Management Plan

Half Moon Caye Natural Monument
and
Blue Hole Natural Monument

Belize Audubon Society

2008 - 2013

OAK FOUNDATION

AVINA
Wildtracks, 2007

Half Moon Caye Natural Monument
Blue Hole Natural Monument
Management Plan 2008 - 2013

This management plan has been prepared to provide a framework for the combined management of two national protected areas – Half Moon Caye Natural Monument and Blue Hole Natural Monument. The plan was developed in consultation with the staff of Belize Audubon Society (the co-managers), stakeholders, and with input from the Forest Department. It is submitted by Belize Audubon Society to the Forest Department as per the BAS co-management agreement.

Statement of Acceptance:

I have reviewed the combined Half Moon Caye Natural Monument / Blue Hole Natural Monument Management Plan and approve the management strategies and activities for fulfilling the goals and objectives contained therein.

Minister for Natural Resources — Date
Honorable Gaspar Vega

Witness — Date
Mr. Wilbur Sabido
Chief Forest Officer

President, Belize Audubon Society — Date
Mr. Earl Green

Witness — Date
Mrs. Anna D. Hoare
Executive Director
Belize Audubon Society

Foreward...

Protected areas in Belize have great importance for its many functions to our nation thus Belizeans pride themselves with protecting over 43% of national territory albeit only 13% of the marine protected area. As the country examines the viability and sustainability of its protected areas, Belize Audubon Society continues to be one of the oldest institutional managers with a mandate to manage nine ecologically important protected areas. With the establishment and management of protected areas comes the financial and technical responsibility for nature conservation. In the ever changing world that we live in today, it is by means of the protection of natural areas that we succeed in maintaining the natural processes, biological and natural resources, evolution and special characteristics that represent the natural heritage of Belize and all other countries. It is for this reason that Belize Audubon Society is diligently working at promoting the establishment and proper maintenance of protected areas that are known to be key conservation sites which support biodiversity, ecosystems, oxygen and water recycling as well as contributing to water purification through watersheds, soil preservation, food and habitat functions. These functions can only be maintained if management of these areas occurs. Thus it is with great pride that we have formulated comprehensive management plans for Half Moon Caye Natural Monument and Blue Hole Natural Monument, two protected areas of unique features and both part of the Belize Barrier Reef Reserve System – World Heritage Site. .

In many protected areas, management plans are non-existent or too simple and may not have been adequately implemented mainly due to a lack of resources, both human and financial. This may stem from a lack of understanding of the many contributions to the socio-economic and environmental dimensions that these protected areas make. This in turn, may be a reflection of a scarcity of knowledge among users and policy makers who do not fully understand the importance of these areas and its management. Belize's protected areas need management plans to enable managers to seriously address real issues that affect sustainability. Many activities related with use of natural resources are occurring so that not only is management essential but improved management effectiveness is critical.

The combined Half Moon Caye Natural Monument and Blue Hole Natural Monument new management plan is very comprehensive and is based on specific standards for these protected areas that are managed as one unit. These protected areas are within the Lighthouse Reef Atoll, is considered one of the highest priority areas in the Mesoamerican Barrier Reef system with high biological importance, unique geological formations and the most pristine, highest percentage reef cover in Belize as WWF stated in a 2002 report. These sites are considered a unique part of our Belizean heritage with a long history and culture of use. Regionally and globally its importance is recognized through its designation by UNESCO in 1996 as two of the seven protected sites under the Belize Barrier Reef Reserve System.

Half Moon Caye Natural Monument is approximately 9700 acres of both terrestrial and marine ecosystems. This caye was first declared a protected area in 1928 as a crown reserve primarily for the protection of the large nesting colony of white phase red-footed boobies and magnificent frigate birds. In addition, the southeast beach is also a nesting site for sea turtles. Furthermore, these sites are important due to its coral and fish life density and diversity, with the south of the natural monument also being an important fish spawning aggregation as well.

The unique Blue Hole Natural Monument was designated a natural monument in 1981 and designated part of the Barrier Reef System World Heritage site system in 1996 because of its unique geological formations found within the sinkhole. This specular site has attracted divers worldwide. Both these sites provide protection for fifteen species of concern under the IUCN Red List Programme.

Wildtracks, 2007

As managers of Half Moon Caye Natural Monument and Blue Hole Natural Monument, BAS works persistently at providing on site management by way of a cadre of qualified people such as park manager, park directors, wardens, marine biologist and buffer community members involved through the local advisory committees. All these activities are addressed in this comprehensive management plan that aims at transforming into practice real meaningful and relevant conservation. The challenge at this time is to implement the management plan with the limitations in human and financial resources and all other nuances. In view of this challenge, our management plan is more inclusive of relevant stakeholders to provide meaningful management to Half Moon Caye Natural Monument and Blue Hole Natural Monument.

On this important milestone, we would like to thank all those who have been very active in the formulation of the management plan especially the Belize Audubon Staff particularly those at Half Moon Caye and Blue Hole Natural Monument, and we are grateful to AVINA and the OAK Foundation who provided the funds for this project. Our heartfelt thanks go to Paul and Zoe Walker who compiled the management plan and to all those who contributed in the production of the plan. Thank you.

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Acknowledgments

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Tour Operators of San Pedro, Caye Caulker and Belize City

Special thanks to Angela Gall for her input
And to Rachel Graham, Emma Hickerson and Nola Barker

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September, 2006
Revised, December, 2007

Section One

Introduction

1. Introduction

1.1 Background and Context

The Atlantic coast of Mesoamerica has the second longest barrier reef in the World, extending from the Yucatan in Mexico southwards to the Bay Islands in Honduras - the majority of it lying within Belize waters (WWF, 2002). With its low population and relatively low rate of coastal development, Belize is recognized for having some of the least impacted reef areas in the region, and the highest diversity of fish species (ReefBase, 2006). This is particularly so for Lighthouse Reef Atoll, one of four unique atolls in the region, lying approximately 80km east south east of Belize City.

Lighthouse Reef is considered one of the highest priority areas in the Mesoamerican Caribbean Reef system, with high biological importance, unique geological formations and the most pristine, highest percentage reef cover in Belize (WWF, 2002).Two protected areas are located within this atoll – Half Moon Caye and Blue Hole Natural Monuments, both considered important components of not only Belize's marine protected areas system, but also on a regional and international level. As such, both Natural Monuments were designated by UNESCO in 1996 as two of seven protected areas that combine to form the Belize Barrier Reef Reserve System – World Heritage Site.

