surveys at these six sites, are *Undaria agaricities*, *Orbicella annularis*, *Pseudodiploria strigosa*, *Porities asteroides* and *Porities porities* – these are important reef building bolder corals and branching cementing corals that give the reef its structure, and support a healthy coral reef system (Figures 25 and 26; BAS data, 2015; Romero, pers. com.).

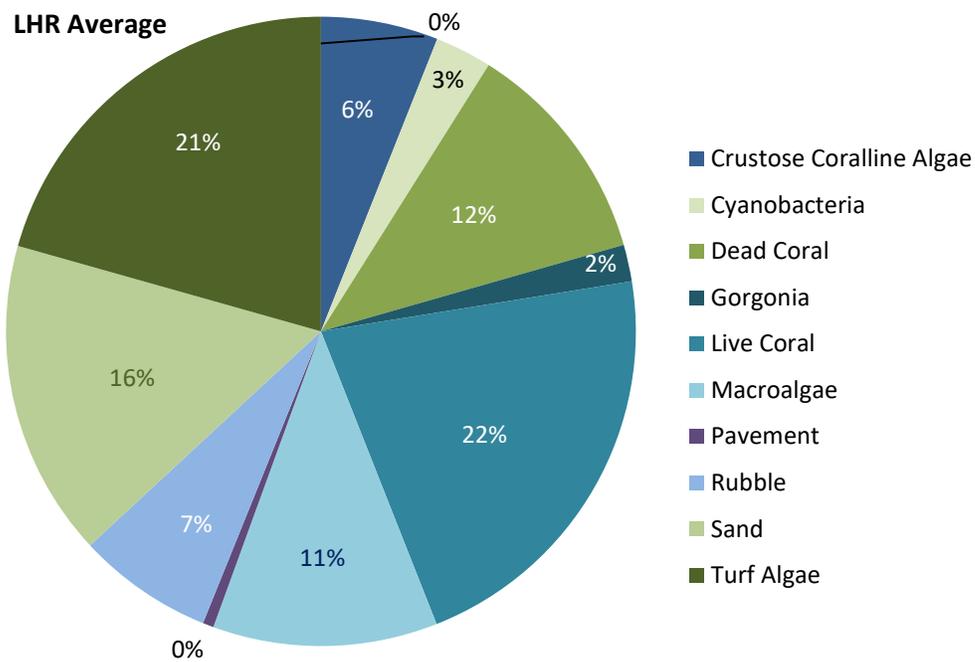


Figure 25: Relative coral species composition of Lighthouse Reef Atoll, averaged over Survey Sites, BAS, 2015

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Relative coral species composition of LHR Survey Sites (BAS data, 2015)

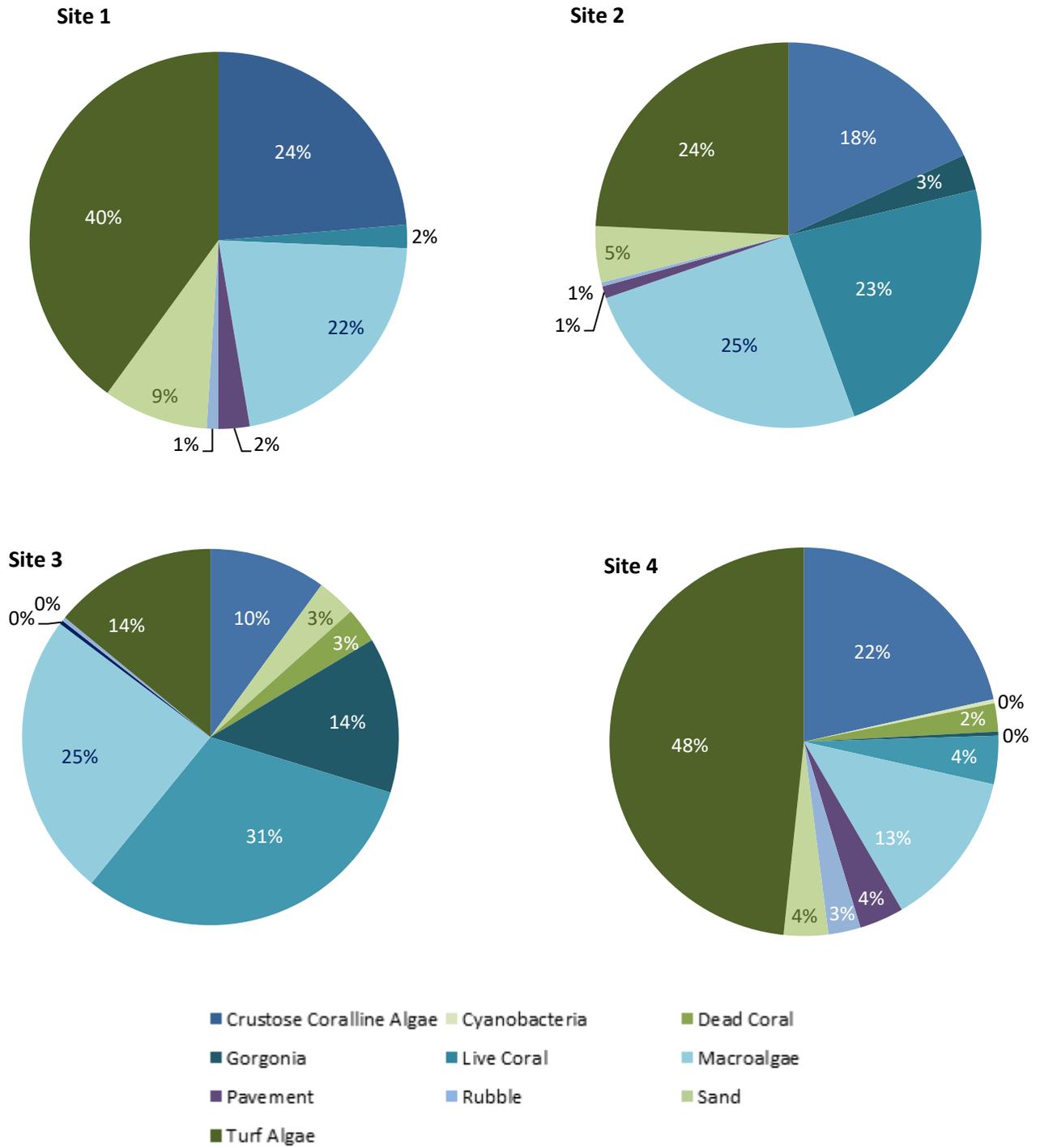


Figure 26: Relative coral species composition of LHR Survey Sites, BAS data, 2015

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Seagrass

The most important component of marine vegetation on the Atoll is the seagrass, growing in large patches on the shallow lagoon floor. Seagrass meadows are essential for maintaining the ecological health of the shallow marine ecosystems within the atoll, with an important role in nutrient cycling and sediment stabilization. They are also a critical ecosystem for many fish and invertebrate species - an acre of seagrass can support up to 40,000 fish and 50 million small invertebrates (Seagrass Ecosystems Research Laboratory, 2005).

At Lighthouse Reef, an atoll with a low abundance of mangrove, seagrass beds fill a critical role as a nursery area for many reef fish (including commercial species such as tarpon, hogfish, yellowtail snapper and great barracuda), and for the key herbivore guild species assemblage, the parrotfish.

The majority of areas dominated by turtle grass (*Thalassia testudinum*) are considered to be healthy, and subjected to little anthropogenic or natural disturbance. Concerns have been raised as to the effect increasing boat activity may be having in areas of high visitation, by stirring up the sediment and increasing the turbidity of the water, which prevents light from reaching the seagrass, and can cause smothering of leaves. In 2015, water clarity was also affected in localized areas by an algal bloom in front of Half Moon Caye, though this was only temporarily, and with limited impacts on the seagrass health.

Boat propellers can also directly affect seagrass by cutting or tearing the leaves, roots and rhizomes, and seagrass scars in *Thalassia* beds can take 3 to 5 years to begin healing (US Fish and Wildlife Service, 1999). Seagrass areas adjacent to Half Moon Caye are predominantly in shallow water, and are therefore potentially more susceptible to boat impacts, though impacts currently appear to be minimal, and boats are largely confined to specific boat channels within HMCNM itself to minimize impacts.



Most recently, seagrass in the shallow waters around Half Moon Caye have been smothered by a deep blanket of sargassum, which blocks access to sunlight. Sargassum is a recent seasonal issue affecting the Belize coastline in the last two years.

Terrestrial Ecosystems

Two terrestrial ecosystems are recorded for Half Moon Caye (Meerman et al., 2004):

Tropical coastal vegetation on recent sediments (including both littoral forest and herbaceous beach vegetation)

Woody perennial crops (in the form of the coconut plantation)

Historically, anecdotal reports suggest that a further two ecosystems once occurred on the caye (**Coastal fringe *Rhizophora mangle* - dominated vegetation** and **Mixed mangrove scrub** (Verde J. pers. com.)), both of which were eradicated by human activity. These ecosystems do occur elsewhere on the Atoll, associated with other cayes of the area, and are critically important for maintaining the health of the marine ecosystems and species of the Atoll.

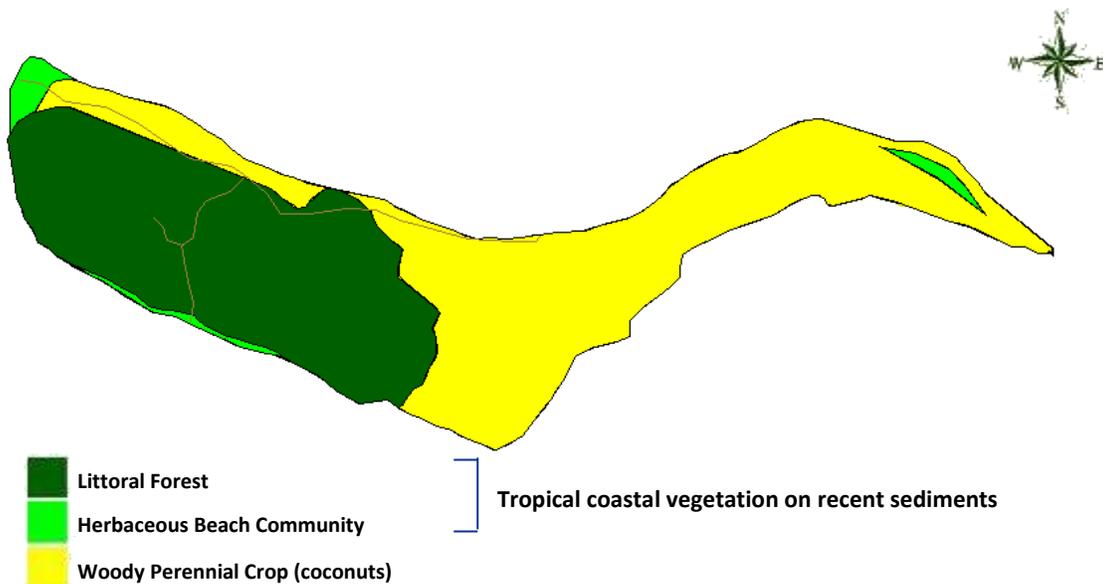


Figure 27: Terrestrial Ecosystems of Half Moon Caye. Data: P. Walker, 2005

Tropical coastal vegetation on recent sediments

*A combination of Tropical littoral forest and Herbaceous beach communities
Belize Ecosystem Map legend code 69.*

Littoral forest and herbaceous beach communities (Tropical coastal vegetation on recent sediments) are significantly under-represented within Belize's National Protected Areas System (Meerman, 2005; Walker et al., 2013). Of the estimated 16,820 ha of national coverage, only 8.5% lies within protected areas (below the national target of 10%), of which 2.7% is protected by Half Moon Caye Natural Monument. This presents a very significant shortfall in view of the

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importance of this ecosystem in maintenance of cayes, with caye vegetation playing a critical role in stabilization of the caye beaches, prevention of erosion, in providing habitat for endangered species, anchoring of turtle nesting beaches, supporting refueling in migratory birds, and in the maintenance of island specialist species such as the Allison’s anole and the island leaf-toed gecko.

Littoral forest covers 19 acres of southern Half Moon Caye. It is a dynamic ecosystem, adapted to survive in small, isolated patches on cayes, and to withstanding and recovering from the devastating impacts of hurricane force winds and saline soils. It has evolved and persisted with very limited connectivity between individual tracts – indicating a significant resilience to natural impacts. It is a matrix of distinct species assemblages that occur in relatively discrete areas, influenced partly by topographical variation, and partly by past and present anthropogenic impacts. The canopy height ranges from 6m to 10m, with predominant tree species including zericote (*Cordia sebestena*), blackbead (*Pithecellobium keyense*), gumbolimbo (*Bursera simaruba*), mol-che / wild saffron (*Sideroxylon americanum*), canistel / mamme-cerilla (*Pouteria campechiana*), and shortleaf fig (*Ficus citrifolia*). The zericote, gumbolimbo and mol-che are of key importance in providing nesting structure for the red-footed booby and magnificent frigatebird nesting colony. Zericote trees form a belt along the southwestern shore, stretching back some 40-50m from the higher coastal ridge. Behind this lies a belt of forest dominated by gumbolimbo and mol-che. To the northeast of this belt is a species assemblage dominated by gumbolimbo, mamme-cerilla and fig - largely within a slightly lower-lying area where organic humus build-up is more evident. Behind this, mamme-cerilla forms an almost mono-specific stand.



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Anthropogenic impacts upon this ecosystem are both historical and current. Between 1962 (Stoddart) and 1995 (Meerman), the saltwater palmetto (*Thrinax radiata*) was eradicated from the caye as a direct result of over-harvesting, though recolonization is now taking place for this and other species, both naturally and through assisted planting, with naturally-sourced stock from other cayes on the Atoll.

The low **herbaceous beach vegetation** is typically found on the seaward edge of the littoral forest, on and above the splash zone of the beach. Grouped within the same UNESCO ecosystem classification unit as littoral forest, the extent and species composition of this very dynamic and fragile system are tied to the dynamics of sand accumulation and loss, variations in aspect, wind exposure, drainage, humus content and human disturbance, as well as wave and storm action (Stoddart, 1962).

As with the littoral forest component of this clumped ecosystem category, the beach herbaceous vegetation is under threat in many areas in Belize – often being removed to create white sandy beaches for tourism and residential developments. Even on Half Moon Caye, the herbaceous beach community has been cleared to enhance tourism appeal in the public high-use access areas. Trampling by visitors in more remote parts of the cayes could become a significant threat to this system, requiring continued careful visitor management to minimize impacts.



Woody Perennial Crops

Belize Ecosystem Map legend code 83

Coconuts currently occupy slightly over 50% of the caye. The coconuts and white sandy beaches of the eastern portion of the caye today are important components of the features that attract tourism visitation.

Records of the historical ‘invasion’ of Half Moon Caye by coconuts date back to 1720, and by 1830 a portion of the eastern tip of the island had been cleared and planted with scattered coconuts – though in 1962, “fully two-thirds is occupied by high forest”, including a “luxuriant growth of the wild plum and saltwater palmetto” (Stoddart, 1962). The extent (and presumably also the condition) of the littoral forest remained more or less unchanged until 1928 when the Young family started a prolonged period of active clearance to develop a coconut plantation, which continued into the 1960’s. Most subsequent impacts have been caused by the invasion by coconuts into the littoral forest. The overall trend has been of a decline in the extent of natural vegetation, with some lower herbaceous plant species being lost completely as they become smothered by fallen coconut leaves. A comprehensive coconut removal program has been implemented, to remove this species from the littoral forest area.



Historical ecosystems of Half Moon Caye Natural Monument:

Coastal fringe *Rhizophora* mangle – dominated forest

Mixed mangrove scrub

Belize Ecosystem Map legend code 49

Belize Ecosystem Map legend code 50

Red mangrove (*Rhizophora mangle* occurred historically on the northern shore of the western half of Half Moon Caye (J. Verde, pers. com.), but was extirpated prior to the 1960's. Historically, coastal fringe red mangrove may have occurred along much of the north and northwest beaches of the Caye, and probably also along significant portions of the more exposed southeast and easterly beaches. Despite the key role played by this ecosystem in terms of erosion control and as a critical fisheries nursery area, these coastal fringe mangroves would have been targeted for clearance by the earlier settlers on the cayes. By 1962, only red mangrove seedlings were reported, with no established mature stands (Stoddart, 1962). Surprisingly, whilst red mangrove propagules are seen relatively commonly floating along the sheltered northwest coast (thought to originate from Long Caye), very few have become established, with mangrove propagules being removed by wave action associated with storm events.

Mangroves are, however, present on other cayes on the Atoll. Long Caye has a policy of not removing mangroves. Both Hat Caye and Northern 2 Cayes have some small mangrove removal – Hat Caye generally as a result of the establishment of fishing camps, and Northern 2 Cayes as a result of development interests. Sandbore Caye once supported mangroves, but recent development interests have resulted in their removal.

Mixed mangrove scrub is not currently reported on the island, though it seems highly likely that small stands of this vegetation type would once have occurred in some of the lower-lying areas bordering the littoral forest – most probably in areas where buttonwood (*Conocarpus erectus*) still occurs today. Typically, all three mangrove species (Black (*Avicennia germinans*), white (*Laguncularia racemose*) and Red (*Rhizophora mangle*)) occur in association with Buttonwood (*Conocarpus erectus*), a mangrove associate. White mangrove (*Laguncularia racemose*) was observed on the western tip of the cayes in the 2004 survey.

1.5.2 Flora and Fauna

Terrestrial Flora

A total of 47 naturally occurring native species of plant, representing 33 families, were identified as occurring within the littoral forest and herbaceous beach community of Half Moon Caye (Table 18; BAS, 2007). Species distribution is non-uniform throughout the beach vegetation zone, with a variety of species being dominant in different areas and changing with time.

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Terrestrial Plant Species of Half Moon Caye / 1		
Family	Species	Common name
Adiantaceae	<i>Acrostichum aureum</i>	
Aizoaceae	<i>Sesuvium portulacastrum</i>	Seaside purslane
Amaranthaceae	<i>Alternanthera flavescens</i> <i>Iresine diffusa</i>	
Amaryllidaceae	<i>Hymenocallis littoralis</i>	Spider lily
Apocynaceae	<i>Echites umbellata</i>	vine
Arecaceae	<i>Cocos nucifera</i> <i>Thrinax radiata</i>	Coconut** Chit, Salt-water Palmetto
Aristolochiaceae	<i>Aristolochia pentandra</i>	Aristolochia
Asteraceae	<i>Sphagneticola trilobata</i>	Creeping daisy
Boraginaceae	<i>Cordia sebestena</i> <i>Tournefortia gnaphloides</i>	Red-flowering zericote Sea lavender
Brassicaceae	<i>Cakile lanceolata</i>	Caribbean sea rocket
Burseraceae	<i>Bursera simaruba</i>	Gumbo limbo
Capparaceae	<i>Capparis flexuosa</i>	
Casuarinaceae	<i>Casuarina equisetifolia</i>	<i>Casuarina**</i>
Combretaceae	<i>Conocarpus erecta</i> <i>Laguncularia racemosa</i> <i>Terminalia catappa</i>	Buttonwood White Mangrove Almond**
Convolvulaceae	<i>Ipomoea violacea</i> <i>Ipomoea pes-caprae</i>	Beach morning glory
Cyperaceae	<i>Cyperus planifolius</i> <i>Fimbristylis cymosa</i>	Flatleaf flatsedge Hurricane grass
Euphorbiaceae	<i>Chamaesyce blodgettii</i> <i>Chamaesyce mesembrianthemifolia</i>	Chicken weed Chicken weed
Fabaceae		
<i>Mimosoideae</i>	<i>Pithecellobium keyense</i>	Xo-coy, red fowl
<i>Papilionoideae</i>	<i>Canavalia rosea</i> <i>Dalbergia ecastaphyllum</i> <i>Sophora tomentosa</i>	Seaside bean Chaperno, dogwood
Lauraceae	<i>Cassytha filifirmis</i>	Jaundice tie-tie
Malvaceae	<i>Sida acuta</i>	Broomweed, chi-chi-be
Moraceae	<i>Ficus citrifolia</i>	Fig
Nyctaginaceae	<i>Neea psychotrioides</i>	Salat
Olcaceae	<i>Ximenia americana</i>	Sour plum
Passifloraceae	<i>Passiflora suberosa</i>	Passionflower
Phytolaccaceae	<i>Rivina humilis</i>	Tomatillo
Poaceae	<i>Cenchrus incertus</i> <i>Digitaria horizontalis</i> <i>Eragrostis ciliaris</i> <i>Sporobolus virginicus</i>	Seashore dropseed
Polygonaceae	<i>Coccoloba uvifera</i>	Sea-grape
Rhizophoraceae	<i>Rhizophora mangle</i>	Red Mangrove

Terrestrial Plant Species of Half Moon Caye / 2		
Family	Species	Common name
Rubiaceae	<i>Erithalis fruticosa</i>	Black torch, botoncillo
	<i>Ernodea littoralis</i>	Wild cherry
	<i>Hamelia patens</i>	Xcanan, Polly redhead*
	<i>Spermacoce sp.</i>	
Sapotaceae	<i>Pouteria campechiana</i>	Mamey cerilla, sapotilla
	<i>Sideroxylon americanum</i>	Mol-che
Solanaceae	<i>Solanum donianum</i>	Solanum
Surianaceae	<i>Suriana maritima</i>	Bay cedar
Verbenaceae	<i>Lippia nodiflora</i>	Beach Lippia
	<i>Stachytarpheta jamaicensis</i>	Stachytarpheta*

* Denotes species now thought to be absent
 ** Denotes introduced species
 The 1996 record of black mangrove (*Avicennia germinans*) is discounted, and not included in the species list

Table 18: Terrestrial Plant species of Half Moon Caye

In 2007, commonly encountered plants included coastal searocket, beach bean, limestone sandmat, Caribbean sea spurge, beach spiderlily, beach morning glory, seaside purslane, sand couch grass, creeping oxeye and sea lavender. Some species recorded in 1962 and 1995, such as blue porterweed (*Stachytarpheta jamaicensis*) and xcanan (*Hamelia patens*), had disappeared by 2007, (Stoddart, 1962; Meerman, 1995; BAS, 2007) whilst others, such as Buttonwood (*Conocarpus erectus*) appear to be re-colonizing. Additionally, three introduced species (coconut, almond and casuarinas) occur on the island.

This is a relative diverse species assemblage for this ecosystem type, especially in view of the distance of Lighthouse Reef Atoll from other island and mainland populations. The natural vegetation of cayes such as Half Moon is dynamic in both species occurrence and stature – changes often reflecting both natural cycles and anthropogenic impacts (Stoddart, 1962). As one of the very few island locations where these species are protected, Half Moon Caye plays a crucial role in their continued survival and in providing the opportunity to study the impacts and dynamics of natural processes of colonization and succession that take place in such a locality.

Anthropogenic impacts upon the flora of Half Moon Caye have historically caused local extinction of the chit palm (*Thrinax radiata*) and red mangrove (*Rhizophora mangle*) and more recently, of *Hamelia patens* and *Stachytarpheta jamaicensis* (BAS, 2007). Both the chit palm and the red mangrove are currently in the process of re-colonizing the island, though populations are still tenuous.

Marine Flora

Three species of seagrass have been recorded from the two Natural Monuments and are considered representative of Lighthouse Reef Atoll (Table 19; Graham R., 2004; Chi et al., 2006).

Marine Plant Species of Lighthouse Reef Atoll		
Family	Species	Common name
Hydrocharitaceae	<i>Thalassia testudinum</i>	Turtle grass
Cymodoceaceae	<i>Syringodium filiforme</i>	Manatee grass
	<i>Halodule wrightii</i>	Shoal grass

Table 19: Marine Plant Species of Lighthouse Reef Atoll

Fish

Lighthouse Reef has been identified as a high priority conservation target for its outstanding fish diversity, based on a combination of the low human impact levels, the near-pristine nature of the reefs, and the connectivity with the open ocean, (Kramer et al, 2002). Of the 550+ fish species recorded in Belize (ReefBase, 2006), more than 140 have been recorded on Lighthouse Reef Atoll to date, and in the deep waters surrounding the Atoll. Five are considered to be Critically Endangered or Endangered at a global scale, including the critically endangered goliath grouper and endangered Nassau grouper, great and scalloped hammerheads, and bluefin tuna (IUCN, 2016), all of which have been targeted

Fish Species of International Concern	
Critically Endangered	
Goliath Grouper	<i>Epinephelus itajara</i>
Endangered	
Nassau Grouper	<i>Epinephelus striatus</i>
Whale Shark	<i>Rhincodon typus</i>
Great Hammerhead	<i>Sphyrna mokarran</i>
Scalloped Hammerhead	<i>Sphyrna lewini</i>
Vulnerable	
Queen Triggerfish	<i>Balistes vetula</i>
Hogfish	<i>Lachnolaimus maximus</i>
Mutton Snapper	<i>Lutjanus analis</i>
Cubera Snapper	<i>Lutjanus cyanopterus</i>
Tarpon	<i>Megalops atlanticus</i>
Yellowmouth Grouper	<i>Myctoperca interstitialis</i>
Rainbow Parrotfish	<i>Scarus guacamaia</i>

Table 20: Fish Species of International Concern (IUCN, 2016)

and / or for sport fishing in the past. The whale shark has recently been upgraded to Endangered (IUCN, 2016), and a further eight species are considered Vulnerable (Table 20; IUCN, 2016).

A number of fish surveys have been conducted both within the protected areas and on the Atoll generally. In 1995, a survey at HMCNM provided a baseline species list for incorporation into the draft management plan, identifying a total of 60 fish species over a period of 3 days (BAS, 1997). Between 1995 and 2005, expert divers from REEF (Reef Environmental Education Foundation) recorded 114 species within the Half Moon Caye Natural Monument. A rapid assessment of 11

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fore-reef sites in the Southern half of Lighthouse Reef was conducted in 1999 using the AGRRA protocol (Kramer et al., 1999). A BAS survey conducted in 2002 showed that 15% more fin-fish were recorded within HMCNM than in comparable habitats on the Atoll outside the protected area, with species composition dominated by hogfish, queen triggerfish, mutton snapper and Nassau grouper. For BHNM this figure was much lower, at 12.8% (Arana, 2002). In 2004, a Rapid Marine Assessment of the two Natural Monuments highlighted the lack of abundant large predatory fish of the grouper, snapper and jack families, suggesting a depletion of these groups from unsustainable fishing (Graham et.al, 2004).

The snappers, groupers and hogfish are targeted by fishermen and, like other large predatory fish species, have high tourism appeal, being very popular with recreational divers. Many of these species form spawning aggregations at predictable times and places, making them highly vulnerable to fishing pressure. Three known spawning aggregation sites are located on the reef drop-off of Lighthouse Reef - Sandbore, Half Moon Caye Elbow and South Point (Table 21).



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Species Recorded at Spawning Aggregation Sites of Lighthouse Reef Atoll		
Sandbore Nassau grouper Black grouper Yellowfin grouper Tiger grouper Bar jack Yellow jack * Crevalle jack * Horse-eye jack	South Point Mutton snapper Dog snapper Yellowtail snapper Red hind Black grouper Tiger grouper Bar jack Yellow jack Crevalle jack Horse-eye jack Ocean triggerfish Jolthead porgy Permit Smooth trunkfish	Half Moon Caye Cubera snapper Dog snapper Nassau grouper* Red hind* Black grouper Yellow grouper* Tiger grouper* Amber jack* Bar jack Blue runner Yellow jack* Crevalle jack* Horse-eye jack White margate Ocean triggerfish Jolthead porgy* Permit Smooth trunkfish Blue parrotfish Midnight parrotfish
SPAG Site	Vulnerability	Ecological Importance
Sandbore	2	3
South Point	2	3
Half Moon Caye	1	3
(1) Vulnerability: (Existing and future fishing pressure) 1. Low vulnerability 2. Medium vulnerability 3. High vulnerability (2) Ecological Importance: (Based on the number of species and individuals spawning at the site) 1. Low importance 2. Medium importance 3. High importance *have not been observed aggregating in 2014 / 2015 MBRS SPAG Monitoring Recommendations (Heyman et. al. 2003)		

Table 21: Spawning Aggregation Sites of Lighthouse Reef Atoll (Heyman et. al. 2003)

Of these, only Sandbore and Half Moon Caye Elbow are protected by law, through Statutory Instrument 161 (GoB, 2003). A fourth spawning aggregation site, ‘Deep Bank’ is known from fisher reports to be important for dog and Cubera snapper, but hasn’t yet been located (Romero, pers. com., 2015). As the spawning events at these sites often represent most or all of the total annual reproductive output of these species on the Atoll, the reduction in population

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abundance caused by even moderate fishing pressure has had both ecological and socio-economic consequences. Evidence suggests that once a spawning aggregation has been ‘fished out’ it may well be permanently lost, as it is unlikely to reestablish itself. As these sites are often used by a number of species throughout the year at different times (including the commercially important groupers, snappers, jacks and grunts), their year-round protection is critical for the long term maintenance of these aggregating species.

The commercially important **Nassau grouper** is perhaps the most vulnerable of the species known to congregate at the spawning aggregation sites (Heyman et al., 2002; Paz et al., 2001; BAS, 2006). Of nine originally known spawning locations in Belize, Sandbore was once identified as one of only two remaining viable sites for this species (Paz et al., 2001). Numbers have fluctuated over the years (Table 22; Paz et al., 2001; Heyman et al., 2002), but from 2013 to 2015, a steady increase in Nassau grouper maximum count estimates has been observed at the site, with the 2015 monitoring providing an estimate of 3,500 individuals (BAS, 2016). Similar increases are also being seen at other key spawning aggregation sites, including Caye Glory.

Nassau Grouper maximum counts at Sandbore												
2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1800	2500	1800	1205	1495	1250	2050	2000	1300	1350	1203	2750	3500

Table 22: Nassau Grouper maximum counts at Sandbore (Belize Spawning Aggregation Group, February 2014; BAS, 2015)

Fishermen described congregations of between 20,000 and 30,000 spawning Nassau grouper in the 1980’s at the Sandbore site, but have reported significant declines in numbers over the last fifteen years. This reflects the national decline in this species by more than 80% since the late 1970’s, attributed primarily to fishing pressure, particularly at spawning aggregation sites. It has been estimated recently that one-third of all known Nassau grouper spawning aggregation sites in the Caribbean region have disappeared. 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. Individual Nassau grouper are known to be highly mobile, and may travel 30km in one day to move to the spawning grounds in time for the mass spawning at the full moon - one tagged individual from Belize was even known to move over 250km within the Mesoamerican reef system (Sala et. al, 2001; Rhodes, 2007). This makes them very vulnerable to fishing pressure, even when the spawning aggregation sites can be adequately protected.

Although the Sandbore site is outside the two protected areas, BAS does provide a surveillance and enforcement presence, with targeted patrols in the area during the full moon spawning period. However, the logistical challenges posed by the distance from Half Moon Caye make it difficult to provide full protection. This makes it particularly vulnerable to illegal transboundary fishing at night, particularly from Honduran boats.

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The Half Moon Caye Elbow spawning aggregation site is also used by Nassau grouper, but in very low numbers - the maximum number observed in January 2002 was ten (Heyman et al., 2002), and only one was recorded in January 2006 (BAS data). There is little long term data available for determining trends in the spawning populations for this site. However, it is identified as being important as a multi-species spawning aggregation site, with twenty species being recorded using the location over the course of the year (Heyman et al., 2002).

Other grouper species - the **goliath, yellowmouth, yellowfin** and **tiger groupers** - are also recorded on the Atoll (Table 23). The **red grouper** has been recorded at HMCNM by REEF expert divers (REEF, 1996) but not in more recent surveys. Like the Nassau grouper, these species are commercially important, both for fishing and tourism.

Nine snapper species have been recorded on the Atoll. The **mutton snapper** and the **Cubera snapper** are both key commercial finfish species, and recorded in all reef habitat types as well as seagrass areas. Both utilize spawning aggregation sites - mutton snapper have been recorded at South Point and Cubera snapper at Half Moon Caye (Heyman et al., 2003).

The **hogfish** (IUCN: Vulnerable) are recorded in all reef habitat types and seagrass at HMCNM, and are known to form spawning aggregations at a site at Southern Lighthouse Reef, in 25m of water just off the shelf edge (Heyman and Boucher, unpublished).

Groupers and Snappers of Lighthouse Reef

Rock hind	<i>Epinephelus adscensionis</i>
Graysby	<i>Epinephelus cruentatus</i>
Coney	<i>Epinephelus fulvus</i>
Red hind	<i>Epinephelus guttatus</i>
Goliath grouper (CR)	<i>Epinephelus itajara</i>
Nassau grouper (EN)	<i>Epinephelus striatus</i>
Red Grouper (NT)	<i>Epinephelus morio</i>
Black grouper	<i>Mycteroperca bonaci</i>
Yellowmouth grouper (VU)	<i>Mycteroperca interstitialis</i>
Tiger grouper	<i>Mycteroperca tigris</i>
Yellowfin grouper	<i>Mycteroperca venenosa</i>
Mutton snapper (VU)	<i>Lutjanus analis</i>
Schoolmaster	<i>Lutjanus apodus</i>
Blackfin snapper	<i>Lutjanus buccanella</i>
Cubera snapper (VU)	<i>Lutjanus cyanopterus</i>
Gray snapper	<i>Lutjanus griseus</i>
Dog snapper	<i>Lutjanus jocu</i>
Mahogany snapper	<i>Lutjanus mahogani</i>
Lane snapper	<i>Lutjanus synagris</i>
Yellowtail snapper	<i>Ocyurus chrysurus</i>

CR Critically Endangered

EN Endangered

VU Vulnerable

NT Near Threatened

Table 23: *Grouper and Snappers of Lighthouse Reef*

Herbivorous fish populations, such as some species of parrotfish (Scaridae) and surgeonfish (Acanthuridae) are the dominant grazers of the reef ecosystem, and considered important for the maintenance of the health of the reef. These species keep algal growth under control and effectively reduce algal cover, increasing substrate availability for coral recruitment (Mumby et al., 2006). The **rainbow parrotfish** (IUCN: Vulnerable), one of the largest species in this family,

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was not recorded in the literature at HMCNM between 1995 and 2013, though anecdotal reports suggest it may have been seen near Long Caye in 2000 (Beveridge, pers. com.). More recently, in 2013, four individuals were reported at the Sandbore spawning aggregation site (BAS, 2013). In 2014 / 2015, this species was reported in very low numbers in the waters around Half Moon Caye (Romero, pers. com., 2015), suggesting that the population is slowly recovering, and that the legislation banning fishing for parrotfish is leading to improved viability of this and other large parrotfish species. Several other species of large parrotfish are also present at HMCNM, including the **stoplight, blue, midnight** and **queen parrotfish**.

The colorful reef species are also commercially important for dive tourism. Angelfish, triggerfish, the large parrotfish, grunts and damselfish all help to enhance the dive sites and maintain Lighthouse Reef's reputation as a global premier dive site. It has been shown that divers rate the abundance, size and diversity of reef fish highly as attributes that they seek in a dive site, above the condition of the reef itself (Williams & Polunin, 2000). Increasing the value of large species such as rays and sharks, the large parrotfish, groupers and snappers to the tourism industry, and to Belize's economic as a whole. Greatest diversity and abundance of reef fish were recorded on the Half Moon Caye Wall and fore-reef.



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Lighthouse Reef Atoll is considered important for elasmobranchs, with at least 14 species of sharks and rays known to use the Atoll and the deeper waters outside (Table 24; Graham, 2015), providing an important foraging ground as well as reproductive and nursery areas for many of these shark and ray species.

Shark and Ray Species of Lighthouse Reef Atoll		2004	2007	2008	2009	2010	2011	2012	2013	2014
Caribbean Reef Shark (NT)	<i>Carcharhinus perezi</i>									
Nurse shark	<i>Ginglymostoma cirratum</i>									
Black tip Shark (NT)	<i>Carcharhinus melanopterus</i>									
Caribbean Sharpnose Shark	<i>Rhizoprionodon porosus</i>									
Lemon Shark (NT)	<i>Negaprion brevirostris</i>									
Silky Shark (NT)	<i>Carcharhinus falciformis</i>									
Smooth Doghound (NT)	<i>Mustelus canis</i>									
Tiger Shark (NT)	<i>Galeocerdo cuvier</i>									
Great Hammerhead (EN)	<i>Sphyrna mokarran</i>									
Scalloped Hammerhead (EN)	<i>Sphyrna lewini</i>	<i>Tour guide / fisher consultations</i>								
Whale shark (EN)	<i>Rhincodon typus</i>	<i>From acoustic receivers</i>								
Shortfin Mako (VU)	<i>Isurus oxyrinchus</i>	<i>From skeletal remains</i>								
Southern stingray	<i>Dasyatis americana</i>									
Spotted eagle ray (NT)	<i>Aetobatus narinari</i>									
Caribbean whiptail stingray	<i>Himantura schmardae</i>									
Yellow stingray	<i>Urobatis jamaicensis</i>									

Table 24: Sharks and Rays of Lighthouse Reef Atoll (MarAlliance, 2015)

The **Caribbean reef shark** is the most abundant shark species on the Atoll, and has been recorded consistently from 2007 to 2014 (Graham, 2015). This seascape species requires large interconnected marine ecosystems, and has been tracked crossing from Lighthouse Reef Atoll to Turneffe and Glover’s Reef Atolls, as far south as the reef near Sapodilla Cayes in southern Belize – and presumably on into Guatemalan and Honduran waters (Graham, 2015). It is an iconic species of the Blue Hole Natural Monument, which also occasionally hosts the **great hammerhead**. The **nurse shark**, too, has been consistent in its presence and, along with the **Caribbean sharpnose** and **lemon sharks**, uses the seagrass flats and patch reefs of the Atoll. The lemon sharks are known to use nursery areas near Long Caye and Northern 2 Cayes (Graham, pers. com., 2015), and the area may also be important as a reproductive ground for the **Smooth Dogfish**, as one was found to have six near-term pups.

Sharks also use the deeper waters outside the Atoll. The presence of the **Whale Shark** at the Atoll has been confirmed from acoustic work (Graham, 2003), and the **Tiger Shark** has been recorded at Lighthouse Reef in 2009. This species rarely ventures over coral reefs and is more likely to be found outside the atoll, in the deeper waters (Deloach and Humann, 1999). The deep

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sea **Short Fin Mako** has also been reported, based on skeletal remains found on the Atoll, and on reports from sport fishers.

Studies at the two adjacent atolls of Glover’s Reef and Turneffe Atoll have also demonstrated the presence of several deep water species. Smooth dogfish (*Mustelus canis insularis*) (Chapman, 2011), the bigeye sixgill (*Hexanchus nakamurai*) and the extremely rare goblin shark (*Mitsukurina owstoni*) (Graham, 2007), and the presence of Galapagos shark (*Carcharhinus galapagensis*) and night shark (*Carcharhinus signatus*) at Glover’s, suggests that these species may also pass through the deeper waters of the Lighthouse Reef Atoll. The latter two are not considered common inhabitants of the waters of Central America (Chapman et al., 2011). **Spotted Eagle Rays** have been observed in all reef habitats at Lighthouse Reef Atoll.

Currently both the whale shark and the nurse shark are protected under Belize legislation (2003 and 2011 respectively) and the ban on the use of seine / gill nets and longlines within marine protected area boundaries has provided a degree of protection for sharks, demonstrated by increased abundance of sharks recorded inside versus outside of the marine protected areas in Southern Belize (Graham unpublished data). There is increasing realization of the touristic value provided by the presence of other shark species, which may lead to a move towards greater protection. Many of these elasmobranch species are commercially important for both the fishing and dive tourism industries. Despite their globally Endangered status (IUCN 2011) both great and scalloped hammerheads are still fished in Belize. However, as a contracting party to the International Commission for the Conservation of Atlantic Tunas (ICCAT), Belize is no longer permitted to export hammerhead products, which may provide additional management measures, if enforced, for hammerheads (Graham, pers. com.).

Based on recent research, shark and ray populations on Lighthouse Reef Atoll have been considered to be stable (Graham pers, com., 2015). However, with recent reports on the scale of legal shark fishing on the Atoll, and continued reports of illegal transboundary long lining and the use of nets on the reef channels, it is now thought that the populations are declining.

Lighthouse Reef Atoll and the associated drop-off also provides important habitat for pelagic and migratory species such as marlin, sailfish, wahoo, kingfish, tuna (bonito, yellowfin), mackerel, and jack (amber, horse-eye, crevalle).

The invasive **lionfish** (*Pterois volitans*) are found throughout Lighthouse Reef Atoll, from the reef to the seagrass beds and mangroves, and have been caught up to depths of 150m (Westby (Anecdotal information in: Belize Fisheries Dept et al., draft). Lionfish are known to be voracious predators, able to expand their stomach volumes over thirty times to accommodate large prey (Fishelson, 1997), and have a broad diet that includes a large range of juvenile fish, shrimps and crabs (Morris and Akins 2009). Limited surveys of lionfish gut content from the adjacent Turneffe Atoll suggest that just over half the prey (52%) are shrimp, the remainder are juvenile fish species – juvenile damselfish, gobies, parrotfish and grouper (red hind) (Anderson, 2010).