Half Moon Caye Natural Monument consists of both terrestrial and marine components, within a total reserve area of approximately 9,700 acres. Located at UTM 442999; 1902099, the caye itself (currently 41.5 acres in size), was first declared as a protected area in 1928 in recognition of its importance for the large nesting colony of white-phase red-footed boobies, along with a large number of magnificent frigatebirds. The south-east facing beach on Half Moon Caye itself is also important for sea turtles - loggerhead, green and hawksbill turtles have all been recorded nesting here. In the deeper waters on the south of the protected area is one of Belize's internationally important fish spawning aggregation sites. The reef, including the spectacular wall where the atoll drops away into the depths, is highlighted for its density and diversity of both corals and fish.

Eight miles to the north, at UTM 443519; 1914493 lies the 1,023 acre Blue Hole Natural Monument, designated in 1996 to protect the geological formations found within the sinkhole – attracting 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 fifteen species of concern under the IUCN Redlist programme (Rated as Critically endangered, Endangered or Vulnerable)

Half Moon Caye and Blue Hole Natural Monuments, both designated as Natural Monuments under the National Parks System Act (1981), are managed through a co-management agreement between Belize Audubon Society and the Protected Areas office of the Forest Department of the Government of Belize. This management plan is being developed for Belize Audubon Society, as the co-management body, to guide management activities for the next five years.

1.2 Purpose and Scope of Management Plan

The management of the two protected areas is guided by their categorization as Natural Monuments (under the National Parks System Act, 1981, revised 2003), and by their designation as part of Belize's World Heritage Site. With the drafting of a comprehensive National Protected Areas Policy and System Plan, there is the possibility of re-designation to standardize with the more internationally recognized IUCN standards, with Half Moon Caye being a Category II protected area, and Blue Hole a Category III. These designations define further how the two protected areas should be managed, with the emphasis for Half Moon Caye being on ecosystem protection and recreation, whilst management of the Blue Hole is focused more towards the conservation of natural features.

The major goal of both Half Moon Caye and Blue Hole Natural Monuments is to conserve biodiversity and natural features by protecting important ecosystem, habitats, and species. This is to be achieved through:

- Providing marine species with a refuge from harvesting activities through the continued designation of both protected areas as no-take 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, juvenile rearing and feeding
- Protecting an important spawning aggregation site, to enhance reproductive capacity, particularly of commercial fish species;
- Enhancing capacity building in stakeholders for management participation, through education, public awareness and collaboration;
- Providing opportunities for scientific research in near-pristine reef conditions
- 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, an underwater sinkhole;
- Providing two well-managed tourism resources – two of the most popular dive destinations in Belize

This management plan has been developed with input from identified stakeholders, with staff input, both at management and field level; discussions with both Forest and Fisheries Department personnel; focused questionnaires targeted at the fishermen using Lighthouse Reef (particularly of Copper Bank, Chunox and Sarteneja); through participation from stakeholders in the Lighthouse Reef Threat Assessment (WCS, 2004); through input from the current lighthouse keeper; through interviews with dive boat operators and staff in both San Pedro and Caye Caulker; through interviews with tourists diving at the Blue Hole and visiting Half Moon Caye; and based on past research work conducted in the area – ranging from the original descriptive analysis of the Lighthouse Atoll by Stoddart (Stoddart, 1962) to the recent Rapid Marine Assessment conducted in 2004 (Graham et. al., 2004), additional terrestrial fieldwork conducted for this management plan, and including the output of a number of ecoregional conservation planning efforts.

The management plan is designed to guide Belize Audubon Society, the co-managers of the two protected areas, through the next five years, providing a framework for both broad management activities as well as more specific research and monitoring activities. At present, the Forest Department is the Government authority to which the management plan is to be submitted for approval, though during the course of the management plan implementation, the direct Government authority may change as the National Protected Areas Policy and System Plan is implemented, possibly leading to the formation of a separate protected areas authority.