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Fish Species of Lighthouse Reef Atoll / 1		
Family	Species	Common name
CARCHARHINIFORMES		
Carcharhinidae	<i>Carcharhinus falciformes</i>	Silky shark (NT)
	<i>Carcharhinus leucas</i>	Bull Shark (NT)
	<i>Carcharhinus melanopterus</i>	Blacktip shark (NT)
	<i>Carcharhinus perezi</i>	Caribbean reef shark (NT)
	<i>Galeocerdo cuvier</i>	Tiger shark (NT)
	<i>Negaprion brevirostris</i>	Lemon Shark (NT)
	<i>Rhizoprionodon porosus</i>	Caribbean sharpnose shark
Sphyrnidae	<i>Sphyrna mokarran</i>	Great Hammerhead (EN) Scalloped Hammerhead (EN)
	<i>Sphyrna lewini</i>	
Triakidae	<i>Mustelus canis</i>	Smooth dogfish (NT)
ORECTOLOBIFORMES		
Ginglymostomatidae	<i>Ginglymostoma cirratum</i>	Nurse shark
Rhincodontidae	<i>Rhincodon typus</i>	Whale shark (EN)
MYLIOBATIFORMES		
Dasyatidae	<i>Dasyatis americana</i>	Southern stingray Caribbean whiptail
	<i>Himantura schmardae</i>	stingray
Myliobatidae	<i>Aetobatus narinari</i>	Spotted eagle ray (NT)
Urolophidae	<i>Urobatis jamaicensis</i>	Yellow stingray
ACTINOPTERYGII (Ray-finned fish)		
ALBULIFORMES		
Albulidae	<i>Albula vulpes</i>	Bonefish
ANGULLIFORMES		
Congridae	<i>Heteroconger halis</i>	Brown garden eel
Muraenidae	<i>Gymnothorax funebris</i>	Green moray
	<i>Gymnothorax miliaris</i>	Goldentail moray
	<i>Gymnothorax moringa</i>	Spotted moray
AULOPIFORMES		
Synodontidea	<i>Synodus intermedius</i>	Sand diver
BELONIFORMES		
Belonidae	<i>Ablennes hians</i>	Flat needlefish
BERYCIFORMES		
Holocentridae	<i>Holocentrus adscensionis</i>	Squirrelfish
	<i>Holocentrus marianus</i>	Longjaw squirrelfish
	<i>Holocentrus rufus</i>	Longspine squirrelfish
	<i>Myripristis jacobus</i>	Blackbar soldierfish
	<i>Sargocentron vexillarium</i>	Dusky squirrelfish
ELOPIFORMES		
Elopidae	<i>Megalops atlanticus</i>	Tarpon
GASTEROSTEIFORMES		
Aulostomidae	<i>Aulostomus maculatus</i>	Trumpetfish

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Fish Species of Lighthouse Reef Atoll / 2		
Family	Species	Common name
PERCIFORMES		
Apogonidae	<i>Apogon lachneri</i>	Whitestar cardinalfish
	<i>Apogon townsendi</i>	Belted cardinalfish
	<i>Phaeoptyx pigmentaria</i>	Dusky cardinalfish
Carangidae	<i>Carangoides bartholomaei</i>	Yellow jack
	<i>Carangoides ruber</i>	Bar jack
	<i>Caranx crysos</i>	Blue Runner
	<i>Caranx hippos</i>	Crevalle jack
	<i>Caranx latus</i>	Horse-eye jack
	<i>Trachinotus falcatus</i>	Permit
Chaenopsidae	<i>Acanthemblemaria spinosa</i>	Spinyhead blenny
	<i>Chenopsis ocellata</i>	Bluethroat pikeblenny
	<i>Emblemaria pandionis</i>	Sailfin blenny
	<i>Lucayablennius zingaro</i>	Arrow blenny
Chaetodontidae	<i>Chaetodon capistratus</i>	Foureye butterflyfish
	<i>Chaetodon ocellatus</i>	Spotfin butterflyfish
	<i>Chaetodon striatus</i>	Banded butterflyfish
	<i>Prognathodes aculeatus</i>	Longsnout butterflyfish
Cirrhitidae	<i>Amblycirrhitus pinos</i>	Redspotted hawkfish
Echeneidae	<i>Echeneis naucrates</i>	Sharksucker
	<i>Echeneis neucratoides</i>	Whitefin sharksucker
Gerreidae	<i>Gerres cinereus</i>	Yellowfin mojarra
Gobiidae	<i>Bathygobius soporator</i>	Frillfin goby
	<i>Coryphopterus eidolon</i>	Pallid goby
	<i>Coryphopterus lipernes</i>	Peppermint goby
	<i>Coryphopterus personatus</i>	Masked / glass goby
	<i>Ctenogobius saepepallens</i>	Dash goby
	<i>Elacatinus dilepis</i>	Orangesided goby
	<i>Gnatholepis thompsoni</i>	Goldspot goby
Grammatidae	<i>Gramma loreto</i>	Fairy basslet
	<i>Gramma melacara</i>	Blackcap basslet
Haemulidae	<i>Anistremus virginicus</i>	Porkfish
	<i>Haemulon album</i>	White margate
	<i>Haemulon aurolineatum</i>	Tomtate
	<i>Haemulon carbonarium</i>	Caesar grunt
	<i>Haemulon flavolineatum</i>	French grunt
	<i>Haemulon plumieri</i>	White grunt
Inermiidae	<i>Haemulon sciurus</i>	Bluestriped grunt
	<i>Emmelichthyops atlanticus</i>	Bonnetmouth
Istiophoridae	<i>Inermia vittata</i>	Boga
	<i>Makaira nigricans</i>	Atlantic blue marlin
Kyphosidae	<i>Kyphosus sectator</i>	Chub
Labridae	<i>Bodianus rufus</i>	Spanish hogfish
	<i>Clepticus parrae</i>	Creole wrasse
	<i>Halichoeres bivittatus</i>	Slippery dick

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Fish Species of Lighthouse Reef Atoll / 3		
Family	Species	Common name
Labridae	<i>Halichoeres garnoti</i>	Yellowhead wrasse
	<i>Halichoeres maculipinna</i>	Clown wrasse
	<i>Halichoeres pictus</i>	Rainbow wrasse
	<i>Halichoeres radiatus</i>	Puddingwife
	<i>Lachnolaimus maximus</i>	Hogfish
	<i>Thalassoma bifasciatum</i>	Bluehead wrasse
	<i>Xyrichtys martinicensis</i>	Rosy razorfish
	<i>Xyrichtys splendens</i>	Green razorfish
Labrisomidae	<i>Malacoctenus boehlkei</i>	Diamond blenny
	<i>Malacoctenus triangulatus</i>	Saddled blenny
Lutjanidae	<i>Lutjanus analis</i>	Mutton snapper
	<i>Lutjanus apodus</i>	Schoolmaster
	<i>Lutjanus buccanella</i>	Blackfin snapper
	<i>Lutjanus cyanopterus</i>	Cubera snapper
	<i>Lutjanus griseus</i>	Gray snapper
	<i>Lutjanus jocu</i>	Dog snapper
	<i>Lutjanus mahogani</i>	Mahogany snapper
	<i>Lutjanus synagris</i>	Lane snapper
	<i>Ocyurus chrysurus</i>	Yellowtail snapper
Malacanthidae	<i>Malacanthus plumieri</i>	Sand tilefish
Mullidae	<i>Mulloidichthys martinicus</i>	Yellow goatfish
	<i>Pseudupeneus maculatus</i>	Spotted goatfish
Opistognathidae	<i>Opistognathus aurifrons</i>	Yellowhead jawfish
Pomacanthidae	<i>Abudefduf saxatilis</i>	Sergeant major
	<i>Centropyge argi</i>	Cherubfish
	<i>Chromis cyanea</i>	Blue chromis
	<i>Chromis multilineata</i>	Brown chromis
	<i>Holacanthus ciliaris</i>	Queen angelfish
	<i>Holacanthus tricolor</i>	Rock beauty
	<i>Microspathodon chrysurus</i>	Yellowtail damselfish
	<i>Pomacanthus arcuatus</i>	Grey angelfish
	<i>Pomacanthus paru</i>	French angelfish
	<i>Stegastes adustus</i>	Dusky damselfish
	<i>Stegastes diencaeus</i>	Longfin damselfish
	<i>Stegastes leucostictus</i>	Beaugregory
	<i>Stegastes partitus</i>	Bicolor damselfish
	<i>Stegastes planifrons</i>	Threespot damselfish
	<i>Stegastes variabilis</i>	Cocoa damselfish
Priacanthidae	<i>Heteropriacanthus cruentatus</i>	Glasseye snapper
	<i>Priacanthus arenatus</i>	Bigeye
Scaridae	<i>Cryptotomus roseus</i>	Bluelip parrotfish
	<i>Scarus coelestinus</i>	Midnight parrotfish
	<i>Scarus coeruleus</i>	Blue parrotfish
	<i>Scarus croicensis</i>	Striped parrotfish
	<i>Scarus guacamaia</i>	Rainbow parrotfish (VU)
	<i>Scarus taeniopterus</i>	Princess parrotfish

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Fish Species of Lighthouse Reef Atoll / 4		
Family	Species	Common name
Scaridae	<i>Scarus vetula</i>	Queen parrotfish
	<i>Sparisoma atomarium</i>	Greenblotch parrotfish
	<i>Sparisoma aurofrenatum</i>	Redband parrotfish
	<i>Sparisoma chrysopterygum</i>	Redtail parrotfish
	<i>Sparisoma radians</i>	Bucktooth parrotfish
	<i>Sparisoma rubripinne</i>	Redfin parrotfish
	<i>Sparisoma viridae</i>	Stoplight parrotfish
Sciaenidae	<i>Equetus punctatus</i>	Spotted drum
Scombridae	<i>Acanthocybium solandri</i>	Wahoo
	<i>Scomberomorus cavalla</i>	King mackerel
	<i>Scomberomorus regala</i>	Cero
	<i>Thunnus albacares</i>	Yellowfin tuna
Serranidae	<i>Cephalopholis cruentata</i>	Graysby
	<i>Cephalopholis fulvus</i>	Coney
	<i>Epinephelus adscensionis</i>	Rock hind
	<i>Epinephelus guttatus</i>	Red hind
	<i>Epinephelus itajara</i>	Goliath grouper (CR)
	<i>Epinephelus striatus</i>	Nassau grouper (EN)
	<i>Hypoplectrus indigo</i>	Indigo hamlet
	<i>Hypoplectrus nigricans</i>	Black hamlet
	<i>Hypoplectrus puella</i>	Barred hamlet
	<i>Hypoplectrus unicolor</i>	Butter hamlet
	<i>Liopropoma mowbrayi</i>	Cave bass
	<i>Mycteroperca bonaci</i>	Black grouper
	<i>Mycteroperca interstitialis</i>	Yellowmouth grouper
	<i>Mycteroperca tigris</i>	Tiger grouper
	<i>Mycteroperca venenosa</i>	Yellowfin grouper
<i>Rypticus saponaceus</i>	Greater soapfish	
<i>Serranus tabacarius</i>	Tobaccofish	
<i>Serranus tigrinus</i>	Harlequin bass	
Sparidae	<i>Calamus bajonado</i>	Jolthead porgy
	<i>Calamus calamus</i>	Saucereye porgy
Sphyraenidae	<i>Sphyraena barracuda</i>	Barracuda
PLEURONECTIFORMES		
Bothiidae	<i>Bothus lunatus</i>	Peacock Flounder
SCORPAENIFORMES		
Scorpaenidae	<i>Scorpaena plumieri</i>	Spotted scorpionfish
TETRAODONTIFORMES		
Acanthuridae	<i>Acanthurus bahianus</i>	Ocean surgeonfish
	<i>Acanthurus chirurgicus</i>	Doctorfish
	<i>Acanthurus coeruleus</i>	Blue tang
Balistidae	<i>Balistes vetula</i>	Queen triggerfish
	<i>Canthidermis sufflamen</i>	Ocean triggerfish
	<i>Melichthys niger</i>	Black durgon
Diodontidae	<i>Diodon hystrix</i>	Porcupinefish

Fish Species of Lighthouse Reef Atoll / 5		
Family	Species	Common name
Monacanthidae	<i>Aluterus scriptus</i>	Scrawled filefish
	<i>Cantherhines macrocerus</i>	Whitespotted filefish
	<i>Cantherhines pullus</i>	Orangespotted filefish
Ostraciidae	<i>Lactophrys bicaudalis</i>	Spotted trunkfish
	<i>Lactophrys trigonus</i>	Trunkfish
	<i>Lactophrys triqueter</i>	Smooth trunkfish
Tetraodontidae	<i>Canthigaster rostrata</i>	Sharpnose puffer
	<i>Sphoeroides spengleri</i>	Bandtail puffer

Table 25: Fish Species of Lighthouse Reef Atoll



Nurse Shark

R. Graham

Birds

The bird fauna of Half Moon Caye is composed of a small number of resident species (the red-footed booby, magnificent frigatebird, white-crowned parrot, cinnamon hummingbird, osprey and great-tailed grackle), supplemented by a seasonal influx of migrants (Table 24). The first comprehensive survey took place in 1958, with 87 species being recorded (Verner, 1961). Several studies since then have increased the species inventory to 128 species, and provided benchmark figures for the iconic white-phase red-footed booby and magnificent frigatebird populations.

The red-footed booby and the magnificent frigatebird both nest in large numbers on the caye each year – and the nesting colony is the original reason for the establishment of the Natural Monument. There have been several studies of the birds of Half Moon Caye, primarily focused on the mixed nesting colony of red-footed booby colony and magnificent frigatebirds, and ongoing monitoring of the population is included in the management activities. A preliminary study by Salvin in 1864 established the caye as a known red-footed booby nesting location, and in 1961, the population was estimated at 3,500 (including immatures but not nestlings) (Verner, 1961). Current estimates place the population at approximately 3,700 (BAS, 2015). Whilst reports indicate that the colony has been stable between 1958 and 1991, anecdotal information suggests that the colony is half the size it was originally, before the 1931 hurricane (Cross, 1992).



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The colony does, however, appear to be very resilient - Hurricane Hattie, whilst causing severe impacts to the vegetation, is thought to have resulted in a delay of the start of the nesting season, but no serious reduction in the number of nests (Stoddard, 1969). More recent storms also do not appear to have significantly impacted the population, though whether this will continue to be true, with the predicted increase in large hurricanes over the coming years, is not yet known.

A number of surveys over the years concentrated on active nests rather than actual population estimates. Nest survey results varied dependent on the time of year and the time available for nest counts. The low count in 1988 may have been a result of impacts by Hurricane Gilbert (Pomeroy, 1988; Cross, 1992), and the low number of nests in 1995 is thought to reflect the timing of the survey, at the start of the nesting season (Table 26).

Red-footed Booby Nesting Population		
Year	Number of nests	Observer
1958	1389	Verner
1975	1285	Goshen students
1978	1329	Weyer
1981	1231	Rhodes and Mann
1988	886	Pomeroy
1991	1325	Cross
1995	28	Miller and Miller

Table 26: Red-footed booby nest survey results

Boobies, fast, long distance fliers capable of traveling hundreds of miles in a day, search for squid and small fish, and provide a useful indicator of the condition of the marine environment of their feeding grounds. Although the red-footed booby is widespread throughout the tropics, there are three geographically separate races. The Belize sub-species, *S. sula sula*, is found throughout the western Caribbean. They concentrate in only a limited number of breeding colonies, most of which are unprotected, making them very vulnerable. Half Moon Caye supports what is considered to be the only viable breeding colony in the western Caribbean. .

Because boobies generally do not recognize humans as a threat, they have been easily exploited in the past, with the colony at Half Moon Caye being no exception. Until a permanent BAS staff base was established on the cay, lighthouse keepers and fishermen would both stock up on eggs during the nesting season. Introduced dogs, cats, rats and other man-associated predators have also been a threat for the same reasons, and reports suggest that the large population of native black iguanas also raid nests, taking eggs and young nestlings (Pomeroy, 1989).

The second species using the colony is the magnificent frigatebird. A 1991 survey of the nesting magnificent frigatebirds estimated the presence of seventy-one nests (Cross, 1992). Current monitoring by BAS places the population at approximately 1,730 individuals (BAS, 2015).

The black catbird was reported as resident on Half Moon Caye many years ago, but hasn't been recorded in recent surveys. It has, however, been recorded from the adjacent Long Caye, and most recently, its presence has been confirmed on Northern Two Cayes (R. Martinez, 2015). The

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golden fronted woodpecker and tropical mockingbird, too, have both been recorded on Long Caye but are not represented on the Half Moon Caye list – it would be reasonable to expect these species to establish or re-establish a presence on Half Moon Caye.

As well as the resident species, the cayes of Lighthouse Reef Atoll are important as a migratory bird stopover and refueling point and, being the most isolated of the three atolls, is thought to have the highest concentration of migrants of any comparable area in the region (L. Jones, pers. com.). Many thousands of migrants that have meandered off course end up on Half Moon Caye and other remote cayes every spring and fall. Some migrants that would normally follow the mainland coast may end up on Half Moon Caye after being blown offshore by shifting winds, or drawn to the lighthouse in large numbers. Others may use Half Moon Caye as part of a straight line migration path down the Yucatan Peninsula coastline, through Ambergris Caye and then on to Half Moon, Glover’s Reef and Sapodilla Cayes, and from there to Guatemala and Honduras, where they hook up again with the mainland and its “infinite” resources.

Twelve monitoring sites have been set up across the Atoll to assist in monitoring migratory bird species, with training of the Research Assistant and rangers in species identification. A comparison of the migratory species recorded on Half Moon Caye with those of migratory species surveys on the remote San Andres Island, offshore of Columbia, shows an 87.5% species overlap. If they do wander off course, islands such as Half Moon Caye 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. Other migrants that might occur on the cayes but have not yet been recorded include the American kestrel, black-necked stilt, solitary sandpiper, common tern, least tern, white-winged dove, mourning dove, common nighthawk, olive-sided, alder and least flycatcher, gray kingbird, and Lincoln’s sparrow (L. Jones, pers. com.)



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Bird Species of Lighthouse Reef Atoll /1		
Species		Status
Brown Booby	<i>Sula leucogaster</i>	uV
Red-footed Booby	<i>Sula sula</i>	vP
Brown Pelican	<i>Pelecanus occidentalis</i>	cV
Magnificent Frigatebird	<i>Fregata magnificens</i>	vP
Least Bittern	<i>Ixobrychus exilis</i>	oT
Great Blue Heron	<i>Ardea herodias</i>	uV
Great Egret	<i>Ardea alba</i>	uV
Snowy Egret	<i>Egretta thula</i>	uV
Little Blue Heron	<i>Egretta caerulea</i>	uV
Tricolored Heron	<i>Egretta tricolor</i>	oV
Cattle Egret	<i>Bubulcus ibis</i>	fT
Green Heron	<i>Butorides virescens</i>	fV
Yellow-crowned Night-Heron	<i>Nyctanassa violacea</i>	uT
Blue-winged Teal	<i>Anas discors</i>	oT
Lesser Scaup	<i>Aythya affinis</i>	oT
Osprey	<i>Pandion haliaetus</i>	fP
Common Black-Hawk	<i>Buteogallus anthracinus</i>	x
Merlin	<i>Falco columbarius</i>	uT
Peregrine Falcon	<i>Falco peregrinus</i>	fT
Sora	<i>Porzana carolina</i>	oT
American Coot	<i>Fulica americana</i>	oT
Clapper Rail	<i>Rallus longirostris</i>	cP
Black-bellied Plover	<i>Pluvialis squatarola</i>	uW
Collared Plover	<i>Charadrius collaris</i>	F
Semipalmated Plover	<i>Charadrius semipalmatus</i>	oT
Killdeer	<i>Charadrius vociferus</i>	uT
Greater Yellowlegs	<i>Tringa melanoleuca</i>	uT
Willet	<i>Catoptrophorus semipalmatus</i>	oT
Spotted Sandpiper	<i>Actitis macularia</i>	cW
Ruddy Turnstone	<i>Arenaria interpres</i>	fW
Sanderling	<i>Calidris alba</i>	fW
Western Sandpiper	<i>Calidris mauri</i>	oT
Least Sandpiper	<i>Calidris minutilla</i>	uT
Wilson's Snipe	<i>Gallinago delicata</i>	oT
Laughing Gull	<i>Larus atricilla</i>	uV

Status
Legend

v = very common	P = permanent resident
c = common	S = seasonal resident
f = fairly common	V = visitor
u = uncommon	T = transient (migrant)
o = occasional	W = winter resident
l = local	F = former resident

X = one or two records only

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Bird Species of Lighthouse Reef Atoll / 2		
Species		Status
Semipalmated Sandpiper	<i>Calidris pusilla</i>	oT
Western Sandpiper	<i>Calidris mauri</i>	oT
Least Sandpiper	<i>Calidris minutilla</i>	uT
Wilson’s Snipe	<i>Gallinago delicata</i>	oT
Laughing Gull	<i>Larus atricilla</i>	uV
Ring-billed Gull	<i>Larus delawarensis</i>	oW
Herring Gull	<i>Larus argentatus</i>	oW
Royal Tern	<i>Sterna maxima</i>	cV
Sandwich Tern	<i>Sterna sandvicensis</i>	uV
Bridled Tern	<i>Sterna anaethetus</i>	oV
White-crowned Pigeon	<i>Columba leucocephala</i>	fS
White-winged Dove	<i>Zenaida asiatica</i>	cT
Yellow-naped Parrot	<i>Amazona auropalliata</i>	T
Yellow-billed Cuckoo	<i>Coccyzus americanus</i>	fT
Smooth-billed Ani	<i>Crotophaga ani</i>	x
Groove-billed Ani	<i>Crotophaga sulcirostris</i>	oW
Lesser Nighthawk	<i>Chordeiles acutipennis</i>	uT
Yucatan Nightjar	<i>Caprimulgus badius</i>	x
Chimney Swift	<i>Chaetura pelagica</i>	uT
Green-breasted Mango	<i>Anthracothorax prevostii</i>	fS?
Cinnamon Hummingbird	<i>Amazilia rutila</i>	fP
Ruby-throated Hummingbird	<i>Archilochus colubris</i>	uT
Ringed Kingfisher	<i>Ceryle torquata</i>	
Belted Kingfisher	<i>Ceryle alcyon</i>	fW
Yellow-bellied Sapsucker	<i>Sphyrapicus varius</i>	oT
Caribbean Elaenia	<i>Elaenia martinica</i>	x
Least Flycatcher	<i>Empidonax minimus</i>	cW
Eastern Wood-Pewee	<i>Contopus virens</i>	vT
Yellow-bellied Flycatcher	<i>Empidonax flaviventris</i>	cT
Acadian Flycatcher	<i>Empidonax virescens</i>	cT
Willow Flycatcher	<i>Empidonax traillii</i>	fT
Great Crested Flycatcher	<i>Myiarchus crinitus</i>	cT
Sulphur-bellied Flycatcher	<i>Myiodynastes luteiventris</i>	oT
Piratic Flycatcher	<i>Legatus leucophalus</i>	oT
Grey Kingbird	<i>Tyrannus dominicensis</i>	o
Eastern Kingbird	<i>Tyrannus tyrannus</i>	cT

Status
Legend

v = very common	P = permanent resident
c = common	S = seasonal resident
f = fairly common	V = visitor
u = uncommon	T = transient (migrant)
o = occasional	W = winter resident
l = local	F = former resident

X = one or two records only

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Bird Species of Lighthouse Reef Atoll / 3

Species		Status
White-eyed Vireo	<i>Vireo griseus</i>	cT
Yellow-throated Vireo	<i>Vireo flavifrons</i>	fT
Philadelphia Vireo	<i>Vireo philadelphicus</i>	uT
Red-eyed Vireo	<i>Vireo olivaceus</i>	cT
Yellow-green Vireo	<i>Vireo flavoviridis</i>	oT
Black-whiskered Vireo	<i>Vireo altiloquus</i>	x
Purple Martin	<i>Progne subis</i>	cT
Northern Rough-winged Swallow	<i>Stelgidopteryx serripennis</i>	uT
Bank Swallow	<i>Riparia riparia</i>	uT
Cliff Swallow	<i>Petrochelidon pyrrhonota</i>	uT
Barn Swallow	<i>Hirundo rustica</i>	cT
Veery	<i>Catharus fuscescens</i>	fT
Gray-cheeked Thrush	<i>Catharus minimus</i>	uT
Swainson's Thrush	<i>Catharus ustulatus</i>	cT
Wood Thrush	<i>Hylocichla mustelina</i>	cT
Gray Catbird	<i>Dumetella carolinensis</i>	vT
Black Catbird	<i>Melanoptila glabrirostris</i>	F
Cedar Waxwing	<i>Bombycilla cedrorum</i>	oT
Blue-winged Warbler	<i>Vermivora pinus</i>	oT
Golden-winged Warbler	<i>Vermivora chrysoptera</i>	oT
Tennessee Warbler	<i>Vermivora peregrina</i>	vT
Nashville Warbler	<i>Vermivora ruficapilla</i>	x
Northern Parula	<i>Parula americana</i>	cW
Mangrove Warbler	<i>Dendroica petechia</i>	v
	<i>(erithachorides group)</i>	
Yellow Warbler	<i>Dendroica petechia</i>	cW
Chestnut-sided Warbler	<i>Dendroica pensylvanica</i>	cT
Magnolia Warbler	<i>Dendroica magnolia</i>	cT
Cape May Warbler	<i>Dendroica tigrina</i>	uT
Black-throated Blue Warbler	<i>Dendroica caerulescens</i>	uT
Yellow-rumped Warbler	<i>Dendroica coronata</i>	uT
Black-throated Green Warbler	<i>Dendroica virens</i>	fT
Blackburnian Warbler	<i>Dendroica fusca</i>	uT
Yellow-throated Warbler	<i>Dendroica dominica</i>	cW
Prairie Warbler	<i>Dendroica discolor</i>	uW
Palm Warbler	<i>Dendroica palmarum</i>	cW

Status

Legend

v = **very common**

c = **common**

f = **fairly common**

u = **uncommon**

o = **occasional**

l = **local**

X = **one or two records only**

P = permanent resident

S = seasonal resident

V = visitor

T = transient (migrant)

W = winter resident

F = former resident

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Bird Species of Lighthouse Reef Atoll / 4		
Species		Status
Bay-breasted Warbler	<i>Dendroica castanea</i>	uT
Cerulean Warbler	<i>Dendroica cerulea</i>	oT
Black-and-white Warbler	<i>Mniotilta varia</i>	cW
American Redstart	<i>Setophaga ruticilla</i>	vW
Prothonotary Warbler	<i>Protonotaria citrea</i>	fT
Worm-eating Warbler	<i>Helmitheros vermivorus</i>	fT
Swainson’s Warbler	<i>Limnothlypis swainsonii</i>	oT
Ovenbird	<i>Seiurus aurocapilla</i>	cW
Northern Waterthrush	<i>Seiurus noveboracensis</i>	cT
Louisiana Waterthrush	<i>Seiurus motacilla</i>	uT
Kentucky Warbler	<i>Oporornis formosus</i>	uT
Connecticut Warbler	<i>Oporornis agilis</i>	x?
Mourning Warbler	<i>Oporornis philadelphia</i>	uT
Common Yellowthroat	<i>Geothlypis trichas</i>	cW
Hooded Warbler	<i>Wilsonia citrine</i>	cW
Wilson’s Warbler	<i>Wilsonia pusilla</i>	oT
Canada Warbler	<i>Wilsonia canadensis</i>	uT
Yellow-breasted Chat	<i>Icteria virens</i>	cT
Summer Tanager	<i>Piranga rubra</i>	cW
Scarlet Tanager	<i>Piranga olivacea</i>	cT
Chipping Sparrow	<i>Spizella passerina</i>	x
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	x
White-throated Sparrow	<i>Zonotrichia albicollis</i>	x
Rose-breasted Grosbeak	<i>Pheucticus ludovicianus</i>	cT
Blue Grosbeak	<i>Passerina caerulea</i>	cT
Indigo Bunting	<i>Passerina cyanea</i>	vT
Bobolink	<i>Dolichonyx oryzivorus</i>	oT
Great-tailed Grackle	<i>Quiscalus mexicanus</i>	vP
Orchard Oriole	<i>Icterus spurius</i>	uT
Baltimore Oriole	<i>Icterus galbula</i>	cT
Painted Bunting	<i>Passerina ciris</i>	uT
Dickcissel	<i>Spiza americana</i>	uT
Status		
Legend		
v = very common	P = permanent resident	
c = common	S = seasonal resident	
f = fairly common	V = visitor	
u = uncommon	T = transient (migrant)	
o = occasional	W = winter resident	
l = local	F = former resident	
X = one or two records only		

With input from L. Jones, 2005; R. Martinez, 2015

Table 26: Bird Species of Lighthouse Reef Atoll

Herpetofauna

The herpetofauna of Half Moon Caye is comprised entirely of reptile species. The saline conditions found on the cayes, coupled with the lack of surface freshwater, create an environment that is unsuitable for amphibians. Snakes are also absent from Half Moon Caye – in this case distance from mainland and other populations is the main factor in having prevented colonization by species found on locations closer to the mainland, including Turneffe Atoll.

Ten reptile species have been recorded from Half Moon Caye (Table 29), six of which are terrestrial residents of the littoral forest and three are marine turtles. Six species are now globally threatened - the three marine turtles (loggerhead, green and hawksbill), the infrequently recorded fourth marine turtle species (the leatherback), the American crocodile and the island leaf-toed gecko (Table 27). Allison’s anole merits inclusion because of its very limited range and because it is likely to be a biogeographically distinct population from that on Cuba.

Reptiles of International Concern of Lighthouse Reef Atoll	
Critically Endangered	
Hawksbill Turtle	<i>Eretmochelys imbricata</i>
Endangered	
Loggerhead Turtle	<i>Caretta caretta</i>
Green Turtle	<i>Chelonia mydas</i>
Vulnerable	
Leatherback Turtle	<i>Dermochelys coriacea</i>
American Crocodile	<i>Crocodylus acutus</i>
Island Leaf-toed Gecko	<i>Phyllodactylus insularis</i>

Table 27: Reptiles of International Concern of Lighthouse Reef Atoll

Former records of the basilisk lizard (*Basiliscus vittatus*) and Carolina Anole (*Anolis carolinensis*) are considered erroneous and are discounted, and recent reports suggest that the anthropogenically introduced wood furrowed turtle (*Rhinoclemmys areolate*) has disappeared since 2004.

All four species of sea turtle in Belize’s waters have been recorded at Lighthouse Reef Atoll, and are of conservation interest (critically endangered, endangered or vulnerable, IUCN, 2016). In-water surveys suggest that whilst numbers are increasing, the majority (91%) of turtles recorded are juveniles (Scales et al. 2011). Half Moon Caye consistently has the most recorded turtle nest and turtle activity in with Sandbore demonstrating the second most turtle activity. Both these cayes have a relatively large beach area for turtles to nest on. Nest surveys have been incorporated into the BAS biodiversity monitoring activities for the last four years, and encompass all cayes of Lighthouse Reef.

Number of Turtle Nests per Caye		
Year	HMC	Sandbore
2013	5	7
2014	11	4
2015	14	6

Table 28: Number of turtle nests per caye

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In 2012, five nests were recorded on Half Moon Caye – two loggerhead, two green and one hawksbill. In the same year, Sandbore had seven successful nests – one loggerhead, five green and one unknown. These surveys indicate that the numbers of nests remain stable over the years. In 2015, the majority of turtles nesting on cayes of Lighthouse Reef Atoll were loggerhead and green turtles, with only two hawksbill nests recorded (Romero, pers. com., 2015).



Loggerhead turtle nesting at Sandbore, 2012
(The nest had a clutch estimated at 180 eggs, with a hatch success of 90% (BAS, 2012).

Turtles were heavily harvested for over 250 years in Belize, and as relatively recently as 1925 their numbers were considered 'inexhaustible' (Stoddart, 1962). On Half Moon Caye, turtles were hunted with nets, and nationally their numbers were considered seriously depleted by the 1960's (Smith, et al., 1992). Older fishermen interviewed by Smith (1989) attested to "definite changes in the numbers of sea turtles." Some who had been lighthouse keepers or had grown up on Half Moon Caye remembered 8-10 nests per week, and hundreds per season - so many green turtles that they were digging up previously laid eggs and even nesting during the day (Smith et. al., 1992). Northern Two Cayes (Sandbore and Northern Caye) are also reported to have had hundreds of green turtles nesting in past decades, with 15 being recorded on the beach in one night in the 1970's (Smith et. al., 1992). Today, nesting is rare, with fewer than 10 green turtle nests reported per year (Smith, et al, 1992). Further emphasizing the severity of the rapid decline in nesting turtles is the discovery that, for the hawksbill at least, the individuals nesting on a particular beach form a distinct population – whose feeding ranges overlap with other nesting populations, but with virtually no cross-nesting recruitment (Chacon, D. 2004). Once a nesting-beach population has crashed, there is therefore very little likelihood of it being recolonized by females from another nesting area.

Whilst the dramatic decline in the number of turtles nesting on Half Moon Caye follows regional (and indeed global) trends of decreasing marine turtle populations, it is also to some extent a reflection of the relative ephemeral nature of sandy nesting beaches on such exposed islands. Stoddart (1962) noted that the 1931 hurricane effectively removed a 20-30 yard wide stretch of the sandy beach, exposing the underlying bedrock. Hurricane Ivan, in 2004, also had a dramatic impact on the southeastern turtle-nesting beach – burying it under 30-50cm of coral rubble. This thick layer of rubble effectively blocked access to the upper beach for gravid female turtles. Similarly it has been noted that accumulated washed up garbage can impair turtle nesting behavior or even render nesting beaches inaccessible (Smith, et. al., 1992).

Marine Turtles of Half Moon Caye

The critically endangered **hawksbill turtle** has a protracted nesting season of 6 months or more – peaking in June and July, with the period between nesting generally being 2-4 years, sometimes longer. With a regional average of 4.5 nests per female in the years they breed, the 1 to 3 nests recorded on LHR in all probability represent only 1 or 2 females coming ashore to breed. Nesting occurs at night, generally at high tide, with a clutch size of 50-200 eggs. Nests tend to be concealed in beach vegetation quite high on the beach and except for a faint asymmetrical crawl leading to and from the sea, there is seldom any obvious evidence of the visiting female. The loss of beach vegetation on Half Moon Caye may deter nesting females (Smith, et al., 1992). Hawksbills are recorded as having nested on Half Moon Caye in 2004 (Majil, 2005), though only two nests were recorded in 2015.

The endangered **Loggerhead** (*Caretta caretta*) occurs throughout Belize, and 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 nest at scattered locations throughout the offshore cayes from May through August, including Lighthouse Reef Atoll. 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. In 1990, it was estimated that fewer than 40 loggerheads nest annually in Belize now. Nest counts (Smith, 1990) and staff observations (Chan, D., pers. com) indicate that fewer than 10 Loggerhead nests were nesting annually on Half Moon Caye – possibly representing nesting by only 2-3 individuals - a drastic decline from historical numbers.

Endangered **Green turtles** (*Chelonia mydas*) are primarily a tropical species, ranging throughout the Atlantic, Pacific and Indian oceans, though they are also known to range into temperate seas at times. They are primarily herbivorous, feeding mostly on sea grasses and seaweeds. Nesting generally occurs in spring and early summer, at night, and usually at high tide. Females excavate nests on sandy beaches above high-water mark, and lay clutches of 100-150 eggs. Females normally breed every 2-3 years, but may lay several clutches in a single season. They now nest in low density on several offshore cayes, including Northern Two Cayes and Half Moon Caye. 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 Northern Two Cayes and Half Moon Caye apparently hosted hundreds of nests per year into the early twentieth century. Nest counts (Smith, 1990) and recent staff observations (Chan, D., Romero, E., pers. com.) indicate that fewer than 10 green turtles nests are made annually now on Half Moon Caye – possibly representing nesting by only 2-3 individuals: a drastic decline from past numbers.

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Recent studies have tracked nesting hawksbill turtles from Lighthouse Reef Atoll (R. Graham, pers. com.), indicating that whilst they make extensive use of the Atoll, they also travel to other atolls in the Mesoamerican reef area (Graham, R. pers. com.). Wabaki, a female hawksbill tagged on 29th July, 2016, used the Atoll extensively during the first weeks after release, then headed south to Nicaragua, stayed there for a few days before travelling rapidly northwards to Banco Chichorro, in Mexican waters (Figure ...).

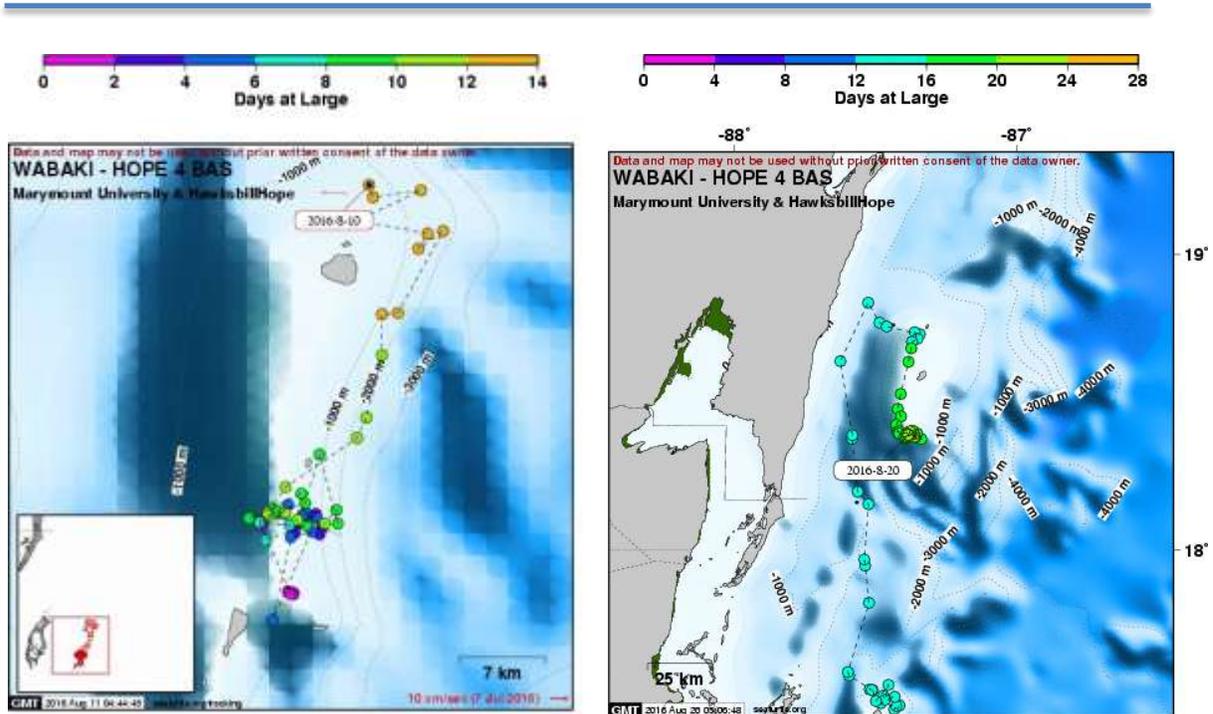


Figure 28: Hawksbill turtle (tagged on 29/7/16 at Lighthouse Reef Atoll). Location and track from tagging to 10/8/2016 (Left), and ten days later on 20/8/2016 (Right).

WABAKI - Hope 4 BAS (Belize Audubon Society) was tagged by Mark Rimkus / Marymount University, as part of the HawksbillHope project. (www.seaturtle.org)

Allison's anole (*Anolis allisoni*), one of five lizard species to be found on Half Moon Caye, has a very disjointed distribution, occurring in Cuba, Half Moon Caye, Long Caye, Northern Caye (Lighthouse Reef Atoll) and the Bay Islands of Honduras. It is possible that the Belize / Honduras population might be genetically distinct from that of Cuba, and as a result it merits inclusion on Belize's National List of Critical Species (Walker, P., pers. obs.). This species is relatively abundant on Half Moon Caye, occurring throughout the western half of the Caye – both in the coconut plantation (where there is abundant ground debris for cover) and in the littoral forest and littoral herbaceous / shrubby habitats.



Allison's Anole (Anolis allisoni)

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Activity height (depending upon vegetation) ranges from 0.75m to 12m or more. It can rapidly change color from bright green to dull brown. The **Brown anole** (*Anolis sagrei*) is abundant on Half Moon Caye, is very variable in coloration and is found throughout all habitats on the caye. It is principally active on the ground and up to 2m elevation on vegetation. This species is widely distributed throughout the western Caribbean and is generally considered a human commensal.

The **island leaf-toed gecko** (*Phyllodactylus insularis*) is Belize's only endemic reptile. Records (Lee, J., 1996, 2000) of its presence on the Bay Islands and from Isla Guanaja of Honduras are apparently erroneous (Wilson, L.D., pers. com.) with the specimens now attributed to *Phyllodactylus palmeus*. Its endemism is the justification for its inclusion on Belize's National List of Critical Species (Meerman, J.C., 2005). It is relatively abundant on Half Moon Caye, and utilizes the same areas as Allison's anole. 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 - in addition to Half Moon Caye, it has also been recorded on Long Caye and Twin Cayes on Glovers Reef Atoll, and recently from several cayes off the coast of southern Belize (Crawl Caye, False Caye, Lagoon Caye, Peter Douglas Caye and West Snake Caye) (Boback, S.M., 2005).

Black iguanas (*Ctenosaura similis*) are common on the caye, with all size classes being observed, despite presumed heavy predation on eggs and hatchlings by rats. Adults are largely vegetarian, and whilst predation of bird nestlings (in the booby colony) has not been reported, it is likely that they will compete with rats in eating chicks that fall from the nests. The **green iguana** (*Iguana iguana*) has been present on Half Moon Caye for several decades, having been positively identified in the early 1960's. Primarily associated with riparian and lacustrine forest habitats, the green iguana is not expected to be found on a small marine caye distant from the mainland. This, and the lack of authenticated records from other Belize cayes, strongly supports the thought that the species was introduced as a food source by fishermen or lighthouse keepers, many decades ago. The population is thought to be in decline (during the December 2004 survey, only a single sub-adult specimen (2-3 yrs old) was observed), and they are now uncommon on the Caye - and may disappear from the caye within the next few years. As the species has been successfully reproducing on the caye for several decades (and as recently as 2004, K. Forman, pers. com.), it appears likely that the principle cause for the decline is predation on eggs and hatchlings by rats, and the declining availability of freshwater. Standing water was mapped in 1962, in a mud hole on the island, with reported attempts to fill it with coconut debris (Stoddart, 1962). This freshwater source was probably an important component of the iguanas' habitat, and its gradual loss might be an additional factor in the decline in iguana numbers.

The **furrowed wood turtle** (*Rhinoclemmys areolate*) is thought to have been introduced to the caye by tour guides (Ramclam, S., pers. com). Two individuals were photographed and positively identified in 2004 (Forman, K., pers. com.). Whilst Half Moon Caye is not appropriate habitat for

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this species, it is possible that adults could survive there - however no individuals have been recorded recently.

The **American crocodile** (*Crocodylus acutus*) has been recorded at low densities on the Lighthouse Reef Atoll (Platt et.al., 1997), with very occasional sightings on the beaches of Half Moon Caye itself (D. Chan, pers. com.). Staff observations indicate occurrences of crocodile sightings on the island tend to be shortly after storm events. Nesting on Half Moon Caye has not been reported, and its habitat quality to this species is presumed to be significantly reduced following the historical removal of fringing red mangrove. The American crocodile is rated as Vulnerable (IUCN, 2006), with the Belize population currently rated nationally as Near Threatened (Meerman, 2005) – with the likelihood that this national status will be elevated to Vulnerable or Endangered as nesting habitat is removed for tourism and residential development (Walker, P., pers. obs.).

Herpetofauna of Lighthouse Reef Atoll		
Species		Status
Chelonidae		
Loggerhead turtle	<i>Caretta caretta</i>	EN
Green turtle	<i>Chelonia mydas</i>	EN
Hawksbill turtle	<i>Eretmochelis imbricata</i>	CR
Gekkonidae		
Island leaf-toed gecko	<i>Phyllodactylus insularis</i>	VU
Iguanidae		
Black iguana, Spiny-tailed iguana	<i>Ctenosaura similis</i>	
Green iguana, Bamboo chicken	<i>Iguana iguana</i>	
Polychrotidae		
Allison’s anole, Giant anole	<i>Anolis allisoni</i>	
Brown Anole	<i>Anolis sagrei</i>	
Crocodylidae		
American crocodile	<i>Crocodylus acutus</i>	VU

IUCN Threatened Species Criteria (2016)

CR Critically Endangered

EN Endangered

VU Vulnerable

Table 29: Herpetofauna of Lighthouse Reef Atoll

Invertebrate Species

Coral Species

67 species of Scleractinian coral (stony corals) have been recorded for Belize to date, of which 48 species of scleractinian coral of 24 genera have been recorded on Lighthouse Reef Atoll (Table 30). Forty six species (of thirty six genera) of non-coral invertebrates were recorded during the Rapid Marine Assessment of both protected areas (Graham et. al. 2004), considered an under-representation of the invertebrate diversity that exists on Lighthouse Reef Atoll.

The fore-reef at Half Moon Caye Natural Monument has some of the best coral coverage on the Belize Barrier Reef Reserve System (Romero, E. pers. com.; Dive guide consultations, 2015).



Elkhorn Coral

R. Graham

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Coral Species of Lighthouse Reef Atoll / 1

Species	Fore-reef	Reef shelf	Backreef	Patch Reef	Blue Hole Reef
<i>Acropora cervicornis</i>	X	X	X	X	X
<i>Acropora palmata</i>	X	X	X	X	X
<i>Agaricia agaricites</i>	X	X	X	X	X
<i>Agaricia fragilis</i>	X	X			X
<i>Agaricia grahamae</i>	X			X	X
<i>Agaricia lamarcki</i>	X	X			
<i>Agaricia tenuifolia</i>	X	X	X	X	X
<i>Colpophyllia natans</i>	X	X	X	X	X
<i>Dendrogyra cylindrus</i>		X	X	X	
<i>Dichocoenia stokesi</i>	X	X	X	X	X
<i>Diploria clivosa</i>			X	X	X
<i>Diploria labyrinthiformis</i>	X	X	X	X	X
<i>Diploria strigosa</i>	X	X	X	X	X
<i>Eusmilia fastigiata</i>	X	X		X	X
<i>Favia fragum</i>			X	X	X
<i>Isophyllastrea rigida</i>		X			
<i>Isophyllia sinuosa</i>				X	X
<i>Leptoseris cucullata</i>	X	X			X
<i>Madracis decactis</i>	X			X	
<i>Madracis mirabilis</i>	X	X			
<i>Madracis pharensis</i>	X				
<i>Madracis senaria</i>					X
<i>Manicini areolata</i>	X		X	X	
<i>Meandrina meandrites</i>	X	X	X	X	
<i>Millepora alcicornis</i>	X	X	X	X	X
<i>Millepora complanata</i>		X	X	X	X
<i>Monterasma annularis</i>	X	X	X	X	X
<i>Monterasma annularis complex</i>	X	X	X	X	X
<i>Montastraea cavernosa</i>	X	X	X	X	X
<i>Montastraea faveolata</i>	X	X	X	X	X
<i>Montastraea franksi</i>	X	X	X	X	X
<i>Mussa angulosa</i>	X	X	X	X	X
<i>Mycetophyllia alicae</i>	X	X			
<i>Mycetophyllia ferox</i>	X	X			
<i>Mycetophyllia lamarckiana</i>	X	X			
<i>Porites astreoides</i>	X	X	X	X	X
<i>Porites branneri</i>			X		
<i>Porites colonensis</i>	X				
<i>Porites furcata</i>	X	X	X	X	X
<i>Porites porites</i>	X	X	X	X	X
<i>Scolymia sp.</i>	X		X		X
<i>Siderastrea radians</i>	X	X	X	X	X
<i>Siderastrea siderea</i>	X	X	X	X	X

Coral Species of Lighthouse Reef Atoll / 2

Species	Fore-reef	Reef shelf	Backreef	Patch Reef	Blue Hole Reef
<i>Siderastrea stellata</i>	x			x	x
<i>Solenastrea bournoni</i>		x			
<i>Stephanocoenia intersepta</i>	x	x	x	x	x

Table 30: Coral Species of Lighthouse Reef Atoll

Commercial Species

Lighthouse Reef Atoll has historically been known as a key production area for the **Queen conch** (*Strombus gigas*) fishery in Belize, and to a lesser extent, the **Caribbean Spiny Lobster** (*Panulirus argus*). The Queen Conch, the most targeted species at Lighthouse Reef, is listed as an Appendix II species by the Convention on International Trade in Endangered Species (CITES) in 1992, as a result of regional concerns on the state of the resource. To ensure the long term viability of the national conch fishery, Belize has implemented a rigid requirement for conch quotas, season closure and assessment and monitoring procedure. Reports from the 1960’s suggest that conch were once so numerous that they had to be swept aside to land boats on Half Moon Caye (Stoddart, 1962). However, even as far back as 1996, there was evidence that the national population was declining, and at Lighthouse Reef Atoll, the population was heavily skewed towards predominantly juveniles. This was confirmed during conch surveys from 1999 onwards, which demonstrated a significant decline in the adult population. In sixteen sites surveyed in 1999, 82.5% of the conch observed were juvenile. In a similar survey in 2002, 100% were juveniles. This pattern has been shown to be continuing, with juveniles outnumbering adults in pre and post fishing season surveys. This skew encourages illegal take of undersized specimens. Monitoring is conducted twice a year using the Long-term Atoll Monitoring Protocol (LAMP), with surveys conducted just after the closing of the season in July (July 1st-September 30th) and immediately before the opening of the season in

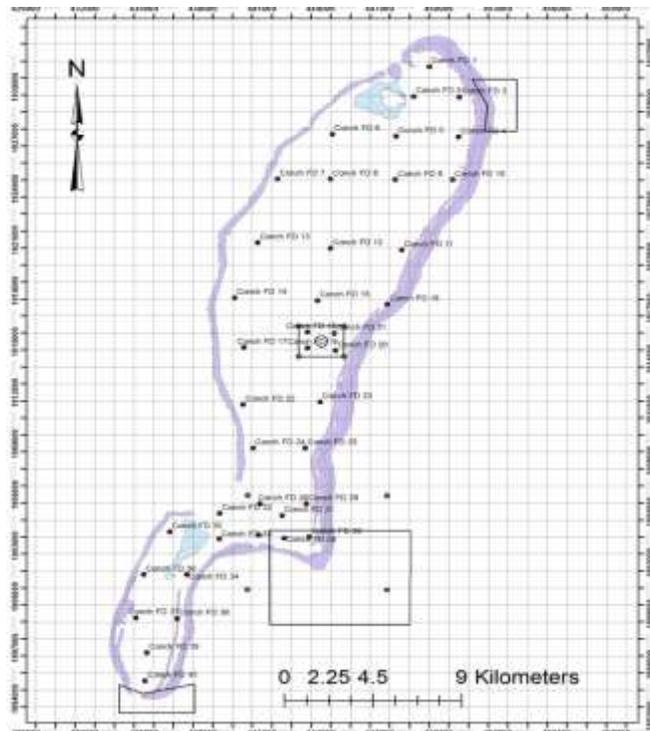


Figure 29: Survey Sites for national conch survey

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September (October 1st-June 30th), across Lighthouse Reef Atoll (Figure 29).