E. Hickerson

Section Two

Current Status

2. Current Status

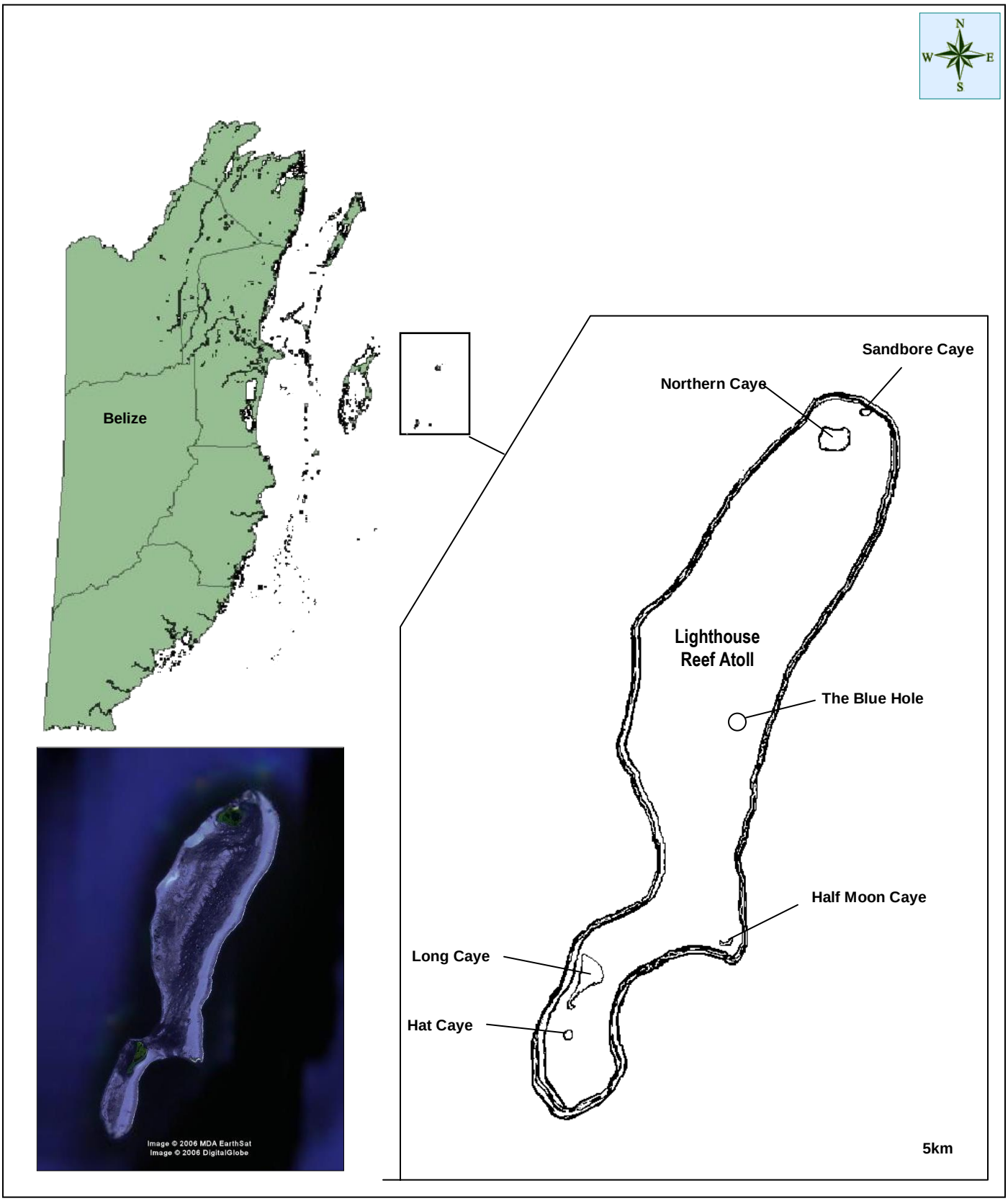
2.1 Location

Both Half Moon Caye and Blue Hole Natural Monuments are located within Lighthouse Reef Atoll, the furthest of three atolls from the shore of the Central American country of Belize (Map 1, Map 2). Lighthouse Reef Atoll is approximately 80 kilometers east-south-east of Belize City (Photograph 1). Whilst separated from the main portion of the Belize Barrier Reef, these two protected areas are considered part of this important natural resource, being two of seven protected areas included within the Belize Barrier Reef Reserve System - World Heritage Site.

Photograph 1: The three atolls of the Belize Barrier Reef (**NASA)**

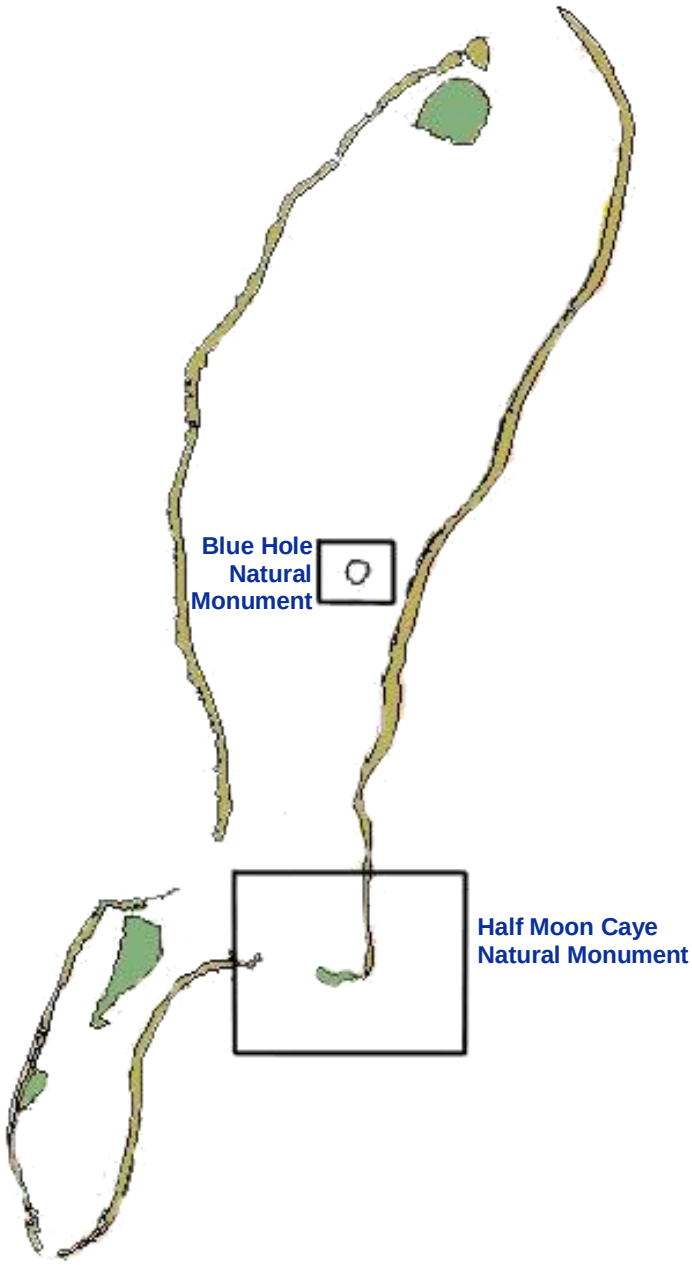
Access to both protected areas is by sea, though there is a small private airstrip associated with the Lighthouse Reef Resort, on Northern Caye, one of the other cayes within the Atoll.

The main stakeholders of the Atoll itself are the tourism and fishing industries, based on or close to the mainland. Whilst there are no communities as such within the Atoll, there are a number of tourism developments with resident employees, individual house lots, and a resident lighthouse keeper and his assistant on Half Moon Caye itself. A second lighthouse is manned on Sandbore Caye to the north. The majority of tourism is focused on day trips from Caye Caulker or San Pedro, with some tour operators based out of some of the other cayes, Belize City, and Placencia. The Atoll is also visited by live-aboard dive boats.

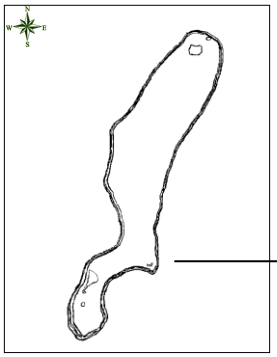


Map 1: Location of Half Moon Caye and Blue Hole Natural Monuments
Belize Base Map: BERDS (Biodiversity and Environment Resources System)
Satellite Imagery: DigitalGlobe, 2006

Map 2: Location of Half Moon Caye and Blue Hole Natural Monuments on Lighthouse Reef (ArcView)



2.1.1 Half Moon Caye Natural Monument



Map 3: Lighthouse Reef Atoll, showing location of Half Moon Caye Natural Monument

Photograph 2: Half Moon Caye (D. Hebenthal)

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 Halfmoon 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*

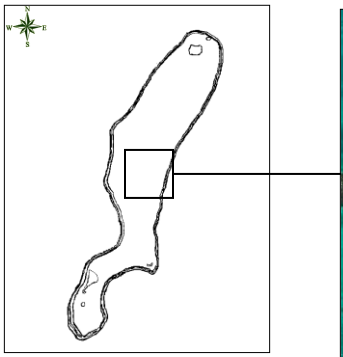
Table 1: Boundaries as defined by the Half Moon Caye Natural Monument Statutory Instrument 30 of 1982

Location	Latitude Longitude		UTM	
North West Corner	17º 14’	87º 34’	439740	1905300
North East Corner	17º 14’	87º 30’	446840	1905300
South East Corner	17º 11’	87º 30’	446840	1899800
South West Corner	17º 11’	87º 34’	439740	1899800

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 SI. A new shape file for the caye itself was also generated, using geo-referenced field data collected during the management planning process.

Half Moon Caye acts as the operational headquarters for management of both Half Moon Caye and the Blue Hole, with basic facilities for housing wardens, research accommodation, visitors’ centre 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.

2.1.2 Blue Hole Natural Monument



Map 4: Lighthouse Reef Atoll, showing location of Blue Hole Natural Monument

Photograph 3: The Blue Hole (D. Hebenthal)

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:

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

Location	UTM Coordinates	
North West Corner	442 350	1915 425
North East Corner	444 650	1915 425
South East Corner	444 650	1913 625
South West Corner	442 350	1913 625

Blue Hole Natural Monument has no visitor facilities other than the mooring buoys provided for the dive boats. Visitors generally include both Blue Hole and Half Moon Caye within their itineraries, with Half Moon Caye providing basic visitor facilities.

2.2 Regional Context

Half Moon Caye and Blue Hole Natural Monuments are both located within the Lighthouse Reef Atoll, the furthest of Belize's three atolls from the mainland, and one of only four such atolls in the Western Hemisphere. They are part of the Mesoamerican Barrier Reef System, the World's second largest barrier reef, and an assemblage of ecosystems of remarkable biodiversity and beauty, as well as of great scientific value, and importance for many species of conservation concern, among them the critically endangered hawksbill turtle (*Eretmochelys imbricata*) and goliath grouper (*Epinephelus itajara*), and the endangered green and loggerhead turtles (*Chelonia mydas* and *Caretta caretta*).

Half Moon Caye and Blue Hole are two of a serial nomination of seven sites that have been recognized as components of the Belize Barrier Reef Reserve System - World Heritage Site, as representative of the Belize Barrier Reef, under criteria (iii). based on the classic examples of fringing, barrier and atoll reef types (Table 3).

Table 3: The Seven 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)

The Mesoamerican Barrier Reef System 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 offering employment in the fishing and tourism industries to more than a million people living in coastal areas (GEF, 2001). It lies at the intersection of two regions – Central America and the Wider Caribbean - with characteristic flora and fauna from both, leading to the area being highlighted as a world biodiversity hotspot (Conservation International, 2003), as well as an ecoregional priority for conservation planning efforts (WWF, 2002).

Belize has within its waters an estimated 1,420 km² of reef - 5.5% of the reefs of the Wider Caribbean (World Resources Institute, 2004), with the lowest average incidence of coral disease in the region (Wilkinson, 2002). In 1983, Belize signed the **Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region** with the primary objective being protection of the ecosystems of the marine environment, following recognition of the regional importance of the Mesoamerican Barrier Reef System (MBRS), the majority of which lies within Belizean waters (Table 4).

More recently, 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 themselves through the Tulum Declaration in June 1997 to the development of a 15-year Action Plan – the **Mesoamerican Barrier Reef System Project** - for the conservation and sustainable use of this ecosystem. This initiative, adopted by the Heads of State in June 1999, is supported by the **Central American Commission on Environment and Development** (CCAD), which works to harmonize environmental policies within the region.

In the Wider Caribbean region, recent studies have shown that nearly two-thirds of coral reefs are threatened by human activities (World Resources Institute, 2004). One of the areas highlighted as

having the lowest impacts is Belize, with its small population and relatively low coastal development rate. Within Belize, Lighthouse Reef (including both Blue Hole and Half Moon Caye Natural Monuments), is considered one of the most pristine reef areas, being located far from the mainland, and therefore a critical component of high regional importance in the maintenance and conservation of the reef system.

Table 4: International Conventions and Agreements of Relevance to Blue Hole Natural Monument and Half Moon Caye Natural Monument

Convention on Biological Diversity (Rio de Janeiro, 1992) Ratified in 1993	To conserve biological diversity to promote the sustainable use of its components, and encourage equitable sharing of benefits arising from the utilization of natural resources ***HMCNM and BHNM provide an important and integral part in the national protected areas system, protecting biodiversity and threatened species, as per Belize's commitment under the CBD.***
Alliance for the Sustainable Development of Central America (ALIDES) (1994)	Regional alliance supporting sustainable development initiatives. ***BAS initiatives within the buffer zone communities of BHNM and HMCNM are targeted at stimulating sustainable economic and environmental development***
Central American Commission for Environment and Development (CCAD) (1989)	Regional organisation of Heads of State formed under ALIDES, responsible for the environment of Central America. Initiated Mesoamerican Biological Corridors and Mesoamerican Barrier Reef Systems Programmes. ***Data gathered through monitoring initiatives within both HMCNM and BHNM are shared regionally through MBRS.***
Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena de Indias, Colombia, 1983)	Regional convention with the objective of protecting the marine environment of the Wider Caribbean through promoting sustainable development and preventing pollution. ***HMCNM and BHNM provide an important and integral part in the national protected areas system, protecting biodiversity and threatened species, as per Belize's commitment under this Convention.***
Convention Concerning the Protection of the World Cultural and Natural Heritage (Paris, 1972)	The World Heritage Convention requires parties to take steps to identify, protect and conserve the cultural and natural heritage within their territories. ***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.***
International Convention for the Protection and Conservation of Sea Turtles for the Western Hemisphere (December 21st, 1997)	To protected and conserve sea turtle species of the Western Hemisphere ***HMCNM protects one of the few turtle nesting beaches largely unimpacted by human development.***
The UN Convention on the Law of the Sea (1982)	Establishes a comprehensive framework for issues related to the sea and directly interacts with the Convention on Biodiversity in relation to the Marine Environment. ***Lighthouse Reef Atoll is the eastern-most location in Belize, and is therefore is probably more affected by oceanic interactions than many other areas of coastal Belize***

The presence of several spawning aggregations within or adjacent to the atoll are further evidence of its importance as a breeding area for commercial fin fish species such as grouper and snapper. Half Moon Caye itself provides a nesting site for marine turtles, important to the survival of these marine reptiles within the region. But 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.

Reefs in this 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 is thought to have been caused by increasing surface water temperatures, with subsequent bleaching being registered in 2002. Whilst Lighthouse Reef has been affected, 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 reef biodiversity.

Conservation of these two Natural Monuments is also a step towards fulfilling Belize's international commitments under the **Convention on Biological Diversity**, signed in 1992, and the **International Convention for the Protection and Conservation of Sea Turtles for the Western Hemisphere**, signed in 1997 (Table 4).

2.3 National Context

As well as the national and regional importance in providing two 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 – the Blue Hole and Half Moon Caye Wall 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.

The Atoll supports national endemics such as the white-lined toadfish (*Sanopus greenfieldorum*), and it is thought that with further research, potentially unique assemblages of endemic fauna may be discovered within the Blue Hole (WWF, 2000).