Shell length, lip width and lip thickness are measured and used to group conchs into three categories:

- **Juvenile conch:** less than or equal to 176mm in length (Belize Fisheries Department bench mark) and having no shell lip;
- **Adult conch:** greater than 176mm in length;
- **Reproducer:** any conch bearing a shell lip, irrespective of the length of the conch.

The management presence at Half Moon Caye prevents incursions by fishermen, and is reflected by the higher density of both conch and lobster. Surveillance at Blue Hole Natural Monument is more challenging, however, with fishermen regularly entering the Natural Monument to harvest conch illegally, reflected by the 2002 survey results, when no conch were encountered within the boundaries. Results from 2012 show a much more balanced age structure, with an equal percentage of adults and juveniles. This is thought to be due to the early closure of the conch season towards a more sustainable conch fishery, allowing for the replenishment of conch stocks.

The Caribbean spiny lobster is also harvested from the Atoll, but to a lesser extent. Results from 23 monitoring sites in 2015 demonstrated that there were more males than females; more adults than juveniles and that the highest number of individuals was found within the boundaries of the protected area (Figure 30, BAS data, 2015). A minimum harvestable size (3 inch carapace length and 4 ounce tail meat) and a closed season (February 15-June 14), have been set in place for the sustainable management of this fishery, but despite the efforts these regulations still need to be fully enforced to allow for the replenishment of stock across the Atoll.

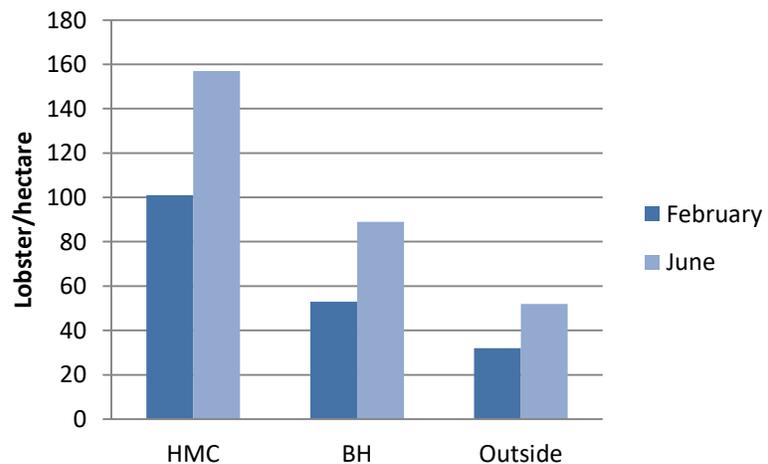


Figure 30: Lobster density inside and outside the Natural Monuments

Sea cucumbers are also being targeted as a commercial species. The sea cucumber fishing season runs from May 1st to June 30th, with a total annual catch quota set for 2016 of 300,000 lbs, to ensure continued sustainability. Two boats held licenses for extraction of sea cucumber

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(*Holothuria mexicana*) at Lighthouse Reef Atoll in 2015. Sea cucumber numbers have declined on the Atoll as a result of harvesting (Romero, pers. com., 2015)

There is legislation in place to ensure that lobster conch and sea cucumbers populations are sustainable, but unless enforcement can be improved, these fisheries, particularly conch, face an uncertain future.

Whilst little work has been conducted on the non-coral invertebrates of the two protected areas, there is no doubt that both protected areas (but particularly Half Moon Caye) have a very rich and diverse invertebrate community, with sponges, crustaceans, mollusks, tunicates and echinoderms utilizing the many micro-habitats created by the reef structure to the greatest extent possible.

1.5.3 Past and Present Research

Significant baseline research has been undertaken on and around Half Moon Caye, the Blue Hole and Lighthouse Reef Atoll generally, from geological surveys, surveys of the caye fauna and flora, and of the coral reef. More recently, most research has focused on reef assessments and fish spawning aggregations, with little formal terrestrial research in the last decade.

A baseline for monitoring visitor impacts was established for Half Moon Caye Wall in 1989 during a CEDAM International expedition, but with no follow-up monitoring. This data will, however, provide the baseline essential for future monitoring work. A rapid assessment of the effects of coral bleaching followed the 1998 bleaching episode, and Belize Audubon Society has established a long term monitoring program focused on the coral health of the atoll. Monitoring is also in place for commercial fish species, lobster and conch, in liaison with Fisheries Department.

Whilst the following list of research activities is not considered comprehensive, it does provide a guide to the areas of work that have been conducted in the past on Lighthouse Reef Atoll and within the two protected areas.

Belize Audubon Society annual monitoring activities include:

- Nassau grouper spawning and aggregation
- Sea grass health,
- Conch density survey
- Lobster density survey,
- Coral bleaching assessment,
- White Phase Red Footed Booby Bird count
- Sea turtle nesting activity on Half Moon Caye and Sandbore Caye
- Beach profiling
- Migratory bird count

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Terrestrial

- 1864 Salvin O.** A fortnight amongst the sea-birds of British Honduras. *Ibis* 6:373-387
Salvin was the first to record the presence of the red-footed booby nesting colony on Half Moon Caye
- 1961 Verner J.** Nesting Activity of the Red-footed Booby in British Honduras. *The Auk*, 78.
Verner studied the red-footed booby colony in greater depth in 1958, and returned to the site again in 1994, giving a useful insight into the comparative condition of the colony
- 1962 Stoddart, D.R.** - Extensive geophysical survey, vegetation mapping and plant identification for Half Moon Caye, with detailed compilation of historical data. Remains, to date, the authoritative work on the Caye.
- 1969 Stoddart D. R.** Post hurricane changes on the British Honduras Reefs and Cayes, October 30 – 31 1961. *Atoll Research Bulletin*. 95: 1-42. Stoddart did further work in 1961, following the passage of Hurricane Hattie
- 1978 Goshen College.** Census of red-footed booby population by two students from Goshen College. This was considered more of an estimate than an in-depth survey (Pomeroy, 1989)
- 1982 Fosberg, F.R., D.R. Stoddart, M-H. Sachet, & D.L. Spellman.** Plants of the Belize Cays. *Atoll Research Bulletin*, No. 258. Smithsonian Institute. An annotated checklist of the plants recorded on Belize's cayes.
- 1989 Caroline Pomeroy.** Masters thesis – collection and compilation of historical, cultural and ecological data on Half Moon Caye. Useful additional historical and cultural data, but significant errors in ecological data.
- 1991 Lee, J.C.** - 1991 survey of *Anolis allisoni* and *Phyllodactylus insularis* on Half Moon Caye, Lee reported both species to be abundant. Also searched for reported *Anolis carolinensis*, and concluded that it does not occur there. See Lee, J.C. (1996).
- 1992 Cross W.E.** Half Moon Caye Natural Monument, Belize: Investigated status of red-footed booby and magnificent frigatebird, December for Belize Audubon Society.
- 1995 B. Miller and C. Miller.** Avian surveys: Half Moon Caye Natural Monument. An in-depth survey of the bird population (resident and migrant) of Half Moon Caye, with additional information on mammals (bats and rats).

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- 1995 Meerman, J.C.** Terrestrial survey of Half Moon Caye. Added several plant species to the list of those previously recorded by Fosberg et. al. (1982). Noted a previous misidentification (*Basiliscus vittatus*) by Pomeroy (1989), and discussed confusion of juvenile *Anolis allisoni* with *Anolis carolinensis* (which are concluded to be not present, Lee, J.C. (1996), Walker, P. (2006)).
- 1997 Platt, S.G. & Thorbjarnarson, J.B.** - National survey of American crocodiles included Lighthouse Reef Atoll within the survey.
- 1997 Veitch, D.** 1997 Field assessment of ship rats on Half Moon Caye, towards the development of an eradication program. Veitch, D. (1997). Eradication of Rats from Half Moon Caye. Unpublished report for the Belize Audubon Society.
- 1999 Platt S.G., J.C. Meerman and T.R. Rainwater.** Diversity, observations, and conservation of the herpetofauna of Turneffe, Lighthouse, and Glovers Atolls, Belize
- 2003 Strickland E.** A Nest Count of Red Footed Boobies on Half Moon Caye. Unpublished report for Belize Audubon Society.
- 2005 Taff, I.C.** An Observational Study of Nesting Behavior of Red Footed Boobies on Half Moon Caye. Unpublished report for Belize Audubon Society.
- 2006 Walker P.** Rapid ecological assessment of vegetation and herpetofauna of Half Moon Caye; validation of existing data for use in management planning.

Marine

- 1962 Stoddart, D. R..** Described much of the coral reef around Half Moon Caye, and on the rest of the Atoll.
- 1969 Stoddart, D. R..** Post hurricane changes on the British Honduras Reefs and Cayes, October 30 – 31 1961. Atoll Research Bulletin. 95: 1-42. Stoddart did further work in 1961, following the passage of Hurricane Hattie
- 1999 Kramer P. and B. G. Bischof.** Rapid assessment using AGRRRA protocols comparing three locations in the wider Caribbean
- 1989 CEDAM International** Mapped Half Moon Caye Wall to provide a baseline for subsequent evaluation of diver impact.
- 1999 McField. N. D.,** Surveyed coral response during and after the mass bleaching event of 1998.

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2003 Ecochard et. al. Used the Half Moon Caye Elbow spawning aggregation site as a trial site for modeling bathymetry requirements for the formation of spawning aggregations

2004 Graham R. et. al. Rapid Marine Assessment of Half Moon Caye Natural Monument and Blue Hole Natural Monument

2007 Rhodes K. Nassau grouper (*Epinephelus striatus*) Tagging Report, Sandbore, Northern Lighthouse Reef, Belize

2011 Scales K. L., J.A. Lewis, J.P. Lewis, D. Castellanos, B.J. Godley, R.T. Graham. Insights into habitat utilisation of the hawksbill turtle, *Eretmochelys imbricata* (Linnaeus, 1766), using acoustic telemetry.

Geology

1970's Jaques Cousteau. Made the Blue Hole famous worldwide through filming the first major exploration, removing a sample stalactite for further study

1995 Cambrian Foundation. Repeated Cousteau's expedition, focusing on evidence for sea level changes provided by the geological structure, and sediment core analysis to provide information on events such as major dust storms

2008 Gischler, E., E. A. Shinn, Oschmann W., Fiebig J. and Buster N. A. A 1500-Year Holocene Caribbean Climate Archive from the Blue Hole, Lighthouse Reef, Belize. *Journal of Coastal Research* 24, 6, pages 1495 – 1505.

2013 Gischler, E., F. S. Anselmetti, E. A. Shinn. Seismic stratigraphy of the Blue Hole (Lighthouse Reef, Belize), a late Holocene climate and storm archive

1.6 Cultural and Socio-Economic Values

1.6.1 Stakeholder Use

The predominant stakeholder uses of Lighthouse Reef Atoll are for tourism and fishing.

Lighthouse Reef Atoll is recognized as one of Belize’s most important conch grounds, with the Natural Monuments playing an important part as replenishment areas (Majil, I., pers. com., 2015). The fishing sector utilizing Lighthouse Reef is part of a traditional industry that provides direct employment to between 160 and 200 fishermen who primarily utilize the shallow protected waters of the Atoll. The majority of Lighthouse Reef Atoll fishermen originate from the northern fishing communities - Copper Bank, Chunox and Sarteneja, travelling to Lighthouse Reef from Belize City in sailing sloops with a crew of between eight and twelve fishermen per boat, and one cook. Sailing from Belize City, they take eight to ten hours to reach the atoll, then stay out for six to twelve days, filling the boat’s central ice box with primarily for queen conch (*Strombus gigas*), spiny lobster (*Panulirus argus*) and fin-fish, before returning to Belize City to sell their catch to the National or Northern Fishermen Cooperatives, and to restaurants and hotels. Recently there has been a gradual increase in the use of fiberglass skiffs, carrying fewer people (generally four), and relying on being able to establish temporary fishing camps on the cayes from which to base fishing activities.

Conch and lobster have both declined since the early 1980’s, when the industry was at its peak. The most important commercial species is the Queen conch – 75% of the product from Lighthouse Reef Atoll is considered to be conch (Traditional fisher, pers. com., 2015). This is regulated by size regulations and gear restrictions (a ban on the use of SCUBA). Surveillance of fishing has been further strengthened by legislation that prohibits fillet and dicing to prevent undersized harvesting (SI 90 of 2003). National conch landings are now regulated through an annual quota, set to ensure sustainability of stocks - in the 2014 Queen conch fishing season (Figure 31), national landings were estimated at 723,120 lbs (85% of the national catch quota) with earnings amounting to \$8.88 million (Fisheries Department, 2016).

Lobster (*Panulirus argus*)

- Minimum carapace length is 3 inches.
- Minimum tail weight is 4 ounces.
- Closed season is February 15th-June 14th
- No person shall take berried females or molting individuals.

Queen conch (*Strombus gigas*)

- Shell length should exceed 7 inches.
- Market clean weight should exceed 3 ounces.
- Closed season is from July 1st -September 30th.

Sea cucumber

- Fishing or harvesting requires a species permit
- Closed season is from 1st July to 30th April

Figure 32: Regulations for Fisheries Management

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The lobster fishery is currently regulated by a fishing season (from June 15th to February 14th of the following year), a size limit, a ban on the use of SCUBA and other gear restrictions, and license limitations. Whilst in the past there has been continued optimism that lobster is being harvested at a sustainable level (Gillet, 2003), there have been concerns for the continued long term ecological sustainability of the lobster fishing industry, with average size per lobster declining, and the value of the catch per fisherman, in some cases, no longer sufficient to support a fisherman and his family (Traditional fisher, pers. com., 2015; Sarteneja community consultations, 2009, 2010, 2011; Monkey River fishermen, 2012). However, despite this, the annual catch landings are reported to have remained relatively stable over the last 27 years, ranging from between 400,000 and 600,000 lbs (Fisheries Department, 2016).

Nationally, the annual economic benefits from reef and mangrove-dependent fisheries is estimated at between US\$14–16 million (Cooper et. al, 2008), though the protected areas themselves are non-extractive, acting as replenishment zones for the Atoll. 90% of the conch and lobster is exported through the two fishing cooperatives, the remaining 10%, and the majority of the finfish, are sold for local consumption. Finfish delivery to the cooperatives has dropped significantly over the last 25 years, from a peak in 1983 of 1,003,785 lbs to current levels (2009) of less than 10,000 lbs (Fedler, 2011) – representing a 90% decline in deliveries. This reflects the declining catch, the increased direct sale to the domestic market, and the declining export market, with the majority of fishermen focusing on the more lucrative conch and lobster.

In 2016, Belize rolled out its Managed Access regime for the country, including Lighthouse Reef Atoll (Area 7). Managed Access, a rights based fisheries management tool, provides preferential access for traditional fishers of the Atoll within a regulatory framework, to improve sustainability of the fisheries resources. Belize Audubon Society is collaborating with the Belize Fisheries Department to ensure the success of the program, extending boat to boat communication to engage fishermen, as well as extending surveillance and enforcement activities across the Atoll. Managed Access integrates fishermen in the decision making, with the establishment of a Managed Access Committee, with fisher representation for identification of traditional fishers, and to provide a mechanism for two way communication.

With concerns for future pressure on the resources from continued fishing, BAS is considering investigating the feasibility of declaration of the entire Atoll as a Special Management Area, to give fishermen and the tourism industry a vested interest in self-regulation and wise use of the resources.

Coconut Harvesting

Coconuts have been cultivated on Half Moon Caye for over 200 years (Stoddart, 1962), with extensive clearance of natural vegetation starting around 1928, a supplemental income for the resident lighthouse keepers. With the transition of day to day responsibility for the lighthouse from Port Authority to BAS, there is no longer a resident lighthouse keeper, and harvesting of coconuts is now limited to on-island use.

1.6.2 Archaeological Sites, Cultural and Historical Values

During the Early Postclassic, there is evidence that the Maya began to move towards the coast and the cayes, to develop a complex trading network, with trans-shipment points along established sea trade routes, that peaked in the Late Postclassic (1300 – 1500A.D.) (Awe J.J. et. al., 2001). The discovery of four small coral mounds, a large conch shell midden, and pottery shards from the Postclassic period on Northern Caye suggests that the Maya reached Lighthouse Reef Atoll, despite its distance from the mainland. Postclassic period Maya potshards were also discovered on Long Caye (Awe et. al. 2001), supporting the presence of Maya on Lighthouse Reef. It would therefore be logical that Half Moon Caye, whilst not necessarily being inhabited by Maya, may well have hosted fishing or trading groups from the adjacent cayes.

From the days of the Spanish conquistadors and the British buccaneers, Lighthouse Reef has been an outpost for passing ships, with Half Moon and the other cayes of the Atoll sporadically being used as a base by pirates. Pottery shards discovered on the adjacent Long Caye date back to as early as the late 16th/ early 17th century (Awe et. al., 2001).

Being the outermost reef in Belizean waters with little of its structure above sea level, Lighthouse Reef Atoll has always been hazardous to shipping, leading to the construction of the original lighthouse, which came into service in 1820 (Stoddart, 1962).

This first lighthouse was replaced in 1848, with a more modern lighthouse being installed (Pomeroy, 1989). The Atoll has a history of shipwrecks, and though many of the early shipwrecks have not been documented, it is likely that numerous explorers and traders foundered on the Lighthouse Reef rim. Hurricanes, uncharted waters and piracy also contributed to causing wrecks on the reef. Some of the wrecks have now disappeared but many are still visible on the reef and several are used as dive sites (Table 28).

The construction of the lighthouse also led to the installation of the first lighthouse keepers. The early kerosene fired lighthouses required three lighthouse keepers to be present, working on rotation, living with their families living on the island - at one time there were 23 children living on the Caye, with their own teacher. Many of the occupants also sold coconuts and

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coconut oil, fish and marine turtles for a living, these products being transported to Belize City for sale. The community also farmed fruit and vegetables including plantains, cassava, melons and tomatoes; and kept chickens, pigs and dogs. The crops were eventually ceased due to a growing rat problem (Pomeroy, 1989). In the 1960's, in addition to keeping the lighthouse, the Young family also built wooden sailboats on the island for sale within Belize, developing a national reputation for the quality of their workmanship.

In 1979, the Port Authority converted the Lighthouse from kerosene to solar power. Although this decreased the brightness of the light, it also reduced the amount of maintenance work required and hence the number of lighthouse keepers needed. The lighthouse is now managed by Belize Audubon Society, under a management agreement with the Belize Port Authority.



Shipwrecks of Lighthouse Reef Atoll		
Date	Name of Vessel	Information
1719	The Bangor	A galley lost off Sandbore Caye <i>en route</i> from Jamaica to Belize. Captain Nathaniel Uring and other survivors camped on Half Moon Caye
1751	Unknown	Two Rhode Island sloops and a Jamaican snow were lost on the north keys of Lighthouse Reef
1815	The Lord Blandtyre	A Scottish merchantman (Captain M ^l Lea) coming from Jamaica was wrecked in August on the Southern Four Keys, Lighthouse Reef
1821	The Barrosa	An English merchantman (Captain Anderson) coming from London totally lost on 8 th November on the Southern Fourth Reef of Lighthouse Reef, the crew and most of the cargo were saved.
1950's	The Johnny Two	A wooden refrigerated ship, lost on the main reef north of Northern Two Cayes.
1971	The Ormlund	A 350-400ft, 4000 ton steel Norwegian freighter was wrecked on the reef immediately north of Half Moon Caye when it lost power during a storm.
2005	MV Transfer	A large cargo vessel grounded on the reef north of Half Moon Caye. Despite attempts to refloat the vessel it could not be removed from the reef. It has been stripped and cleaned and left to disintegrate.
Undated	The Hantord	Lost south of the Bangor on the reef, no date is available
	The Spitfire	Apparently an iron ship,, lost on the eastern reef, south of Northern Two Cayes
	The Sabo	A 25-35ft freighter that grounded on the reef and is now used as a dive site.
	"Northern Wreck"	At the northern tip of the atoll close to one of the reef passes.
	?	Two small cargo vessels are wrecked South of Half Moon Caye.

Table 31: Shipwrecks of Lighthouse Reef (www.ambergriscafe.com)

1.6.3 Tourism and Recreation Use

Under their designation as Natural Monuments, Half Moon Caye and Blue Hole Natural Monuments are both open for visitation, contributing towards one of the goals for management:

“ To provide recreational and educational opportunities for Belizean and international visitors in a manner that is compatible with the natural environment”

Half Moon Caye and Blue Hole Natural Monuments play an important role in bringing tourism to Belize, with significant tourism-based stakeholder interests in the Atoll. Visitation to Half Moon Caye and Blue Hole has fluctuated over recent years, with a peak in 2010 of 16,395 (Figure 33; BTB, 2012; BAS 20145). In 2014, visitation was reported as 13,178 (BAS, 2015). The majority of visitors are on day tours, arriving at Lighthouse Reef from San Pedro or Caye Caulker on dive excursions, diving Blue Hole, then stopping at Half Moon Caye for lunch, before going on to dive Half Moon Caye Wall, the Aquarium and other sites around the Atoll, then heading back to the Ambergris Caye or Caye Caulker in the afternoon. The dock is able to accommodate up to 8 or 9 dive boats at any one time – over time, these boats have got larger, accommodating more visitors, reducing the number that can tie up, leading to plans to lengthen the structure.

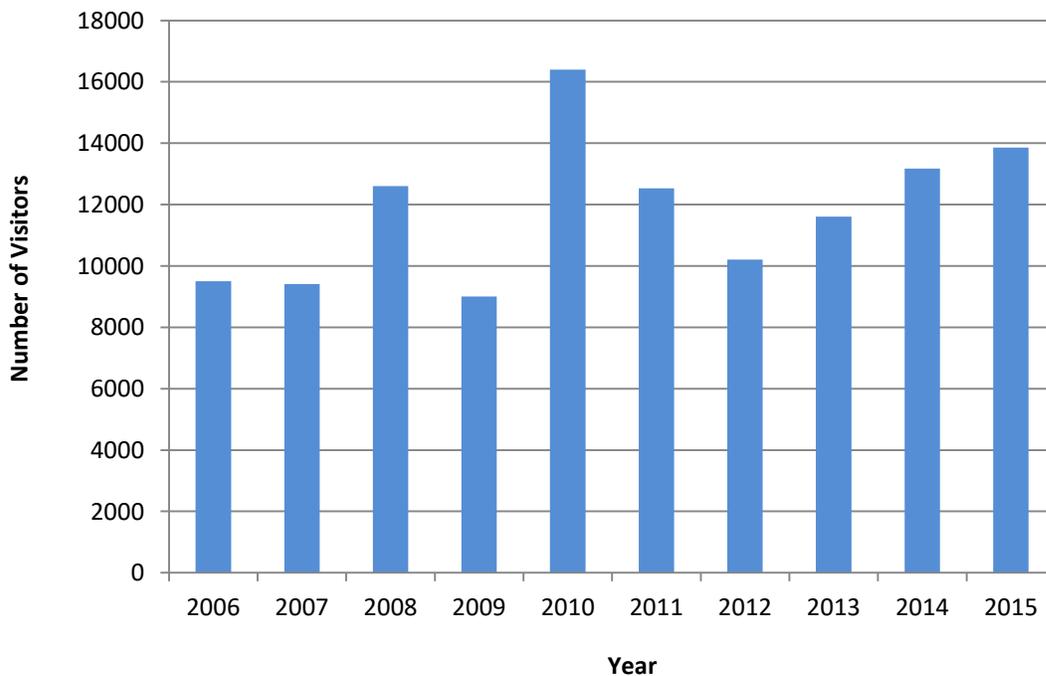


Figure 33: Annual visitation to Half Moon Caye and Blue Hole Natural Monuments (BTB, 2012; BAS, 2016)

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Whilst there is no community established on the Atoll itself, there are three all-inclusive resorts operating either seasonally or throughout the year, with residential staff dependent on the level of demand for overnight tourism visitation. These resorts provide a base for diving and sport fishing activities, and operate under a best practices regime. There is concern that a fourth resort proposed for construction on Northern 2 Cayes may not be built and managed to best environmental practices standards, and may cause unacceptable environmental impacts to the Atoll.

Live-aboard dive boats (Sundancer and Aggressor), based out of Belize City, also include the protected areas within their itineraries. Sundancer includes the Atoll in its itinerary for nine months of the year, staying for five nights each week, and generally carry around 20 guests and 7 crew members. The Aggressor follows the same itinerary, but visits throughout the year, carrying 19 guests and 6 crew members. Both boats are focused primarily on dive sites, with one day spent diving the Blue Hole. A pocket cruise ship (Sea Cloud) – a windjammer - also visits the area once a year. Belize Audubon Society ensures that mooring buoys are appropriate for the size and location of boats visiting the Natural Monuments, to ensure minimal environmental damage. BAS works with the Belize Port Authority and tourism stakeholders to ensure that mooring buoys and channel marker buoys are adequate in number and appropriate for the site and size of vessels.

Island Expeditions maintains a tented camping base on Half Moon Caye for six months of the year (the dry season), hosting a maximum of 20 visitors at any one time, and conducting snorkeling and kayaking tours across the Atoll. There are also occasionally overnight visitors who make use of the camp site - whilst independent camping is allowed on the caye, not many visitors make the most of this opportunity, and there are some questions as to whether a camping permit may be needed first from the Belize Forest Department.



Wildtracks

Island Expedition Tented Campsite

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Over the Easter period, up to twenty yachts visit the Atoll from Guatemala and, to a lesser extent, Honduras. This has caused concern in the past, as these visitors are not necessarily aware of the rules and regulations on boating in Belize, of the rules and regulations within the Natural Monuments, or navigation in the fragile coral reef environment of the Atoll. There have been past issues with use of jet skis and kite surfing within the protected areas, diving without the required Belize tour guide and legislated tour guide ratio, and fishing of regulated species with regulated gear. This is now being addressed through collaboration with BTB and Belize Port Authority for the Easter period for improved enforcement of visitor activities, and through forwarding guidelines to the relevant Guatemalan and Honduran boats before the Easter period, outlining registration requirements for boats entering Belize waters, Belize regulations relevant to diving, and more specifically what activities are and are not permitted within the Natural Monuments.

Current levels of visitation are considered sustainable, though effects of tourism-related impacts are being seen on the reef and seagrass. Zones are being used to manage visitor activities, to reduce potential impacts. Visitor facilities at Half Moon Caye are relatively basic, with amenities such as a picnic site and toilets primarily for day visitors from the dive boats. An Interpretive Centre provides information on the wildlife, both terrestrial and marine, and on the structure of the Blue Hole, whilst a small shop supplies souvenirs, film and other basic supplies.

1.6.4 Education Use

The primary focus during the span of the previous management period has been raising awareness among the fishermen utilizing Lighthouse Reef of the fragility of the reef, the role of protected areas in fisheries management, and the need for conservation. The marine education program is currently focused on several target groups and a number of activities.

A wish to involve Lighthouse Reef fishermen in biodiversity monitoring activities has led to a series of training opportunities based from Half Moon Caye and other areas of the Atoll, in an effort to demonstrate to these stakeholders the effectiveness of no-take zoning and resulting spill-over effects.

There has also been recognition of the need for training in alternative and supplemental livelihoods within the stakeholder communities, with a number of alternative livelihoods training opportunities being offered. Education efforts have also been increased within the coastal fishing communities of Copper Bank, Chunox and Sarteneja, working with the primary and high schools towards developing greater awareness of coral reefs and the threats they face.

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There has been little scope, however, for on-site educational activities for stakeholders from the northern fisher communities within the protected areas themselves, with the logistical problems of access and financial costs involved.

In 2012, however, BAS pioneered a new strategy for resource user engagement - the 'Boat to Boat activity'. A team comprised of BAS personnel, Fisheries Department, and Coast Guard meet with the fishers on their vessels at the Atoll, ensuring that BAS is able to target its core stakeholders, share relevant information related to LHRA, and receive feedback on issues impacting the resource users. This strategy has proven effective, and is to be incorporated into the Community Program.

Opportunities for raising awareness through bringing students to the protected areas has had to be limited to a small number of day visits, with restricted numbers being able to make the most of the opportunity. Use of the Natural Monuments as the site for the BAS annual summer camp trip from Belize City has become so popular that in 2015, BAS had to schedule two trips to meet demand. This trip seeks more to engage the Belize City population rather than the immediate resource users, and plays an important part in ensuring Belizeans remain connected to their World Heritage Site.

On Half Moon Caye itself, the Visitors Centre provides information for the education of the constant flow of tourists that pass through the Natural Monuments, raising awareness of the not only the protected areas but also the organization and its role in conservation in Belize, and the justifications behind the establishment of Blue Hole and Half Moon Caye Natural Monuments. BAS recognizes that more educational activities are needed for the tour operators and tour guides. A first step towards this has been the re-establishment of the Light House Reef Atoll Advisory Committee.

2. Conservation Planning

Conservation planning is a structured process that identifies and assesses the species and ecosystems of concern, the threats that impact them, and the strategies that can be used within the management of the area to mitigate these threats.

2.1 Conservation Targets

Conservation targets are species, species assemblages or ecosystems that have been selected as representing the biodiversity of a protected area – such that strategic actions, taken to ensure their continued viability and reduce the pressures impacting them, will adequately address the conservation management needs of the protected area as a whole.

2.1.1 Identification of Conservation Targets

Eleven conservation targets, were selected to represent and encompass the biodiversity values of the two Natural Monuments and, where relevant, the Atoll, and to provide a basis for setting goals, developing strategies and actions, and monitoring success.

For the purposes of the Management Action Planning process, the selected targets were required to meet the following criteria, where possible (adapted from TNC, 2007):

- **Targets should represent the biodiversity of the site.** The focal targets should represent or capture the array of ecological systems, communities, and species of importance at the project area and the multiple spatial scales at which they occur.
- **Targets reflect ecoregion or other existing conservation goals.** Focal targets should reflect efforts at the regional and national level where they exist, such as the National Protected Areas System Plan. Focal targets should be grounded in the protection of the two Natural Monuments, but also take into account the larger seascape of the Atoll, and components that lie outside the MPAs.

Conservation Targets for Half Moon Caye / Blue Hole Natural Monuments

- Coral Reefs
- Littoral Forest
- Mangroves
- Seagrass
- Commercial Species
- Spawning Aggregation Sites
- Sharks and Rays
- Marine Herbivorous Species
- Marine Turtles
- Nesting Birds
- Blue Hole (Geological Features)

- **Targets are viable or at least feasibly restorable.** Viability (or integrity) indicates the ability of a conservation target to persist for many generations. If a target is on the threshold of collapse, or conserving a proposed target requires extraordinary human intervention, intervention may not represent the best use of limited conservation resources.
- **Targets are highly threatened.** All else being equal, focusing on highly threatened targets will help ensure that critical threats are identified and addressed through conservation actions.

Ecosystem and species assemblage targets were selected to represent the Natural Monuments and, where relevant, the Lighthouse Reef Atoll:

Ecosystem Level Targets: Assemblages of ecological communities that occur together, share common ecological processes, and have similar characteristics. **Two coastal** and **three marine** ecosystems have been selected:

- ***Coral Reef Ecosystem***
- ***Littoral Forest***
- ***Mangroves***
- ***Seagrass***

Species Assemblages: Groups of species that share common natural process or have similar conservation requirements:

- ***Spawning Aggregations***
- ***Commercial Species***
- ***Sharks and Rays***
- ***Marine Herbivorous Species***
- ***Marine Turtles***
- ***Nesting Birds***

One target has been selected for its unique geological features:

- ***Blue Hole***

As the Blue Hole is not a biodiversity target, it is not included in this assessment. 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 32).

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Conservation Targets and Nested Targets for the larger Lighthouse Reef Atoll		
Conservation Target	Nested Target	
Coral Reef Ecosystem	Staghorn coral CR Elkhorn coral CR Fire coral EN Boulder star coral EN Star coral EN Diadema	Parrotfish Reef fish species Endemic reef species Ecotourism Diving Snorkeling
Littoral Forest	Migratory bird species Island leaf-toed gecko EN Allison’s anole Black iguana	Sandy beaches Marine turtles (nesting beaches) American saltwater crocodiles (nesting sites) Green iguanas
Mangroves	Juvenile fish species Juvenile lobster (in the larger LHR)	American saltwater crocodiles
Seagrass	Parrotfish Conch Black tip sharks (juvenile)	Juvenile fish species
Commercial species	Lobster Conch Finfish Nassau grouper EN	Sport fishing species Non-traditional species (e.g., sponge, seaweed, urchins) Sea cucumber
Spawning Aggregations	Nassau grouper EN Cubera snapper Dog snapper Blue parrotfish Mutton snapper Midnight parrotfish	Permit Black grouper Reef fish species (spawning) Jacks Yellowtail snapper Schoolmaster
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)
Marine Herbivore Species	Rainbow parrotfish Midnight parrotfish Queen parrotfish Stoplight parrotfish Yellowtail parrotfish	Doctorfish Blue tang Ocean surgeonfish
Marine Turtles	Hawksbill turtle CR Loggerhead EN Green turtle EN	
Colony Nesting Birds	Red footed booby Magnificent frigate bird White-crowned pigeon Osprey	

Table 32: Conservation Targets and Key Nested Targets

2.2 Assessing Biodiversity Viability

The Viability Assessment, as 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

Each Conservation Target was assessed 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

Conservation Targets	Seascape Context	Condition	Size	Viability Rank
Coral Reefs	Fair	Fair	Good	Fair
Littoral Forest	Poor	Good	Good	Fair
Mangroves	Good	Very Good	Good	Good
Seagrass	Very Good	Very Good	Very Good	Very Good
Commercial Species	Fair	Fair	Fair	Fair
Spawning Aggregations	Poor	Fair	Good	Fair
Sharks and Rays	Poor	Fair	Fair	Fair
Marine Herbivorous Species	Good	Fair	Good	Good
Marine Turtles	Poor	Fair	Fair	Fair
Colony nesting Birds	Fair	Very Good	Very Good	Good
Project Biodiversity Health Rank				Fair

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The overall viability rating for the conservation area is **FAIR**, with six targets rating as **FAIR**, three targets rating as **GOOD** (Mangroves, marine herbivorous species and colony nesting birds, with only one target, seagrass, rating as **VERY GOOD**).

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Ecosystems: Coral Reef Communities																							
Current Status	2007 Status	Goal	Objectives:																				
FAIR	GOOD	GOOD	<ul style="list-style-type: none"> ▪ To ensure anthropogenic pressures on the Lighthouse Reef are minimised to allow recovery of corals where possible ▪ To ensure adequate protection of resilient sites of Lighthouse Reef Atoll 																				
Justification		Species / ecosystems nested in this target																					
<p>The coral reefs of Lighthouse Reef Atoll include fore-reef, back-reef, reef slope, and patch reef, and are considered some of the most pristine in Belize. Over 55 species of hard corals have been recorded in the waters of the Atoll, with dominant species including <i>Orbicella</i>, <i>Porites</i> and <i>Undaria</i>. Despite significant national decline in reef health, with hurricane impacts affecting reef structure, increasing incidence of coral bleaching, and the loss of a large percentage of <i>Acropora</i>, the Atoll still stands out for the beauty and diversity of its marine life, and Half Moon Caye Wall still rates as one of the best dive sites in Belize. The relatively high coral cover and diversity at numerous sites, along with the great variability in physical parameters, may increase the Atoll’s resilience to climate change, though corals in the shallow waters of the Blue Hole show poor coral health.</p> <p>In 2004, coral cover on the HMC fore reef ranged from 12% to 43%, whilst the patch reefs showed lower coral cover, averaging 6.25%, with high macroalgal cover (averaging 68%, but as high as 79% in some sites) (Graham et. al., 2004). Reef surveys in 2015 demonstrate average live coral cover in the range of 25 - 30%, with an average macro-algal cover of 10 – 15% (BAS data, 2015), suggesting that the Atoll shows a similar pattern of slow recovery to the rest of the western Caribbean.</p>		<p>The reefs are composed of many scleractinian coral species, including ten critically endangered or endangered species:</p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">Staghorn Coral</td> <td style="width: 50%;"><i>Acropora cervicornis</i> CR</td> </tr> <tr> <td>Elkhorn Coral</td> <td><i>Acropora palmata</i> CR</td> </tr> <tr> <td>Lamarck’s Sheet Coral</td> <td><i>Agaricia lamarcki</i> EN</td> </tr> <tr> <td>Pillar Coral</td> <td><i>Dendrogyra cylindrus</i> EN</td> </tr> <tr> <td>Elliptical Star Coral</td> <td><i>Dichocoenia stokesii</i> EN</td> </tr> <tr> <td>Fire Coral</td> <td><i>Millepora striata</i> EN</td> </tr> <tr> <td>Star Coral</td> <td><i>Orbicella annularis</i> EN</td> </tr> <tr> <td>Star Coral</td> <td><i>Orbicella faveolata</i> EN</td> </tr> <tr> <td><i>Orbicella</i> Coral</td> <td><i>Orbicella franksi</i> EN</td> </tr> <tr> <td>Rough Cactus Coral</td> <td><i>Mycetophylia ferox</i> EN</td> </tr> </table> <p>This target links to species assemblage targets – healthy coral reef provides a diverse range of habitats for a multitude of fish and invertebrates, including commercially important species. It also supports herbivores such as the large parrotfish, which are critical for maintaining healthy reef by reducing macroalgal cover, ensuring coral recruitment sites are available for continued coral health, particularly in recovery following bleaching episodes.</p>		Staghorn Coral	<i>Acropora cervicornis</i> CR	Elkhorn Coral	<i>Acropora palmata</i> CR	Lamarck’s Sheet Coral	<i>Agaricia lamarcki</i> EN	Pillar Coral	<i>Dendrogyra cylindrus</i> EN	Elliptical Star Coral	<i>Dichocoenia stokesii</i> EN	Fire Coral	<i>Millepora striata</i> EN	Star Coral	<i>Orbicella annularis</i> EN	Star Coral	<i>Orbicella faveolata</i> EN	<i>Orbicella</i> Coral	<i>Orbicella franksi</i> EN	Rough Cactus Coral	<i>Mycetophylia ferox</i> EN
Staghorn Coral	<i>Acropora cervicornis</i> CR																						
Elkhorn Coral	<i>Acropora palmata</i> CR																						
Lamarck’s Sheet Coral	<i>Agaricia lamarcki</i> EN																						
Pillar Coral	<i>Dendrogyra cylindrus</i> EN																						
Elliptical Star Coral	<i>Dichocoenia stokesii</i> EN																						
Fire Coral	<i>Millepora striata</i> EN																						
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<i>Orbicella</i> Coral	<i>Orbicella franksi</i> EN																						
Rough Cactus Coral	<i>Mycetophylia ferox</i> EN																						

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Ecosystems: Littoral Forest			
Current Status	2007 Status	Goal	<i>Objectives:</i>
FAIR	GOOD	VERY GOOD	<ul style="list-style-type: none"> ▪ To protect a nationally important, representative example of Littoral Forest ▪ To ensure the continued structural support of the bird nesting colony ▪ To ensure adequate protection of caye specialists, including the endemic island leaf-toed gecko
Justification		Species / ecosystems nested in this target	
<p>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. 2.7% is within Lighthouse Reef Atoll.</p> <p>The lower herbaceous beach vegetation grows along the coastal strand – a combination of low growing shrubs and vines that provide structure that binds the sand and prevents erosion, as well as providing optimal nesting conditions for marine turtles and American crocodile. Even with this, however, the sandy beaches are constantly shifting, with natural erosion and deposition occurring in response to tide, wind and storm actions.</p> <p>Natural vegetation has been modified and/or cleared extensively on half of Half Moon Caye, to make way for a coconut plantation, the sandy area with its coconut palms being critical for maintenance of tourism values. On other cayes, clearance for development is considered a potential threat, but generally, the cayes retain their natural vegetation cover. As privately owned property, however, their long-term protection cannot be guaranteed.</p>		<p>Nested within the Terrestrial Ecosystem target are both tropical littoral forests and herbaceous beach vegetation, with 47 naturally occurring native species of plant. It provides habitat for the caye specialist lizards - Allison’s anole (<i>Anolis allisoni</i>) and the endemic island leaf-toed gecko (<i>Phyllodactylus insularis</i>), as well as generalists such as the more ubiquitous black iguana (<i>Ctenosaura similis</i>)</p> <p>A number of bird species rely on the littoral forest either as residents, such as the white crowned pigeon (<i>Patagioenas leucocephala</i>) and cinnamon hummingbird (<i>Amazilia rutila</i>), and also provides nesting structure for the world-famous red-footed booby / magnificent frigatebird colony. Migratory bird species such as the American redstart (<i>Setophaga ruticilla</i>), hooded warbler (<i>Wilsonia citrine</i>) and bay breasted warbler (<i>Dendroica castanea</i>) also rely on the littoral forest for replenishment before continuing their migration.</p> <p>The herbaceous beach vegetation and sandy beaches of cayes across the Atoll provide nesting sites for three species of marine turtle – hawksbill (<i>Eretmochelys imbricata</i>), green (<i>Chelonia mydas</i>), and loggerhead (<i>Caretta caretta</i>), and on cayes outside the Natural Monuments, for the American crocodile (<i>Crocodylus acutus</i>).</p>	

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Ecosystems: Mangroves			
Current Status	2007 Status	Goal	Objectives:
GOOD	-	GOOD	<ul style="list-style-type: none"> ▪ To encourage protection of critical mangroves of LHR, important for the long term health of the Atoll, its reef and its fishery
Justification		Species / ecosystems nested in this target	
<p>Whilst there are only a few (three) mangroves on Half Moon Caye, and none in the Blue Hole Natural Monument, mangroves are present on some of the other cayes of Lighthouse Reef Atoll - Long Caye and Northern Two Cayes have extensive mangrove cover, with mangrove-lined lagoon creeks and systems provide an ideal sheltered nursery areas. High connectivity of mangroves to seagrass and reef ecosystems is considered very important for the long term viability of reef health.</p> <p>The complex mangrove roots provide a structure for a whole ecosystem of tunicates, sponges, algae and molluscs, and sheltering other organisms, protecting them from predators in the open waters beyond the roots. Juvenile marine species, including lobster, commercially important finfish species and the ecological important parrotfish species, rely on this connectivity between reef, seagrass and mangrove for long term viability of marine ecosystems on the Atoll. The limited extent of this ecosystem on the Atoll makes it critical to ensure that what mangrove exists is not subject to development impacts.</p>		<p>Red mangrove (<i>Rhizophora mangle</i>) is the dominant mangrove species on the Atoll, supporting the trees. The mangrove channels and lagoons of Northern Two Cayes and Long Caye provide retreats for species such as American crocodiles, and foraging areas for water birds. The branches support heron and egret nests, and provide foraging habitat for transiting migratory birds.</p> <p>Mangroves provide critical nursery habitat for many marine species, including parrotfish – important for maintenance of reef health, and commercial species, including Caribbean spiny lobster, Queen conch and several species of grouper and snapper, all important commercial species that are dependent on the connectivity between the spawning aggregation sites, coral reef, seagrass and mangrove.</p> <p>American crocodiles (<i>Crocodylus acutus</i>) are very rarely seen within Half Moon Caye Natural Monument, but are present in other areas of the Atoll, generally linked to mangrove lined creeks and lagoons of other cayes – particularly the lagoon at Northern Two Cayes.</p>	

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Ecosystems: Seagrass			
Current Status	2007 Status	Goal	Objectives:
VERY GOOD	VERY GOOD	VERY GOOD	<ul style="list-style-type: none"> ■ <i>To protect and maintain seagrass within the Natural Monuments at the current level or improved</i> ■ <i>To work with caye owners and developers to minimise impacts to seagrass on the Atoll</i>
Justification		Species / ecosystems nested in this target	
<p>Seagrass meadows are essential for maintaining the ecological health of the shallow marine ecosystems, with an important role in nutrient cycling and sediment stabilization. Seagrass beds are especially important as a nursery habitat for many species, and are a critical ecosystem for many fish and invertebrate species - an acre of sea grass has been shown to support up to 40,000 fish and 50 million small invertebrates (Seagrass Ecosystems Research Laboratory, 2005).</p> <p>This target focuses on the seagrass beds of Blue Hole and Half Moon Caye Natural Monuments. 90% of these beds are considered to be intact, with only marginal impacts from tourism and boat impacts in the shallow waters around the cayes themselves. Some shallow water seagrasses have been impacted by the thick sargassum beds that have been drifting into the Atoll and accumulating on the beaches and over the shallow waters, shading out the seagrass beneath and affecting the many species associated with this ecosystem.</p>		<p>Three species of seagrass are present on Lighthouse Reef Atoll – turtle grass (<i>Thalassia testudinum</i>), manatee grass (<i>Syringodium filiforme</i>) and shoal grass (<i>Halodule wrightii</i>).</p> <p>Seagrass beds are essential for the Queen conch (<i>Strombus gigas</i>), one of the most important commercial species extracted from the sea. It is also important for the juveniles of many commercial fish species, and for parrotfish - these herbivores play a critical role in maintaining the reef.</p> <p>Nested targets also include the endangered green turtles, which play an important role in maintaining seagrass beds and increase the productivity of this ecosystem through grazing. Lemon and black-tip sharks (<i>Negaprion brevirostris</i> and <i>Carcharhinus melanopterus</i>) also inhabit the seagrass beds of the Atoll, especially around the north-western part of Northern Two.</p>	

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Species Assemblages: Commercial Marine Species			
Current Status	2007 Status	Goal	<i>Objectives:</i>
FAIR	FAIR	GOOD	<ul style="list-style-type: none"> ▪ <i>To maintain and improve the viability of the commercial species of Lighthouse Reef Atoll</i>
Justification		Species / ecosystems nested in this target	
<p>Commercial species support a fishing industry on which many people depend. The role of many of the target finfish species as top predators is also essential in the maintenance of reef community structure. Most commercially important marine species have complicated life cycles that rely on the health and connectivity of the entire marine ecosystem – utilizing not just the reef, but also the seagrass beds and the mangroves at some point during their life cycles, and reflect the state of the reef.</p> <p>Queen conch (<i>Strombus gigas</i>) and Caribbean spiny lobster (<i>Panulirus argus</i>) are both fished extensively throughout the Atoll. fished by two sectors – small groups of fishermen based from fishing camps, with skiffs and larger groups of sailboat fishermen of the northern fishing communities (predominantly Chunox, Copper Bank and Sarteneja) As non-extractive zones, the Natural Monuments act as replenishment areas for the Atoll, a fact recognized by the fishermen using the area (Boat to boat survey, 2015). Ensuring continued sustainable extraction for these fishermen is as much a target as conservation of the species targeted.</p> <p>Commercial finfish species are fished both on the Atoll and at the drop off. There is some illegal fishing on the Atoll and at the spawning aggregation sites outside the protected areas, thought to be primarily by Honduran fishers.</p>		<p>This target covers primarily Queen conch and Caribbean spiny lobster and finfish - the two invertebrate species of highest commercial importance extracted from Lighthouse Atoll. A number of other commercial species are also included - the spotted lobster, stone crab and blue crab though these make up only a small portion of the total catch. In addition octopus and sea cucumbers are also being harvested to sell to local and foreign markets, respectively.</p> <p>Snappers and groupers - both shallow and deep water species - are the predominant commercial finfish species harvested from the Atoll. The endangered Nassau grouper (<i>Epinephelus striatus</i>) has been one of the most targeted species, though the near population collapse has led to fishermen concentrating on other species – for example: black grouper, Cubera, dog and mutton snapper. Hogfish is also considered an important commercial species, as are grunts, and barracuda. Shark species are targeted as well, including the endangered great and scalloped hammerhead sharks. Deep sea snapper - red blackfin and vermilion snapper – are also fished.</p> <p>Increasingly low numbers of commercial species are leading to increased fishing of non-traditional species such as angelfish, with numbers of these species decreasing.</p>	

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Species Assemblages: Spawning Aggregation Sites				
Current Status	2007 Status	Goal	<i>Objectives:</i>	
FAIR	FAIR	GOOD	<ul style="list-style-type: none"> ▪ <i>To improve the viability of the three spawning aggregation sites of Lighthouse Reef Atoll</i> 	
Justification for Target Selection		Species, Communities or Ecological Systems		
<p>Many of the groupers and snappers form large spawning aggregations at predictable times and places, making them very vulnerable to fishing pressure. In 1998, Nassau grouper spawning in Belize was estimated to have declined by 81% over a 10 year period. These aggregation sites are critical to the maintenance of these fish species and, in Belize, are seasonally protected under SI 161 of 2003. Three sites are known from the Atoll – South Point, Half Moon Caye (within the HMCNM) and Sandbore.</p> <p>The Sandbore site, the most productive Nassau grouper spawning aggregation site currently in Belize, has been monitored by BAS for ten years. Data shows that the site is improving, with a maximum of 3,500 individuals recorded during recent counts (BAS data, 2015).</p>		<p>Sandbore Nassau grouper Black grouper Yellowfin Grouper Tiger grouper Bar Jack Yellow Jack * Crevalle Jack * Horse-eye jack</p> <p>*have not been seen aggregating over the last couple years</p>	<p>South Point Mutton snapper Yellow jack Permit Horse-eye jack Bar Jack Yellowtail snapper Schoolmaster</p> <p><i>(Based on 2016 monitoring data)</i></p> <p>Dog snapper Red hind Black grouper Tiger grouper Bar jack Crevalle jack Ocean triggerfish Jolthead pogy Smooth trunkfish</p> <p><i>Reported from previous survey (Heyman, 2002)</i></p>	<p>Half Moon Caye Cubera snapper Dog snapper Nassau grouper* Red hind* Black grouper Yellow grouper* Tiger grouper* Amber jack Bar jack Blue runner Yellow jack* Crevalle jack Horse-eye jack White margate Ocean triggerfish Jolthead pogy* Permit Smooth trunkfish Blue parrotfish Midnight parrotfish Chubs White Margate</p>

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Species Assemblages: Elasmobranchs (Sharks and Rays)			
Current Status	2007 Status	Goal	<i>Objectives:</i>
FAIR	-	FAIR	<ul style="list-style-type: none"> ▪ <i>To improve the viability of elasmobranch populations of Lighthouse Reef Atoll</i>
Justification		Species / ecosystems nested in this target	
<p>Sharks are top predators in the marine environment – wide ranging species that require large, healthy seascapes for viable populations, and are critical for the maintenance of the coral reef ecosystem. 10 species of sharks and 4 of rays have been recorded at Lighthouse Reef Atoll between 2004 and 2014 during MarAlliance surveys, including several sharks encountered at a Guatemalan fishing camp in 2008. The shallow waters of Long Caye and Northern Two Cayes are important as nursery areas for lemon sharks.</p> <p>Nationally, sharks are under increasing fishing pressure, with demand for shark meat from neighbouring countries, especially during the Lenten season, and growing international demand from countries such as China for both the shark meat and fins. There is a small-scale shark fishery primarily targeting Caribbean sharpnose and Caribbean reef sharks. Shark nets are still washing up in the Atoll and deep long liners intercepted (Graham, pers. com. 2015), demonstrating that this fishing pressure is still occurring, though it is thought that the Guatemalan fishers now act middlemen, paying Belize fishers to do the actual fishing.</p> <p>This target also covers other wide-ranging species – dolphins and deep sea fish that move between Atolls and are important in supporting the tourism industry – either through the excitement of seeing them during tours, or through pelagic sport fishing.</p>		<p>Sharks</p> <ul style="list-style-type: none"> Lemon shark Caribbean reef shark Tiger shark Caribbean sharpnose shark Whale shark Nurse shark Blacktip shark Silky shark Scalloped hammerhead Great hammerhead Black tip shark (esp. juv) 	<p>Rays</p> <ul style="list-style-type: none"> Southern stingray Spotted eagle ray Caribbean whiptail stingray Yellow spotted stingray
		<p>A number of other deep sea shark species have been reported from the oceanic waters of Belize, and can be expected to occur near Lighthouse Reef – the smooth dogfish, Galapagos shark and night shark as well as those species listed above that use the Atoll lagoon, walls and the Blue Hole. Transient marine mammals expected to be in the area include the rough-toothed and spinner dolphins, Fraser’s dolphin, Clymene’s dolphin, orcas, humpback whales and pilot whales, sperm whales and potentially pygmy sperm whales thought to pass through the area, based on records from the waters around Turneffe Atoll. Wide-ranging pelagic sport fish species include the blue marlin, white marlin, sailfish, wahoo, dorado, billfish, dolphin fish and king mackerel.</p>	

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Species Assemblages: Marine Herbivorous Species													
Current Status	2007 Status	Goal	Objectives:										
GOOD	GOOD	VERY GOOD	<ul style="list-style-type: none"> ▪ To improve the viability of elasmobranch populations within Lighthouse Reef Atoll 										
Justification		Species / ecosystems nested in this target											
<p>This target focuses on the <i>Diadema</i> and herbivorous fish populations, such parrotfish (Scaridae) and surgeonfish (Acanthuridae) - the dominant grazers of the reef ecosystem, and considered the most important guild for the maintenance of the health of the reef. These species keep algal growth on hard corals under control, effectively reducing algal cover, increasing substrate availability for coral recruitment and providing coral with a competitive advantage (Mumby et al., 2006).</p> <p>Anecdotal evidence suggests that large parrotfish species such as the rainbow and the midnight parrotfish (<i>Scarus coelestinus</i>), have gone from being abundant to scarce on the Atoll. As only adult parrotfish feed on reef algae, the size of the parrotfish recorded at Lighthouse Reef Atoll is important. Midnight parrotfish are the most abundant, with stoplight being the second. Neither the rapid environmental assessment in 2004, nor the stakeholder consultations recorded the rainbow parrotfish.</p> <p>Large shoals of blue tang and doctorfish have shown similar declines – these are still seen in the shallow waters, but in smaller numbers. Since the ban on fishing of this guild, numbers are starting to increase, though large individuals are still seldom seen, with the exception of the spotlight parrotfish. The requirement for a skin patch on fish fillet has significantly decreased the illegal fishing of this important guild.</p>		<p>The long-spined, or black, sea urchin (<i>Diadema antillarum</i>) is present in the waters of Lighthouse Reef Atoll, but in relatively low numbers. Corallivorous parrotfish species include:</p> <table style="width: 100%; border: none;"> <tr> <td style="padding-right: 20px;">Queen parrotfish</td> <td><i>Scarus vetula</i></td> </tr> <tr> <td>Midnight parrotfish</td> <td><i>Scarus coelestinus</i></td> </tr> <tr> <td>Rainbow parrotfish</td> <td><i>Scarus guacamaia</i> VU</td> </tr> <tr> <td>Stoplight parrotfish</td> <td><i>Sparisoma viridae</i></td> </tr> <tr> <td>Redband parrotfish</td> <td><i>Sparisoma aurofrenatum</i></td> </tr> </table> <p>Lighthouse Reef Atoll still retains a small population of rainbow parrotfish (<i>Scarus guacamaia</i> (Vulnerable – IUCN, 2011), the largest and therefore the most important of the reef-cleaning species, though sightings are based on shoals of low numbers of individuals (a shoal of 8 by Half Moon Caye). Spotlight parrotfish are considered the most common, followed by the midnight parrotfish, which are increasing in numbers following the ban on fishing. Unlike the other species, the spotlight is reported to have a good number of large individuals. Large schools of yellowtail parrotfish are also present.</p>		Queen parrotfish	<i>Scarus vetula</i>	Midnight parrotfish	<i>Scarus coelestinus</i>	Rainbow parrotfish	<i>Scarus guacamaia</i> VU	Stoplight parrotfish	<i>Sparisoma viridae</i>	Redband parrotfish	<i>Sparisoma aurofrenatum</i>
Queen parrotfish	<i>Scarus vetula</i>												
Midnight parrotfish	<i>Scarus coelestinus</i>												
Rainbow parrotfish	<i>Scarus guacamaia</i> VU												
Stoplight parrotfish	<i>Sparisoma viridae</i>												
Redband parrotfish	<i>Sparisoma aurofrenatum</i>												

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Species Assemblages: Marine Turtles			
Current Status	2007 Status	Goal	Objectives: <ul style="list-style-type: none"> ▪ To improve the viability of marine turtles of Lighthouse Reef Atoll
FAIR	FAIR	GOOD	
Justification		Species / ecosystems nested in this target	
<p>Three species of marine turtle (hawksbill, loggerhead and green) use Lighthouse Reef Atoll either as a foraging area or nesting area, with two more species, the leatherback and Ridley’s turtles, known to enter Belize’s oceanic waters, and therefore potentially occurring in the adjacent, deep waters.</p> <p>Since the enforcement of legislation in 2002 (S.I. 66 of 2002), providing turtles with complete protection from exploitation, the number of turtles seen in-water and the number of crawls and turtle nests has increased. In 2015, Half Moon Caye and Sandbore Caye have the highest number of nests, with HMC having 16 confirmed nests and Sandbore, 6.</p> <p>In-water surveys of megafauna conducted in 2013 / 2014 demonstrated that hawksbills were the most abundant species (80%), followed by green, with only limited records of leatherbacks. The majority of hawksbills recorded in the 2013 survey were juveniles, with carapace lengths less than 60cm (Graham, pers. com.).</p> <p>Illegal fishing of turtles was verified by the movement of a tagged individual captured at Lighthouse Reef Atoll, and then carried to Honduras (Graham, pers. com.).</p>		<p>Nesting / foraging species: Hawksbill turtle <i>Eretmochelys imbricata</i> CR Loggerhead <i>Caretta caretta</i> EN Green turtle <i>Chelonia mydas</i> EN</p> <p>Potential transient species: Leatherback turtle <i>Dermochelys coriacea</i> VU Kemp’s ridley turtle <i>Lepidochelys kempii</i> CR</p>	

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Species Assemblages: Colony Nesting Birds			
Current Status	2007 Status	Goal	<i>Objectives:</i> <ul style="list-style-type: none"> ▪ <i>To improve the viability of colony nesting birds of Half Moon Caye</i>
GOOD	GOOD	VERY GOOD	
Justification		Species / ecosystems nested in this target	
<p>The western half of Half Moon Caye was first established as a crown reserve in 1928, in recognition of the importance of the large nesting colony that exists on the south western portion of the caye. The white-phase red-footed booby and the magnificent frigatebird both nest in large numbers on each year, the nesting season stretching for approximately 6 months from courting, to mating, to nesting and caring for the chicks.</p> <p>The colony appears to be stable, and relatively resilient to both the tourism visitation and hurricane impacts of the last twenty years. 2014 population estimates suggest that the red footed booby population is around 3,700 (BAS data), comparing favourably with the 1961 estimate of 3,500 individuals. The magnificent frigatebird has an estimated population of about 1,730 (BAS data, 2015).</p>		<p>Red-footed booby <i>Sula sula</i> Magnificent frigatebird <i>Fregata magnificens</i> White Crown Pigeon <i>Patagioenas leucocephala</i></p>	

2.3 Assessment of Critical Threats

A full assessment was carried out (Table 33), identifying four key threats that were then assessed as part of the Conservation Action Planning process, using the modified WCS Living Landscape tool in the National Management Planning Framework (Level 2) (NPAPSP, 2005). Each threat was rated by:

- the area affected by the threat
- the severity of the threat
- the urgency of the threat
- the recovery time
- the probability of the threat occurring,

...and prioritized (Tables 34 and 35), using the equation:

$(\text{Urgency} + \text{Recovery}) \times \text{Severity} \times \text{Area} \times \text{Probability}$

Based on this assessment, the four most critical threats are considered to be:

- **Unsustainable fishing**
- **Tourism impacts**
- **Introduced Species**
- **Development of Adjacent Cayes**

Assessment of Critical Threats for Lighthouse Reef Atoll

Identified Threats:

- Unsustainable fishing on the Atoll (including recreational / sport fishing)
- Tourism impacts - Diving and Snorkeling, Boat impacts
- Introduced Species (Coconuts, rats and lionfish)
- Development impacts from adjacent cayes

Overall threat status: Very High

Table 33: *Identified Local Anthropogenic Threats in the Lighthouse Reef Atoll area*

Table 34: *Rating Critical Threats*

Table 35: *Prioritization of Identified Threats*

Table 36: *Highest Ranking Pressures and Threats impacting Half Moon Caye Natural Monument*

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Table 33: Identified Local Anthropogenic Threats in the Lighthouse Reef Atoll area	
Fishing Pressure / Unsustainable Fishing Practices	Unsustainable extraction – too many fishermen, too limited a resource
	Illegal fishing of reproductive adults at spawning aggregation sites <i>(significantly decreased at the HMC and Sandbore spawning sites, but still some fishing of the South tip site for Mutton snapper)</i>
	Illegal use of seine / gill nets on reef and in channels
Unsustainable Development:	The potential for development at the northern part of the atoll
Unsustainable Development: Clearance of Mangrove	Removal of important marine nursery areas
	Removal of important habitat for nesting and migrating birds
	Erosion of caye soils
	Removal of important habitat for lizards
	Removal of important nutrient source within the marine system
Unsustainable Development: Anthropogenic Impacts on Sandy Beaches	Removal of herbaceous beach vegetation – an ecosystem that is under-represented within the national protected areas system
	Removal of critical turtle and crocodile nesting habitats
	Light pollution, impacting turtle nesting and hatching success
	Introduction of exotics – <i>Casuarina</i> , coconut palms
Unsustainable Development: Pollution	Contamination of water from boats throughout the Atoll - inappropriate sewage and grey water treatment, leading to eutrophication, with associated accelerated algal growth and coral loss
	Inappropriate solid waste disposal from live-aboard boats and cayes
	Contamination of waters by runoff containing herbicides, insecticides/detergents from cayes (currently at low levels)
	Reduction and pollution of freshwater lenses beneath cayes
Unsustainable Development: Dredging and Associated Sedimentation (potential)	Destruction of seagrass habitat, supporting many vertebrate and invertebrate species
	Sedimentation of coral, reducing coral viability
	Sedimentation of seagrass, reducing seagrass viability
	Re-suspension of pollutants
Unsustainable Development: Invasive Species: Lionfish	Reduction of native marine species – voracious predator of juvenile fish and crustaceans
Boat Impacts	Mechanical damage to coral reef communities and nursery sites (seagrass beds) from anchor damage, sedimentation and propeller damage from shallow water boat traffic, ship and boat groundings
	Pollution from poor fuel management and poorly maintained outboards
Poor Sport Fishing Practices	Non-catch and release
Tourism/ Recreation Impacts	Limited enforcement of tourism regulations
	Pollution from sun blocks and insecticides
Threats from Adjacent Shipping Lane	Blackwater: Sewage, wastewater from toilets and medical facilities. Release of untreated or inadequately treated sewage
	Ballast Water: With potential to introduce invasive species
	Greywater: Wastewater containing a variety of contaminants such as detergents, oil, grease, metals, petroleum hydrocarbons
	Bilge Water: Oil-contaminated water from engine oil leaks, which is flushed out at intervals

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Rating Critical Threats

Rating Critical Threats (adapted from WCS)					
Criteria	Score		Criteria	Score	
AREA	4	Will affect throughout >50% of the area	RECOVERY	3	100+ years or never
	3	Widespread impact, affecting 26 – 50% of the area		2	11 – 100 years
	2	Localized impact, affecting 11 – 25% of the area		1	1 – 10 years
	1	Very localized impact, affecting 1 – 10% of the area		0	Immediate
<hr/>					
SEVERITY	3	Local eradication of target possible	PROBABILITY	1.00	0.76 - 1.00
	2	Substantial effect but local eradication unlikely		0.75	0.51 – 0.75
	1	Measurable effect on density or distribution		0.5	0.26 – 0.50
	0	None or positive		0.25	≤ 0.25
<hr/>					
URGENCY	3	The threat is occurring now and requires action			
	2	The threat could or will happen between 1 – 3 years			
	1	The threat could happen between 3 – 10 years			
	0	Will not happen in > 10 years			

Table 34: Rating Critical Threats

Prioritization of Identified Threats							
Threat	Criteria Ratings					Score (U+R) xAxSxP	Rank
	Area	Severity	Urgency	Recovery	Probability		
Climate Change	4	3	3	3	1.00	72	1
Unsustainable Fishing	4	2	3	2	1.00	40	2
Invasive Rats	4	2	3	2	1.00	40	2
Invasive Lionfish	4	2	3	2	1.00	40	2
Caye Development	4	2	2	3	0.75	30	3
Diver / Snorkeler Impacts	1	1	3	2	1.00	5	4

Table 35: Prioritization of Identified Threats

**Half Moon Caye and Blue Hole Natural Monuments – Management Plan
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Highest Ranking Pressures and Threats impacting Lighthouse Reef Atoll		
Pressure/Threat	Impacts on Biodiversity	Causes
Unsustainable fishing within Atoll	<ul style="list-style-type: none"> ▪ Reduced viability of commercial fish species populations, and associated impacts on trophic structure of area ▪ Likely long-term perturbation of marine ecosystems due to reduced populations of key guilds - larger fish species 	<ul style="list-style-type: none"> ▪ Reliance of stakeholder communities on income from fishing ▪ Limited capacity / resources of PA authority and co-management agency to effectively monitor and enforce fisheries legislation in the wider Atoll
Tourism Activities	<ul style="list-style-type: none"> ▪ Physical damage to reef ▪ Water pollution causing algal blooms ▪ Altered behavior of sharks and other fish from chumming 	<ul style="list-style-type: none"> ▪ Dragging of anchors and / or mooring buoys ▪ Inadequate diving / snorkeling preparation and supervision by tour guides ▪ Improper sewage disposal from live-aboards ▪ Perception of tour guides that shark and fish chumming will increase visitor satisfaction
Introduced Species	<p>Coconuts</p> <ul style="list-style-type: none"> ▪ Reduced viability of the Littoral Forest, with leaves shading out coastal vegetation <p>Rats</p> <ul style="list-style-type: none"> ▪ Reduce the viability of the Littoral Forest through seed consumption, preying on endemic reptiles and potential hunting of eggs and young birds in the nesting colony. <p>Lionfish</p> <ul style="list-style-type: none"> ▪ Prey on juveniles of reef and commercial species 	<p>Coconuts</p> <ul style="list-style-type: none"> ▪ Historical use of the caye as a coconut plantation <p>Rats</p> <ul style="list-style-type: none"> ▪ Limited protocols for preventing invasive species (NOTE: now being addressed) <p>Lionfish</p> <ul style="list-style-type: none"> ▪ Regional invasion

Table 36: Highest Ranking Pressures and Threats impacting Half Moon Caye Natural Monument

**Half Moon Caye and Blue Hole Natural Monuments – Management Plan
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Threats to biodiversity of Lighthouse Reef: Climate Change				
Climate Change	Status:	Historical	Active	Potential
	Conservation Target(s): All			
	Stresses (Direct):			
	<ul style="list-style-type: none"> ▪ Reduced live coral cover ▪ Reduced coral growth rates ▪ Reduced reef biodiversity ▪ Ecological shifts in benthic communities ▪ Erosion of beach ▪ Reduction in extent of herbaceous beach vegetation forest 			
Sources of Stress (Indirect):				
<ul style="list-style-type: none"> ▪ Increased water temperatures ▪ Increased strength of storm events / hurricanes ▪ Sea level rise ▪ Changes in currents ▪ Ocean acidification ▪ Removal of herbivorous species through illegal fishing practices ▪ Other local anthropogenic threats 				
Area	4	The impacts of climate change are currently being experienced at Lighthouse Reef Atoll through increased bleaching and storm events, and it is expected that the severity and frequency of these events will increase over the coming years		
Severity	3	Climate change, a global phenomenon, is the single largest contributing factor to the decline in biodiversity viability of the marine ecosystems in Belize, and is considered a significant risk to a wide range of species and ecosystems throughout Lighthouse Reef Atoll		
Urgency	3	The impacts of climate change are currently being felt at Lighthouse Reef Atoll through increased bleaching and storm events. The severity and frequency of these events is expected to increase over the coming years and strategies to improve resilience need to be developed and implemented as soon as possible.		
Reversibility	3	Climate change impacts may not be reversible within our life time – strategies are geared towards mitigation		
Probability	1.00	Climate change impacts are already happening.		
Management Strategies:				
Strategy 1: Identify resilient areas within Lighthouse Reef Atoll and prioritize for surveillance and enforcement activities				
Strategy 2: Identify and increase protection of resilient reefs, source populations and key larval dispersal routes				
Strategy 3: Establish monitoring protocols that inform management for building reef resilience				
Strategy 4: Engage caye landowners in climate change adaptation strategies – including shoreline protection through conservation / re-planting of mangroves				
Strategy 5: Investigate mechanisms for direct interventions – e.g. promoting higher herbivore densities				
Strategy 6: Strengthen protection of marine trophic structure - maintenance of top predators and herbivores				

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Threats to biodiversity of Lighthouse Reef Atoll : Unsustainable Fishing				
Fishing Pressure / Unsustainable Fishing Practices	Status:	Historical	Active	Potential
	Conservation Target(s): Commercial Species, Coral Reefs			
	Stresses (Direct):			
	<ul style="list-style-type: none"> ▪ Reduced commercial species populations ▪ Trophic shifts in marine ecological communities 			
Sources of Stress (Indirect):				
<ul style="list-style-type: none"> ▪ Limited management presence for size of area ▪ Low income in fishing communities ▪ Traditional occupation ▪ Market demand from fishing coops and export market ▪ Increased local and tourism demand for local fresh fish ▪ Demand for fish (including sharks) from Honduras 				
Area	4	Fishing occurs through more than 75% of the Atoll platform and into the open sea (including some illegal fishing within the Natural Monuments)		
Severity	3	Lobster, conch and finfish populations are considered to be significantly lower than ten years ago		
Urgency	3	Current fishing pressure has significantly reduced lobster, conch and finfish levels, and will continue to unless strategies are implemented to address this		
Reversibility	2	It would be feasible to reduce the fishing pressure with adequate patrols and the strengthening of the prosecution system		
Probability	1.00	Fishing is happening now		
Management Strategies:				
<p>Strategy 1: Strengthen the surveillance and enforcement activities in the Atoll through increased, dedicated patrol team, strategic partnerships, and increased national investment in surveillance and enforcement of the marine environment</p> <p>Strategy 2: Establish zones for fisheries management based on strong scientific data informing decisions</p> <p>Strategy 3: Engage fishermen in implementation of an effective sustainable fisheries management regime for the Atoll through the Managed Access framework</p> <p>Strategy 4: Develop and implement a supplemental / alternative livelihood program targeting traditional users of Lighthouse Reef Atoll, to reduce reliance on marine resource extraction</p>				

Table ...: Threats to biodiversity of Lighthouse Reef Atoll				
Unsustainable Caye Development	Status:	Historical	Active	Potential
	Conservation Target(s): Terrestrial Ecosystems, Seagrass			
	Stresses (Direct):			
	<ul style="list-style-type: none"> ▪ Reduced extent of littoral forest, mangroves and herbaceous beach vegetation ▪ Reduced viability of terrestrial species ▪ Reduced viability of nesting turtle and crocodile populations ▪ Reduced viability of nesting bird populations ▪ Reduced viability of coral reef ▪ Removal of important marine nursery habitat ▪ Reduction / pollution of freshwater lens 			
Sources of Stress (Indirect):				
<ul style="list-style-type: none"> ▪ Infrastructure development with removal of natural vegetation and disturbance of nesting beaches ▪ Increased erosion of caye soils / sandy beaches ▪ Inadequate, unplanned water and fuel management practices, with increased nutrients, sediment and pollutants in marine environment and freshwater lens ▪ Lack of control over development activities on other LHR cayes 				
Area	4	Any large development has the potential to impact the entire Atoll. There is currently only localised development activity, though this may increase in the future.		
Severity	2	Where development occurs, there has generally complete removal of terrestrial vegetation, with associated impacts on biodiversity		
Urgency	2	No new development is happening, but there is the potential for development to start under the Puerto Azul project		
Reversibility	3	It would be feasible to reverse the threat, but there would be very high economic and political barriers.		
Probability	0.75	The potential for development to start under the Puerto Azul project		
Management Strategies:				
<p>Strategy 1: Adopt and promote CZMAI Lighthouse Reef Atoll development guidelines as the development standard for the Atoll</p> <p>Strategy 2: Encourage caye-based residents / developers to adopt and follow best practices development guidelines</p> <p>Strategy 3: Ensure effective surveillance and enforcement against illegal development activities at Lighthouse Reef Atoll – e.g. non-permitted clearance of mangroves, overwater / seawall construction, dredging</p> <p>Strategy 4: Limit dredging on Lighthouse Reef Atoll to small scale non-mechanical operations (artisanal permits only) and for access purposes only (optimum)</p> <p>Strategy 5: Ensure all EIAs for Lighthouse Reef Atoll developments are fully vetted and approved, and take into account best practices and CZMAI guidelines</p>				

Threats to biodiversity of Lighthouse Reef Atoll: Visitor Impacts				
Visitor Impacts	Status:	Historical	Active	Potential
	Conservation Target(s): Coral Reef, sea turtles, bird nesting colony			
	Stresses (Direct): <ul style="list-style-type: none"> ▪ Snorkeler / diver impacts on corals – breakage ▪ Garbage in water ▪ Water contamination from sun screen and insect repellent ▪ Trampling of turtle nesting sites ▪ Noise impacts on bird nesting colony ▪ Altered fish behaviour - chumming ▪ Reduction / pollution of freshwater lens ▪ Illegal fishing ▪ Collection of corals and shells for souvenirs 			
	Sources of Stress (Indirect): <ul style="list-style-type: none"> ▪ Poor tourism practices 			
Area	1	Tourism is confined to discrete areas of reef, to the paths and open sand of Half Moon Caye		
Severity	1	Tourism impacts are considered to have a measurable effect on the conservation targets, but will not result in their eradication		
Urgency	3	Tourism impacts are occurring on a daily basis		
Reversibility	2	Tourism impacts to coral are reversible, but will take time		
Probability	1	There is a very high probability that tourism impacts will occur on any given day		
	Management Strategies: <p>Strategy 1: Ensure that all tour guides are licensed and implement the required BTB guide to diver ratios</p> <p>Strategy 2: Ensure effective surveillance and enforcement against illegal tourism practices – e.g. breaking of corals or collecting shells as souvenirs, illegal fishing, too many visitors per guide</p> <p>Strategy 3: Ensure that all visitors are aware of the rules and regulations for the Natural Monuments</p> <p>Strategy 4: Ensure infrastructure is in place to minimize tourism impacts on the reef – signs, mooring and navigation channel buoys, designated dive sites</p> <p>Strategy 5: Provide training for tour guides and boat captains in tourism best practices, as part of BAS-certification process</p> <p>Strategy 6: Address issues of fish chumming</p> <p>Strategy 7: Provide best practices / regulations information to private vessels on arrival, as a sign-off checklist, covering fisheries legislation, greywater / blackwater management and other regulations</p> <p>Strategy 8: Monitor effluent discharge from boats overnighting at LHR / HMC.</p>			

Threats to biodiversity of Lighthouse Reef Atoll: Invasive Species - Rats			
Invasive Species - Rats	Status:	Historical	Active
	Conservation Target(s): Sea Turtles, Bird Nesting Colony, Littoral Forest		
	Stresses (Direct): <ul style="list-style-type: none"> ▪ Presumed predation of eggs and nestlings of red-footed booby ▪ Presumed predation of turtle hatchlings ▪ Observed predation of lizard species ▪ Removal of seeds and seedlings of littoral forest species 		
	Sources of Stress (Indirect): <ul style="list-style-type: none"> ▪ Introduced rats 		
Area	3	Rats are present on over 50% of Half Moon Caye	
Severity	1	Impacts from rats are considered to have a measurable effect on the conservation targets, but will not result in their eradication	
Urgency	3	Rats are a constant issue on the Half Moon Caye	
Reversibility	2	It is possible to remove the rats, but only with considerable effort, and continued vigilance once this has been achieved	
Probability	1	Impacts from rats are expected to occur on a daily basis	
	Management Strategies: Strategy 1: Implement the 2015 / 2016 rat eradication plan Strategy 2: Implement Bio Security Plan for maintaining a rat-free caye Strategy 3: Engage tour guides and operators in implementing activities that ensure Half Moon caye remains rat-free		

2.3.1 Strategies to Reduce Threats

The primary cross cutting mitigation strategies were identified during the threat assessment and the targets each strategy addresses were identified (Table 37).

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Key Cross-Cutting Strategies	Coral Reefs	Littoral Forest	Mangroves	Seagrass	Commercial Species	Spawning Aggregations	Sharks and Rays	Marine Herbivores	Marine Turtles	Colony Nesting Birds
<i>Strengthen surveillance and enforcement activities in the Atoll through increased, dedicated patrol team and strategic partnerships</i>										
<i>Engage caye landowners in climate change adaptation strategies</i>										
<i>Adopt and promote CZMAI Lighthouse Reef Atoll development guidelines as the development standard for the Atoll</i>										
<i>Ensure all EIAs for Lighthouse Reef Atoll developments are fully vetted and approved, and take into account best practices and CZMAI guidelines</i>										
<i>Ensure that all visitors are aware of the rules and regulations for the Natural Monuments</i>										
<i>Identify resilient areas within Lighthouse Reef Atoll in the context of site level management and contribution to the national MPA system</i>										
<i>Provide best practices / regulations information to boats on arrival</i>										
<i>Strengthen protection of marine trophic structure - maintenance of top predators and herbivores</i>										
<i>Ensure effective surveillance and enforcement against illegal development activities at Lighthouse Reef Atoll</i>										
<i>Encourage caye-based residents / developers to adopt best practices development guidelines</i>										
<i>Establish zones for fisheries management based on informed decisions and strong scientific data</i>										
<i>Engage fishermen in implementation of an effective sustainable fisheries management regime for the Atoll</i>										
<i>Develop and implement a supplemental / alternative livelihood program targeting traditional users of Lighthouse Reef Atoll</i>										
<i>Identify and increase protection of resilient reefs, source populations and key larval dispersal routes</i>										
<i>Establish monitoring protocols that inform management for improving reef resilience</i>										
<i>Investigate mechanisms for direct reef-based climate change interventions</i>										
<i>Ensure that all tour guides are licensed and implement the required BTB guide to diver ratios</i>										

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Key Cross-Cutting Strategies	Coral Reefs	Littoral Forest	Mangroves	Seagrass	Commercial Species	Spawning Aggregations	Sharks and Rays	Marine Herbivores	Marine Turtles	Colony Nesting Birds
<i>Provide training for tour guides and boat captains in tourism best practices, as part of BAS-certification process</i>										
<i>Limit dredging on Lighthouse Reef Atoll to small scale non-mechanical operations, if at all</i>										
<i>Address issues of fish chumming</i>										
<i>Ensure infrastructure is in place to minimize tourism impacts on the reef – signs, mooring buoys, designated dive sites</i>										
<i>Monitor effluent discharge from boats overnighting at LHR / HMC</i>										

Table 37: Cross-cutting Strategies

2.4 Monitoring of Success of Conservation Strategies

The series of indicators allocated to each conservation target during the planning process provides a measures of success framework for site level monitoring, which have been incorporated into the Science Program. Monitoring the success of conservation strategies is an integrated component of the Management Action Planning process (Table 38).

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Measuring Success – Lighthouse Reef Monitoring Framework						
Category	Indicator	Methods	Frequency	Location	Who	Cost
Coral Reefs						
Status	IRHI	MBRS protocols, 2010 baseline	Annual	BAS monitoring sites,	BAS	Moderate
Stress	Turbidity	Visibility estimates at monitoring sites,	Annual	BAS monitoring sites	BAS	Low
Stress	Coral bleaching	Belt transect method	Annual	12 BAS monitoring sites	BAS	Low
Source of Stress	No. incidence of significant increased turbidity / year	Patrol reports Visibility estimates	After Coral Bleaching warning	Long Caye, Northern 2 Cayes, Hat Caye, Sandbore Caye, HMC	BAS	Low
Strategy	No. of incidences of illegal fishing of parrotfish / yr	Patrol Reports	Annual	Lighthouse Reef Atoll	BAS	Low

Table 38: Measuring Success – Lighthouse Reef Monitoring Framework

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Measuring Success – Lighthouse Reef Atoll Monitoring Framework / 2						
Category	Indicator	Methods	Frequency	Location	Who	Cost
Terrestrial Indicators						
Status	Extent of littoral forest	Satellite imagery, Interpretation through GIS group	Annual	LHR (Long Caye, Northern 2 Cayes, Sandbore Caye Hat Caye HMC	BAS	Low
Status	Extent of Mangrove	Satellite imagery, Overflight Interpretation through GIS group	Annual	LHR (Long Caye, Northern 2 Cayes, Sandbore Caye Hat Caye HMC	BAS	Low
Source of Stress	% of developments following best practices guidelines	Overflight; site survey	Annual	LHR (Long Caye, Northern 2 Cayes, Sandbore Caye Hat Caye HMC	BAS	Low
Source of Stress	No. of incidents of poor development practices reported and confirmed /year	Patrol reports	Annual		BAS DoE	Low
Strategy	Adopt and promote LHRA Development Guidelines (CZMAI)	Signed agreement by land owners	Every 5 years		BAS	Low

Table 38: Measuring Success – Lighthouse Reef Monitoring Framework / 2

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Measuring Success – Lighthouse Reef Atoll Monitoring Framework / 3						
Category	Indicator	Methods	Frequency	Location	Who	Cost
Commercial Species						
Status	Conch density	LAMP survey National Conch Survey	LAMP: pre and post season NCS: Every 2 years	LAMP: 37 BAS monitoring sites across LHR NCS: 40 sites across LHRA	BAS	Medium
Stress	Average catch per boat (conch and lobster, finfish?)	Managed Access protocols – record books Data provided by fishermen	Conch season (October 1 st – June 30 th) / Lobster Season (July 15th - Feb 15th)	LHR	BAS/ Fisheries Dept.	High
Source of Stress	Weight of illegal product	Weigh confiscated product	All year	LHR	BAS / Fisheries Dept.	Low
Strategy	# of day/ routine patrols	Patrol reports/annual reports	Annual summary	LHR	BAS/Coast Guard / Fisheries Dept.	Low
Status	Lobster density & reproductive population density	LAMP surveys (BAS)	Twice per year (Pre and Postseason)	LAMP: 37 BAS monitoring sites across LHR	BAS	Medium

Table 38: Measuring Success – Lighthouse Reef Monitoring Framework / 3

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Measuring Success – Lighthouse Reef Atoll Monitoring Framework / 4						
Category	Indicator	Methods	Frequency	Location	Who	Cost
Commercial Species						
Strategy	No. of fishing infractions as a % of total number fishing boats / year	Patrol Reports / Annual report	Annual	BAS	BAS Fisheries Department	Low
Strategy	% of illegal fishing cases presented that are successfully prosecuted / year	Fisheries Compliance Unit report	Annual	BAS	BAS Fisheries Department	Low
Spawning Aggregations						
Status	Grouper spawning population (annual / maximum)	Spawning Aggregation Monitoring Protocol for the Mesoamerican Reef and Wider Caribbean (2004) Revised edition,	Jan., Feb. (and if possible (Dec., March)	Sandbore	BAS	Medium
Status	Population abundance of spawning snapper (cubera & dog) and Groupers		Twice per year during peak (April and May)	Half Moon Caye	BAS	Medium

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Measuring Success – Lighthouse Reef Atoll Monitoring Framework / 5						
Category	Indicator	Methods	Frequency	Location	Who	Cost
Spawning Aggregations						
Status	Population abundance of spawning snapper (cubera and dog) and Groupers	Spawning Aggregation Monitoring Protocol for the Mesoamerican Reef and Wider Caribbean Revised edition (2004),	Once a year (March)	South-tip	BAS	Medium
Strategy	# of night and daytime patrols monitoring sites during spawning peak	Patrol reports/annual reports	Spawning season (3 times per year - more at HMC because of proximity)	Sandbore/HMC/South-tip	BAS/Coast Guard/Belize Fisheries Dept.	Medium
Stress	# of fishers caught fishing illegally at SPAGs	Patrol reports/annual reports	Spawning season	Sandbore, South Point and HMC	BAS	Low
Seagrass						
Status	Seagrass biomass	SeagrassNet Caribbean Monitoring Protocol	4 times/yr	BAS monitoring site	BAS	Low
Status	Seagrass height	SeagrassNet Caribbean Monitoring Protocol	4 times/yr	BAS monitoring site	BAS	Low

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Measuring Success – Lighthouse Reef Atoll Monitoring Framework / 6						
Category	Indicator	Methods	Frequency	Location	Who	Cost
Seagrass						
Status/stress	Seagrass % cover	SeagrassNet Caribbean Monitoring Protocol	4 times/yr	BAS monitoring site	BAS	Low
Status/stress	Light intensity	SeagrassNet Caribbean Monitoring Protocol	4 times/yr	BAS monitoring site	BAS	Low
Marine Turtles						
Status	# successful turtle nests total / per caye	Research and Management Techniques for the Conservation of Sea Turtles, IUCN Marine Turtle Specialist Group.	Annual (between May -December)	HMC, Sandbore, Northern 2 Caye, Long Caye	BAS	Medium
Status	% hatch success		Annual (between May -December)	HMC, Sandbore, Northern 2 Caye, Long Caye	BAS	Medium
Colony Nesting Birds						
Status	# red footed boobies	BAS protocol: 8 belt transects 4 x Length	Annually (between Feb. and Sept.)	HMC	BAS	Low
Status	# magnificent frigatebirds	BAS protocol: 8 belt transects 4 x Length	Annually (between Feb. and Sept.)	HMC	BAS	Low

Table 38: Measuring Success – Lighthouse Reef Monitoring Framework /6

2.5 Planning for Climate Change

2.5.1 Site Resilience Assessment

When planning management strategies for climate change, it is important to determine areas of resilience and vulnerability, and to identify adaptive strategies that can assist in maintaining the viability of biodiversity whilst increasing social resilience at both site and stakeholder community level. This assessment of the predicted implications of climate change has been conducted for Lighthouse Reef Atoll (including Half Moon Caye and Blue Hole Natural Monuments), based on the **conservation targets** identified during conservation planning, and on the **environmental services** provided by the protected area in question, identified during the management planning process.

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

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 1950s, 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

2.5.2 Identified Resources of Lighthouse Reef Atoll

The following resources have been identified as important for Lighthouse Reef Atoll:

The Fisheries Sector consists primarily of a traditional capture fisheries focused on lobster, conch and finfish. Lighthouse Reef Atoll is one of the key national fishing grounds, particularly for conch.

Resource	Comment
<ul style="list-style-type: none"> ▪ Conch, Lobster 	LHR contributes to both national conch and lobster production, providing an important income for traditional fishermen and the Northern fishing communities
<ul style="list-style-type: none"> ▪ Snapper / Grouper 	The spawning aggregation sites of Lighthouse Reef Atoll are important for the maintenance of snapper and grouper populations, maintaining populations of important commercial species, including the Nassau Grouper

The Tourism Sector Lighthouse Reef Atoll is considered a nationally important tourism resource for Belize, generating significant foreign income for the national economy.