2.3.1 Legal and Policy Framework

The national objectives for conservation revolve around the protection, conservation and rational use of Belize's natural resources within the context of sustainable human development. These goals are supported by the **National Strategy on Biodiversity,** through the National Biodiversity Strategy and Action Plan (Jacobs and Castaneda, 1998), one of Belize's commitments following the signing of the Convention on Biological Diversity in 1992 (later ratified by Belize in 1995). The overall goal under the Strategy on Biodiversity reflects the national objectives - ecological and economic sustainability over the long term, and recognizes the need to build both human and institutional capacity to effectively manage the biodiversity resources within Belize. It also moves towards decentralization of the management of these resources, with a strong focus on co-management partnerships such as that formed between the Ministry of Natural Resources and the Environment, Local Government and Belize Audubon Society, and on community-based participation and ownership of conservation efforts.

This is further strengthened by the National Policy on Protected Areas (NPAPSP, 2005), which was developed following a full review of the national protected areas system. It was accepted by Cabinet in January 2005, and centers around the following policy statement:

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

Also contributing to the conservation framework of Belize are a number of laws designed to protect wildlife and national heritage within Belize (Figure 1). Administered under the Forest Department are the Forest Act (1924, last revised 2000), Wildlife Protection Act (1981), and the National Parks System 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 Fisheries Act (1948), administered under the Fisheries Dept, is the principal governing legislation to regulate the fishing industry, and is directly concerned with maintaining sustainable fish stocks and protecting the marine and freshwater environments. It also provides protection for nesting turtles and nest sites. Marine turtles themselves have been given protection since the original Fisheries Ordinance in 1940. Fisheries Department, whilst not responsible for Half Moon Caye and Blue Hole, does provide a supporting role for the co-managers, especially in the enforcement of the no-take regulations of the protected areas.

National Legislation Protecting Fauna, Flora, and National Heritage

The National Parks Systems Act (1981)

Empowers government to create or maintain a "national system" of protected areas.

The Fisheries Act (1980)

Enables the Minister responsible for fisheries to declare an area as a marine reserve, within the fishing limits of Belize

The Wildlife Protection Act (1981)

"to provide for the conservation, restoration and development of wildlife, for the regulation of its use and for all other matters connected therewith"

Environmental Protection Act (1992)

"to promote the preservation and improvement of the environment, the rational use of natural resources, the control of pollution, and matters connected therein"

The Forest Act (1990)

Promotes the forestry industry, with the implementation of conservation techniques

Figure 1

The Environmental Protection Act (1992) was developed under the Department of the Environment a department of the Ministry of Natural Resources and 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 minimised.

The Port Authority has jurisdiction over the lighthouse at Half Moon Caye, being mandated to ensure the safety of navigational channels through navigational aids, including the lighthouse situated on 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.

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, governing natural resources other than wildlife. These Acts regulate activities including dredging and prospecting.

National Protected Areas System

At present, Belize has 36% of its terrestrial area and 13% of its marine area under some form of protection – either as national or nationally recognized private protected areas (NPAPSP, 2005). Both Blue Hole Natural Monument and Half Moon Caye Natural Monument were created under the National Parks System Act of 1981 (revised, 2003), two of four Natural Monuments in Belize, both managed by Belize Audubon Society under a co-management agreement with the Ministry of Natural Resources and the Environment (Figure 2).

Figure 2: Natural Monuments of Belize

Blue Hole Natural Monument
Half Moon Caye Natural Monument
Victoria Peak Natural Monument
Thousand Foot Falls Natural Monument

Within Belize, three different Government Ministries have mandates for the creation of national protected areas. The first, the Forest Department of the Ministry of Natural Resources and the Environment, is responsible for the administration of the Forest Act and National Parks System Act.

The second, the Ministry of Agriculture, Fisheries and Cooperatives is responsible for marine reserves created under the Fisheries Act. The Ministry for Tourism is responsible for the creation of Archaeological Reserves under the National Institute of Culture and History Act (Figure 3).

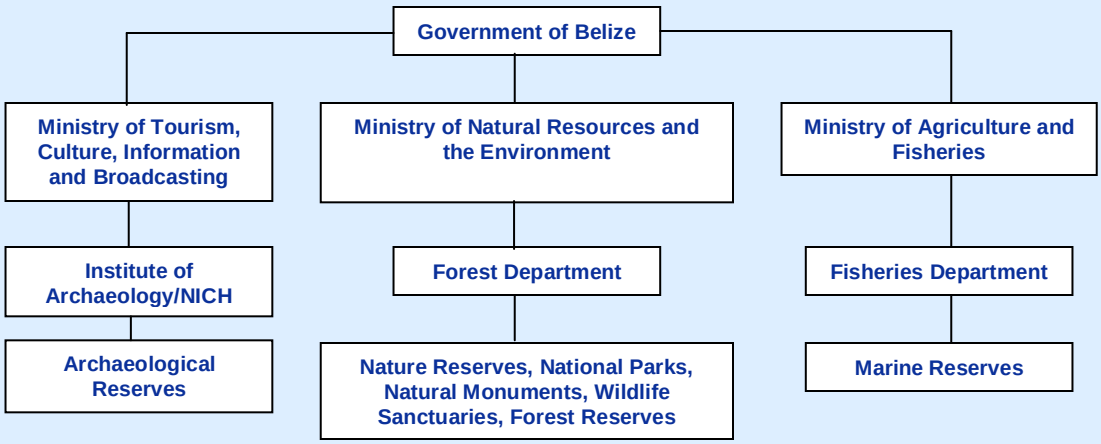


Figure 3: Government Agencies with Legal Jurisdiction over Protected Areas
(Adapted from De Vries et. al., 2003)

Blue Hole and Half Moon Caye Natural Monuments fall under the National Parks System Act, administered by the Forest Dept., and co-managed by Belize Audubon Society.

Currently, national protected areas formed under the National Parks System Act fall within five distinct categories, each protected by restrictions strictly defined by law (Table 5). Four of these (Nature Reserve, National Park, Natural Monument and Wildlife Sanctuary) provide full protection to the natural resources, with use concentrating on tourism, research and education. The fifth (Forest Reserve) is for land set aside for controlled natural resource extraction of timber and/or non-timber products, to ensure an adequate supply to the people, industries and timber trade of Belize both now and in the long term. It also recognizes the importance of tourism and environmental protection.