Resource	Comment
<ul style="list-style-type: none"> ▪ Blue Hole 	A world renowned, “must dive” dive site
<ul style="list-style-type: none"> ▪ Healthy reef 	Several popular, world class dive sites are found along the walls of the Atoll, ranked by tour guides as among the top sites in Belize for tourism appeal.
<ul style="list-style-type: none"> ▪ Sandy beaches 	Half Moon Caye is known for its sandy beach and turtle nesting, adding to the touristic appeal of the protected area. Sandy beaches elsewhere on the Atoll also provide nesting sites for turtle species and the American crocodile, all species with high touristic appeal
<ul style="list-style-type: none"> ▪ Fly-fishing / sport fishing 	LHR is a fly-fishing destinations, contributing to tourism income, and supporting tourism operations in San Pedro and Caye Caulker

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Ecosystem Service: The health of the marine environment is critical to the social and economic health of Belize. The ecosystem services provided by the coral reefs, seagrass and mangroves cannot be over-estimated. Scenic values and coral reefs also provide the foundation for an active tourism industry.

Ecosystem	Ecosystem Services
<ul style="list-style-type: none"> ▪ Mangroves 	<p>The mangrove ecosystem provides a highly productive 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 filtering land based pollutants from caye-based hotel operations on Long Caye and Northern Two Cayes.</p>
<ul style="list-style-type: none"> ▪ Seagrass 	<p>Lighthouse Reef Atoll has extensive seagrass beds, with high connectivity to reef and mangrove, 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 CO₂ absorbing qualities.</p>
<ul style="list-style-type: none"> ▪ Corals 	<p>Lighthouse Reef Atoll has diverse reef types, ranging from reef wall to reef crest, back reef and patch reefs, with a high diversity of reef species. The reef crest breaks the force of the waves protecting the cayes and infrastructure</p>
<ul style="list-style-type: none"> ▪ Littoral forest 	<p>The cayes of Lighthouse Reef Atoll support some of the last, and most important, remnants of extensive littoral forest, considered one of the most threatened ecosystems in Belize. The coastal strand vegetation is important for stabilizing turtle and crocodile nesting beaches, and maintaining the caye.</p>

2.5.3 Identification of the Primary Climate Change Elements

The primary climate change elements associated with Lighthouse Reef Atoll are identified as:

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

For each target, the impacts of the identified primary climate change elements (sea level rise, increased sea surface temperature, increased intensity of storms, ocean acidification, decreased precipitation, increased air temperature), were rated on a scale of 1 to 4 (Table ..). Ratings took into consideration factors such as the severity, scope, contribution and irreversibility of each climate change element.

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Table 39: Climate Change Predictions (B2 Scenario) for Lighthouse Reef Atoll			
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 the 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 sea 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 has 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 of 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 occurring throughout Central America; 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

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Climate Change Predictions (B2 Scenario) for Lighthouse Reef Atoll / 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)	<p>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.</p> <p>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.</p> <p>Increased concentration and seasonality of agrochemical delivery</p>	<p>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)</p>

Climate Change Predictions (B2 Scenario) for Lighthouse Reef Atoll / 3			
Climate Change Impacts	Current Status	25 - 50 yrs	100 yrs
Ocean acidification (molluscs and crustaceans)	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). 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 by 2040 (Simpson et al., 2009). Predicted 30% decrease in pH. 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 39: Climate Change Predictions (B2 Scenario) for Lighthouse Reef Atoll

2.5.4 Climate Change Assessment Outputs

Target	Threat (based on Climate Change phenomena)	Certainty : The certainty that the effect of Climate Change will occur or the cause of the described impact will affect the target	Severity: Level or damage to this key element, which can destroy it in 50 years	Scope: Geographical coverage of the target that will be impacted in 50 years	Irreversibility : The impact is permanent or cannot be reversed naturally or through human action
Lighthouse Reef Atoll	Sea level rise	Very High	Medium	Very High	Very High
	Sea temperature rise	Very High	High	Very High	Very High
	Increased strength of storms	High	High	Very High	High
	Ocean acidification	Very High	High	Very High	Very High
	Decreased Precipitation	Very High	Medium	Very High	Very High
	Increased Air Temperature	Very High	Medium	Very High	Very High

Table 40: Assessment of Climate Change Impacts on Lighthouse Reef Atoll

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Climate Change Impacts	Ecosystems		
	Coral Reefs	Seagrass	Mangrove
Sea level rise	<p>Coral reefs may be able to keep up with sea level rise, barring other impacts (anthropogenic impacts, bleaching, acidification, disease and erosion). It is also dependent on rate of sea level rise. Changes in dispersal / recruitment routes / sources.</p> <p>There may be a loss of deeper corals, shift in distribution, as light availability decreases. Increased sedimentation and reduced light availability due to shore erosion.</p> <p>Possible reduction in water temperature with increased water exchange between deep water and Atoll lagoon.</p>	<p>Increases in water depths above present meadows will reduce light availability and changes in currents may cause erosion and increased turbidity of water column. Shifts in distribution of seagrass beds.</p> <p>Over the medium term, seagrass should be able to survive in increased water depth</p>	<p>Greatest climate change challenges that mangrove ecosystems face are inundation, habitat loss, distribution shift. Greater inundation of fringing mangroves lenticels in aerial roots can cause the oxygen concentrations in the mangrove to decrease, resulting in death.</p> <p>Damage to coral reefs may adversely impact mangrove systems depending on the reefs to provide shelter from wave action.</p> <p>If inland migration cannot occur, then mangroves may disappear.</p> <p>Increase in salinity of ground water – more saltwater intrusion may also affect distribution.</p> <p>Changes in dispersal patterns for mangrove propagules</p>
Sea surface temperature rise	<p>Increased coral bleaching, potential mortality and erosion, and eventual loss of ecosystem functionality.</p> <p>Increased prevalence of coral disease.</p> <p>Possible impacts from new invasive species and algal blooms.</p> <p>A shift towards more tolerant species and symbiont types, and more opportunistic species, with reduced diversity.</p> <p>May alter localized current patterns and therefore larval dispersion.</p> <p>Less tolerant species will disappear –though increased sea level rise may assist against increased water temperature.</p>	<p>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 <i>T. testudinum</i>). Higher temperatures may increase epiphytic algal growth, reducing available sunlight.</p>	<p>Reduced oxygen content in water in mangrove areas.</p> <p>Loss of reef may reduce protection from erosion and storm events, increasing risk to mangroves.</p>

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Climate Change Impacts	Ecosystems		
	Coral Reefs	Seagrass	Mangrove
Increased frequency and intensity of storms	<p>Increased mechanical damage of corals, increased sedimentation. Reduced ability of colonies to re-establish after storm events.</p> <p>Removal of macro algae, resulting in more available substrate for recruitment.</p> <p>Fragmentation – dispersal and colonization</p>	<p>Massive sediment movements that can uproot or bury seagrass. It may also become harder for seagrasses to become re-established.</p> <p>Would be exacerbated by anthropogenic impacts – primarily dredging and landfill</p>	<p>Destruction, inundation, changes in sediment dynamics.</p> <p>Possible increase in nutrients / growth.</p> <p>Large storm impacts result in mass mortality.</p> <p>Projected increases in the frequency of high water events could affect mangrove health and composition due to changes in salinity, and inundation.</p> <p>More frequent inundation is also projected to decrease the ability of mangroves to photosynthesize.</p>
Ocean acidification (corals, lobster / conch)	<p>Decreases in coral calcification rates, growth rates and structural strength. Also other invertebrates.</p> <p>Weakening of reef matrix.</p> <p>If there are areas of localised calcification, acidification will have a drastic impact on the localized environment.</p> <p>Change in ratio of accretion / dissolution</p>	<p>Possible direct positive effect on photosynthesis and growth, as in some situations, seagrass is carbon limited.</p> <p>Higher CO₂ levels may also increase the production and biomass of epiphytic algae on seagrass leaves, which adversely impact seagrasses by causing shading.</p> <p>The acidification of seawater could counter the high pH formed by photosynthesis in dense seagrass stands, thus increasing seagrass photosynthesis and productivity.</p>	<p>Positive increase in growth.</p> <p>However, damage to coral reefs may adversely impact mangrove systems that depend on the reefs to provide shelter from wave action.</p> <p>May affect mangrove root communities – especially invertebrates, such as molluscs.</p>
Decreased Precipitation	<p>There is a hypothesis that the increased algal bloom may be attributed to reduced precipitation, resulting in decreased visibility – might be positive, may shade the corals</p>		<p>Reduction of freshwater lens, effect on carbon uptake and photosynthesis.</p> <p>Decreased precipitation results in a decrease in mangrove productivity, growth, and seedling survival, and may change species composition favouring more salt tolerant species and shrubby growth forms. Projected loss of the inner caye to un-vegetated hypersaline flats</p>

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Climate Change Impacts	Ecosystems		
	Coral Reefs	Seagrass	Mangrove
Air Temperature			<p>May alter phenological patterns - timing of flowering and fruiting.</p> <p>At temperatures above 25°C, some species show a declining leaf formation rate.</p> <p>Above 35°C have led to thermal stress affecting mangrove root structures and establishment of mangrove seedlings.</p> <p>At leaf temperatures of 38-40°C, almost no photosynthesis occurs (IUCN, 2006).</p> <p>Possible localized changes in distribution.</p>

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Climate Change Impacts	Resources		
	Commercial Species	Spawning Aggregations	Colony Nesting Birds
Sea level rise	<p>Conch: May experience shift in range or habitat loss linked to changes in critical habitat</p> <p>Snapper / grouper / lobster: Shift in range / habitat loss of both adult and juvenile lobster – linked to inundation of mangrove, shift in seagrass distribution, changes in coral reef</p>	Potential changes in water currents affecting viability of spawning aggregation sites	The cayes may become inundated, Salt incursion of water table altering terrestrial vegetation cover, with changes in species presence / diversity, reducing structural support of nesting colony and availability of nesting sites...
Sea surface temperature rise	<p>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)</p> <p>Lobster: Possible effects on larval and adult lobsters and reproduction.</p> <p>Loss of critical habitat</p> <p>May affect physiological processes, and disease may become more prevalent.</p> <p>Possible impacts from new invasive species and algal blooms.</p> <p>Changes in currents and larval dispersal</p>	Decrease of upwelling currents - decrease in ocean productivity with potential loss of spawning aggregation sites.	Potential impacts on food sources
Increased frequency and intensity of storms	<p>Reef, seagrass and mangrove destruction, increased sedimentation</p> <p>Possible impacts on larval dispersal / survival (potential for wider dispersal of larvae)</p>	<p>Greater frequency of water swells in upwelling areas, with increasing nutrients.</p> <p>Lengthened storm season may reduce spawning period.</p>	<p>Habitat destruction and increased sedimentation;</p> <p>Possible impacts on dispersal / survival.</p> <p>Inundation of nests from higher groundwater</p>

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Climate Change Impacts	Resources		
	Commercial Species	Spawning Aggregations	Colony Nesting Birds
Ocean acidification (corals, lobster / conch)	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 a skeleton of CaCO ₃) Possible increase in seagrass productivity	Unknown how fish respond to changes in pH balance Potential decrease in egg viability Potential decrease in viability of eggs and juveniles	
Decreased Precipitation	Possible changes in salinity impacting larval dispersal. Lobster migration patterns and times will change. More frequent, higher salinity pulses before equalization with main seawater body. There is a hypothesis that increased algal bloom may be attributed to reduced precipitation		Possible changes in littoral forest species composition to more drought tolerant species may impact structural suitability of littoral forest for supporting nesting colony
Air Temperature	Potential impacts on mangroves as a nursery habitat		Potential impact on hatch success

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Climate Change Impacts	Resource		
	Littoral Forest / Coastal Community	Parrotfish	Marine Turtles
Sea level rise	The cayes may become inundated, with loss of vegetation. Salt incursion of water table may alter terrestrial vegetation cover, with changes in species presence / diversity. Potential loss of low-lying crocodile and turtle nesting beaches	Shift in range / habitat loss of both adult and juvenile parrotfish – linked to inundation of mangrove, shift in seagrass distribution, changes in coral reef	Permanent inundation of nesting beaches Partial inundation may reduce hatch success and alter beach vegetation, destabilizing nesting beaches
Sea surface temperature rise	Removal of some or all natural vegetation with less time for regeneration between storms, lower scrubby vegetation, change in forest structure / reduced species diversity. Increased erosion, loss of part or entire cayes, changes in beaches. Arrival of opportunistic species. Impacts on ability to provide structural support for bird colonies (nesting / roosting)	Shifts in distribution / abundance of seagrass, decreased health of coral reef, Distribution shift into deeper, cooler waters	Shifts in distribution for foraging Changing dispersal patterns with changing ocean currents, also resulting in increased mortality following beaching of large amounts of sargassum
Decreased precipitation	Reduction of freshwater lens, affecting carbon uptake and photosynthesis by plants. Decreased precipitation may result in a change in species composition favouring more salt tolerant species.		Possible changes in beach community vegetation to more drought resistant species may affect ability to stabilize nesting beaches

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Climate Change Impacts	Resource		
	Littoral Forest / Coastal Community	Parrotfish	Marine Turtles
Increased frequency and intensity of storms	Higher air temperature could cause more arid conditions – drier soils Potential change in species composition favouring more heat tolerant species.	Habitat destruction - seagrass and mangroves; sedimentation. Possible impacts on larval dispersion / survival.	Increased potential for inundation of nests during storm events Removal of nesting beaches, deposition of corals and boulders over existing beaches, by storm events Impacts on dispersal / survival of both adults and nestlings
Ocean acidification		Habitat loss (impacts on reef). Impacts on larval viability and adult growth rates. Possible increase in seagrass productivity	Habitat loss (impacts on reef), reduced sand production for beaches. Possible increase in seagrass productivity - positive impact on foraging.
Increased Air Temperature		Potential impacts on / loss of mangroves – critical nursery habitat	Female biased sex ratio >31°C females; 29 -- 30°C 50:50; <29°C males. Warming of beaches, resulting in increased egg mortality, shorter hatching time with smaller average hatching size, reducing survival potential.

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Each target is then assessed for the impacts of the identified primary climate change elements (increased intensity of storms, decreased precipitation, increased air temperature and increased water temperature), each element being rated on a scale of 1 to 4 (Table 41). Ratings took into consideration factors such as the severity, scope, contribution and irreversibility of each climate change element (Table 42).

As a non-biodiversity target, the Blue Hole was not included in this part of the assessment.

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 41: Ratings for Selection of Priority Conservation Targets

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<i>Predicted climate change element</i>	<i>Conservation Targets</i>							
	<i>Coral Reef</i>	<i>Seagrass</i>	<i>Mangroves</i>	<i>Littoral Forest</i>	<i>Commercial Species</i>	<i>Spawning Aggregations</i>	<i>Marine Turtles (Nesting)</i>	<i>Colony Nesting Birds</i>
<i>Increased sea level</i>	High (3)	Low (1)	High (3)	Medium (2)	Medium (2)	Medium (2)	High (3)	Medium (2)
<i>Increased sea temperature</i>	Very High (4)	Medium (2)	Medium (2)	Low (1)	Medium (2)	Medium (2)	Medium (2)	Low (1)
<i>Decreased Precipitation</i>	Low (1)	-	Medium (2)	High (3)	Low (1)	-	Medium (2)	Medium (2)
<i>Increased frequency of storms</i>	Medium (2)	Medium (2)	High (3)	Very High (4)	High (3)	Medium (2)	Very High (4)	Very High (4)
<i>Ocean acidification</i>	Very High (4)	Positive (0)	Low (1)	Low (1)	High (3)	Medium (2)	Medium (2)	Low (1)
<i>Increased air temperature</i>	Low (1)	-	Medium (2)	Medium (2)	Low (1)	-	High (3)	Low (1)
<i>Averaged Rating</i>	2.50	1.25	2.17	2.17	2.00	2.00	2.67	1.83
	Selected		Selected	Selected			Selected	

Table 42: Ratings for Prioritization of Conservation Targets

Selected Targets:

- **Coral Reef**
- **Mangroves**
- **Littoral Forest**
- **Nesting Marine Turtles**

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2.5.5 Climate Change-Related Threat Assessment

During the conservation planning workshops, a threat assessment was conducted highlighting the highest current anthropogenic threats to each of the key conservation targets. Potential threats that may evolve as a result of climate change have also been identified (Table 43). These threats were then assessed using a series of ratings (Table 44).

Key Conservation Target	Current Anthropogenic Threats	Potential Climate Change-Related Anthropogenic Threats
Coral Reef	<ul style="list-style-type: none"> ▪ Boat impacts ▪ Poor tourism practices <ul style="list-style-type: none"> ▪ Sun screen ▪ Physical damage ▪ Collection of souvenirs ▪ Poor fishing practices <ul style="list-style-type: none"> ▪ Illegal fishing of parrotfish ▪ Physical destruction of coral ▪ Clearance of beach vegetation <ul style="list-style-type: none"> ▪ Increased beach erosion / sedimentation ▪ Pollution from grey and blackwater (caye developments and boats) 	<ul style="list-style-type: none"> ▪ Increased pressure to dredge near cayes, as sea level rises ▪ Increased pressure to construct seawalls and permanent jetties with increased erosion from increased intensity of storm events ▪ Increased illegal fishing of parrotfish as catch decreases and fishermen have reduced incomes ▪ Increased sea water temperature will exacerbate the potential for algal blooms ▪ Ocean acidification will adversely affect calcification of skeleton of corals, and therefore the structure of the reefs
Mangroves	<ul style="list-style-type: none"> ▪ Clearance for caye development ▪ Clearance for aesthetics ▪ Clearance for fishing camps ▪ Use for cooking fuel 	<ul style="list-style-type: none"> ▪ Increased mangrove clearance for construction of seawalls to address sea level rise and increased erosion
Littoral Forest	<ul style="list-style-type: none"> ▪ Clearance for caye development ▪ Clearance for fishing camps 	<ul style="list-style-type: none"> ▪ Salination of freshwater lens over-extraction of water
Marine Turtles	<ul style="list-style-type: none"> ▪ Removal of beach vegetation ▪ Barriers to beach access ▪ Illegal fishing 	<ul style="list-style-type: none"> ▪ Increased pressure to construct seawalls to address sea level rise and increased erosion, preventing access to nesting beaches ▪ Increased illegal fishing of turtles by Honduran fishermen as catch decreases and fishermen have reduced incomes

Table 43: Current Anthropogenic Threats and Potential, Climate-Change Related Anthropogenic Threats

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Ranking Criteria	Rating		Rating Definitions
Certainty: The certainty that the effect of Climate Change will occur or the cause of the described impact will affect the target	Very High	4	Confirmed
	High	3	Considered very probable but not confirmed
	Medium	2	Considered probable
	Low	1	Considered a limited probability, much debate
Severity: Level or damage to this key element, which can destroy it in 50 years	Very High	4	Destroys the ecosystems or its production activities
	High	3	Seriously degrades the target
	Medium	2	Moderately degrades the target
	Low	1	Slightly impairs the target
Scope: Geographical coverage of the target that will be impacted in 50 years	Very High	4	75% - 100% of the geographic coverage
	High	3	50% - 75% of the geographic coverage
	Medium	2	25% - 50% of the geographic coverage
	Low	1	<25% of the geographic coverage
Irreversibility: The impact is permanent or cannot be reversed naturally or through human action	Very High	4	Not reversible, even with human intervention
	High	3	Reversible but at high cost or very long term (> 100 yrs)
	Medium	2	Reversible with human intervention
	Low	1	Naturally reversible or with little human intervention and / or little cost

Table 44: Rating Criteria for Assessing Climate Change Adaptation Threats per Target (after TNC)

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Assessment of Climate Change Adaptation Threats					
	Certainty	Severity	Scope	Irreversibility	Averaged Score
Coral Reef					
Increased pressure to dredge near cayes, as sea level rises	Low (1): Current caye developments follow best practices. Potential threat of large scale development of Northern 2 Caye. This would elevate the rating to (2)	High (3): This would remove corals from the areas dredged, and seriously degrade coral reef adjacent to the cayes, and have the potential to reduce water clarity throughout much of the reef	Medium (2): Effects will impact a wide area around the dredging area	High (3): Corals in the area being dredged will probably not recover; Corals impacted by the sedimentation from dredging will recover over time, if not impacted by other issues. Addressed through engagement of developers in best practices, surveillance and enforcement of development activities within the Atoll, and use of the EIA process.	2.25
Increased pressure to construct seawalls and permanent jetties with increased erosion from increased intensity of storm events	Low (1): Current caye developments follow best practices. Potential threat of large scale development of Northern 2 Caye. This would elevate the rating to (2)	Low (1): Low impacts from cement during construction. Will reduce erosion of coastline and sediment load in water	Low (1): Very limited scope of impact – the immediate area of construction	Medium (2): Easily reversible, though there would be resistance from developers. Addressed through engagement of developers in best practices, surveillance and enforcement of development activities within the Atoll, and use of the EIA process.	1.25
Increased illegal fishing of parrotfish as catch decreases and fishermen have reduced incomes	High (3): Fishermen have not been confirmed as fishing parrotfish, however illegal fishing by Honduran fishermen is thought to target all species	High (3): Parrotfish are considered key to the maintenance of healthy corals. Reduced populations, particularly of large species, will impact the resilience of the reef	Very High (4): Fishing pressure occurs throughout the reef, even in the non-extractive MPAs. The probability of parrotfish being fished is therefore across the Atoll	Medium (2): The ban on fishing parrotfish has been demonstrated to work, though as incomes decrease, the lure of illegally fishing parrotfish will increase. This can be addressed through implementation of Managed Access, increased surveillance efforts against transboundary fishers, and surveillance and enforcement of existing legislation re. parrotfish.	3.00

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Assessment of Climate Change Adaptation Threats					
	<i>Certainty</i>	<i>Severity</i>	<i>Scope</i>	<i>Irreversibility</i>	<i>Averaged Score</i>
Coral Reef					
Increased sea water temperature will exacerbate the potential for algal blooms in areas of grey / blackwater pollution	Medium (2): Past algal blooms have been associated with poor grey / blackwater management by live-aboard boats moored on the Atoll	Low (1): There is discussion as to whether short-term algal blooms might shade corals, reducing the water temperature and therefore stress on the corals	Low (1): Current levels of algal bloom are very limited – generally associated with overnight boat mooring	Medium (2): It would be possible to mitigate the issue of grey / blackwater pollution through providing best practices / regulations information to boats on arrival and monitoring effluent seepage from boats overnighing at LHR / HMC. This may also be an issue of future caye development, with the need for engagement of developers in adoption of best practices	1.50
Mangroves					
Increased mangrove clearance for construction of seawalls	Low (1): Current caye developments follow best practices. Potential threat of large scale development of Northern 2 Caye. This would elevate the rating to (2)	Low (1): Low impacts from cement during construction. Will reduce erosion of coastline and sediment load in water	Low (1): Very limited scope of impact – the immediate area of construction	Medium (2): Easily reversible, though there would be resistance from developers. Addressed through engagement of developers in best practices, surveillance and enforcement of development activities within the Atoll, and use of the EIA process.	1.25
Littoral Forest					
Salination of freshwater lens through sea level rise and over-extraction of water	Very High (4): The freshwater well at HMC is brackish – salt water intrusion is considered to have occurred. No data from other cayes	High (3): The Littoral Forest is currently coping with the level of salinity, but increased salinity may stress this ecosystem, particularly during times of drought	Very High (4): This will affect all Littoral Forest on all of the cayes	Very High (4): It would be impossible to prevent sea level rise. However over-extraction of water can be mitigated through engagement of developers in best practices.	3.75

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Assessment of Climate Change Adaptation Threats					
	<i>Certainty</i>	<i>Severity</i>	<i>Scope</i>	<i>Irreversibility</i>	<i>Averaged Score</i>
<i>Marine Turtles</i>					
<i>Increased pressure to construct seawalls, preventing access to nesting beaches</i>	<i>Low (1): Current caye developments follow best practices. Potential threat of large scale development of Northern 2 Caye. This would elevate the rating to (2)</i>	<i>Low (1): Low impacts from cement during construction. Will reduce erosion of coastline and sediment load in water</i>	<i>Low (1): Very limited scope of impact – the immediate area of construction</i>	<i>Medium (2): Easily reversible, though there would be resistance from developers. Addressed through engagement of developers in best practices, surveillance and enforcement of development activities within the Atoll, and use of the EIA process. Also through building awareness of the importance of leaving coastal vegetation, and management of light pollution, for successful nesting.</i>	<i>1.25</i>
<i>Increased illegal fishing of turtles by Honduran fishermen as catch decreases and fishermen have reduced incomes</i>	<i>Very High (4): MarAlliance tracking data shows a turtle of LHR being caught by fishermen and carried to Honduras</i>	<i>Medium (2): The current level of illegal take is balanced by increased numbers of turtles and nests. However, if more fishermen become involved in this illegal trade, the population may be seriously degraded below its current levels</i>	<i>High (3): Illegal fishing for turtles is opportunistic, and not carried out by traditional fishermen of the area. It is generally thought to be occurring outside the Atoll</i>	<i>High (3): Populations are only just starting to recover from pre-moratorium levels. This can be addressed through increased surveillance efforts against transboundary fishers, and continued engagement of traditional fishers through the Managed Access framework.</i>	<i>3.00</i>

2.5.6 Ranked Outputs

The assessment provides a prioritisation for potential threats that may occur as a result of changes in climate, based on the level of impact they would have on the specific targets (Table 45).

As climate change impacts increasingly affect the economic resources of the LHR stakeholder communities, a predicted result would be a potential increase in illegal fishing at the spawning aggregation sites, and of species such as parrotfish and marine turtles, both of which have a market with the Honduran transboundary fishing vessels.

Climate Change Related Threat	Averaged Score
Salination of freshwater lens through sea level rise and over-extraction of water	3.75
Increased illegal fishing	
Increased illegal fishing of turtles by Honduran fishermen as catch decreases and fishermen have reduced incomes	3.00
Increased illegal fishing of parrotfish as catch decreases and fishermen have reduced incomes	3.00
Increased pressure to dredge near cayes, as sea level rises	2.25
Increased sea water temperature will increase the potential for algal blooms in areas of grey / blackwater pollution	1.50
Modification of shoreline	
Increased mangrove clearance for construction of seawalls to address sea level rise and increased erosion	1.25
Increased pressure to construct seawalls and permanent jetties as erosion increases from increased intensity of storm events	1.25
Increased pressure to construct seawalls, preventing access to nesting beaches	1.25

Table 45: Summary of Climate Change-Related Threat Assessment Outputs

2.5.7 Building Resilience to Climate Change

A series of climate change adaptation strategies were then developed based on the assessment outputs, and including performance indicators for measuring success of implementation.

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Climate Change Adaptation Strategies: Coral Reef					Indicators
GOAL	Improving resilience of coral reef of Lighthouse Reef Atoll				Maximum % live coral cover Average % live coral cover
OBJECTIVE	Reduce the identified potential anthropogenic impacts on the coral reefs of LHR				
Strategy	Strategic Actions	Responsible Body	Partners / Collaborators	Timeline	Indicator
Mitigate tourism impacts on the LHR coral reef	<ul style="list-style-type: none"> ▪ Ensure infrastructure is in place to minimize tourism impacts on the reef – signs, mooring buoys, designated dive sites 	BAS	BTB, Port Authority	Ongoing	<ul style="list-style-type: none"> ▪ Management effectiveness rating for visitor management infrastructure
	<ul style="list-style-type: none"> ▪ Develop LHR BAS-certification system for tour operators and caye developers 	BAS / BTB	BTB	1-2 year	<ul style="list-style-type: none"> ▪ Number of BAS-certified tour operators using LHR
	<ul style="list-style-type: none"> ▪ Provide training for tour guides and boat captains in tourism best practices, as part of BAS-certification process 	BAS / BTB	BTB As part of BAS certification	1-2 year	<ul style="list-style-type: none"> ▪ Number of tour guides taking and passing the training course
	<ul style="list-style-type: none"> ▪ Include best practices for use of chemicals (e.g. sun screen, detergent) on dive boats in the training as part of BAS-certification process 	BAS / BTB	BTB As part of BAS certification	1-2 year	<ul style="list-style-type: none"> ▪ % of boats implementing best practices for use of chemicals
	<ul style="list-style-type: none"> ▪ Enforce BTB regulations re. guide:visitor ratio (Standards: Belize Standards: Code of practice for recreational scuba diving services) Declaration of compulsory standard) Order, 2016 	BTB / BAS	BTB	Ongoing	<ul style="list-style-type: none"> ▪ Number of infractions per year
	<ul style="list-style-type: none"> ▪ Provide best practices / regulations information to boats on arrival, as a sign off checklist, covering parrotfish legislation and greywater / blackwater management and other regulations 	BAS	Port Authority	Ongoing	<ul style="list-style-type: none"> ▪ % of boats approached that sign on to list of best practices
	<ul style="list-style-type: none"> ▪ Monitor effluent discharge from boats overnighing at LHR / HMC. 	BAS	Port Authority	Ongoing	<ul style="list-style-type: none"> ▪ % of boats checked that show significant discharge

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Climate Change Adaptation Strategies: Caves					
GOAL	To improve the resilience of coral reef of Lighthouse Reef Atoll				<i>Indicator</i>
OBJECTIVE	Reduce the identified potential anthropogenic impacts on the coral reefs of LHR				Maximum % live coral cover LHR Average % live coral cover LHR
<i>Strategy</i>	<i>Strategic Actions</i>	<i>Responsible Body</i>	<i>Partners / Collaborators</i>	<i>Timeline</i>	<i>Indicator</i>
Mitigate development impacts on the LHR coral reef	▪ Engage caye developers (both residential and tourism-focused) in management activities / good stewardship of LHR	BAS	LHR Advisory Committee As part of BAS certification	Ongoing	▪ % caye developers considered engaged and supportive of BAS activities
	▪ Develop LHR BAS-certification system for LHR caye developers, based on the ICZMP - LHR	BAS	BTB	1-2 year	▪ Number of BAS-certified developers /resorts using LHR
	▪ Engage caye developers in maintenance of beach vegetation and mangrove	BAS	As part of BAS certification	1 year	▪ % of caye beaches impact by seawalls
	▪ Engage caye developers in best practices for grey and blackwater management	BAS	As part of BAS certification		▪ % caye developers considered to be effectively managing grey and black water
	▪ Monitor for effluent discharge from developments at LHR / HMC, and address issues	BAS	DoE As part of BAS certification	Ongoing	▪ Number of cayes that show indications of effluent discharge (excessive algal growth)
Improve resilience of the reef at LHR	▪ Identify resilient reefs within LHR	BAS		1-3years	▪ % live coral cover at resilient reef sites
	▪ Include surveillance of resilient reefs in patrols to reduce illegal fishing pressure	BAS		Ongoing	▪ % of patrols py that include identified resilient reef sites
	▪ Ensure effective enforcement of legislation protecting parrotfish	BAS		Ongoing	▪ Number of infractions per year ▪ Herbivore biomass
	▪ Strengthen awareness of reasons for parrotfish legislation among fishermen	BAS		Ongoing	▪ Number of infractions per year ▪ Herbivore biomass

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Climate Change Adaptation Strategies: Lighthouse Reef Atoll					
GOAL	To improve the viability of mangroves of Lighthouse Reef Atoll				Indicators
OBJECTIVE	Reduce the identified potential anthropogenic impacts on the mangroves of LHR				% of 2015 extent of mangroves of LHR that remains intact
Strategy	Strategic Actions	Responsible Body	Partners / Collaborators	Timeline	Indicator
Improve mangrove viability at LHR	▪ Map existing mangrove extent from aerial photography and boat based GPS mapping	BAS		1 st Year	▪ Baseline of mangrove extent of LHR
	▪ Engage caye developers in maintenance of mangrove, through increased awareness	BAS	Forest Department – As part of BAS certification	Ongoing	▪ % of 2015 extent of mangroves of LHR that remains intact
	▪ Oppose clear-felling of mangrove for development through the EIA process and the Mangrove legislation	BAS	DoE Forest Department	Ongoing	▪ % of 2015 extent of mangroves of LHR that remains intact
	▪ Include surveillance of activities in mangrove areas in quarterly patrols	BAS	DoE Forest Department	Ongoing	▪ % of 2015 extent of mangroves of LHR that remains intact
	▪ Address issues of illegal mangrove clearance through the Forest Department and DoE	BAS	Forest Department DoE	Ongoing	▪ % of 2015 extent of mangroves of LHR that remains intact
GOAL	To improve the viability of littoral forest of Lighthouse Reef Atoll				Indicators
OBJECTIVE	Reduce the identified potential anthropogenic impacts on littoral forest of LHR				% of 2015 extent of littoral forest of LHR that remains intact
Improve littoral forest viability at LHR	▪ Map existing littoral forest extent from aerial photography and land based GPS mapping	BAS		1 st Year	▪ Baseline of littoral forest extent of LHR
	▪ Engage caye developers in maintenance of littoral forest, through increased awareness of values and management of freshwater lens	BAS	As part of BAS certification	Ongoing	▪ % of 2015 extent of littoral forest of LHR that remains intact

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Climate Change Adaptation Strategies: Lighthouse Reef Atoll					
GOAL	To improve the viability of littoral forest of Lighthouse Reef Atoll (continued)				Indicators
OBJECTIVE	Reduce the identified potential anthropogenic impacts on littoral forest of LHR				% of 2015 extent of mangroves of LHR that remains intact
Strategy	Strategic Actions	Responsible Body	Partners / Collaborators	Timeline	Indicator
Improve littoral forest viability at LHR	▪ Oppose clear-felling of littoral forest for development through the EIA process	BAS	DoE	Ongoing	▪ % of 2015 extent of littoral forest of LHR that remains intact
	▪ Include surveillance of development activities in littoral forest areas in quarterly patrols	BAS	DoE	Ongoing	▪ % of 2015 extent of littoral forest of LHR that remains intact
	▪ Engage caye developers in seasonal monitoring of freshwater lens on the cayes – salinity and contamination (dry, wet and norther seasons)	BAS	As part of BAS certification	Ongoing	▪ Results from water quality testing of groundwater per caye
GOAL	To improve the viability of marine turtles of Lighthouse Reef Atoll				Indicators
OBJECTIVE	Reduce the identified potential anthropogenic impacts on marine turtles of LHR				# of successful turtle nests py # of turtle nests affected by anthropogenic activity per year
Improve nesting success of marine turtles	▪ Engage caye residents and developers in maintenance of beach vegetation and mangrove	BAS	As part of BAS certification	Ongoing	▪ % of caye beaches impact by seawalls ▪ % caye beaches with natural vegetation removed (per caye)
	▪ Engage caye residents in monitoring of turtle nesting activity	BAS		Ongoing	▪ # of reported turtle nests per year per caye
	▪ Provide best practices for caye residents / developers for reducing impacts on turtle nest success	BAS	As part of BAS certification	Ongoing	▪ % of caye developments following best practices
Reduce illegal fishing of marine turtles at LHR	▪ Address the issue of Honduran fishing vessels and illegal fishing at Lighthouse Reef	BAS	Coastguard Immigration	Ongoing	▪ Number of transboundary fishing issues addressed py ▪ % of patrols that cover transboundary hotspots

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Climate Change Adaptation Strategies: Lighthouse Reef Atoll					
GOAL	To improve the viability of marine turtles of Lighthouse Reef Atoll				Indicators
OBJECTIVE	Reduce the identified potential anthropogenic impacts on marine turtles of LHR				# of successful turtle nests py # of turtle nests affected by anthropogenic activity per year
<i>Strategy</i>	<i>Strategic Actions</i>	<i>Responsible Body</i>	<i>Partners / Collaborators</i>	<i>Timeline</i>	<i>Indicator</i>
Reduce illegal fishing at LHR	▪ Strengthen fisheries management at LHR through Managed Access	BAS	Fisheries Department		▪ LHR is managed as a Managed Access site
	▪ Engage fishermen in the development of a successful Managed Access fishery at LHR	BAS	Fisheries Department		▪ % LHR fishermen considered engaged in the MA process
	▪ Assist fishermen in income diversification to reduce reliance on the LHR fishery	BAS	Fisheries Department		▪ % LHR fishermen engaged in an income diversification activity

3. Management Planning

3.1 Management and Organizational Background

Regulatory authority for Half Moon Caye and Blue Hole Natural Monuments lies with the Forest Department (Ministry of Forestry, Fisheries and Sustainable Development). As with many national protected areas in Belize, site management lies with a co-management agency, with responsibilities presented in a co-management agreement. Half Moon Caye and Blue Hole Natural Monuments are managed as a single unit by Belize Audubon Society (BAS), a non-governmental organization. Over the years, since its establishment in 1969, BAS has grown from a small group of interested citizens to a leading conservation organisation in Belize, successfully co-managing seven national protected areas, despite limited resources. With a vision and a mission that reflects the need for sustainable management of natural resources and a balance between people and the environment, BAS focuses on providing not only protection for wildlife and the environment, but also benefits to adjacent communities and other stakeholders.

Goal
Half Moon Caye and Blue Hole Natural Monuments

To protect and preserve natural resources and nationally significant natural features of special interest and unique characteristics to provide opportunities for interpretation, education, research and public appreciation for the benefit of current and future generations, within a functional conservation area.

The Belize Audubon Society is a membership organization guided by a multi-sectoral Board of Directors and led by the Executive Director. With over 40 staff, effective organizational management is achieved through a framework of internal policies and procedures.

Co-management

BAS has a five year co-management agreement with the Forest Department for Half Moon Caye and Blue Hole Natural Monuments, as two of the seven protected areas managed by the NGO, and signed on December, 2013.

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Under this agreement, BAS is responsible for:

“the day-to-day management and administration of the protected area(s), preparation and implementation of management and operational plans for the protected area(s), and the management and development of the finances of the protected area(s), as detailed in the National Protected Areas Co-Management Framework.

a) Day-to-day management and administration of the protected area(s) shall include, but not be limited to, the following: staff recruitment and retention, staff supervision and development, expenditures and accounting, equipment and procurement, and management and financial audits with oversight provided by the Regulatory Agency.

b) The management and operational plans shall be developed as per the Management Plan template in conjunction with the Regulatory Agency.

c) The management and development of finances of the protected area(s) shall include, but not be limited to, the following: identifying and securing grant funding, and working to diversify financing mechanisms jointly with the Regulatory Agency and in partnership with other third parties.

The Forest Department (Government of Belize), as the regulatory agency, is responsible for:

“... providing management oversight with respect to the management of the protected area(s) and patrolling and law enforcement support.

a) Management oversight shall include, but not be limited to, the following: technical input in the development of protected area management and development plans, approval of management plans, training in legal proceedings and monitoring and evaluation of protected area management activities.

b) Patrolling and law enforcement support shall be in collaboration with the national law enforcement agencies and shall include the following: participation in protection patrols when requested by the Manager, including leading search, seizure and arrest operations when necessary; and the necessary support for the prosecution of offenses.

Belize Audubon Society

Vision: Belize Audubon Society is a national conservation leader and development partner that inspires people to live in harmony with and benefit from the environment

Mission: The Belize Audubon Society is a non-governmental, membership-based organization dedicated to the sustainable management of our natural resources through leadership and strategic partnerships with stakeholders for the benefit of people and the environment.

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c) Financing support shall include to the extent possible, but not be limited to, the following: budget appropriations, project funding, and fiscal incentives such as tax exemptions.”

In 2014, BAS revised its Strategic Plan for the organisation, to develop a “comprehensive roadmap setting the direction of BAS’ work over the next five years, with a ten year outlook” (BAS Strategic Plan, 2014).

This focuses on four focal areas, considered critical to the effectiveness of the organization:

Focal Areas of BAS 2014 Strategic Plan

- **Sustainable Natural Resources Management:** To continue to work toward improving the environmental integrity of key marine and terrestrial protected areas in Belize through effective, collaborative natural resources management.
 - *Protected areas management*
- **Research and Monitoring:** To integrate science-based decision-making for adaptive management of protected areas and buffering environs
 - *Sustained Monitoring Program for marine and terrestrial systems*
 - *Integrate science-based decision-making for adaptive management*
- **Environmental Education and Awareness:** To develop and implement an environmental education strategy for BAS to build knowledge, skills, and experience that would help to create more environmentally responsible citizens
 - *Environmental Education*
 - *Community Outreach*
- **Organizational Development:** To strengthen the capacity of BAS to continue as a conservation leader and key development partner for the country of Belize.
 - *Improving Organizational Effectiveness*
 - *Branding and Marketing of BAS*

Within this Strategic Plan, the management of Half Moon Caye and Blue Hole Natural Monuments falls under the Sustainable Natural Resource Management Program, supported by

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the other Programmatic Areas (the Administration and Operations Unit, and the Environmental Education and Community Outreach Unit).

The day-to-day management of the Belize Audubon Society is the responsibility of the Executive Director and senior management staff. The Executive Director oversees the Program Directors, who are in turn responsible for the effective implementation of the program activities at site level.

Management strategies and activities for the protected areas are implemented by the Protected Area Manager, based from the BAS office in Belize City, with the support of the senior site manager and the other Program managers (Environmental Education, Science and Administration). Day to day activities (staff supervision, patrolling, tourism management, infrastructure maintenance and upkeep, fee collection etc.) are the responsibility of the Senior Site Manager, supported by an Assistant Site Manager, a Marine Biologist, Research Assistant, three Park Rangers and a Coxswain. The Site Manager reports to the Protected Area Director responsible for the two Natural Monuments.

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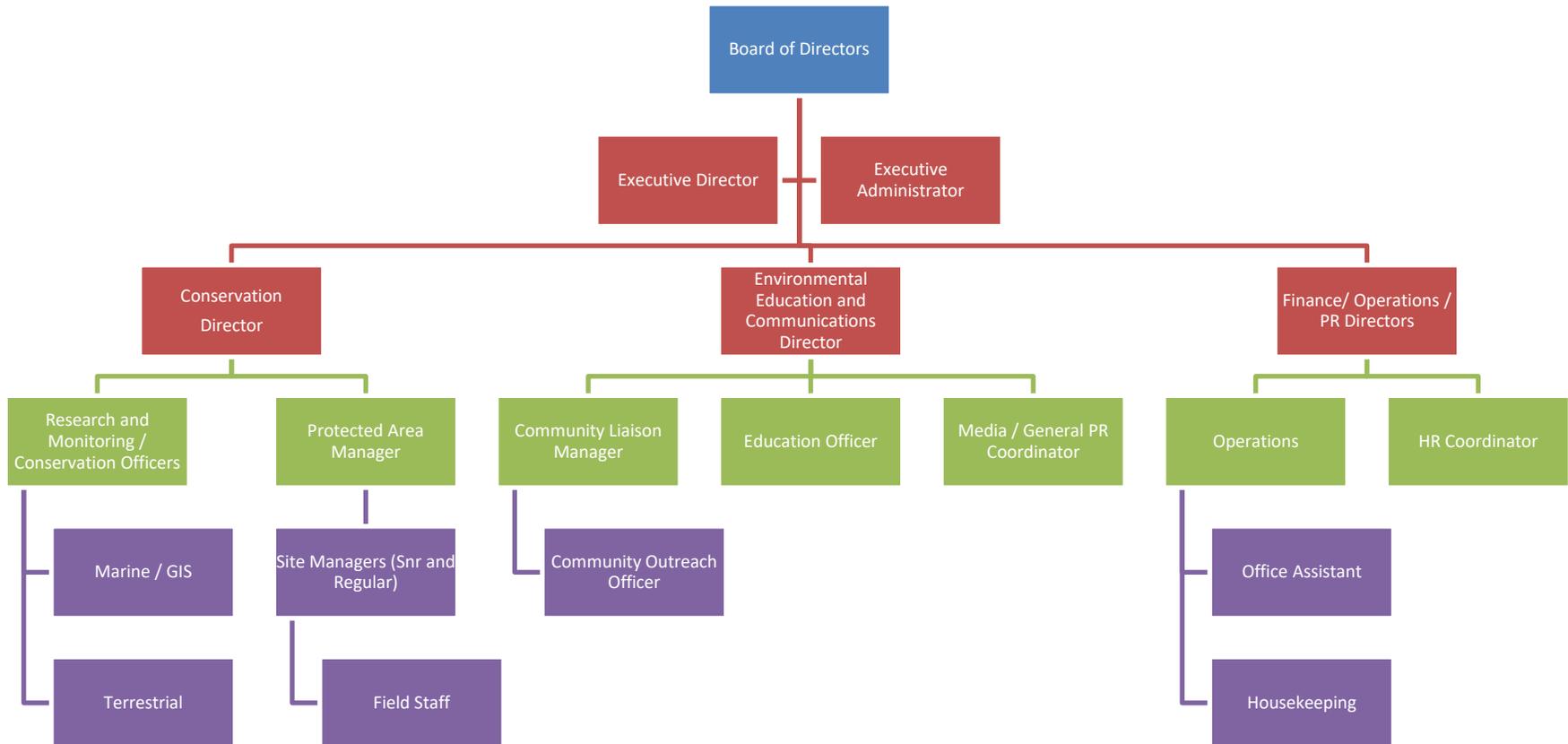


Figure 34: Belize Audubon Society Organizational Diagram

3.2 Review of Previous Management Plan

The 2007 - 2012 management plan for Half Moon Caye and Blue Hole Natural Monuments was the first for these sites to use the standardised national management planning framework, with the inclusion of conservation planning.

The Plan was valid up to the end of 2012. It included a number of discrete objectives and strategies that have been evaluated here to provide an indication of implementation success. Four primary objectives were identified for management of the protected areas, and rated out of a possible total of 4, based on the level of achievement.

Objective	Score	Comments
1. To protect and maintain marine and terrestrial ecosystems and geological formations through the implementation of conservation planning strategies, with increased participation from fishing and tourism stakeholders.	3	Surveillance and enforcement activities are professional and ongoing, as are visitor management activities and addressing threats to conservation targets. However, the general trend for target viability is still downwards. As surveillance and enforcement extends to the rest of the Atoll, with the introduction of Managed Access, BAS will need to extend its resources and strengthen its partnerships to meet the increased logistical challenges.
2. To identify and address priority areas for research, and implement a robust and ongoing biodiversity monitoring program to ensure informed conservation management of Half Moon Caye and Blue Natural Monuments	3	Research and monitoring has now been institutionalised at organization level rather than strictly site level. Monitoring activities are ongoing and results are informing management, but some strengthening is possible, particularly for identification of resilient reef sites and monitoring of climate change and climate change impacts.
3. Effective management of Blue Hole and Half Moon Caye Natural Monuments in which stakeholders participate and benefit.	3	BAS is investing more in reaching out and engaging its tourism and fishing stakeholders – both were participatory in the development of this management plan
4. To ensure that the necessary administration structure is in place for the support of management activities within BHNM, HMCNM and the adjacent area	4	The governance and administration structure of BAS has been significantly strengthened since 2007, and a Stakeholder Advisory Committee has been established, with active participation of its members.
Average Score	3.25	
<p>Scores</p> <p>1: No change</p> <p>2: Implementation has started, but there are no successful outputs to date</p> <p>3: Partial success of implementation and outputs</p> <p>4: The objective and expected outputs have been successfully achieved</p>		

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Comments: Implementation of the four 2007 key objectives achieved an average score of 3.25 out of 4.00 (81.3%), demonstrating both the achievements over the past years, but also those objectives that would benefit from further strengthening. An assessment was also conducted of the implementation success of the six individual management programs presented in the 2007 – 2013 management plan:

- Natural Resource Management Program
- Research and Monitoring Program
- Community Participation Program
- Public Use Program
- Site and Infrastructure Management Program
- Administration Program

The assessment was based on the same four point rating system, with the following summarized outputs:

Management Programs	Averaged Score out of 4	%
Natural Resource Management	2.75	68.8
Research and Monitoring Program	2.53	63.2
Community Participation	2.39	59.7
Public Use Program	2.59	63.3
Site and Infrastructure Management	3.03	75.6
Administration Program	2.83	70.7
Averaged		66.9%

Comments:

- Overall, implementation of the strategies and achievement of outputs of the first management plan from 2008 – 2016, and has been moderately successful, with an overall average of 66.9% success implementation.
- The strongest area is identified as the Site and Infrastructure Management Program, with a rating of 3.03 out of 4.00 (75.6%), with the installation of new staff and visitor infrastructure.
- The weakest area is identified as the Community Participation Program, with a rating of 2.39 out of 4.00 (59.7%), but is still considered moderately successful. With the logistical difficulties of holding meetings in the stakeholder communities, community engagement has been challenging. General stakeholder participation is greatly improved, with an active multi-sectoral Advisory Committee, and the first of annual meetings with tourism stakeholders. Most recently, BAS has started boat to boat discussions, to improve liaison with the fishers of Lighthouse Reef Atoll, prior to the Managed Access roll out.

3.3 Management Strategies

Management strategies of Half Moon Caye and Blue Hole Natural Monuments take into consideration the following:

- A multi-stakeholder approach
- Improved dialogue with stakeholders
- An emphasis on the involvement and engagement of stakeholders through the Advisory Committee
- Sound management supported by structured monitoring and research
- The roll-out of the Managed Access Program for Lighthouse Reef Atoll
- Extending the scope of surveillance, enforcement and biodiversity monitoring activities to mitigate external impacts to the biodiversity of the Natural Monuments – particularly unsustainable fishing and caye development
- Inclusion of mangrove as a conservation target, in recognition of its importance to the viability of marine species of the Atoll, despite its limited presence within the management scope of the two Natural Monuments
- Strengthening management through collaboration with other organizations of Belize and the region
- Strengthening long term financial sustainability mechanisms

...and site-specific issues

- Maintaining the conservation, biodiversity and World Heritage values of the two Natural Monuments
- Ensuring that tourism activities are ecologically sustainable

3.3.1 Legal Restrictions

Blue Hole and Half Moon Caye Natural Monument were both designated under the 1981 National Parks System Act (revised as the National Protected Areas System Act, 2015). Under this Act a Natural Monument is described as, *“Any area reserved for the protection and preservation of nationally significant natural features of special interest or unique characteristics to provide opportunities for interpretation, education, research and public appreciation.”*

Under the law, the following activities are prohibited and if carried out are offenses punishable by fines and possible imprisonment. No person shall:

- Disturb the natural features of a natural monument, but may use the unit for interpretation, education, appreciation and research.
- Enter or remain within any nature reserve, wildlife sanctuary or natural monument except under the authority and in accordance with the conditions of a permit issued by the prescribed officer on payment of the prescribed fee.

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- Permanently or temporarily reside in or build any structure of whatever nature whether as a shelter or otherwise.
- Damage, destroy or remove from its place therein any species of flora
- Hunt any species of wildlife.
- Quarry, dig or construct roads or trails.
- Modify or replace any sign and facilities provided for public use and enjoyment;
- Introduce organic or chemical pollutants to any water.
- Clear land for agriculture.
- Graze domestic livestock.
- Carry firearms, spears, traps or other means of hunting or fishing.
- Introduce exotic species of flora or fauna.
- Catch fish by any means whatsoever.

Also included in the legislation are a number of more general regulations:

- prohibit the setting off of fireworks of any description or the making of any type of noise whatsoever;
- require that any dog brought into the area be kept on a leash not over four feet (1.2 meters) long;
- prohibit the playing of radios, tape players, gramophones and musical instruments altogether or in a manner which is disturbing to other visitors;
- prohibit any act that detracts from the good order or general enjoyment of the area;
- prohibit the selling of any food, beverage or goods except by licensed parties.

3.3.2 Guidelines for Recreational Activities

Rules and Guidelines

General

- All visitors to the protected areas are required to pay the assigned fee by the management authority.
- Boats docking at Half Moon Caye Natural Monument are asked to utilize the pier provided by the managing authority.
- Those tour boats engaged in snorkelling and diving activities are required to utilize mooring buoys provided by the management authority.
- The removal of corals, shells, flora, and fauna from within the protected areas is strictly prohibited.
- All refuse/garbage is to be taken out of the protected areas by visitors and tour operators upon their leaving.
- Absolutely no fishing or other extraction of any resources is allowed within the delineated boundary of the protected areas.
- Facilities within the protected areas are to be utilized as stipulated by the protected areas management team.

Snorkelling

- No more than 20 snorkelers will be allowed to be present at the same time in an area of 100 square yards.
- Snorkelling parties within the water are not to exceed eight (8) individuals per group over a particular site.
- Each party of eight is to be accompanied by one certified guide as mandated in the cruise tourism policy.
- Boats are to make use of moorings where available as anchors destroy fragile corals. (Where moorings are unavailable, boat operators are to anchor in areas cleared of corals/patch reef or seagrass beds (i.e. areas of sand substratum)
- Garbage is to be well-stowed, especially plastic cups, plates and bags that can easily be blown overboard.
- It is preferable that snorkelers utilize some form of floatation device for added buoyancy, keeping them above the corals.
- No standing on the reef. Snorkelers should not utilize sites where the water column is less than three (3) feet above the reef/coral formations.
- Minimal kicking is allowed in shallow areas as kicking can stir up sediments that can kill corals.
- The touching, handling and feeding of sharks and other marine life are strictly prohibited.
- Never chase, harass or try to ride the marine life within the park.

Rules and Guidelines

Diving

- All divers entering the water must be fully certified for open water diving at a minimum.
- All efforts should be made to avoid the reef areas when entering and leaving the water.
- Divers are asked to stay off the bottom (substratum) and to never stand or rest on corals.
- The use of gloves is discouraged as it encourages divers to hold on to corals.
- Divers are not allowed to remove anything, living or dead, from the area except recent garbage.
- Only divers with advance diving skills are allowed to take cameras and video on dives as this equipment may be cumbersome and may affect the diver's buoyancy and mobility.
- No motorised diving is permitted within the protected areas

Bird Watching

- Birders are asked to keep on the trails maintained by the Belize Audubon Society. (These trails are kept cleared of items that are potentially injurious to birders.)
 - Birders are asked to be respectful of others and to keep noise levels down along birding trails.
 - Only eight persons at a time are allowed on the bird deck at Half Moon Caye Natural Monument.
 - Birders are asked to remove all garbage/refuse brought in the trails and deck and to dispose of them responsibly after leaving the island.
 - Birds are not to be taken from nest or harassed in anyway.
-

3.3.3 Critical Management Activities

Management programs focus on achieving the following broad objectives.

Objective One: Protection of Biodiversity

- Enhancing capacity building in stakeholders for participation in management, through education, public awareness and collaboration
- Providing protection for the red-footed booby colony of Half Moon Caye, and for the littoral forest
- Providing protection for nesting marine turtles
- Protecting the unique geological karst features of the Blue Hole
- Providing opportunities for scientific research in near-pristine reef conditions

Objective Two: Maintenance of Commercial Fish Stocks

- Providing commercial marine species of Lighthouse Reef with a refuge from harvesting activities through the continued designation of both protected areas as non-extractive replenishment zones
- Enhancing local and regional fish stocks through increased recruitment and spill-over of adults and juveniles into adjacent areas, and protection of marine habitats critical to lifecycle stages such as spawning,
- With the roll out of the rights-based fishery Managed Access roll out at Lighthouse Reef Atoll, Belize Audubon Society will also be taking on collaborative responsibility for fisheries surveillance and enforcement with the Belize Fisheries Department, as well as fisheries data collection from the fishermen.

Objective Three: Building Stakeholder Support and Benefits

- Providing two well-managed tourism resources – two of the most popular dive destinations in Belize, contributing significantly to livelihoods
-

3.3.4 Management Zones

Developing zonation for Half Moon Caye Natural Monument takes into account a number of criteria:

Conservation Criteria

- The need for protection of representative marine ecosystems of the Lighthouse Reef Atoll
- The need for protection of commercial marine species
- The need for protection of the marine turtle species, foraging areas and nesting beach
- The need for protection for the nesting bird colony and lizard species of Half Moon Caye
- The need for protection of the spawning aggregation site
- The need to minimize visitor impacts on the environment

Human Use Criteria

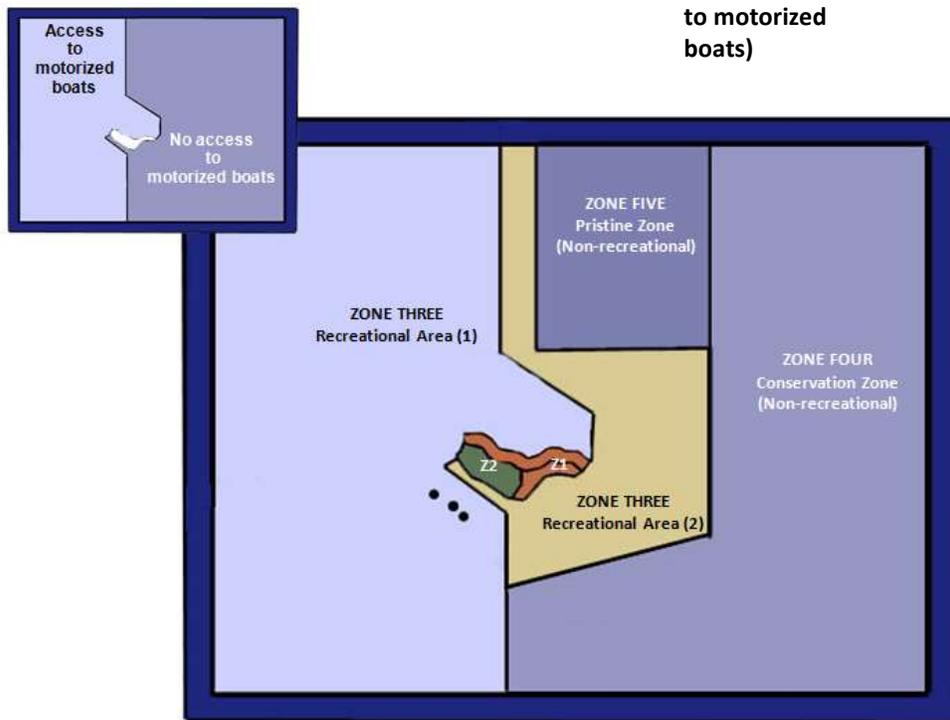
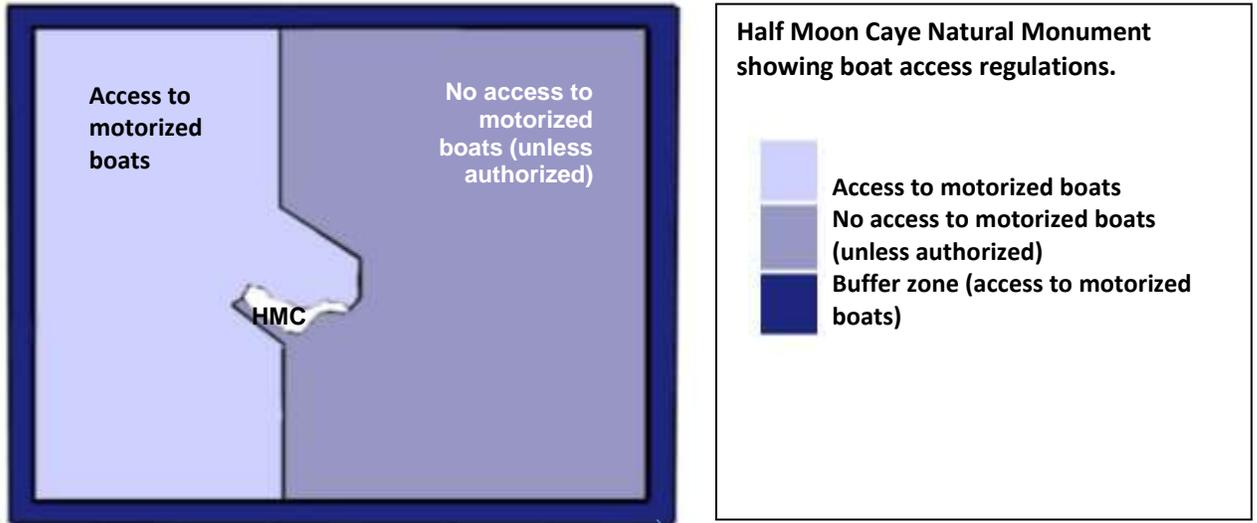
- Providing resource replenishment for the fishing industry
 - Providing access for research
 - Providing an educational resource and interpretive information
 - Providing recreation areas for divers and snorkelers
 - Providing a resource that is of benefit to tour guides and tour operators
 - Providing designated anchoring points to minimize impact to reef
 - Providing staff and visitor facilities
 - Include Port Authority facilities – lighthouse keeper’s and assistant keeper’s houses, old and new lighthouse, and associated facilities
 - Providing continued harvesting of coconuts for the lighthouse keeper within Zone One
-

Overall planning goals allow for two primary usage zones – an area that permits access to motorized boat traffic, and an area that does not, with a 200m buffer zone running along the inside perimeter of the protected area (Figure 35), to remove uncertainties in terms of boundaries with respect to enforcement. Overlying this basic partition of access, six zones have been identified, each with a different set of permitted activities (Figure 36). In reality, however, management only focuses on operationalization of the two primary divisions.

A more detailed description of management zones for Half Moon Caye is presented in the previous management plan (2007 – 2012) and in the Public Use Plan (BAS, 2009) for the protected areas.

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No access to motorized boats (unless authorized)



- Zone One (Z1): Protected Areas Service Zone
- Zone Two (Z2): Terrestrial Conservation Zone
- Mooring buoys

Figure 35: Management Zones of Half Moon Caye

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Half Moon Caye Natural Monument Management Zones			
Zone		Objective	Regulations/Guidelines
Zone One	Protected Areas Service Zone Access routes, and core area with HMCNM infrastructure and facilities,	<ul style="list-style-type: none"> ▪ To provide administration and support facilities for HMCNM and BHNM ▪ To provide an access area, visitor registration, information and park interpretation for visitors ▪ To provide camping facilities for overnight visitors ▪ To provide basic research facilities ▪ To provide protection for nesting turtles during nesting season 	<ul style="list-style-type: none"> ▪ Boats to follow designated, marked access routes ▪ Boats to dock and disembark only at designated facilities ▪ Camping permitted at camping site ▪ Recreation allowed on designated beach areas ▪ Recreational snorkeling and diving prohibited within 100m of north shore – slow boat zone ▪ Prevent disturbance of turtles during nesting season
Zone Two	Terrestrial Conservation Zone	<ul style="list-style-type: none"> ▪ To protect and maintain biodiversity and ecosystem function of the littoral forest and herbaceous beach vegetation ▪ To protect the nesting bird colony – with particular focus on the red-footed booby ▪ To protect the island leaf-toed gecko and Allison’s anole 	<ul style="list-style-type: none"> ▪ Non-extractive use only ▪ Regulated access for visitors, limited to existing trails ▪ No further vegetation clearance ▪ No camping or fires ▪ No disturbance of wildlife ▪ Authorized education and research activities permitted
Zone Three	Recreational Area 1 Snorkeling and diving (Access permitted for motorized boats)	<ul style="list-style-type: none"> ▪ To protect and maintain biodiversity and ecosystem function ▪ To provide an area for recreational diving and snorkeling. 	<ul style="list-style-type: none"> ▪ Non extractive use only ▪ Recreational snorkeling and diving permitted ▪ Boat mooring only at recognized mooring points ▪ Education activities permitted ▪ Authorized research activities permitted
	Recreational Area 2 Snorkeling and diving (No access permitted for motorized boats)	<ul style="list-style-type: none"> ▪ To protect and maintain biodiversity and ecosystem function ▪ To provide an area for recreational diving and snorkeling. ▪ To protect the Half Moon Caye spawning aggregation site. 	<ul style="list-style-type: none"> ▪ Non extractive use only ▪ Recreational snorkeling and diving permitted ▪ No access by unauthorized boats ▪ Education activities permitted ▪ Authorized research activities permitted
Zone Four	Conservation Zone – Open Sea	<ul style="list-style-type: none"> ▪ To maintain and protect a representative sample of biodiversity and ecosystem function with minimal human impact. ▪ To provide an area for research activities 	<ul style="list-style-type: none"> ▪ Non extractive use only ▪ No recreational snorkeling or diving permitted ▪ Authorized research activities permitted ▪ No access by unauthorized boats
Zone Five	Pristine Zone – Representative area of back and fore reef	<ul style="list-style-type: none"> ▪ To maintain and protect a representative sample of biodiversity and ecosystem function with minimal human impact. 	<ul style="list-style-type: none"> ▪ Non extractive use only ▪ No access by unauthorized boats ▪ No recreational snorkeling or diving permitted ▪ Restricted research permitted (no collection)
Zone Six	Buffer Zone – a 200m buffer zone that runs immediately inside the protected area boundary	<ul style="list-style-type: none"> ▪ To minimize conflict with fishermen in areas where boundary is indistinct and enforcement a problem 	<ul style="list-style-type: none"> ▪ Non extractive use only ▪ No recreational snorkeling and diving permitted ▪ Authorized research activities permitted

Table 46: Half Moon Caye Natural Monument Management Zones

Management Zones - Blue Hole Natural Monument

The Blue Hole Natural Monument provides permanent protection to unique geological features of the sink hole, and to access for research and tourism (divers and snorkelers). A number of issues were identified during public use planning consultations in 2009 (Public and Resource Use Plan, 2009) that have also been identified during management planning consultations in 2015. These include:

- Increasing evidence of sediment impacts on the coral rim of the Blue Hole
- Increased impacts on coral from divers and snorkelers
- Evidence of impacts on seagrass areas in boat access areas
- Safety concerns for sky diving activities associated with the Blue Hole
- Shark Chumming*

*Shark chumming has now been banned but is still included in the list, as illegal chumming is, at times, still an issue. Three additional issues have also been identified in 2016:

- Use of mechanized diving apparatus
- Low flying tourism charter flights
- High-intensity use by Guatemalan / Honduran yachts during Easter

Developing zonation for the Blue Hole Natural Monument has taken into account a number of criteria:

Conservation Criteria

- To protect the geological features of the Blue Hole
- To protect representative marine ecosystems of the Lighthouse Reef Atoll
- To protect commercial marine species for resource replenishment
- To protect marine turtle species, and their foraging areas
- To minimize visitor impacts on the wildlife and environment (including sharks)

Human Use Criteria

- To provide a first class dive location – the Blue Hole
- To provide recreation areas for divers and snorkelers
- To provide a replenishment area for the fishing industry
- To provide access for research
- To provide an educational resource
- To provide a resource that is of benefit to tour guides and tour operators
- To provide designated anchoring points to minimize impact to reef

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Overall planning goals allow for three primary divisions – the central sinkhole (one of Belize’s prime dive sites), the surrounding shallow reef rim, patch reef and seagrass, and a 200m buffer zone running along the inside perimeter of the protected area, to remove uncertainties in terms of boundaries with respect to enforcement (Figure 36).

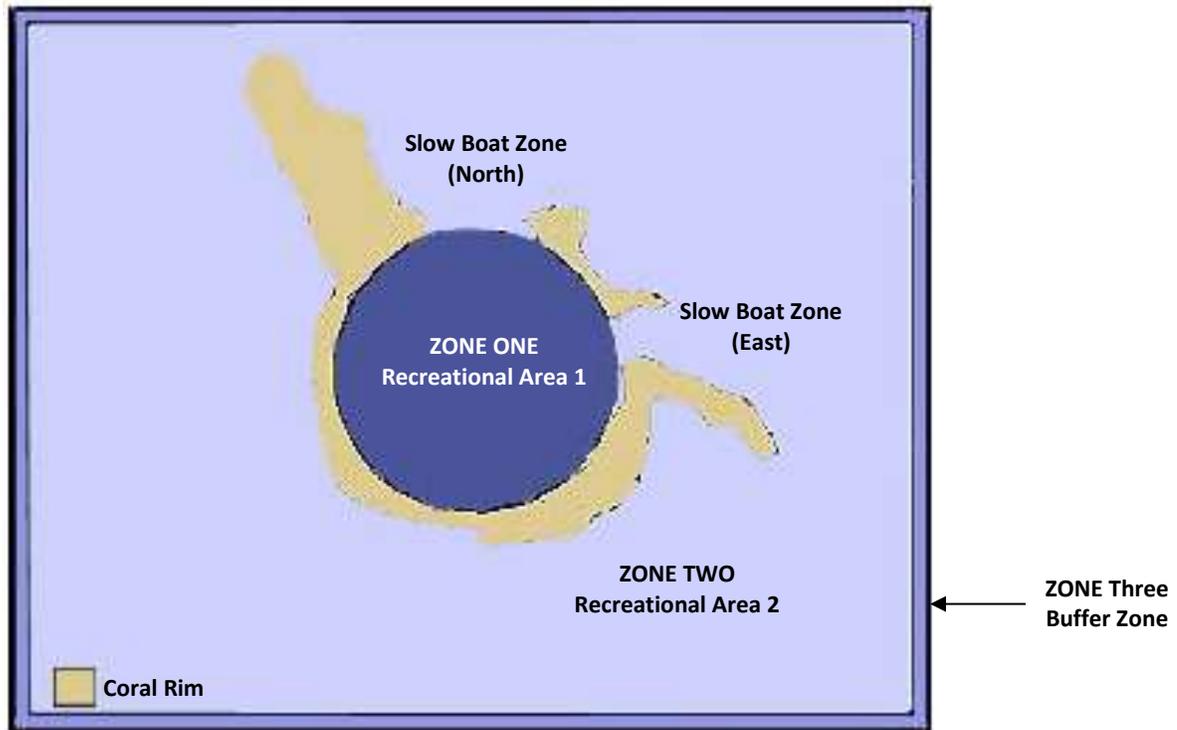


Figure 36: Provisional Zones of Blue Hole Natural Monument

A more detailed description of management zones for Half Moon Caye is presented in the previous management plan (2007 – 2012) and in the Public Use Plan for the protected areas.

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Blue Hole Natural Monument Management Zones			
Zone		Objective	Regulations/Guidelines
Zone One	Recreational Area 1 The Blue Hole	<ul style="list-style-type: none"> To protect and maintain the geological features and ecosystems of the Blue Hole To provide safe dive opportunities for visitors wishing to dive the Blue Hole To provide protection for the coral rim of the Blue Hole To provide an area for research activities 	<ul style="list-style-type: none"> Non extractive use only Recreational diving and snorkeling permitted Dive groups to have approved dive leader, approved group size to leader ratio, and all divers to be Advanced Divers or above All activities (including sky diving) require approval in advance from BAS Boats to follow designated, marked access/exit routes, and to slow on entry and exit to Blue Hole No fish/shark chumming No mechanized dive equipment Authorized research activities permitted
Zone Two	Recreational Area 2 Snorkeling and diving	<ul style="list-style-type: none"> To protect and maintain biodiversity and ecosystem function To provide an area for recreational diving and snorkeling. To provide access to the Blue Hole To provide an area for research activities 	<ul style="list-style-type: none"> Non extractive use only Recreational diving and snorkeling permitted Snorkeling and dive groups to have approved dive leader, and approved group size to leader ratio Education activities permitted All activities (including sky diving) to require approval in advance from BAS Boats to follow designated, marked access routes and to slow on entry and exit to Blue Hole Boat mooring only at recognized mooring points No fish/shark chumming Authorized research activities permitted
Zone Three	Buffer Zone – a 200m buffer zone that runs immediately inside the protected area boundary	<ul style="list-style-type: none"> To minimize conflict with fishermen in areas where boundary is indistinct and enforcement a problem To provide an area for research activities 	<ul style="list-style-type: none"> Non extractive use only No recreational snorkeling and diving permitted Authorized research activities permitted

Table 47: Blue Hole Natural Monument Management Zones

3.3.5 Limits of Acceptable Change

With increasing visitation comes the potential for increasing impacts to the environment, with the ever-present dilemma of how a protected area can develop a sustainable financial income from tourism without resulting in significant damage to the natural resources that attract the visitors. This poses the question that, given increasing recreational use and the inevitable impact this will have on the local environment, what are the biophysical and social conditions that should be considered as acceptable to both conservation planners and to visitors.

Planning for visitor management was completed in 2009 (PRUP, 2009), based on the recognition of a number of specific values that are essential for both the conservation management of the area and for future appreciation by visitors. This is supported by the development of a Limits of

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Acceptable Change framework that provides a means for resolving the complex issues of minimizing visitor impacts (both biophysical and social) and maximizing visitor satisfaction through provision of the experiences they seek.

- The quality of the marine environment, which forms the basis for all other human values and benefits associated with the two protected areas
- The dependence of recreational activities on the maintenance of near-pristine conditions
- The importance of economic and social benefits to both local stakeholders and to the Belize economy as a whole
- The value of the protected areas as recreational and educational resources

Management objectives of Blue Hole Natural Monument and Half Moon Caye Natural Monuments seek to ensure that visitors feel they are getting the experience they seek, whilst minimizing the impact on the biodiversity. Management actions therefore have to achieve or maintain the conditions required for these objectives, with monitoring in place to ensure feedback as to whether the actions have succeeded. The full Limits of Acceptable Change is presented in the previous management plan (BAS, 2007 – 2013), and in the Public and Resource Planning report (2009).

3.3.6 Management Challenges and Limitations

An assessment of management effectiveness was conducted in 2015, as part of the management planning process. The evaluation questionnaire for this assessment was completed in October 2015, with participation and input from the Executive Director, program managers and field staff of Belize Audubon Society, the co-management organization for Half Moon Caye – Blue Hole Natural Monuments. It was prepared using the modified national management effectiveness indicators (Young et. al., 2005, modified by Walker et al., 2010), and provides a snapshot of the state of management effectiveness in October 2015, to identify key strategies for strengthening management for integration into the updating of the management plan.

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National Management Effectiveness Indicators

Under the National Protected Areas Policy and System Plan, management effectiveness is evaluated through the **Monitoring Package for Assessing Management Effectiveness of Protected Areas** (Young et. al. 2005, modified by Walker et al., 2009), based on seven different indicator categories:

1. Resource Information
2. Resource Administration, Management and Protection
3. Participation, Education and Socio-economic Benefits
4. Management Planning
5. Governance
6. Human Resources
7. Financial and Capital Management

A score of 1 to 4 is allocated to each indicator, and is then expressed as a percentage to facilitate comparison with other assessments. The indicators are then averaged for each group (Table 48).

Outputs of Indicator Categories			
Indicator Category	Average Score	Average (as a %)	Rating
1. Resource Information	3.36	84.1	Very Good
2. Resource Administration, Management and Protection	3.28	81.9	Very Good
3. Participation, Education and Socio-Economic Benefit	3.19	79.6	Very Good
4. Management Planning	3.33	83.3	Very Good
5. Governance	4.00	100	Very Good
6. Human Resources	3.57	89.3	Very Good
7. Financial and Capital Management	3.38	84.4	Very Good
Overall	3.44	86.1%	Very Good

Table 48: Results for Indicator Categories

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Whilst the majority of Indicator Categories have increased ratings since the 2009 assessment, two categories have decreased ratings – Resource Information and Resource Administration Management and Protection. This decrease is largely attributable to the increasing awareness of the importance of information in informed management decisions, and the increasing role BAS is playing in monitoring the Atoll beyond the protected area boundaries (and therefore requirement of increased resource and manpower). The only indicator identified as potentially benefitting from significant strengthening is **Indicator 3.9: Capacity building within the stakeholder communities**, scoring 1.00.

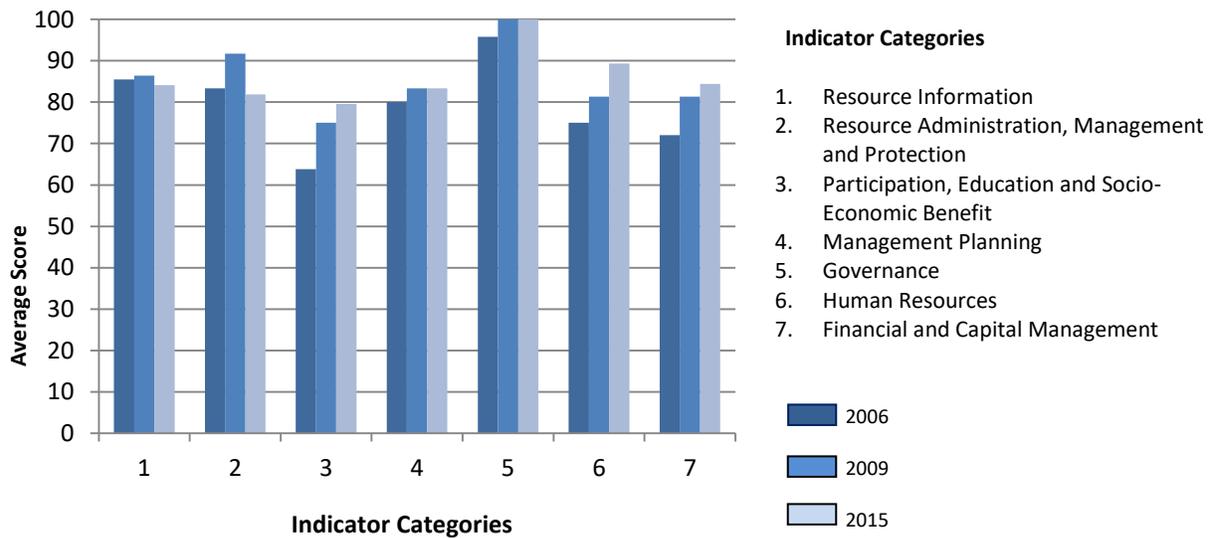
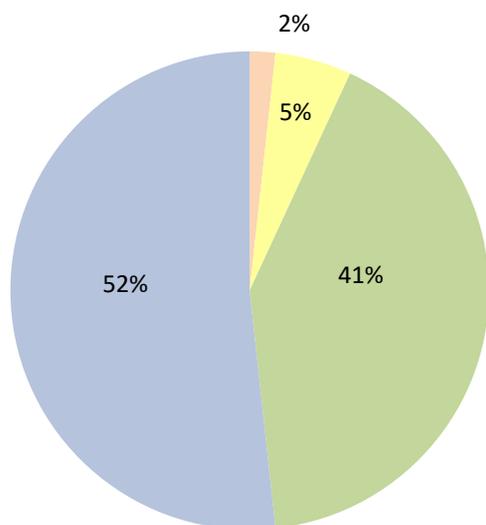


Figure 38: Comparison of 2006 / 2009 / 2015 results



	Rating	Range
4	Very Good	>75%
3	Good	>50 – 75%
2	Fair	>25 – 50%
1	Poor	≤ 25%

Figure 39: 2015 results - % indicators per rating

Resource Information

Half Moon Caye and Blue Hole Natural Monuments rate as **VERY HIGH** for Section One: Resource Information, with a mean score of 3.36 (84.1%). This is, however, lower than the 2009 assessment rating, though it should be noted that the small downward shift of 2.3% is based primarily on (i) improved use of information for management, and therefore the improved institutional knowledge that there are currently information gaps that could be filled to improve management, and (ii) the limited planning for identifying research needs and engaging researchers to address specific knowledge gaps.

Recommended Management Actions

- Develop and implement a water quality monitoring plan for HMCNM-BHNM / LHR Atoll, to provide baseline and ongoing information for physical parameters and water contamination issues (NB: This is planned as part of the national roll out under the National Coral Reef Monitoring Network)
 - Strengthen regular implementation of beach profiling for Half Moon Caye
 - Conduct annual aerial photographic surveys of all Atoll cayes to document changes in shape, size and ecosystem coverage
 - Conduct annual assessments of areas damaged by watercraft groundings, to provide updates on the physical environment for tracking recovery
 - Develop an inventory for marine plants and marine megafauna, and integrate monitoring into the monitoring program
 - Ensure the littoral forest shapefile is updated and available
 - Review research gaps for the Atoll (in the draft BAS Strategic Plan) and identify researchers interested in targeting these gaps
 - Conduct an updated REA of the protected areas, and extend to the entire Atoll
-

Resource Administration, Management and Protection

Half Moon Caye and Blue Hole Natural Monuments rate as **VERY GOOD** for Section Two, with a mean score of 3.28 (81.9%). This is a decrease of 0.8%, though scores are either 3.00 (**GOOD**) or 4.00 (**VERY GOOD**), reflecting the overall strength of administrative capacity within the Belize Audubon Society structure.

Recommended Management Actions

- Collaborate with the Lands Information Centre to correct the shapefiles for Half Moon Caye and Blue Hole in the National Protected Areas System dataset
- Strengthen the permitting processes:

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- Clarify roles and responsibilities for issuing of research permits for the protected areas with Forest and Fisheries Departments, and harmonize for adoption of clear protocols
- Clarify whether camping permits are required from Forest Department for International Expeditions and independent campers, for adoption of clear protocols
- Ensure written Standard Operating Procedures are available for the field staff, covering all eventualities that may occur where possible
- Collaborate with Fisheries Department for the implementation of Managed Access roll out at Lighthouse Reef Atoll
- Review and revise / update the Public Resource Use Plan
- Adopt / develop best practices for caye development / resort management for the Atoll with the participation of resort managers, and develop an associated recognition / incentive system (e.g. “approved by BAS” certification scheme)
- Strengthen cost and time effectiveness of surveillance through use of drones, particularly for the more distant Blue Hole and Sandbore spawning aggregation site
- Strengthen surveillance and enforcement, with improved ability to conduct night patrols through use of GPS navigation and night vision equipment
- Maintain and strengthen collaborative partnership with coastguard for armed presence on the Atoll
- Provide training for all members of the enforcement team in BAS Standard Operating Procedures for surveillance and enforcement activities for the Atoll
- Strengthen engagement and collaboration with tour operators to improve best tourism practices, address chumming and improve compliance with tourism laws
- Strengthen collaborative partnership with tourism police unit for effective enforcement of tourism regulations (e.g. tour-guest ratios, licenses, visitor qualifications for diving the Blue Hole etc.) and enforcement of BAS regulations (e.g. no fish / shark chumming)
- Increasing field staff by two rangers to build a targeted special enforcement team for the Atoll
- 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
- Continue digitizing the visitor log book and surveillance and enforcement data

Participation, Education and Socio-Economic Benefits

Whilst this was the lowest rating Indicator Category, Half Moon Caye and Blue Hole Natural Monuments still rated as **VERY GOOD** for Indicator Section Three, with a mean score of 3.18 (79.6%). This is an increase on the 2009 result of 75.0%, with strengthened engagement of the stakeholder communities and resource users.

Recommended Management Actions

- Develop and implement a formal communication strategy for Half Moon Caye and Blue Hole Natural Monuments, targeting all stakeholders (both Government and non-government), tourism and fisheries
 - Improve consistency and effectiveness of outreach, education and engagement activities within a well-defined strategy, with identification of ongoing funding streams for outreach activities, reducing project-based funding dependency – potentially through use of non-discretionary funding
 - Continue to engage tourism and fishing stakeholders, both at the Atoll and in the target communities
 - Continue and strengthening provision of opportunities to stakeholders to provide input, feedback and recommendations into protected area management decisions
 - Translate science outputs into layman’s terms for ease of access by staff, fishing and tourism stakeholders
 - Review strategic value of building capacity of stakeholders – northern communities, fishermen and tourism stakeholders – this is currently not an activity implemented by BAS
 - Strengthen capacity of the Advisory Committee in its role in disseminating information to stakeholders
 - Continue to build awareness in the northern fishing communities of the role of the protected areas and mangroves in maintaining fish stocks at Lighthouse Reef Atoll, and maintenance of Atoll health generally
-

Management Planning

Half Moon Caye and Blue Hole Natural Monuments rate as **VERY GOOD** for Section Four, with a mean score of 3.33 (83.3%). This remains the same as the 2009 rating, though will increase in 2016 with the finalization of the updated management plan.

Recommended Management Actions

- Complete the revision of the management plan and submit the document to Forest Department for approval
 - Review and revise the Public Resource Use Plan
 - Strengthen annual monitoring and evaluation of success of outputs of strategies and activities, as well as strategy and activity implementation
-

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Governance

Overall, Half Moon Caye and Blue Hole Natural Monuments score 4.00 (100%) for all indicators, rating as **VERY GOOD**, with no change from the 2009 assessment.

Recommended Management Actions

- Continue strengthening the role and input of the Advisory Committee
 - Develop a formal agreement with the Fisheries Department for collaboration, particularly with Managed Access rollout bringing extra responsibilities
-

Human Resources

Half Moon Caye and Blue Hole Natural Monuments rate as **VERY GOOD**, scoring an average of 3.57 (89.3%), a significant increase from the 2009 rating of 81.3%.

Recommended Management Actions

- Ensure continued staff satisfaction for field staff retention
 - Continue ongoing capacity building of staff
 - Strengthen the capacity of the Science Program to disseminate results at community level
 - Investigate feasibility of increasing the field staff from seven to nine to nine, to improve surveillance and enforcement capacity
 - Maintain collaborative partnerships with Belize Coastguard and BTB for effective surveillance and enforcement activities
 - Locate funds for prioritized capacity building needs identified during annual staff evaluations, in addition to utilizing opportunistic trainings.
-

Financial and Capital Management

Half Moon Caye and Blue Hole Natural Monuments score **3.38 (84.4%)** for Financial and Capital Management, rating as **VERY HIGH**, an increase from the 2009 rating of 81.3%.