Table 5: Protected Areas Categories under the National Parks System Act and Forest Act

Category	Legal Foundation	Purpose	Activities Permitted
Nature Reserve	National Parks System Act, 1981	for the protection of biological communities or species, and maintain natural processes in an undisturbed state	Research, education
National Park	National Parks System Act, 1981	for the protection and preservation of natural and scenic values of national significance for the benefit and enjoyment of the general public	Research, education, tourism
Natural Monument	National Parks System Act, 1981	for the protection and preservation of natural features of national significance. Includes: ***Half Moon Caye Natural Monument*** ***Blue Hole Natural Monument***	Research, education, tourism
Wildlife Sanctuary	National Parks System Act, 1981	for the protection of nationally significant species, biotic communities or physical features.	Research, education, tourism
Forest Reserve	Forest Protection Act, 1927 Forest Act, 1990	for the protection of forests for management of timber extraction and/or the conservation of soils, watersheds and wildlife resources	Research, education, tourism, logging

A recent reassessment of protected areas and national protected area policies under the National Protected Areas Policy and System Plan, NPAPSP identifies priorities and major gaps in ecosystem representation, and seeks to strengthen current protected areas legislation, and provide greater regional and international integration.

Recognising its human and financial constraints and limitations, the Ministry of Natural Resources and the Environment has delegated management of nine of the national protected areas (including Half Moon Caye and Blue Hole Natural Monuments) to the Belize Audubon Society under a co-management agreement, revised in 2005.

Whilst the barrier reef system does not have full protected status within Belize, there are 13 marine protected areas within the system (totaling 608,742 acres) - eight of these are designated under Fisheries Department as Marine Reserves, the remaining five being under Forest Department (Table 6). In addition, 11 spawning aggregation sites have been identified and declared as marine reserves, though some of these, such as that at Half Moon Caye, already fall within protected areas. A number of these protected areas allow for general use, with some regulated extractive use, but both Blue Hole and Half Moon Caye have strict, 'no-take' non-extractive use policies. Whilst contributing only 1.8% towards the total marine protected area, the importance of Half Moon Caye and Blue Hole Natural Monuments is increased far beyond their size, through the importance of their location on the near-pristine Lighthouse Reef Atoll, and through the geological value of the Blue Hole.

Table 6: Marine Protected Areas in Belize				
Protected Area	**Mgmt. / Co-mgmt**	**IUCN Category**	**SI**	**Area (Acres)**
Bacalar Chico National Park & Marine Reserve	Forest Department Fisheries Dept.	IV	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.	IV	48 of 1998	180,508.5
Gladden Spit	Fisheries Dept. Friends of Nature	IV	95 of 2003	25,978.3
Glover's Reef Marine Reserve	Fisheries Dept.	IV	70 of 1996	86,653
Half Moon Caye Natural Monument	Forest Dept. BAS	II	30 of 1982	9,771
Hol Chan Marine Reserve	Fisheries Dept.	II	57 of 1987	3,813
Laughingbird Caye National Park	Forest Dept. Friends of Nature	II	94 of 1996	10,119
Port Honduras	Fisheries Dept. / TIDE	IV	9 of 2000	100,000
Sapodilla Caye Marine Reserve	Fisheries Dept / TASTE	IV	117 of 1996	38,594
Southwater Caye Marine Reserve	Fisheries Dept.	IV	118 of 1996	117,875
Swallow Caye Wildlife Sanctuary	Forest Dept. / FOSC	IV	102 of 2002	8,972

The Government has developed a funding mechanism to assist in management and development activities within protected areas – the Protected Areas Conservation Trust (PACT), through a 'conservation tax' of Bz$7.50 levied on non-residents as they leave the country. This fund can then be accessed by recognized protected areas managers throughout Belize (such as Belize Audubon Society) through an application and assessment process.

2.3.2 Land Tenure

Half Moon Caye and Blue Hole Natural Monuments are both national protected areas, declared as protected areas 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, Half Moon Caye has been privately owned even before 1928, when the red-footed booby colony was declared a Crown Reserve. The caye was originally divided into a number of parcels which, over time (and with the encouragement and support of BAS), were incorporated into the protected area through purchase or the cancellation of leases (Table 7).

The lighthouse and the land immediately surrounding it is owned by the Port Authority (Port Authority, pers. com., 2006)

Table 7: Historical Land Tenure of Half Moon Caye Natural Monument		
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

2.3.3 Evaluation of the Importance of the Protected Area

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, 2004; Figure 4).

Figure 4: Ecoregional Importance of the Lighthouse Reef

One of the best-developed coral atolls in Caribbean…

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 Mesoamerican Caribbean Reef (2002)

Half Moon Caye Natural Monument

Half Moon Caye Natural Monument consists of both terrestrial and marine components, important for not only the endangered species it protects (Figure 5), but also for its contribution towards sustaining fish, lobster and conch stocks for the fishing industry, and for its attraction as a tourism destination. The terrestrial component, a 41.5 acre sand and rubble caye, support possibly the only viable breeding colony of white-phase red-footed boobies in the western Caribbean (Jones, pers. com.). The marine component, approximately 9,727 acres, includes a portion of the edge of

Figure 5: Species of International Concern of HMCNM and BHNM

Critically Endangered	
Hawksbill Turtle	*Eretmochelys imbricata*
Goliath Grouper	*Epinephelus itajara*
Black Grouper	*Mycteroperca bonaci*
Endangered:	
Loggerhead Turtle	*Caretta caretta*
Green Turtle	*Chelonia mydas*
Nassau Grouper	*Epinephelus striatus*
Whale Shark	*Rhincodon typus*
Vulnerable	
Queen Triggerfish	*Balistes vetula*
Hogfish	*Lachnolaimus maximus*
Mutton Snapper	*Lutjanus analis*
Cubera Snapper	*Lutjanus cyanopterus*
Rainbow Parrotfish	*Scarus guacamaia**
Whitelined Toadfish	*Sanopus greenfieldorum***
Cerulean Warbler	*Dendroica cerulean*
American Crocodile	*Crocodylus acutus*

**May already be locally extinct at Lighthouse Reef*
***Highlighted in Ecoregional Conservation Planning for the Mesoamerican Caribbean Reef (WWF, 2004)*

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 Half Moon Wall, in the south of the protected area. Here, spur and groove coral formations harbour over 280 species of fish (Kramer and Kramer, 2002), including three vulnerable IUCN red-listed species (queen triggerfish, hogfish, and cubera snapper), the endangered loggerhead and green turtles, and the critically endangered hawksbill turtle. The rainbow parrotfish (IUCN: Vulnerable) has been recorded from the Lighthouse Reef Atoll, but not since the 1995 working expedition (BAS, 1996)

The sandy beach of the caye itself is an important nesting site for two species of marine turtle – loggerhead and green turtles, and the hawksbill turtle has been recorded from the nearby reef. The littoral forest, recognized as a severely under represented ecosystem within the 1995 National Protected Areas System Plan, and more recently under the NPAPSP gap analysis (Meerman, 2005) provides not only nesting sites for the red-footed booby and magnificent frigatebird colony, but also for white-crowned pigeons and cinnamon hummingbird, and an important waypoint for migratory birds – particularly warblers.