Recommended Management Actions

- Ensure the annual work plan budget is sufficient to cover effective management of the protected areas

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- Investigate ways to increase effectiveness of community engagement, outreach and education through greater continuity, with reduced dependency on project-based funding
 - Continue development of a long term funding plan that integrates a BAS business arm to cover administrative costs
 - Strengthen current standard operating procedures for financial management through presentation in a written document(s)
 - Address equipment gaps for improved surveillance and enforcement, water catchment and equipment for implementation of a more focused water quality monitoring program
 - Address the need for more interpretive signs
 - Include a line item in the annual work plan for employment of skilled casual labour to maintain infrastructure at the Natural Monuments
-

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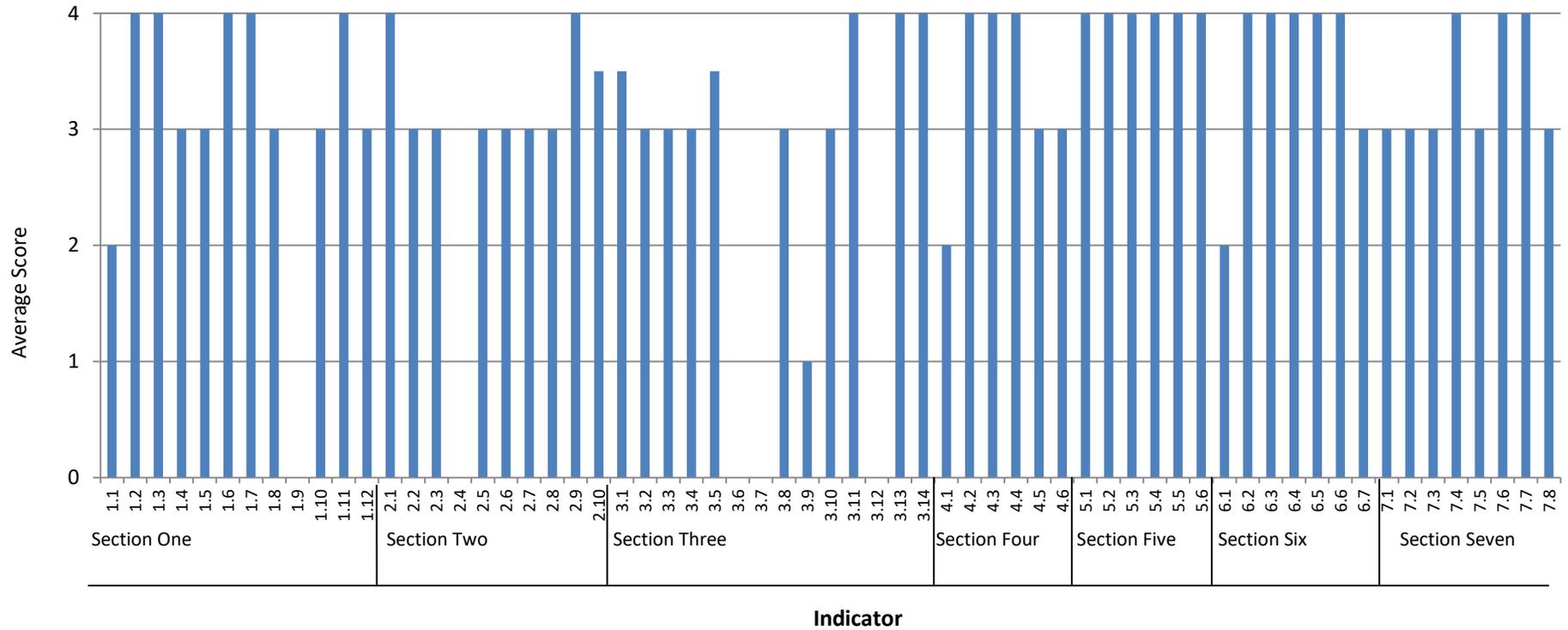


Figure 40: Mean Management Effectiveness score by indicator – sorted by Indicator Section

Non-Biodiversity Indicators (Young et. al. 2005)

<p>1. Resource Information</p> <p>1.1 Physical Environment 1.2 Biotic Environment 1.3 Cultural and Archaeological Resources 1.4 Social and Economic Context 1.5 Resource Use and Occupancy 1.6 Tenures and Claims 1.7 Conservation Target 1.8 Systematic Threat Assessment 1.9 Traditional Knowledge 1.10 Information Management Systems 1.11 Environmental Monitoring Activities 1.12 Functional Scientific Research Activities</p> <p>2. Resource Management</p> <p>2.1 Legal: Legal Status 2.2 Legal: Boundary Survey and Demarcation 2.3 Legal: Permit, and Approval Processes 2.4 Tenure Claim Conflict Resolution 2.5 Guidelines and Best Management Practices 2.6 Natural Resource Management 2.7 Protection: Surveillance Activities 2.8 Protection: Enforcement Activities 2.9 Visitor and Tourism Management Activities 2.10 Visitor and Tourism Monitoring Activities</p>	<p>3. Community Participation and Benefits</p> <p>3.1 Communication Activities 3.2 Stakeholder Engagement 3.3 Educational Activities 3.4 Dissemination of Knowledge and Information 3.5 Level of Stakeholder Participation in Management 3.6 Local Actors Leading Management 3.7 Volunteer Activities 3.8 Strength of Social Capital 3.9 Capacity Building Strategies 3.10 Socio-Economic Benefits Strategy 3.11 Extent of Local Economic Benefits 3.12 Sustainable Use for Economic Benefit 3.13 Employment in activities related to the protected area 3.14 Local Recognition of Protected Area Benefits</p> <p>4. Management Planning</p> <p>4.1 Management Plan Implementation 4.2 Operational Plan Implementation 4.3 Regulation and Zoning Implementation 4.4 Long Term Management Needs Identification 4.5 Program Monitoring and Evaluation 4.6 Research Program</p>	<p>1. Governance</p> <p>5.1 Protected area objectives 5.2 Co-management agreements 5.3 Administrative autonomy 5.4 Advisory Committee 5.5 Board of Directors 5.6 Inter-organizational mechanisms</p> <p>6. Human Resources</p> <p>6.1 Qualified Site Manager 6.2 Site Manager Availability 6.3 Administrative Staff Availability 6.4 Technical, Scientific, and Professional Staff Availability 6.5 Operations Staff Availability 6.6 Human Resource Assessment 6.7 Training and Development</p> <p>7. Financial and Capital Management</p> <p>7.1 Funding Adequacy 7.2 Long term Funding Plan 7.3 Financial Management 7.4 Infrastructure Adequacy 7.5 Equipment Adequacy 7.6 Internal Access Adequacy 7.7 Signage Adequacy 7.8 Maintenance Adequacy</p>
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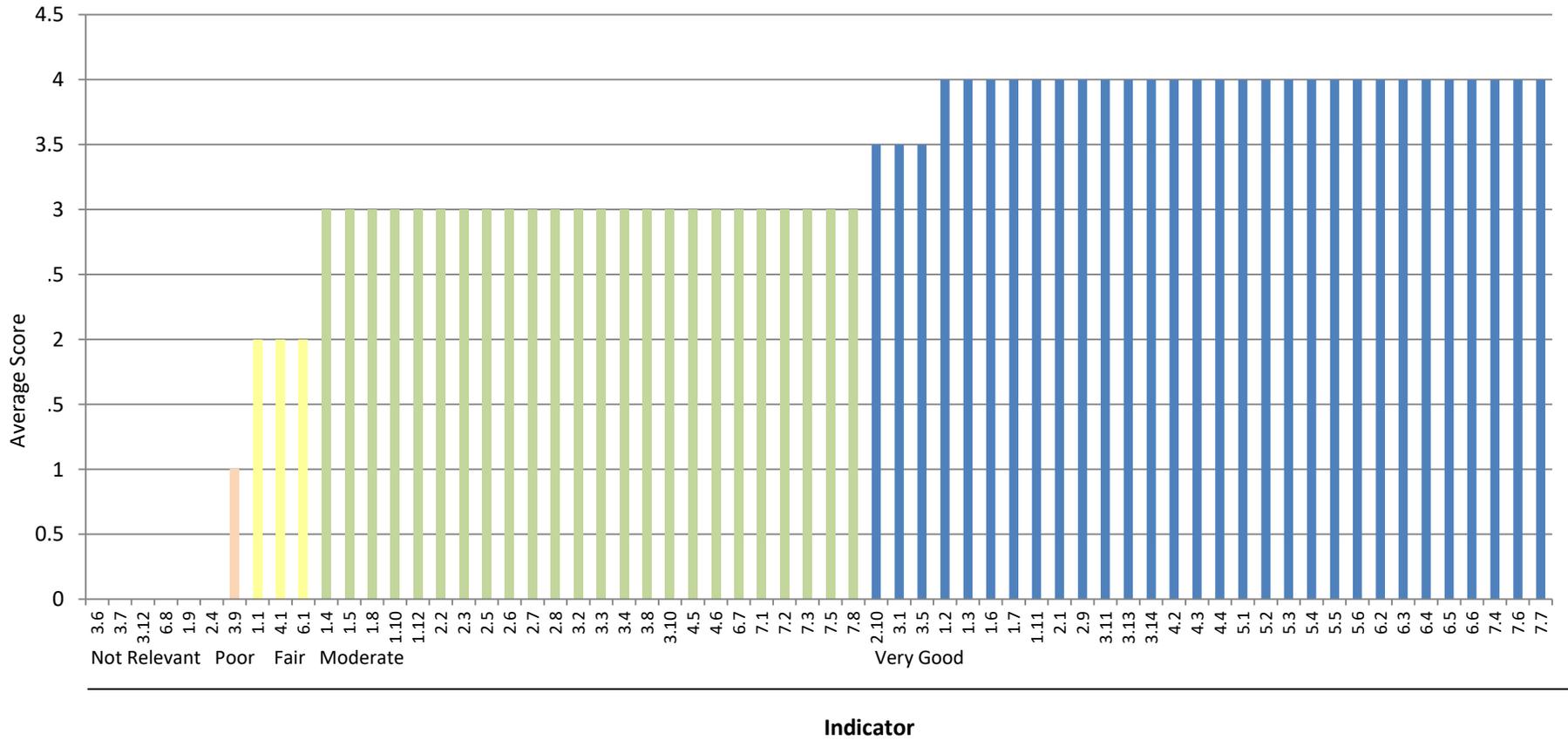


Figure 41: Mean Management Effectiveness score by indicator – sorted by Score

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3.3.7 Biodiversity Indicators

A conservation planning exercise conducted in 2015, as part of the management plan updating process, reviewed the conservation targets for both Half Moon Caye and Blue Hole Natural Monuments and merged the outputs. The review resulted in a final list of eleven targets with viability ratings ranging from **Poor** to **Very Good**, and an overall rating for the health of the species and biological systems of the protected area of **Fair** (Table 50).

Half Moon Caye: Viability Ranking for Conservation Targets			
Conservation Target	2007	2015	Trend
Spawning Aggregation Sites	Fair	Poor	▼
Sharks and Rays	-	Poor	
Commercial Marine Species	Fair	Fair	-
Coral Reef	Good	Fair	▼
Parrotfish / Herbivores	Good	Fair	▼
Marine Turtles	Fair	Fair	-
Littoral Forest	Good	Fair	▼
Mangroves	-	Good	
Blue Hole	Good	Good	-
Nesting Birds	Good	Good	-
Seagrass	Very Good	Very Good	-
Overall Viability Rating of Half Moon Caye Natural Monument			
Very Good:	>= 3.75	Viability criteria at or above desired future status	
Good:	3.0 – 3.74	Viability at or above minimum threshold for biological integrity	
Fair:	1.75 – 2.99	Viability criteria at or above a minimum restorable level	
Poor:	<1.75	Viability criteria below minimum restorable status (probably unrecoverable)	

Table 50: Viability Ratings for Conservation Targets of Half Moon Caye and Blue Hole Natural Monuments (Management Plan, 2007 and 2015)

The general trend is for stable or reduced target viability, with no targets showing an improvement. This reflects climate change impacts on the coral reef, with the increase in sea surface temperatures, increasing impacts of tropical storms, as well as the pressure on the commercial marine species within the Atoll.

3.4 Management Programs and Objectives

Management programs group management objectives within related areas – for example, grouping objectives related to natural resource management, or to research and monitoring. 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. There are four programs within the overall Management Strategy for Half Moon Caye and Blue Hole Natural Monuments:

- A. Natural Resource Management Program**
- B. Research and Monitoring Program**
- C. Environmental and Awareness Program**
- D. Administration Program**

The conservation strategies identified in the conservation planning section of this management plan are integrated into the management programs, contributing towards the adaptive management process. Also taken into account are the recommendations of the Lighthouse Reef Atoll Coastal Zone Management Guidelines (CZMAI, 2013; endorsed, 2016), and those of the recent World Heritage Site assessment for outstanding universal values and subsequent activities (WHS, 2015; Burgos-Acosta et al., 2015).

3.4.1 Priority Areas for Action

Priority areas for action were identified during conservation planning, which highlighted a number of strategies required for maintaining and improving conservation target biodiversity viability (Table 51).

Priority Areas of Action for Blue Hole / Half Moon Caye Natural Monument			
Priority	Rank	Conservation Target	Primary Threat
High Priority	1	Spawning Aggregations	Illegal Fishing
	1	Sharks and Rays	Unsustainable Fishing
	2	Commercial Species	Unsustainable Fishing
	3	Coral Reef	Climate Change
Medium Priority	4	Herbivores	Unsustainable Fishing
	4	Littoral Forest	Invasive Coconuts
	4	Marine Turtles	Unsustainable Fishing
Lower Priority	5	Mangroves	Caye Development
	6	Blue Hole	Tourism / Boat Impacts
	7	Nesting Birds	Rats
	8	Seagrass	Boat Impacts

Table 51: Prioritized Conservation Targets

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...and the leverage value of key cross cutting strategies (Table 52)

Key Cross-Cutting Strategies	Coral Reefs	Littoral Forest	Mangroves	Seagrass	Commercial Species	Spawning Aggregations	Sharks and Rays	Marine Herbivores	Marine Turtles	Colony Nesting Birds
<i>Engage caye landowners in climate change adaptation strategies</i>										
<i>Promote adoption of Lighthouse Reef Atoll development guidelines by developers (CZMAI)</i>										
<i>Ensure all EIAs for Lighthouse Reef Atoll developments are fully vetted, and take into account best practices and CZMAI guidelines</i>										
<i>Strengthen surveillance and enforcement activities on the Atoll through increased, dedicated patrol team and strategic partnerships</i>										
<i>Ensure that all visitors are aware of the rules and regulations for the Natural Monuments</i>										
<i>Identify resilient reef areas within Lighthouse Reef Atoll in the context of site level management and contribution to the national MPA system</i>										
<i>Provide best practices / regulations information to boats on arrival</i>										

Table 52: Key Cross-cutting Strategies

3.4.2 Management Policies

Belize Audubon Society, the site co-management partner, has a number of standard policies in place to assist management effectiveness, contained within the BAS Policy and Operations Manual (BAS, 2003, revised). This includes well defined policies in the areas of transport, health and safety, community relations and advocacy, and also provides guidance on incident management and standard operating procedures.

3.4.3 Management Strategies and Actions

Management strategies and activities are presented under the four Management Programs (Table 53). An annual work plan and budget is developed by the Protected Area Manager with input from the Senior and Assistant site managers, site staff, and other protected area managers. This incorporates relevant activities based on the management plan, and additional activities highlighted during the annual monitoring and evaluation process.

**Half Moon Caye and Blue Hole Natural Monuments – Management Plan
2017-2021**

Half Moon Caye and Blue Hole Natural Monuments - Management Programs			
Natural Resource Management	Research and Monitoring	Environmental Education and Awareness	Administration
Surveillance and Enforcement <ul style="list-style-type: none"> ▪ Boundaries and Zones ▪ Surveillance and Enforcement ▪ Awareness of Regulations ▪ Human Resources and Training ▪ Reporting 	Monitoring Program Framework <ul style="list-style-type: none"> ▪ Data Collection, Management and Access ▪ Reporting and Data Dissemination ▪ Research Permits ▪ Training 	General	Accounting
Visitor Management and Safety <ul style="list-style-type: none"> ▪ Visitor Management and Safety 		Baseline and Monitoring <ul style="list-style-type: none"> ▪ Priority Research ▪ General Research ▪ Monitoring of Impacts ▪ Conservation Targets ▪ Biodiversity Indicators ▪ Climate Change ▪ Socio-Economic Monitoring 	Environmental Education <ul style="list-style-type: none"> ▪ Nature School ▪ Engagement of Schools ▪ Resource User Awareness
Impact Mitigation <ul style="list-style-type: none"> ▪ Caye Development ▪ Invasive Species ▪ Boat Impacts ▪ Petrochemical Issues 	Visitor Information		Human Resources <ul style="list-style-type: none"> ▪ Human Resource Management ▪ Capacity Building
Management of Priority Conservation Targets	Stakeholder Outreach, Engagement and Communication <ul style="list-style-type: none"> ▪ Stakeholder Outreach, Engagement and Communication 		Communication and Collaboration <ul style="list-style-type: none"> ▪ Communication and Collaboration ▪ Formal Agreements
Site Infrastructure and Maintenance <ul style="list-style-type: none"> ▪ Infrastructure ▪ Equipment ▪ Site maintenance ▪ Equipment maintenance 	Collaboration and Communication	Strengthening Livelihoods <ul style="list-style-type: none"> ▪ Capacity building (tour guides) ▪ Strengthening women and youth groups (Fishing Communities) 	Planning and Reporting <ul style="list-style-type: none"> ▪ Financial Sustainability Planning ▪ Operational Planning and Reporting ▪ Risk Planning and Management ▪ Monitoring and Evaluation

Table 53: Half Moon Caye and Blue Hole Natural Monuments Management Programs

3.5 Natural Resource Management Program

The Natural Resource Management Program falls under the responsibility of the Protected Area Manager and Site Manager, with the support of the field staff, and is administered under five primary sub-programs:

- **Surveillance and Enforcement**
- **Visitor Management and Safety**
- **Impact Mitigation**
- **Management of Conservation Targets**
- **Site Infrastructure and Maintenance**

These focus on ensuring the maintenance of healthy, functional ecosystems of not just the two Natural Monuments, but also of the larger seascape of Lighthouse Reef Atoll. The identified strategic objectives for BAS’s overall Natural Resource Management Program include:

- Continue to engage and integrate the relevant stakeholders in the management of the protected areas
- Enhance surveillance and enforcement at the protected areas
- Promote the sustainable management of the protected areas through visitor management and safety
- Modernize facilities to support management of sites and enhancement of visitor experience
- Institute monitoring and evaluation of management practices for protected areas

BAS Strategic Plan (2014 – 2019)

Activities are focused on surveillance and enforcement of the protected areas and the larger Atoll, of fisheries and tourism regulations, and direct biodiversity management interventions where required, to address current and future anthropogenic impacts, and build

Natural Resource Management
Program Goal
<i>To protect and maintain marine and terrestrial ecosystems and geological formations through the implementation of conservation planning strategies and strengthening of partnerships</i>
NRM 1: Surveillance and Enforcement
<ul style="list-style-type: none"> ▪ Boundaries and Zones ▪ Surveillance and Enforcement ▪ Human Resources and Training ▪ Reporting ▪ Awareness of Regulations
NRM 2: Visitor Management and Safety
<ul style="list-style-type: none"> ▪ General Visitor Management ▪ Visitor Safety
NRM 3: Impact Mitigation
<ul style="list-style-type: none"> ▪ Caye Development ▪ Invasive Species ▪ Boat Impacts ▪ Petrochemical Issues
NRM 4: Management of Conservation Targets
<ul style="list-style-type: none"> ▪ Commercial Species ▪ Sharks and Rays ▪ Spawning Aggregations ▪ Littoral Forest ▪ Mangroves ▪ Coral Reef ▪ Sandy Beaches
NRM 5: Site Infrastructure and Maintenance
<ul style="list-style-type: none"> ▪ Management and Visitor infrastructure ▪ Infrastructure maintenance ▪ Equipment maintenance ▪ Site maintenance

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resilience for climate change. As the only surveillance and enforcement unit permanently active on Lighthouse Reef Atoll, BAS has taken on a surveillance and enforcement role that extends beyond the boundaries of the protected area, in collaboration with the Fisheries Department, Forest Department, and Belize Coastguard as Managed Access rolls-out to the Atoll.

Program Challenges and Limitations

- the need to better demarcate the boundaries of the protected areas
- the remoteness of the Atoll, and the size of the area to be patrolled
- insufficient human resources for the current patrol area
- changing fisheries regime –Managed Access roll-out
- insufficient human and financial resources and boat for the increased patrol area under MA
- illegal fishing and transboundary incursions
- increasing tourism visitation
- potential for high impact caye development
- potential for expansion of HMCNM into open water, with an increased surveillance and enforcement requirement

Challenges and limitations are addressed primarily through partnerships with both Government authorities (Forest Department, Fisheries Department, Belize Coastguard, Belize Tourism Board, and the Belize Port Authority) and with resource users of the Atoll – the tour guides and traditional fishermen.

The scope of management is expected to expand with Managed Access roll-out to Lighthouse Reef Atoll in 2016, with BAS taking on much of the surveillance and enforcement responsibility associated with the MA program, and with the proposed realignment of the boundaries to include “open sea”, recognised as an under-represented ecosystem under the National Protected Areas System.

Natural Resource Management Program

NRM 1: Effective Surveillance and Enforcement

NRM 1.1 Surveillance and Enforcement

NRM 1.1.1 Boundaries and Zones

- Demarcation of boundaries of both protected areas, with sufficient marker buoys to ensure visual recognition of boundaries at all key points (500m apart)
- Collaborate with the Lands Information Centre to update the shapefiles for Half Moon Caye and Blue Hole in the National Protected Areas System dataset
- Ensure all staff, enforcement partners, tourism and fisheries stakeholders are aware of boundaries, zones and regulations (including SPAG sites)

NRM 1.1.2 Surveillance and Enforcement

- Continue and strengthen surveillance and enforcement of protected area regulations at Half Moon Caye and Blue Hole Natural Monuments in partnership with the Forest Department
- Ensure surveillance activities are strategic and effective, based on BAS enforcement data, incidence mapping and identification of hotspots, key times, key offending boats (both tourism and fishing) and integration of SMART technology
- Expand surveillance and enforcement activities and resources to support Managed Access / Areas roll-out at Lighthouse Reef Atoll, in collaboration with the Fisheries Department
- Maintain and strengthen collaborative partnerships with Fisheries Dept, Forest Department, Belize Tourism Board and Belize Coast Guard towards effective surveillance and enforcement within LHR, with clearly defined roles and responsibilities
- Maintain and strengthen collaborative partnership with the Belize Coastguard for armed patrols on the Atoll and permanent presence on HMC, with clearly defined roles and responsibilities
- Maintain and strengthen engagement and communication with fishers, with particular focus on MA committee fishers and using a boat to boat approach
- Strengthen cost and time effectiveness of surveillance through use of drones, particularly for surveillance of caye development and the more distant Blue Hole and spawning aggregation site
- Implement effective enforcement of visitor regulations in the two Natural Monuments, in collaboration with BTB (e.g. tour guide-guest ratios, licenses, visitor qualifications for diving the Blue Hole etc.) and enforcement of BAS regulations (e.g. chumming issue)
- Strengthen communication with DoE and partner to integrate surveillance of caye development impacts and illegal development activities at Lighthouse Reef Atoll – e.g. non-permitted clearance of mangroves, overwater / seawall construction, and dredging
- Increase night patrols within the PAs and extend to key areas of LHR, with improved capacity through use of GPS navigation and night vision equipment
- Increase surveillance and enforcement at spawning aggregation sites during peak spawning times
- Integrate surveillance and enforcement requirements for conservation strategies – e.g. resilient reef areas, parrotfish
- Strengthen surveillance and enforcement of research regulations within the PAs, and LHR generally, in collaboration with the Fisheries and Forest Depts.

Natural Resource Management Program

NRM 1: Effective Surveillance and Enforcement

NRM 1.1 Surveillance and Enforcement

NRM 1.1.5 Awareness of Regulations

- Ensure all tour guides, fishermen and LHR Atoll residents are aware of location, rules and regulations and rationale for the Natural Monuments
- Inform all visitors arriving at HMC of rules and regulations
- Increase awareness of visiting live-aboard boats on the rules and regulations of HMCNM-BHNM , mooring sites, zones, bilge water / wastewater, restricted recreational activities and non-extractive designation
- Engage LHR fishers for increased support for the PAs and non-extractive regulations, through stakeholder awareness and participation, and understanding of the function of HMCNM-BHNM as replenishment zones
- Engage LHR tourism stakeholders for increased support for the regulations, through stakeholder awareness, improved communication and participation
- Liaise with Guatemalan authorities to ensure compliance of Guatemalan visitors at Easter

NRM 1.1.3 Human Resources and Training

- Ensure staff numbers are maintained at sufficient levels for effective management of HMCNM-BHNM
 - Increase number of field staff to establish a targeted special enforcement team for expansion of surveillance to support Managed Access / Area fisheries roll-out at Lighthouse Reef Atoll
 - Provide training for all members of the enforcement team (including Belize Coastguard) in BAS Standard Operating Procedures for surveillance and enforcement activities for LHR
 - Ensure all staff are aware of location of NM boundaries, zones, legislation and regulations
 - Ensure all staff are fully trained for surveillance and enforcement of fisheries legislation to support Managed Access / Area roll-out
 - 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
 - Provide opportunities for staff to be able to network with rangers from other protected areas to discuss common issues and solutions
 - Ensure ongoing capacity building for all staff for effective surveillance and enforcement of protected area and visitor regulations
 - Ensure rangers are fully equipped and trained for surveillance and enforcement activities (including night patrols)
 - Address staff safety issues and concerns, where feasible
 - Ensure continued high field staff satisfaction for continued staff retention
 - 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
-

Half Moon Caye and Blue Hole Natural Monuments – Management Plan 2017-2021

Natural Resource Management Program

NRM 1: Effective Surveillance and Enforcement

NRM 1.1.4 Reporting

- Maintain comprehensive visitor records
- Maintain comprehensive patrol reports, strengthened with integrated use of SMART system
- Effective reporting and record keeping of illegal activities in the PAs and LHR
- Continue digitizing visitor log book and surveillance and enforcement data

NRM 2: Visitor Management and Safety

NRM 2.1 Visitor Management and Safety

- Review and revise the Public and Resource Use Plan (PRUP) for HMCNM-BHNM
 - Establish Limits of Acceptable Change for HMCNM-BHNM, based on the revised PRUP, in collaboration with stakeholders
 - Advocate for and implement a BAS certification program for tour guides and tour operators
 - Strengthen engagement and collaboration with tour operators to improve best tourism practices, to improve compliance with BTB laws and PA/BAS regulations, as part of BAS-certification process
 - Evaluate BTB recommendations for restricting the number of tour guides / dive guides to those that have passed site-specific training and certification
 - Develop BAS accrediting system for tour companies that show awareness of impact mitigation in their boat handling, mooring, intro. presentations to tourists, and group management, for use as a marketing tool by the tour companies
 - Develop / adopt 'Tourism Best Practices' guide for tour operators, dive leaders and dive boats in collaboration with tourism and reef stakeholders
 - Ensure ongoing capacity building for all staff for effective visitor hospitality and management at Blue Hole and on Half Moon Caye
 - Update regulations on equipment usage in PAs – addition of wind and kite surfing to prohibited activities
 - Review and update policies on sky diving and low flying aircraft in the airspace above the two Natural Monuments
 - Update information on website and in guide books visiting yacht regulations (including registration with Port Authority, need for Belize dive guide, fishing regulations / requirements), mooring buoys, fees, guidelines and regulations etc.
 - Collaborate with BTB for Tourism Police (and Immigration) presence during Easter – peak activity of Guatemala / Honduras yachts
 - Liaise with BTB re. catamaran rental policy Provide introduction to divers arriving at the Blue Hole to ensure awareness of regulations to reduce potential impacts to coral, including ban on motorized diving
 - Develop and implement policies to regulate increasing technical recreational diving / deeper diving at the Blue Hole, in collaboration with Belize Cave Diving Association
 - Ensure infrastructure is in place to minimize tourism impacts on the reef – signs, mooring buoys, designated dive sites
 - Develop and implement policies to regulate low flying air craft – tourism – over the pa
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Half Moon Caye and Blue Hole Natural Monuments – Management Plan 2017-2021

Natural Resource Management Program

NRM 2: Visitor Management and Safety

NRM 2.1: Visitor Management and Safety

- Provide orientation talk to visitors on arrival at HMC to ensure awareness of regulations on the caye
- Post quarterly laminated information updates by picnic tables highlighting priority regulations and activities / sightings of interest
- Provide written guidelines for visitors staying at the caye (e.g. campers, researchers) on how to minimize their environmental footprint
- Continue to maintain controlled visitor access to bird nesting colony through trail design, signs and observation tower
- Maintain information boards on marine turtles in nesting season to increase visitor awareness and prevent impacts on turtle nesting sites
- Strengthen the FD camping permit processes - clarify whether camping permits are required from Forest Department for International Expeditions and independent campers, for adoption of clear protocols
- Lobby against visitation by cruise ships based on potential impacts
- Ensure regulations on no feeding of sharks are fully enforced
- Develop standard protocols in collaboration with tourism and fishing stakeholders for dealing with medical emergencies

NRM 3: Impact Mitigation

NRM 3.1: Caye Development

- Identify and implement best means of improving communication with caye developers and landowners of cayes of Lighthouse Reef Atoll – to identify potential areas of mutual assistance and avoid potential areas of conflict
 - Adopt and promote Lighthouse Reef Atoll development guidelines (CZMAI) as the development standard for the Atoll
 - Develop and disseminate ‘Best Practice Guidelines’ for caye developers and property owners on Lighthouse Reef Atoll, based on the CZMAI guidelines, with inclusion of best construction practices, relevant DoE policies, mangrove legislation, use of native plants in landscaping, insect control, grey and black water management, chemical / gasoline use and storage, etc. in the guidelines
 - Develop LHR BAS-certification / accreditation system in collaboration with BTB for LHR caye developers, based on standards in the guidelines (e.g. “approved by BAS”) with workshops, trainings offered for certification
 - Ensure all EIAs for Lighthouse Reef Atoll developments are fully vetted and approved, and take into account best practices and CZMAI guidelines
 - Strengthen links with Department of the Environment for rapid response to illegal development / pollution events, Lobby for dredging on Lighthouse Reef Atoll to be banned, or limited to small scale non-mechanical operations (artisanal permits only) and for limited boat access purposes only (optimum)
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Natural Resource Management Program

NRM 3: Impact Mitigation

NRM 3.1: Caye Development

- Investigate potential of conservation easement for long term maintenance of mangroves on Long Caye

Half Moon Caye

- Continue to ensure HMC site facilities are maintained to minimize environmental impacts, and that any new structures are built to strict environmental standards
- Ensure implementation of an effective solid waste, greywater / black water management plan for HMC

NRM 3.2: Invasive Species

- Implement the rat eradication plan for HMC and post-removal biosecurity best practices to avoid re-invasion, with adequate engagement of staff, tour guides, fishermen, and visitors for smooth transition
- Work with national partners to implement relevant strategies of the Belize Lionfish Response and Management Plan
- Strengthen stakeholder and staff engagement, support and participation in lionfish removal and use, promoting lionfish as a marketable species
- Close liaison with tour operators, Port Authority / lighthouse keepers and caye owners / developers to increase awareness of threats posed by introduced wildlife on cayes of LHR, and implement guidelines for prevention

NRM 3.3: Boat Impacts

- Provide best practices / regulations information to boats on arrival, as a sign off checklist covering location of PA boundaries, boat channels, approved mooring buoys, use of HMC dock greywater / black water management, and other relevant regulations
- Maintain boat channels and mooring sites, and engage tour operators / boat captains and live-aboards re. compliance for reduced boat impacts
- Enforce mooring regulations for dive boats using the Blue Hole
- Ensure all boats at HMCNM-BHNM are following anti-pollution regulations in collaboration with Port Authority and DoE
- Monitor effluent discharge from boats overnighting at LHR / HMC /BH
- Develop response plan for groundings integrating current policies and procedures, in collaboration with DoE and Belize Port Authority
- Lobby with BPA to declare the Blue Hole a no wake zone, and areas surrounding HMC no wake zone

NRM 3.4: Petrochemical Issues

- Continue to lobby for exclusion of marine protected areas from oil exploration concession areas, when necessary
 - Create / adopt Contingency Plan in collaboration with DoE for mitigation of oil or chemical spills within LHR
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Half Moon Caye and Blue Hole Natural Monuments – Management Plan 2017-2021

Natural Resource Management Program

NRM 4: Management of Conservation Targets

NRM 4.1: General

- Develop 5-year Conservation / Management Action Plan for the Lighthouse Reef Atoll, with full stakeholder participation
- Lobby for Belize's continued commitment to World Heritage Convention
- Ensure staff are aware of the conservation targets and the role of enforcement and surveillance in ensuring their effective management
- Raise awareness of caye owners / developers of LHR of the role of mangroves, littoral forest, seagrass, corals, and best practices for limiting development impacts (sedimentation - erosion following land clearance; wastewater, sewage and solid waste disposal)
- Investigate the feasibility of realignment to include "open sea", an under-represented ecosystem, to the east of HMC as a replenishment zone in collaboration with the Forest and Fisheries Departments, and define management responsibilities

NRM 4.2: Commercial Marine Species, Sharks and Rays, Spawning Aggregations

- Support full implementation of Managed Access roll out at Lighthouse Reef Atoll, in collaboration with the Fisheries Department
- Engage and support fishermen in implementation of the Managed Access framework
- Investigate potential of provision of radios to MA fishers for assistance with surveillance of illegal fishing and piracy, to be based from HMC
- Ensure targeted enforcement against possession of fillet without skin patches, parrotfish, undersize / out of season lobster / conch, out of season / size grouper
- Encourage fisheries diversification into lionfish
- Liaise with fisheries enforcement agencies and NGOs in neighbouring countries for improved management of transboundary fishing issues
- Include Spawning Aggregation sites in patrols at known spawning times
- Assess feasibility of declaration of LHR as a national no shark-fishing area ("special management area") and / or tighter gear restrictions
- Include compliance with shark feeding ban as one of the criteria for qualifying for BAS accreditation scheme, for dive operators who follow BAS best practices
- Communicate and collaborate with national, regional and international organisations / networks concerned with shark conservation
- Collaborate with Fisheries Department to mainstream vessel monitoring system

NRM 4.3: Coral

- Identify and increase protection of resilient reefs, source populations and key larval dispersal routes
 - Investigate potential for designating special management areas in identified high resilience areas, in response to research outputs
 - Designate and enforce specific mooring sites and boat access channels to reduce mechanical impacts on corals by boats
 - Ensure adequate protection of key herbivores to maintain live coral cover and ecological functions
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Half Moon Caye and Blue Hole Natural Monuments – Management Plan 2017-2021

Natural Resource Management Program

NRM 4: Conservation Targets

NRM 4.3: Coral

- Continue to increase awareness of the importance of parrotfish to the health of the reef among key stakeholders
- Strengthen collaboration for continued implementation of coral reef restoration program
- Strengthen maintenance of healthy trophic structure of reef through maintenance of top predators and key herbivores
- Investigate mechanisms for direct interventions – e.g. promoting higher herbivore densities

NRM 4.4: Herbaceous Beach Vegetation / Mangroves

- Continue to effectively manage visitor access to the littoral forest of HMC through maintenance of clear paths, to avoid impacts on natural vegetation cover
- Minimize impacts on nesting birds through controlled visitor access
- Continue zoned and sequential coconut eradication program and seed / seedling planting of selected littoral forest species in areas where coconut eradication has taken place
- Take actions to minimize fire risk in littoral forest on HMC
- Engage caye owners and developers in maintenance of mangroves

NRM 4.5: Sandy Beaches

- Continue to implement guidelines for management of marine turtle nesting on the caye, with training for staff, visitor awareness, and demarcation of turtle nesting areas, to prevent direct impacts
- Implement recommendations developed from beach profiling for improved nesting site viability on HMC
- Ensure all external lights used on facilities at HMC are turtle-friendly (low pressure sodium lights, with a wavelength of between 560 - 620nm)
- Strengthen communication and collaboration with national, regional and international turtle conservation initiatives
- Engage property owners and developers of LHR in protection and monitoring of turtle nests
- Support move for Belize to ratify Convention on Migratory Species

NRM 5: Site Infrastructure and Maintenance

NRM 5.1: Infrastructure

- Maintain policy to be able to extend or replace buildings, but not install any additional buildings
 - Schedule annual assessment of infrastructure maintenance and repair needs (including mooring buoys, dock and observation tower)
 - Schedule preventative maintenance and upkeep of HMCNM-BHNM management infrastructure
 - Conduct annual assessment of potential safety and liability issues, and address those that are identified
 - Ensure solar array and associated battery bank is adequately maintained for effective, long term power generation
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Half Moon Caye and Blue Hole Natural Monuments – Management Plan 2017-2021

Natural Resource Management Program

NRM 5: Site Infrastructure and Maintenance

NRM 5.1: Infrastructure

- Schedule preventative maintenance and upkeep of HMCNM-BHNM visitor infrastructure
- Employment of skilled casual labour to maintain infrastructure
- Invest in a Reverse Osmosis System
- Ensure visitor dock is maintained, and sufficiently large for visitor requirements Ensure sufficient mooring sites are available at BHNM, in front of Half Moon Caye and at HMC dive sites, and appropriate for the increasing boat size
- Engage and collaborate with live-aboard and dive boat companies for maintenance of buoys
- Ensure sufficient navigational buoys are installed for marking boat channels
- Assess potential / cost benefit for expansion of gift shop
- Address the need for improved interpretive signage
- Consult hydrologist on water table and water flow on Half Moon Caye, and use this information to minimize impacts on the water table
- Ensure all external lights used on facilities at Half Moon Caye are of minimal impact to turtle nesting beach
- Ensure Island Expedition maintains infrastructure to BAS safety standards
- Ensure facilities are adequate for pocket cruise ship visitation (Sea Cloud)

NRM 5.2: Equipment

- Address equipment gaps for improved surveillance and enforcement, and water catchment
- Ensure continued maintenance of radio and satellite communication systems
- Schedule preventative maintenance and upkeep of surveillance and enforcement equipment
- Ensure HMC is adequately equipped for emergencies – fire extinguishers, full first aid kits, stretchers, sat phone etc., with maintenance of all safety equipment, and staff training in use
- Ensure boats are insured, and fully equipped with GPS, GPS locator and base radio
- Ensure HMC has the equipment required for regular site maintenance activities, and that staff are trained for basic maintenance activities
- Maintain photographic catalogue of BAS boats and engines in case of theft
- Maintain Night Watchman post to ensure safety of equipment and personnel on HMC

NRM 5.3: Site Maintenance

- Schedule regular site maintenance activities on HMC – trails, staff and visitor facilities, beach cleaning
 - Ensure adequate planning for garbage – both left by visitors and beach debris
 - Continue to request visitors to take their garbage with them
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3.6 Research and Monitoring Program

Research and monitoring ensure informed management, and assess the effectiveness of the Natural Monuments in achieving protected area goals and objectives. The Research and Monitoring Program comes under the responsibility of the Conservation Director, and is administered under three sub-programs:

- **Monitoring Program Framework**
- **Baselines and Monitoring**
- **Collaboration and Communication**

The Research and Monitoring Program is guided by the BAS Marine Monitoring Manual (BAS, 2005) which standardizes monitoring strategies to strengthen BAS’s monitoring efforts for the Blue Hole and Half Moon Caye Natural Monuments, and for the greater Lighthouse Reef Atoll. Whilst this is comprehensive in terms of current monitoring protocols, there is still a need to further integrate assessment and monitoring of climate change impacts and identify resilient areas and critical resources, to ensure integration of these into future planning.

The **Baseline and Monitoring Sub-Program** focuses on those areas identified as information gaps during the management and conservation planning processes. Many of the research activities can be effectively met through engaging research partners for targeted project areas - particularly important in research for informing climate change adaptation. The sub-program calls for a more standardized focus for independent researchers, with priority given to research meeting identified research gaps, and research proposals reviewed by both BAS and the relevant authorities - the Fisheries Department and the Forest Department.

Measuring Success focuses on the status of the conservation targets, effectiveness of conservation strategies and monitoring of biodiversity indicators, to provide guidance for adaptive management. **Collaboration and Communication** is an important component, strengthening standardization of protocols, sharing of information, feeding monitoring outputs into national level programs such as the National Coral Reef Monitoring Network and National Biodiversity Monitoring Framework.

Research and Monitoring
Program Goal
<i>To identify and address priority areas for research, and implement a robust and ongoing biodiversity monitoring program to ensure informed conservation management of Half Moon Caye and Blue Natural Monuments</i>
RM1: Monitoring Program Framework <ul style="list-style-type: none"> ▪ Data Collection, Management and Access ▪ Reporting and Data Dissemination ▪ Research Permits ▪ Training
RM 2: Baselines and Monitoring <ul style="list-style-type: none"> ▪ Priority Research ▪ General Research ▪ Monitoring of Impacts ▪ Conservation Targets ▪ Climate Change ▪ Management Effectiveness ▪ Biodiversity Indicators
RM 3: Collaboration and Communication

Research and Monitoring Program

RM 1: Monitoring Program Framework

RM 1.1 Data collection, Management and Access

- Ensure the BAS Research and Monitoring Program is equipped and staffed for effective program management and strategy implementation
- Maintain database of GIS data, research and monitoring information for use in enhancing the level of coordination between researchers, identifying information gaps, and providing a platform from which the results can be communicated to a wider audience
- Continue implementing an effective, standardized monitoring and data management program for the HMCNM-BHNM , as per the BAS Monitoring Plan
- Review, revise and update the HMCNM-BHNM Monitoring Plan, with integration of:
 - Conservation Planning indicators
 - Climate change factors
 - Acceptable Change parameters
- Use available forums for dissemination of results (e.g. workshops, conferences, school visits, fisher and tour guide meetings)
- Develop digital library of all published work on Lighthouse Reef and make available, where feasible, for download on line
- Ensure results of monitoring and research outputs are available to staff at HMCNM-BHNM and other BAS Program Managers

RM 1.2: Reporting and Data Dissemination

- Ensure mechanisms are in place for easy access to monitoring data
- Effectively integrate monitoring and research results into the adaptive management process
- Ensure quarterly / annual data summaries / reports
- Continue building capacity of rangers for participation in monitoring activities

RM 1.3: Research Permits

- Clarify roles and responsibilities for issuing research permits for the protected areas with Forest and Fisheries Departments, and harmonize for adoption of clear protocols
- Develop a written agreement for research use of the area, to be signed by all researchers using the Natural Monuments, to include rules, regulations and guidelines

RM 1.4: Training

- Ensure all staff (particularly rangers) understand the reasons behind research and monitoring and are engaged and supportive
 - Ensure all staff are aware of, and can articulate, basic research and monitoring outputs (e.g. conch population increasing / decreasing)
 - Ensure any new biologists are trained in species identification, monitoring protocols and data management
 - Train staff and rangers in identification of key species (particularly nesting and migrant birds, turtle nest surveys)
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Research and Monitoring Program

RM 2: Baseline and Monitoring

RM 2.1 Priority Research

- Identify priority research activities from conservation planning and adaptive management requirements
- Disseminate list of priority research activities to current and potential research partners
- Identify resilient areas within LHR in the context of site level management and the national marine protected areas system

RM 2.2: General Research

- Repeat REA of the protected areas, and extend to the entire Atoll, to update baseline information – every two to three years
- Maintain weather station for collection of meteorological data, in collaboration with the Met Office
- Seek international partners for updating of ecosystem mapping for Lighthouse Reef and the two PAs
- Continue to update baseline species lists for fish, corals, birds, marine megafauna and other vertebrates and invertebrates of the protected areas
- Develop inventory of marine plants
- Develop /implement an effective water quality monitoring program in LHR

RM 2.3: Monitoring of Impacts

- Develop / use DoE CSI rapid assessment protocols for post-impact assessments for events (e.g. boat groundings, hurricanes), and produce and disseminate reports for all impact events
- Engage staff and stakeholders, for assessing and monitoring impacts
- Monitor nutrient levels and relative algal growth on a regular basis to monitor anthropogenic impacts using methods such as stable isotope analysis (particularly in high visitor-use areas, adjacent to the caye, mooring buoys and popular dive sites (also in no-impact control site)
- Monitor presence and density of lionfish population following Blue Ventures protocols
- Continue monitoring presence of introduced species – rats, green iguanas
- Monitor caye land use change
- Develop indicators for Limits of Acceptable Change for visitor impacts
- Monitor group size and diver ratio for dive groups in the protected areas

RM 2.4: Conservation Targets

RM 2.4.1 Seagrass

- Update mapping of seagrass extent through satellite imagery and integrate into national data set
- Monitor seagrass status - MBRS seagrass monitoring protocols

Indicators

- *Seagrass biomass*
 - *Seagrass height*
 - *Seagrass % cover*
 - *Seagrass net density*
 - *Light intensity*
 - *Temperature (installation of temperature loggers)*
-

Research and Monitoring Program

RM 2: Baseline and Monitoring

RM 2.4: Conservation Targets

RM 2.4.2 Coral Reefs

- Maintain coral reef monitoring, using standard survey locations
- Continue monitoring permanent transects for bleaching surveys
- Identify coral reef areas of concern (bleaching sites – already identified; resilient sites – some identified), and establish monitoring protocols
- Ensure ecosystem requirements for critical herbivorous species are factored into management decisions and prioritisations
- Continue monitoring program for each of the larger species of parrotfish (particularly rainbow parrotfish) in each protected area, integrated into current surveys (MBRS and SMP)
- Monitor currents on LHR atoll at different times of year (potentially through institutional partnership)

Indicators

- *IRHI*
- *Turbidity*
- *Coral Bleaching*
- *No. incidence of significant increased turbidity / year*
- *No. of incidences of illegal fishing of parrotfish / year*

RM 2.4.3 Mangroves

- Map existing mangrove extent from aerial photography and GPS mapping
- Monitor presence and status of red mangroves on HMC and other cayes of LHR

2.4.4 Littoral Forest

- Map existing littoral forest extent from aerial photography and GPS mapping
- Engage caye developers in seasonal monitoring of freshwater lens on the cayes – salinity and contamination (dry, wet and norther seasons)
- Assess population structure and niche requirements, map distribution of Allison’s Anole and Leaf-toed Gecko on Half Moon Caye and presence/absence on other Cayes of LHRA
- Develop and implement annual monitoring of lizard populations of HMCNM
- Monitor HMC beach profile

Indicators

- *Extent of mangrove*
 - *Extent of littoral forest*
 - *% of developments following best practices guidelines*
 - *No. of incidents of poor development practices reported and confirmed /year*
 - *Change in beach profile*
-

Research and Monitoring Program

RM 2: Baseline and Monitoring

RM 2.4.4 Littoral Forest

- Annual mapping of extent of existing littoral forest extent from aerial photography and GPS mapping
- Engage caye developers in seasonal monitoring of freshwater lens on the cayes – salinity and contamination (dry, wet and norther seasons)
- Develop monitoring program to assess population structure and niche requirements, map distribution of Allison’s Anole and Leaf-toed Gecko on Half Moon Caye and presence/absence on other cayes of Lighthouse Reef Atoll
- Develop and implement annual monitoring of lizard populations of
- Annual survey of migratory bird species, with strengthening of staff in species recognition - 12 sites at HMC and possible 12 more at Northern Caye

Indicators

- *Extent of mangrove*
- *Extent of littoral forest*
- *% of developments following best practices guidelines*

No. of incidents of poor development practices reported and confirmed /year

RM 2.4: Conservation Targets

RM 2.4.5 Commercial Species

- Continue to monitor lobster, conch and finfish within and outside PA
- Develop baseline for deep sea species in collaboration with fishers
- Monitoring of Managed Access indicators

Indicators

- *Conch density*
 - *Average catch per boat (conch and lobster, finfish, sea cucumber, shark)*
 - *Weight of illegal product*
 - *# of day/ routine patrols*
 - *Lobster density & reproductive population density*
 - *No. of fishing infractions as a % of total number fishing boats / year*
 - *% of illegal fishing cases presented that are successfully prosecuted / year*
-

RM 2.4.6 Spawning Aggregations

- Continue annual assessments of spawning aggregations and submitting data to the Spawning Aggregation Working Group

Indicators

- *Grouper spawning population abundance (annual / maximum at Sandbore Spawning site)*
 - *Population of spawning snapper (schoolmaster, yellowtail, cubera & dog at Half Moon Caye Spawning site) and Mutton snapper at South-tip*
 - *Monitoring the population of other reef fish species aggregating to spawn at HMC, Sandbore and South tip spawning site*
 - *# of night and daytime patrols monitoring sites during spawning peak*
 - *# of fishers caught fishing illegally at SPAGs*
-

Research and Monitoring Program

RM 2: Baseline and Monitoring

RM 2.4.7 Marine Turtles

- Continue monitoring nesting activity during nesting season
- Continue engaging staff in logging of all turtle sightings – identification, location, habitat, size estimate, activity
- Continue engaging caye residents in monitoring of turtle nesting activity

Indicators

- # successful turtle nests total / per caye
- % hatch success

RM 2.4.8 Colony Nesting Birds

- Continue annual survey of nesting colony to estimate population size of red-footed boobies and magnificent frigatebirds

Indicators

- # red footed boobies
- # magnificent frigatebirds
- # red footed booby nests

RM 2.5: Biodiversity Indicators

- Maintain annual status reporting of National Management Effectiveness Biodiversity indicators

RM 2.6: Climate Change

- Continue monitoring for coral bleaching, with input into NCRMN
- Establish monitoring protocols that inform management for building reef resilience, coral restoration and replanting
- Continue identifying reef resilient areas within LHR and integrating into surveillance and enforcement and monitoring activities
- Identify technical partnerships for identifying coral recruitment sources for LHR
- Characterize water currents critical for coral recruitment at LHR
- Investigate use of mechanisms for direct interventions – e.g. coral nurseries, shading of key sites, promoting higher herbivore densities
- Work closely with national and international partners to monitor climate change effects and identify appropriate national and regional management strategies

RM 2.7: Socio Economic Monitoring

- Develop Limits of Acceptable Change indicators and monitor
 - Maintain and update accurate socio-economic data on stakeholder communities (fishers and tour guides)
 - Develop baseline and census number of residents and residential properties occupied or under construction on LHR cayes on an annual basis
 - Monitor visitor satisfaction under the Limits of Acceptable Change program
 - Monitor tour guide satisfaction under the Limits of Acceptable Change program
-

Research and Monitoring Program

RM 3: Communication and Collaboration

RM 3.1: Communication and Collaboration

- Continue presenting monitoring results in annual reports
- Continue strengthening engagement with Fisheries and Forest Departments for improved communication and collaboration
- Strengthen communication and collaboration between the Research and Monitoring Program and the other BAS program areas
- Strengthen communication and collaboration with the Climate Change Office on climate change impacts and caye and atoll vulnerability
- Strengthen communication and collaboration with coral monitoring partners / National Coral Reef Monitoring Network
- Communicate and collaborate with national, regional and international organisations / networks concerned with shark conservation
- Strengthen communication and collaboration with national, regional and international marine turtle conservation initiatives
- Strengthen communication and collaboration with other current and future national and international research partners
- Develop mechanisms for tour guides, land owners and other stakeholders to participate in monitoring activities of turtles, coral bleaching and lionfish

Research and Monitoring Program

RM 3: Communication and Collaboration

RM 3.1: Communication and Collaboration

- Engage BTB in climate change adaptation planning
 - Strengthen links with national universities for provision of opportunities and training for Belizean students in research
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3.7 Environmental Education and Community Outreach

BAS firmly believes that “education is at the heart of environmentally sustainable development” (BAS Strategic Plan, 2014), and that building awareness and understanding of the environment and the benefits communities receive from it will encourage better environmental stewardship. The BAS Environmental Education and Awareness Program is focused on four primary areas:

- Environmental Education
- Visitor Information
- Stakeholder Engagement
- Strengthening Livelihoods

Implementation of BAS’s environmental strategy and the management of Environmental Education and Community Development activities are centralized within the Belize City office, the program reaching out to communities buffering all BAS protected areas. The location of Lighthouse Reef Atoll and the Natural Monuments makes it challenging for running on-site education and awareness activities. The focus is therefore on developing a structured framework for stakeholder engagement and communication, and on actively improving engaging key stakeholders at the Atoll.

With both Natural Monuments playing a critical role in Belize’s tourism industry, awareness also extends to informing visitors of the importance and roles of the protected area – its biodiversity, environmental services - and the benefits it provides in terms of community livelihoods and support, and of biodiversity protection. The presentation of interpretative information at HMCNM-BHNM will be strengthened over the next five years starting with the recent renovation of the visitor infrastructure.

Environmental Education and Awareness
Program Goal
<i>Building knowledge, skills, and experience to create more environmentally responsible citizens.</i>
EEA 1: General
EEA 2: Environmental Education <ul style="list-style-type: none"> ▪ Nature School ▪ Engagement of Schools ▪ Resource Users
EEA 3: Visitor Information <ul style="list-style-type: none"> ▪ Interpretive Centre and displays ▪ Interpretive signs ▪ Brochures, booklets
EEA 4: Stakeholder Outreach, Engagement and Communication <ul style="list-style-type: none"> ▪ Community Outreach , Engagement and Communication
EEA 5: Strengthening Livelihoods <ul style="list-style-type: none"> ▪ Strengthen livelihoods / income diversification in northern communities ▪ Partner with other organizations working in northern communities towards alternative / supporting alternative livelihood options

Key Strategic Goals <ul style="list-style-type: none"> ▪ Inform the general public of the ecosystem services, community benefits and biodiversity protection provided by protected areas ▪ Encourage the involvement of local communities in the management of our protected areas ▪ Build capacity among community members, enabling them to actively participate in protected areas management ▪ Strengthen livelihoods associated with the protected area

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BAS has, in recent years, invested more time and resources in reaching out to its HMCNM-BHNM fishing stakeholder communities – particularly Chunox and Copper Bank. There have also been increased stakeholder engagement activities, with boat-based awareness activities focused on the fishermen at the Atoll, and conducted on Lighthouse Reef Atoll. This is particularly important in light of the roll-out of the Fisheries Department national Managed Access program, with BAS taking a more proactive role in management of fisheries on the Atoll.

Tour guide engagement is also increasing, with a series of recent meetings with tour guides of both San Pedro and Caye Caulker - the first step in improved engagement. BAS is focusing on capacity building, a site-specific license system for the Blue Hole, and recognition of tour guides using best practices, through certification.

Environmental Education and Awareness Program

EEA 1: General

EEA 1.1: General

- Socio-economic assessment of stakeholder communities – both fisheries and tourism
- Develop a Communication / Collaboration Plan to structure and guide stakeholder and community communication and collaboration

EEA 2: Environmental Education

EEA 2.1: Nature School

- Strengthen Nature School program
- Include northern fishing communities in Nature School activities

EA 2.2: School Engagement

- Strengthen engagement of stakeholder schools through improved communication with teachers
- Increase teacher awareness of basic environmental services concepts, biodiversity value, conservation, and climate change
- Participate actively in school open days / community days with activities designed to engage community members
- Partner with SACD and other local organizations working in the northern fishing communities for cost-effective delivery of education and outreach programs and activities to schools

EEA 2.3: Improve environmental awareness of key resource users

- Increase fisher and tour guide awareness of basic environment services concepts, biodiversity values of LHR, and climate change
- Continue to build capacity of fishers and tour guides for good stewardship of biodiversity
- Ensure caye / resort owners / managers have access to environmental awareness materials

EEA 3: Visitor Information

EA 3.1: Visitor Information

- Identify target audiences and key messages BAS would like to convey, and develop engaging interpretive displays that address these
- Build capacity of staff and tour guides to be able to host visitors supported by equipment and materials for implementing interpretive experiences
- Produce quarterly laminated information sheets for display at individual picnic tables with recent highlights and targeted visitor information
- Update information boards for trails, platform and turtle nesting sites

Environmental Education and Awareness Program

EEA 4: Stakeholder Outreach, Engagement and Participation

EEA 4.1: Stakeholder Outreach, Engagement and Participation

- Strengthen engagement with fishermen utilizing HMCNM-BHNM through meetings and boat-based discussion
- Strengthen engagement of the northern fisher associations and community leaders through improved communication
- Strengthen mechanisms for ongoing, open communication with tour guides that use HMCNM-BHNM, including annual or biannual meetings
- Produce posters and videos that highlight HMCNM-BHNM Natural Monuments and their socio-economic benefits, for presentation in northern fishing communities
- Engage developing fisher community groups – particularly fisher and women’s groups, and provide opportunities for active participation in protected area activities
- Strengthen Reef Protectors Program, targeting youths from the northern fishing communities, with participation in monitoring and research activities
- Increase targeted communication with, engage and build awareness of stakeholders identified as using poor tourism or fishing practices
- Strengthen engagement of the primary tourism communities using HMCNM-BHNM
- Engage caye owners / developers / resort managers on Lighthouse reef Atoll, for improved ecosystem management (maintenance of mangroves and littoral forest) and reduced environmental impacts, and provide best practices information
- Provide internship opportunities for UB students, assisting with baseline data development and biodiversity monitoring
- Ensure tour guide participation in decisions relating to zonation and / or limits of acceptable change
- Provide opportunities for fishers to participate in training for alternative / supplemental livelihoods
- Ensure tour guide participation in revision of Limits of Acceptable Change criteria for the Natural Monuments
- Strengthen communication with live-aboards
- Improve communication with private recreational vessels using the Atoll, to improve awareness of rules and regulations

EEA 5: Strengthening Livelihoods / Income Diversification

EEA 5.1: Strengthening Livelihoods / Income Diversification

- Assess communities for primary development needs, including needs for strengthening resilience for predicted climate change impacts, and identify those priority areas where BAS can provide support
- Provide capacity building opportunities for fishers and tour guides in areas such as best practices, marketing, financial management, organizational management, First Aid / CPR
Provide capacity building opportunities for youth and women’s groups in the northern fisher communities

3.8 Administrative Program

Organizational, financial and human resource administration is centralized at the Belize Audubon Society office in Belize City. The Protected Area Manager is also based from Belize City, whilst site-level administration, the majority of fee collection activities and management of field staff is based from the station on Half Moon Caye, and directed by the Senior Site Manager.

As part of its ongoing strategic goals for 2014 – 2019, BAS is seeking to improve financial sustainability and increase general awareness of and support for BAS’s work.

Administration
Program Goal
<i>Ensuring that the necessary administration structure is in place for the support of management activities within HMCNM-BHNM and the adjacent area</i>
A 1: Accounting and Records
A 2: Human Resources
<ul style="list-style-type: none"> ▪ Human Resource Management ▪ Capacity Building
A 3: Communication and Collaboration
<ul style="list-style-type: none"> ▪ Communication and Collaboration ▪ Formal Agreements
A 4: Planning and Reporting
<ul style="list-style-type: none"> ▪ Financial Sustainability Planning ▪ Operational Planning and Reporting ▪ Risk Planning ▪ Monitoring and Evaluation
A 5: Monitoring and Evaluation
<ul style="list-style-type: none"> ▪ Management Effectiveness ▪ Management Plan assessment

Key Strategic Goals
<ul style="list-style-type: none"> ▪ Improve organizational effectiveness ▪ Improve BAS’ visibility and messaging across various target audiences to generate more support for BAS and its work.

Administration Program

A 1: Accounting

A 1.1: Accounting

- Prepare timely financial and management accounts and submit monthly
- Prepare, as necessary, project budgets and financial reports
- Prepare quarterly report on use of annual budget, for submission to Executive Director and funding agencies
- Prepare annual accounts and summary for Annual Report and auditing
- Continue maintaining accurate staff payment records
- Move towards eliminating cash flow at the Natural Monuments, with move towards a strengthened credit system

A 2: Governance

A 2.1: Governance

- Ensure the Board of Directors is kept adequately updated on management challenges at Lighthouse Reef Atoll
- Build capacity of Board of Directors for understanding of and input into management decisions for HMCNM-BHNM
- Ensure the LHR Advisory Committee is kept adequately updated on management challenges at Lighthouse Reef Atoll
- Build capacity of LHR Advisory Committee for understanding of, and input into, management decisions for HMCNM-BHNM
- Strengthen the mandate of the LHR Advisory Committee in its role in decision making
- Build capacity of the Managed Access Committee for input into management decisions for improved fisheries at LHR

A 3: Human Resources

A 3.1 Human Resource Management

- Ensure there are sufficient staff for effective visitor and natural resource management and monitoring – at least critical, but preferably optimal level
- Increase number of staff for extended site responsibility – Managed Access roll-out (current) and deep sea extension (potential)
- Employ casual staff for building maintenance / repair activities
- Develop formal Orientation Package for all permanent staff, specific to HMCNM-BHNM
- Ensure all staff are familiar with key BAS documents including the Policies and Procedures and the HMCNM-BHNM Hurricane Plan

A 3.2 Capacity Building

- Develop and implement site level Human Resource Development plan to maximise on present staff skills and interests, identifying key training needs (e.g. Hospitality training, Green Laws training, presentation skills etc.)
- Build capacity of staff to understand the role HMCNM-BHNM plays in the seascape and NPAS
- Ensure that relevant staff are trained in simple accounting procedures, and use of computer
- Staff training in conducting visitor surveys, basic biodiversity monitoring and volunteer management

Administration Program

A 4: Communication and Collaboration

A 4.1: Communication and Collaboration

- Improve cross sectoral communication and collaborative partnerships through a structured Communication / Collaboration Plan targeting:
 - Fisheries Department / Forest Department
 - Belize Coastguard / Port Authority / Belize Tourism Board
 - Partner organizations (e.g. SACD)
 - Stakeholder communities (leaders, community groups, LHR resource users, women, teachers, youths)
 - Northern Fishing Associations / LHR Fishers
 - Tour Operators / tour guides
 - Adjacent caye owners / developers / resort managers
 - NGOs involved in addressing WHS issues

A 4.2: Formal Agreements

- Maintain / develop formal required for effective management:
 - Fisheries Department (Managed Access)
 - Belize Coastguard (Surveillance and Enforcement)
 - Belize Port Authority (Maintenance of lighthouse)
 - Belize Tourism Board (Enforcement of Tourism Regulations on the LHR Atoll)
 - SACD (Joint activities in northern fishing communities)

A 5: Planning and Reporting

A 5.1: Financial Sustainability Planning

- Maintain and strengthen current financial sustainability mechanisms
- Conduct a financial review / cost-benefit analysis of past program activities and outcomes to identify cost-effective, high-impact activities and inform future strategies and activities
- Develop and implement financial plan for HMCNM-BHNM for next five years to set course for economic sustainability

A 5.2 Operational Planning and Reporting

- Develop Annual Work Plan and budget each November, based on the management plan and previous work plan measures of success recommendations, and submit each November
- Keep daily log of activities for HMCNM-BHNM, and prepare monthly report on enforcement activities, general situation report.
- Prepare site-level annual report following BAS parks reporting framework

A 5.3 Risk Planning and Management

- Assess liability issues at HMCNM-BHNM on an annual basis and integrate risk reduction, where feasible, into the annual work plan
- Ensure all staff have basic first aid training, accident emergency procedures, and use of the oxygen kit
- Ensure upkeep of all emergency and safety equipment
- Keep hurricane plan for HMCNM-BHNM updated
- Ensure that all staff are aware of hurricane procedures before start of each hurricane season

Administration Program

A 5: Planning and Reporting

A 5.4: Monitoring and Evaluation

- Conduct annual management effectiveness assessment and submit to PA administration authority
 - Re-evaluate management plan after 2½ years and 5 years
 - Evaluation of annual work plan
-

3.9 Monitoring 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:

- measuring success in implementing the management actions
- measuring success of the conservation strategies in addressing threats and increasing target viability.

Two matrices have been developed to facilitate this process, forming the basis for the annual review of the management plan. Time should be taken to complete each one fully and as accurately as possible at the end of each year, to track using data from the monitoring program. If this is maintained on an annual basis, then this will greatly facilitate any management staff transition handover.

Included is an example of the suggested structure for both Measures of Success matrices (Table 54 and Table 55).

Success is also measured against the matrix of outcome indicators developed across the project (Table 56).

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Table 54. 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						
	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					Desired Status	Comments: Justification for Measure of Success score. Problems, concerns. Notes for inclusion in updated Management Plan
	Year						
Activity	1	2	3	4	5		
NRM 1.1 Surveillance and Enforcement							
NRM 1.1.1 Boundaries and Zones							
<input type="checkbox"/> Demarcation of boundaries of both protected areas, with sufficient marker buoys to ensure visual recognition of boundaries at all key points (500m apart)						Boundaries clearly defined by sufficient, highly visible marker buoys	Current Status: Number of boundary marker buoys has been increased but is still not considered sufficient for surveillance and enforcement
<input type="checkbox"/> Collaborate with Forest Department and the Lands Information Centre to update the shapefiles for Half Moon Caye and Blue Hole in the National Protected Areas System dataset						All national and regional mapping exercises use the correct shape file for HMCNM-BHNM	Current Status: The LIC shapefile has not yet been corrected. Realignment of the protected areas boundaries will be addressed when placing the new buoys
<input type="checkbox"/> Ensure all staff, enforcement partners, tourism and fisheries stakeholders are aware of boundaries, zones and regulations (including SPAG sites)						Staff are fully aware of, and enforcing, boundaries and zone regulations	Current Status: Staff are aware of location of, and enforcing, PA boundaries and zones

**Half Moon Caye and Blue Hole Natural Monuments – Management Plan
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Table 55: Example: Natural Resource Management Program - Status

Measure of Success - Status							
It is important to document clearly the status of each Activity whilst developing Annual Operation Plans, as this allows highlighting of areas that need prioritization							
Management Activities	Present Status (2016)	Status (2017)	Status (2018)	Status (2019)	Status (2020)	Status (2021)	Desired Status
Activity							
NRM 1.1 Surveillance and Enforcement							
Demarcation of boundaries of both protected areas, with sufficient marker buoys to ensure visual recognition of boundaries at all key points (500m apart)	Number of boundary marker buoys has been increased but is still not considered sufficient for surveillance and enforcement						Boundaries clearly defined by sufficient, highly visible marker buoys
Collaborate with Forest Department and the Lands Information Centre to update the shapefiles for Half Moon Caye and Blue Hole in the National Protected Areas System dataset	The LIC shapefile has not yet been corrected. Realignment of the protected areas boundaries will be addressed when placing the new buoys						All national and regional mapping exercises use the correct shape file for HMCNM and BHNM
Ensure all staff, enforcement partners, tourism and fisheries stakeholders are aware of boundaries, zones and regulations (including SPAG sites)	Staff are aware of location of, and enforcing, PA boundaries and zones						Staff are fully aware of, and enforcing, boundaries and zone regulations

**Half Moon Caye and Blue Hole Natural Monuments – Management Plan
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Indicator	Frequency	Current Status (End of 2016)
Conservation Action Planning		<i>To be completed at end of 2016</i>
Integrated Reef Health Index	Annual	
Turbidity	Annual	
Coral bleaching	Annual	
No. incidence of significant increased turbidity / year	After coral bleaching warning	
No. of incidences of illegal fishing of parrotfish / yr	Annual	
Extent of littoral forest	Annual	
Extent of Mangrove	Annual	
% of developments following best practices guidelines	Annual	
No. of incidents of poor development practices reported and confirmed /year	Annual	
Conch density	LAMP: pre and post season NCS: Every 2 years	
Average catch per boat (conch and lobster, finfish?)	Conch season (October 1 st – June 30 th) / Lobster Season (July 15th - Feb 15th)	
Weight of illegal product	All year	
# of day/ routine patrols	Annual summary	
Lobster density and reproductive population density	Twice per year (before and after open season)	
No. of fishing infractions as a % of total number fishing boats / year	Annual	
% of illegal fishing cases presented that are successfully prosecuted / year	Annual	
Grouper spawning population (annual / maximum)	Jan., Feb. (and if possible (Dec., March)	
Population abundance of spawning snapper (cubera & dog) and Groupers	Twice per year during peak (April and May)	
Population abundance of spawning snapper (cubera and dog) and Groupers	Once a year (March)	

Table 56: Indicator Framework

**Half Moon Caye and Blue Hole Natural Monuments – Management Plan
2017-2021**

Indicator	Frequency	Current Status
Conservation Action Planning		
		<i>To be completed at end of 2016</i>
# of night and daytime patrols monitoring sites during spawning peak	Spawning season (3 times per year - more at HMC because of proximity)	
# of fishers caught fishing illegally at SPAGs	Spawning season	
Seagrass biomass	4 times/yr	
Seagrass height	4 times/yr	
Seagrass % cover	4 times/yr	
Light intensity	4 times/yr	
# successful turtle nests total / per caye	Annual (between May - December)	
% hatch success	Annual (between May - December)	
# red footed boobies	Annually (between Feb. and Sept.)	
# magnificent frigatebirds	Annually (between Feb. and Sept.)	
Climate Change		
Maximum % live coral cover	Annually	
Average % live coral cover	Annually	
Management effectiveness rating for visitor management infrastructure	Annually	
Number of BAS-certified tour operators using LHR	Annually	
Number of tour guides taking and passing the training course	Annually / After each course	
% of boats implementing best practices for use of chemicals	Annually	
Number of infractions per year	Annually	
% boats approached that sign on to list of best practices	Annually	
% of boats checked that show significant discharge	Annually	
% of 2015 extent of mangroves of LHR that remains intact	Annually	

**Half Moon Caye and Blue Hole Natural Monuments – Management Plan
2017-2021**

Indicator	Frequency	Current Status
Climate Change		<i>To be completed at end of 2016</i>
Baseline of mangrove extent of LHR	Annually	
% of 2015 extent of littoral forest of LHR that remains intact	Annually	
Baseline of littoral forest extent of LHR	Annually	
Results from water quality testing of groundwater per caye	Annually	
# of successful turtle nests py	Annually	
# of turtle nests affected by anthropogenic activity per year	Annually	
% of caye beaches impact by seawalls	Annually	
% caye nesting beaches with natural vegetation removed (per caye)	Annually	
# of reported turtle nests per year per caye	Annually	
% of caye developments following best practices	Annually	
Number of transboundary fishing issues addressed py	Annually	
% of patrols that cover transboundary hotspots	Annually	
LHR is managed as a Managed Access site	Annually	

Table 56: Indicator Framework

3.8 Timeline

A 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 provides a framework against which implementation effectiveness can be measured. This ensures orderly and planned implementation of activities throughout management plan period (Table 56).

The annual work plan is developed from the timeline by the Protected Area Director, Senior and Assistant Site Managers in November, at the end of each year. This work plan also enables Belize Audubon Society to budget the outlay required for the coming year against activities the Society would like to achieve.

**Half Moon Caye and Blue Hole Natural Monuments – Management Plan
2017-2021**

Table 57: Example: Natural Resource Management Program						
Management Activity	Notes	Year				
		1st	2nd	3rd	4th	5th
NRM 1: Effective Surveillance and Enforcement						
NRM 1.1 Surveillance and Enforcement						
<input type="checkbox"/> Boundaries and Zones						
<input type="checkbox"/> Demarcation of boundaries of both protected areas, with sufficient marker buoys to ensure visual recognition of boundaries at all key points (500m apart)	Responsible: Protected Area Director, Senior Site Manager					
<input type="checkbox"/> Collaborate with the Lands Information Centre to update the shapefiles for Half Moon Caye and Blue Hole in the National Protected Areas System dataset	Responsible: Executive Director, Protected Area Director					
<input type="checkbox"/> Ensure all staff, enforcement partners, tourism and fisheries stakeholders are aware of boundaries, zones and regulations (including SPAG sites)	Responsible: Senior Site Manager					
<input type="checkbox"/> Surveillance and Enforcement						
<input type="checkbox"/> Continue and strengthen surveillance and enforcement of protected area regulations at Half Moon Caye and Blue Hole Natural Monuments in partnership with the Forest Department	Responsible: Protected Area Director, Senior Site Manager					
<input type="checkbox"/> Ensure surveillance activities are strategic and effective, based on BAS enforcement data, incidence mapping and identification of hotspots, key times, key offending boats (both tourism and fishing) and integration of SMART technology	Responsible: Protected Area Director, Senior Site Manager					
<input type="checkbox"/> Expand surveillance and enforcement activities and resources to support Managed Access / Areas roll-out at Lighthouse Reef Atoll, In collaboration with the Fisheries Department	Responsible: Protected Area Director, Senior Site Manager					

3.9 Financing

BAS faces ongoing challenges in securing the necessary finances to continue and further develop its management of the protected areas under its custodianship. HMCNM-BHNM is unusual in Belize in that it generates more than sufficient funds from visitation to support protected area activities, with a surplus that is used to support other BAS protected areas unable to generate sufficient funds to meet their expenditures. As with most participants in the conservation process in Belize, BAS has developed the management of the protected areas under its mandate, its staff and as an institution, largely upon external grants and, more recently, with the re-investment of entrance fees. As the leading national environmental NGO, entrusted by the Government of Belize to manage some of the most prominent national protected areas, BAS has a good record of success in securing international funding to support its management of the parks.

Financial Assessment

This funding analysis uses income and expenditures in 2015 to provide a financial snapshot of total management costs across the different management programs. The protected area has an on-site staff team of six, focused on site level activities, supported by the Protected Area Director and management staff in Belize City active in other program areas – education, awareness, community liaison and administration and finance.

Income: In 2015, HMCNM-BHNM was able to generate all the funds required for implementation of activities within the protected area. 85% of income in 2015 was derived from entrance fees, with a further 6% generated by camping / accommodation fees. Gift shop sales, donations and miscellaneous income (Other) contributed approximately 4% towards total protected area income (Figure 42; BAS data, 2016).

The income from entrance fees and other direct sources is supplemented by grant support from a variety of sources. In 2015, this was largely through an OAK Foundation project entitled "*Safeguarding Biodiversity within the Belize Barrier Reef Reserve System*". BAS is also able to access funds from international agencies for implementation of cross-cutting strategies through the BAS program areas - Research and Monitoring and Education and Awareness, with activities supported through inclusion of Half Moon Caye and Blue Hole Natural Monuments in projects under the. Belize Audubon Society has been able to maintain loyal donor support, with consecutive grants from a number of international donor agencies over the years.

**Half Moon Caye and Blue Hole Natural Monuments – Management Plan
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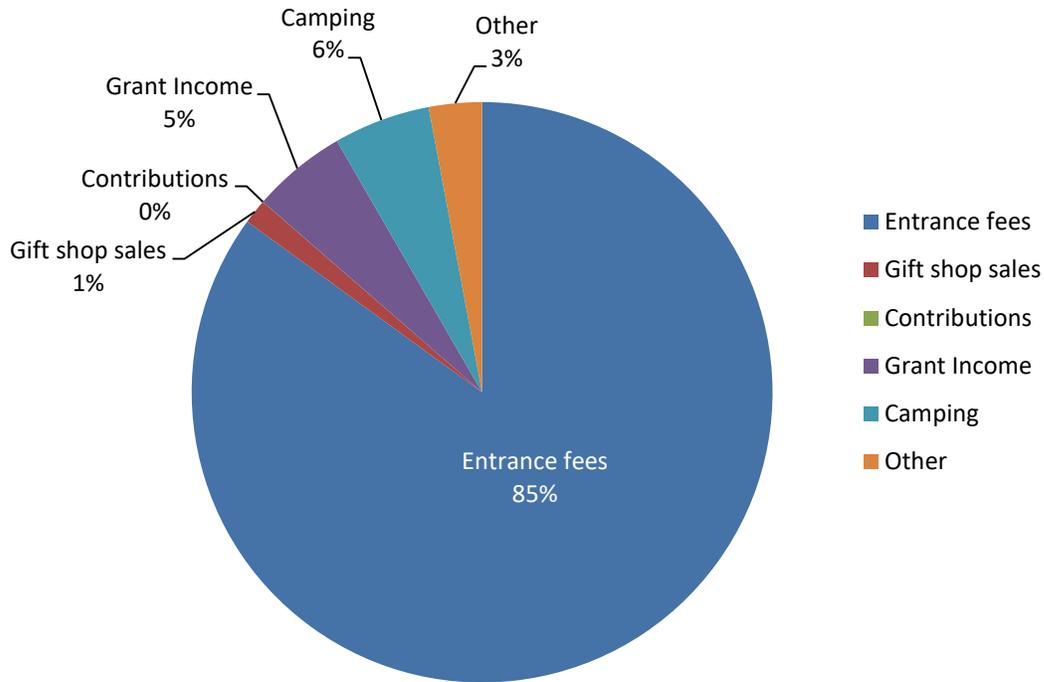


Figure 42: 2015 Breakdown of Income for Half Moon Caye and Blue Hole Natural Monuments (BAS data, 2016)

Expenditures: In 2015, total joint expenditure for Half Moon Caye and Blue Hole Natural Monuments is estimated at approximately Bz\$522,000 (exclusive of contributions to organizational audit, depreciation, bank charges and membership fees). A breakdown of site-specific expenditures for 2015 across seven general accounting areas shows that funds are relatively evenly spread between the four primary expenditure categories (Figure 43). Staff costs (32% - salaries, social security, insurance and casual labour), Administration (13%), Professional Services (22%), and Operations (25%) (BAS data, 2015). As would be expected, the operational costs are relatively high, with the logistical expenses involved in travelling to the Natural Monuments, and in patrolling the Natural Monuments and the wider Atoll by boat.

The investment in both the operational costs and the human resources are expected to increase as BAS takes on more responsibility for implementing collaborative strategies to support the roll out of Managed Access across the Atoll.

Half Moon Caye and Blue Hole Natural Monuments – Management Plan 2017-2021

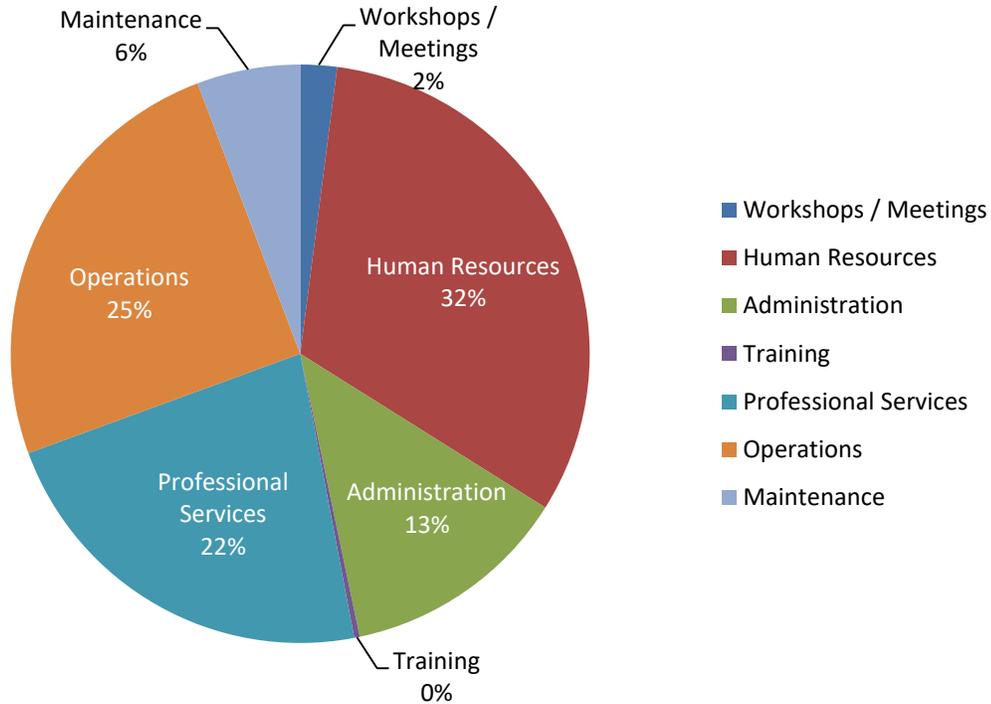


Figure 43: 2015 Breakdown of Expenditures for Half Moon Caye and Blue Hole Natural Monuments (BAS data, 2016)

Operational Expenditures vs Investments: Operational expenditures are the recurring costs necessary to fund operations – salaries, equipment costs, maintenance activities and supplies, fuel etc. In 2015, approximately 85% of funding was allocated to operational costs, with a further 13% to administration, and 22.3% to Professional Services and Capacity Building / Training. Investment in strengthening management in 2015 for the two Natural Monuments, covered revision of the management plan, assessment of management effectiveness, development and implementation of a rat eradication plan for Half Moon Caye, equipment purchase (including an outboard engines and demarcation and mooring buoys), capacity building for staff, implementation of the biodiversity monitoring program, and supporting the establishment of the Lighthouse Reef Advisory Committee.

Personnel: The staffing level of 7 is considered below optimal for the level of surveillance and enforcement and visitor management required. This is being addressed to some extent through collaborative patrols with the Belize Coastguard, Belize Fisheries Department and Belize Tourism Board, though these collaborations still need significant strengthening for addressing rapid response to specific situations.

4. Implementing the Plan

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

At the Start of the Management Plan Period

1. Develop the timeline for all four program areas and activities (Table 57)
2. Develop the two Measures of Success tables for all program areas and activities, defining the current and desired status, and developing implementation and outcome indicators (Tables 54 and 55)
3. Identify those activities scheduled for implementation in the first year and develop the first annual workplan
4. Develop the baseline for the indicators (Table 56), and for information gaps, identify which year this baseline information will be gathered in
5. Implement the Annual Workplan

At the End of the First Year...

1. Update the two Measures of Success tables for all program areas and activities, and measure the success of implementation (Table 54)
2. Define the current status, and status of implementation and outcome indicators (Table 55)
3. Review the workplan, and identify challenges and adaptive strategies, for inclusion in the next workplan (this should be a participatory exercise)
4. Update the status of the indicators and develop a report on the outputs, to be integrated into the Annual Report
3. Identify those activities scheduled for implementation in the second year and develop the second annual workplan, incorporating adaptive strategies from the workplan review
5. Implement the second Annual Workplan

References

Acosta, C.A. & D.N. Robertson. (2001). Population assessments of exploited species at Glover’s Reef Marine Reserve. Annual Progress Report to the Wildlife Conservation Society, 2001. 21 p.

Almada-Villela Patricia, Melanie Mcfield, Philip Kramer, Patricia Richards Kramer and Ernesto Arias-Gonzalez (2002). In: Status of Coral Reefs of the World, 2002. Ed. C. Wilkinsons. Global Coral Reef Monitoring Network.

Andréfouët, S., P.J. Mumby, M. McField, C. Hu & F.E. Muller-Karger. (2002). Revisiting coral reef connectivity. *Coral Reefs* 21:43-48

Anthony, KRN, Kline, DI, Diaz-Pulido, G, Dove, S and Hoegh-Guldberg, O (2008). Ocean acidification causes bleaching and productivity loss in coral reef builders. *Proceedings of the National Academy of Sciences* 105(45): 17442-17446.

Aronson R. B., W.F. Precht, I.G. MacIntyre and T.J.T. Murdoch (1980); Extrinsic control of species replacement on a Holocene reef in Belize: the role of coral disease. *Coral reefs* 17:223-230

Aronson, Richard B., W. F. Precht, I. G. Macintyre, T. J. T. Murdoch (2000). Coral bleach-out in Belize. *Brief Communications, Nature* Vol: 405

Arrivillaga A. & Garcia MA, (2004); Status Of Coral Reefs Of The Mesoamerican Barrier Reef Systems Project Region, And Reefs Of El Salvador, Nicaragua And The Pacific Coasts Of Mesoamerica. p: 473-492. in C. Wilkinson (ed.). Status of coral reefs of the world: 2004. Volume 2. Australian Institute of Marine Science, Townsville, Queensland, Australia. Pp.557.

Balick M. J., Nee M. H. and D.E. Atha (2000). Checklist of the vascular plants of Belize with common names and uses. *Memoirs of the New York Botanical Garden, Volume 85.* New York Botanical Garden Press. ISBN: 0-89327-440-2

Belize Audubon Society (2007). Half Moon Caye Natural Monument and Blue Hole Natural Monument Management Plan 2008 - 2013

Belize Spawning Aggregation Working Group, 2009. Newsletter 2009

Belize Tourism Board (2016) Tourism and Travel Statistics - 2015

Half Moon Caye and Blue Hole Natural Monuments – Management Plan 2017-2021

Burgos-Acosta, A. and B. A. Mitchell (2015). Managing for World Heritage Values: Outstanding Universal Value and Climate Change in the Belize Barrier Reef Reserve System. Belize Audubon Society / Quebec Labrador Foundation

Carilli JE, Norris RD, Black BA, Walsh SM, McField M (2009) Local Stressors Reduce Coral Resilience to Bleaching. PLoS ONE 4(7): e6324.

Choi D. and C. W. Hol (1982). Foundations of Quaternary Reefs in South-Central Belize Lagoon, Central America: GEOLOGIC NOTES *AAPG Bulletin* Volume 66 (1982)

Copeland C. (2005). Cruise ship pollution: Background, laws and regulations and key issues. Congressional Research Service, The Library of Congress, USA.

De'ath Glenn, J. M. Lough, and K..E. Fabricius (2009). Declining Coral Calcification on the Great Barrier Reef. *Science*, Vol. 323, 2 JANUARY 2009. Downloaded from www.sciencemag.org on April 14, 2010

FAO (2010). www.fao.org/fishery/countrysector/FI-CP_BZ/en downloaded 2010

Gibson J., M. McField and S. Wells (1998). Coral reef management in Belize: an approach through Integrated Coastal Zone Management. *Ocean and Coastal Management* 39: 229-244

Gillet V. (2003) The Fisheries of Belize. Fisheries Centre Research Report (2003), Vol. 11(6)

Government of Belize. (2000) Belize Port Authority Act. Chapter 233 (Revised 2000)

Government of Belize (2006). Horizon 2030

Government of Belize (2005). National Protected Areas Policy and System Plan

Government of Belize (2007). National Poverty Elimination Strategy (2007 – 2011)

Government of Belize (2009). National Poverty Elimination Strategy and Action Plan (2009 – 2013)

Government of Belize (2012). National Sustainable Tourism Master Plan of 2030 (Endorsed 2012)

Government of Belize (2015). Growth and Sustainable Development Strategy for Belize 2015-2018

Half Moon Caye and Blue Hole Natural Monuments – Management Plan 2017-2021

- Government of Belize (2015).** National Protected Areas Policy and System Plan (revised)
- Government of Belize (2016).** Belize National Climate Change Policy, Strategy and Action Plan (NCCPSAP)
- Government of Belize (2016).** National Biodiversity Strategy and Action Plan
- Heathy Reefs (2015).** Healthy Reef Initiative Report Card, 2015
- Healthy Reefs (2016).** Healthy Reef Initiative Eco-Audit Results for Belize, 2016
- Heyman and Kjerfve (2001).** The Gulf of Honduras in Ecological Studies, Vol 144. Coastal Marine Ecosystems of Latin America (Eds. U. Seeliger and B. Kjerfve). Springer-Verlag Berlin Heidelberg.
- Heyman W.** (2001). Spawning Aggregations in Belize, The Nature Conservancy.
- Heyman W. and N. Renquena,** (2002). Status of multi-species reef fish spawning aggregations in Belize, The Nature Conservancy, Belize
- Heyman W. and N. Renquena,** (2003). Fish Spawning Aggregation Sites in the MBRS Region: Recommendations for Monitoring and Management, MBRS
- Heyman W. B., Kjerfve, R.T. Graham, K.L. Rhodes and L. Garbutt** (2005). Spawning aggregations of *Lutjanus cyanopterus* (Cuvier) on the Belize Barrier Reef over a 6 year period. Journal of Fish Biology, 67, 83-101
- IUCN 2015.** IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>. (Downloaded 2015)
- IUCN/WCMC** (1996). World Heritage Nomination – IUCN Summary: Belize Barrier Reef System (Belize).
- Jacobs, N. and A. Castenada** (1998). The Belize National Biodiversity and Action Plan. Ministry of Natural Resources and the Environment, Belize.
- Jones H. L.** (2003). Birds of Belize. University of Texas Press. ISBN: 0-292-74066-2
- Kleypas J. A.; Feely R.A., Fabry, V.J., Langdon C., Sabine C.L., Robbins L.L. (2006).** Impacts of Ocean Acidification on Coral Reefs and Other Marine Calcifiers: A Guide for Future Research. A report from a workshop sponsored by the National Science Foundation, the National Oceanic and Atmospheric Administration, and the U.S. Geological Survey

Half Moon Caye and Blue Hole Natural Monuments – Management Plan 2017-2021

Kramer P.A. and P.R. Kramer, (2002). Ecoregional Conservation Planning for the Mesoamerican Caribbean Reef, WWF, Edited by McField M.

Majil, I. (2005). Belize First Annual Report to the Inter-American Convention for the Protection and Conservation of Sea Turtles: Second Conference of the Parties, Nov 16-18, 2004 - Isla de Margarita, Venezuela

Majil I. (2007). Belize National Report, in: Dow et al. (2007) Sea Turtle Nesting in the Wider Caribbean Region ~ WIDECAST Technical Report No. 6 (National Report)

McField M.D. (2000). Influence of disturbance on coral reef community structure in Belize. Proceedings 9th International Coral Reef Symposium, Bali, Indonesia 23-27 October 2000, Vol. 1.

McField, Melanie, L. Carne, A. Thompson and V. Rosado (2010). Managing People for Healthy Reefs: An Evaluation of Visitor Impacts and the Effectiveness of Voluntary Standards for Sustainable Reef Tourism in Belize. Presentation at Belize Science to Action Symposium, February 5th, 2010.

McManus J. W. (Editor). (2001). Priorities for Caribbean Coral Reef Research: Results from an International Workshop of the National Centre for Caribbean Coral Reef Research (NCORE). October 3-5, 2001. Miami, Florida. National Center for Caribbean Coral Reef Research, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, Florida. <http://www.ncoremiami.org>

Meerman, J. C. (2005). Ecosystems Map of Belize – 2004 edition: <http://biological-diversity.info>

Ministry of Natural Resources (1998) Belize's Interim First National Report. Submitted to the Convention on Biodiversity, GoB, January, 1998

Ministry of Natural Resources (2003). National Report on Protected Areas. Government of Belize

NARMAP (1995). National Protected Areas System Plan for Belize

National Hurricane Centre. www.nhc.noaa.gov

Paz G. and T. Grimshaw, (2001). Status report on Nassau groupers for Belize, Central America., Internal report for Green Reef Environmental Institute, Ambergis Caye, Belize. pp 20

Peckol P.M., H. A. Curran, E. Y. Floyd, M. L. Robbart, B. J. Greenstein and K. L. Buckman. (2000). in J.C. Lang (ed.), Status of Coral Reefs in the western Atlantic: Results of initial Surveys,

Half Moon Caye and Blue Hole Natural Monuments – Management Plan 2017-2021

Atlantic and Gulf Rapid Reef Assessment (AGRRA) Program. Atoll Research Bulletin 496. Pp. 146-171

Platt S.G. and J.C. Meerman, (1999). Diversity, Observations, And Conservation Of The Herpetofauna Of Turneffe, Lighthouse, And Glovers Atolls, Belize. British Herpetological Society Bulletin. No.66. 1999

Richardson, R. (2009). Belize and Climate Change: The Cost of Inaction. UNDP

Rhodes K. (2007). Nassau grouper (*Epinephelus striatus*) Tagging Report, Sandbore, Northern Lighthouse Reef, Belize

Sala E, E. Ballesteros and R.M. Starr, (2001), Rapid decline of Nassau Grouper Spawning Aggregations in Belize: Fishery Management and Conservation Needs., Fisheries 26(10): 23-30

Sarteneja Alliance for Conservation and Development (2009). Sarteneja Tourism Development Plan

Shank, B.V. and L. Kaufman (2010) Are Marine Protected Areas Working? Presentation at Belize Science to Action Symposium, February 5th, 2010.

Shank, B. V. and L. Kaufman (2010). Effectiveness of marine managed areas of central and southern Belize: Spatial variations in major community processes and the implications for local management success.. Grant report for the Belize Ecological Monitoring Project: 2006 – 2009. Marine Managed Areas Science Program, Conservation International.

Smith, G. W., K. L. Eckert, and J. P. Gibson. (1992). WIDECASST Sea Turtle Recovery Action Plan for Belize. (Karen L. Eckert, Editor). CEP Technical Report No. 18. UNEP Caribbean Environment Program, Kingston, Jamaica. 86p.

Stoddart D. R (1969). Post hurricane changes on the British Honduras Reefs and Cayes. Atoll Research Bulletin. 95: 1-42

Tal Ezer, D. V. Thattai, B. Kjerfve, and W. D. Heyman (2005). On the variability of the flow along the Meso-American Barrier Reef system: a numerical model study of the influence of the Caribbean current and eddies Ocean Dynamics (2005) 55: 458–475

Tang, L., J. Sheng, B. G. Hatcher, and P. F. Sale (2006). Numerical study of circulation, dispersion, and hydrodynamic connectivity of surface waters on the Belize shelf. Journal Of Geophysical Research, Vol. 111, 2006

UNESCO (1996). 20th Session of the Convention Concerning the Protection of The World Cultural and Natural Heritage (CONF 201).

Half Moon Caye and Blue Hole Natural Monuments – Management Plan 2017-2021

Walker Z. and P. Walker (2005). National Framework for Management Planning under the National Protected Areas Policy and System Plan. Belize Forest Department.

Wantland and Pusey (1971). A guidebook for the field trip to the southern shelf of British Honduras,. October 10-13, 1971 (New Orleans: New Orleans **Geological Society**)

Westphall, Michael J. (1986). *Anatomy and History of a Ringed-Reef Complex, Belize, Central America.* Master Thesis for the University of Miami

Wilkinson, C. (ed.) (1998). Status of Coral Reefs of the World: 1998. Global Coral Reef Monitoring Network and Reef and Rainforest Research Center, Townsville, Australia.

Wilkinson, C. (ed.) (2000). Status of Coral Reefs of the World: 2000. Global Coral Reef Monitoring Network and Reef and Rainforest Research Center, Townsville, Australia.

Wilkinson, C. (ed.) (2002). Status of Coral Reefs of the World: 2002. Global Coral Reef Monitoring Network and Reef and Rainforest Research Center, Townsville, Australia.

Wilkinson, C. (ed.) (2004) Status of Coral Reefs of the World: 2004. Global Coral Reef Monitoring Network and Reef and Rainforest Research Center, Townsville, Australia.

Wilkinson, C. (ed.) (2008). Status of Coral Reefs of the World: 2008. Global Coral Reef Monitoring Network and Reef and Rainforest Research Center, Townsville, Australia.

Wilkinson, C., Souter, D. (eds) (2005) Status of Caribbean Coral Reefs After Bleaching and Hurricanes in 2005 Global Coral Reef Monitoring Network, and Reef and Rainforest Research Centre, Townsville,

World Resources Institute (2005). Belize Coastal Threat Atlas