The littoral forest is an important habitat for the island leaf-toed gecko and Allison's anole, two lizard species of special interest because of their very restricted distributions.

Blue Hole Natural Monument

This World Heritage Site is known for its karstic structure – a large, circular sinkhole some 300m (1,000 ft) in diameter, and 125m (412 ft) in depth with vertical cliffs, and overhanging shelves supporting stalactites, formed in the Pleistocene Era, estimated at 15,000 years ago (Jones et. al. 2002),. The shallow water seagrass and reef that provide the rim of the collapsed cave system support abundant fish species, and as a no-take zone, have the potential to contribute towards the conservation of commercial species such as conch and lobster.

Like the marine component of Half Moon Caye Natural Monument, Blue Hole Natural monument is also important in protecting marine resources, and 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, and possibly provide evidence of long-term climate change, mercury and arsenic fluctuations and deposition from African dust clouds (US Geological Survey, 2001).

It has also been highlighted within the WWF Ecoregional planning for the possibility of harbouring a "unique assemblage of endemic and cryptic species" within the Blue Hole itself (WWF, 2004), though until specific research can take place to investigate the fauna of the Blue Hole, this remains an unknown.

As a national tourism resource, the Blue Hole is one of the best known tourism destinations within Belize, bringing divers from all over the world. Diving the Blue Hole is considered a necessity for any committed diver, bringing benefits to the tourism industry in Belize as a whole.

Beyond the Protected Areas

The open sea to the east of Lighthouse Reef has been highlighted as an under-represented ecosystem within the National Protected Areas System Plan (NPAPSP, 2005), with recommendations that the area identified in the NPASP be protected under the National Protected Areas System. 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. This opportunity has been dealt with under the Natural Resource Management Programme, Activity A87 and A88. Inclusion of this area within the management scope of the Lighthouse Reef conservation areas would require revision of the existing management plan as an adaptive management requirement.

Environmental Services of the Protected Areas

Other than the specific values of the protected areas, the coral reef and seagrass ecosystems present in the two protected areas also provides various ecosystem services:

Table 8: Ecosystem Services of the Blue Hole and Half Moon Caye Natural Monuments	
Regulation	Protection of beaches within the atoll, the main barrier reef itself, and the coastline from storm surges and waves
	A reduction of beach erosion on cayes within the atoll, on the main barrier reef itself, and the coastline
	Providing coral, a major component in the formation of beaches and cayes
	Seagrass plays an important role in stabilizing the substrate and settling turbidity in the water
Recruitment	Whilst the coral reef within the protected areas themselves are no-take zones, they ensure that there are viable populations of commercial species for subsistence and commercial fishing
Cultural	Coral reefs in both protected areas are important resources for tourism and recreation
	Aesthetic appreciation
Support	Coral reefs play an important role in the cycling of nutrients
	Coral reefs and seagrass beds within the protected areas 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
Adapted from UNEP-WCMC, 2006	

2.3.4 Socio Economic Context

National: Belize is a country of many ethnic cultures, with Mestizo, Creole, Maya and Garifuna being the major population groups (CSO, 2002, Figure 6). The original Maya occupants are subdivided into three ethnic groups – the Yucatec Maya of the north, the Mopan Maya of the west and south, and the Ketchi of the southern regions. Belize has a low population currently estimated at approximately 282,600, of which 52% are urban dwellers (CSO, 2004) (Figure 7). Population densities are low, with 12.3 persons per sq. km., concentrated mostly within the coastal plain, Belize Valley and Stann Creek Valley, with much of the remaining country being less suited to human habitation, with waterlogged soils in the coastal plains and steep terrain in the Maya Mountains.

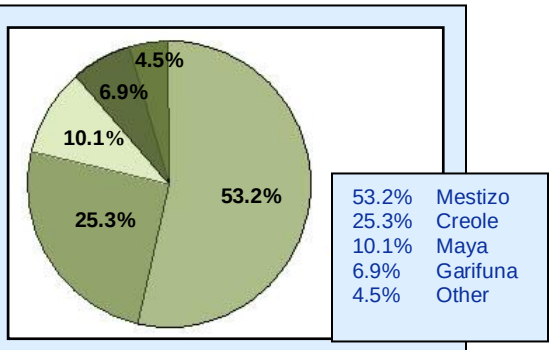


Figure 6: Ethnic Groups of Belize

There is an ongoing emigration of Belizeans to the United States – generally those from urban areas who have completed secondary school or have professional training. There is also a significant influx of Central American refugees – primarily from Guatemala and Honduras - contributing approximately 13% towards the total population of Belize and resulting in the relatively high population growth rate of 2.7%. At the present rate of immigration, it has been calculated that the population of Belize will double in twenty-six years, with much of this immigrant sector tending to be rural-based with low levels of education, placing far greater stress on the natural resources than currently exists.

Figure 7: Belize Demographic Statistics

Population estimate (2004)	282,600
Annual growth rate (2003)	2.4% (1975-2003)
Below Poverty level (2002)	33.5%
Literacy rate (2002)	94%
Per capita GDP (2003)	US$3611.5

Ref: CSO 2000 Census
CSO 2004
Ministry of Health
World Resources Institute, 2002
Living Standards Measurement Survey, 2002
FAO, 2005
www.hdr.undp.org, 2006

Figure 8: The Belize Economy (Exports and Imports) - 2002

Exports	US$290 million	Sugar, bananas, citrus, clothing, fish products, molasses, wood
Imports	US$430 million	Machinery and transportation equipment, manufactured goods; food, beverages, tobacco; fuels, chemicals, pharmaceuticals

Whilst Belize as a whole has been based largely on agriculture, with banana, sugar and citrus (Figure 8), the economy of coastal communities in Belize has been closely linked with the coral reef, with lobster, conch, finfish and shrimp providing income generation. These four fisheries products contribute significantly to the economy of Belize, providing 5% of Belize's national GDP in 2003 (CSO, 2004), with exports valued at Bze$106.8 million (Bz$84.3 million of this contributed by farmed shrimp) (Fisheries Department, 2004).

The fishing sector utilizing Lighthouse Reef is part of an artisanal industry that provides direct employment for over 3,000 people (McConney et. al., 2003). It is nationally comprised of 1,672 active fishermen and 552 sail boats (FAO, 2005), that fish primarily in the shallow protected waters of the Belize Barrier Reef. The majority of the Lighthouse Reef fishermen originate from the three northern mestizo communities of Copper Bank, Sarteneja and Chunox, with a small number of fishermen from Belize City. These fishermen free-dive primarily for Spiny Lobster (*Panulirus argus*) and Queen Conch (*Strombus gigas*), both of which have declined since the early 1980's, when the industry was at its peak. 90% of the lobster and conch is exported through the four fishing cooperatives, the remaining 10%, and the majority of the finfish, being sold for local consumption. Fishermen tend to be between 15 and 35 years of age, often with limited

education, leaving primary school to go directly into fishing (FAO, 2005). Alternative job opportunities within these coastal communities are limited, with few options.

There is also an increasing national reliance on the developing tourism industry, one of the fastest growing sectors in Belize, and rapidly becoming the major foreign exchange earner, with over 1 million tourists arriving in Belize in 2003. The majority of visitors to Lighthouse Reef Atoll are divers, arriving daily on dive boats primarily from San Pedro, Caye Caulker, Belize City or Turneffe Caye. Blue Hole and Half Moon Caye Natural Monuments are two of the most visited protected areas in Belize, with almost 10,000 visitors in 2004 (Figure 9, BAS, 2005). On Lighthouse Reef Atoll, two of the four cayes (Northern Caye and Long Caye) have tourism developments such as Lighthouse Reef Lodge (currently being renovated), either planned or in the process of being constructed/renovated,

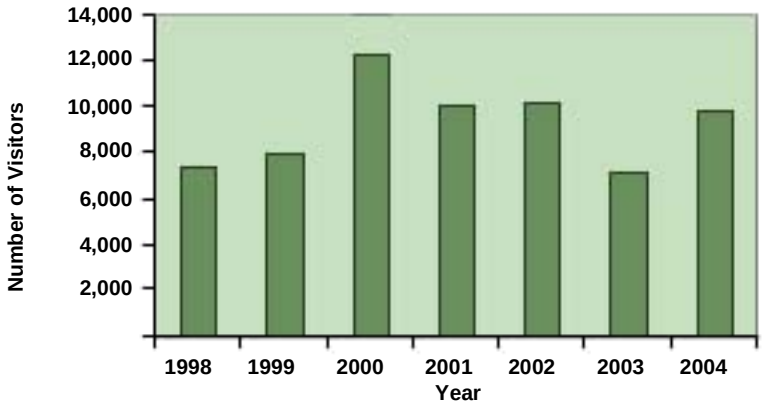


Figure 9: Tourism visitation to Halfmoon Caye (BAS, 2005)

A number of communities have been highlighted as being major stakeholders in the two protected areas, through fishing or tourism (Table 9), and a stakeholder analysis identifies other stakeholder interests and impacts (Table 10).

Table 9: Stakeholder Communities of Half Moon Caye and Blue Hole Natural Monuments

Community	Location (UTM) Distance (km)	Population (approx.)	Population components	Comments
Sarteneja	E16 0378750 N18 2029500 (Approx. 142 km NW)	2,300*	Mestizo	Largest fishing community, concentrating on lobster and conch throughout Belize waters
Chunox	E16 0356500 N18 2023500 (Approx. 149 km NW)	1,443**	Mestizo	Small number of fishing boats, focused on Lighthouse Reef Atoll
Copper Bank	E16 0356700 N18 2026020 (Approx. 151 km NW)		Mestizo	Small number of fishing boats, focused on Lighthouse Reef Atoll. Largest number of fishermen utilizing natural resources of Lighthouse Reef.
San Pedro	E16 0398200 N18 1981250 (Approx. 90 km NW)	4,499**	Mestizo	Tourism destination, 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)	742**	Mestizo	Tourism destination, embarkation point for some visitors to Half Moon Caye and Blue Hole Natural Monuments
Belize City	E16 373850 N19 35160 (Approx. 76km NW)	59,400***	Multi-cultural	Main port and population centre. Tour operators and fishermen using Lighthouse Reef

*** Sarteneja Health Committee, 2005; ** CSO Census data, 2000; *** CSO, 2004**

Table 10: Stakeholder Analysis for Half Moon Caye / Blue Hole Natural Monuments				
Stakeholder	**Influence or Impact of Half Moon Caye / Blue Hole Natural Monuments on Stakeholder**		**Influence or Impact of Stakeholder on Half Moon Caye / Blue Hole Natural Monuments**	
Community Stakeholder Type (I)* Sarteneja, Chunox and Copper Bank	• Protection of conch nursery area, particularly within Half Moon Caye Natural Monument, increasing conch availability • Protection of fish and lobster resources within Half Moon Caye and Blue Hole Natural Monuments, ensuring continued viability of fishery • Exclusion from traditional fishing areas	+ + -	• Low level of cooperation or openly antagonistic towards protected areas and BAS • Illegal fishing within protected areas • Fishing impacts within protected areas (including damage to coral) • Anchor damage to reef	- - - -
Community Stakeholder Type (II)* San Pedro and Caye Caulker	• Income from tour operations using the Natural Monuments as a tourism resource • Income from tour guiding • Income from operation of other tourism associated activities – restaurants, hotels, taxis etc. • Employment opportunities associated with tourism • Exclusion from fishing areas	+ + + + -	• Largely support the conservation goals of the protected areas • Largely cooperate with conservation objectives of the protected areas • Provide marketing, and bring visitors to the two protected areas, increasing sustainability • Provide facilities and transport to facilitate visitation to the protected areas	+ + + +
Tour Guides (including tour boat captains)	• Benefit from having Half Moon Caye and Blue Hole Natural Monuments as a major venue for dive-associated tourism • Income from using the two protected areas for tours	+ +	• Support the conservation goals of Half Moon Caye and Blue Hole Natural Monuments • Provide interpretation for visitors, facilitating overall visitor appreciation • If well trained, assist with visitor management within the protected areas through in-depth briefings • If poorly trained, can result in poor visitor management and increased impact on corals and associated fauna, anchor damage etc. • Impact behaviour of fish through feeding (including sharks)	+ + + - –
Local / National Tour Operators	• Benefit from having Half Moon Caye and Blue Hole Natural Monuments as a major venue for dive-associated tourism • Income from using the two protected areas for tours	+ +	• Provide marketing at a national level, and send visitors to the protected areas, increasing sustainability • Support the conservation goals of Half Moon Caye and Blue Hole Natural Monuments • Increase the potential for exceeding the carrying capacity of the protected area	+ + -
International Tour Operators	• Benefit from having Half Moon Caye and Blue Hole Natural Monuments as a major venue for dive-associated tourism • Income from using the two protected areas for tours	+ +	• Provide marketing at an international level, and send visitors to the protected areas, increasing sustainability • Support the conservation goals of Half Moon Caye and Blue Hole Natural Monuments	+ +
Hotels	• Benefit from having Half Moon Caye and Blue Hole Natural Monuments as a major tourism venue, attracting visitors to the area	+	• Provide marketing of the two protected areas to clients • Support the conservation goals of Half Moon Caye and Blue Hole Natural Monuments	+ +

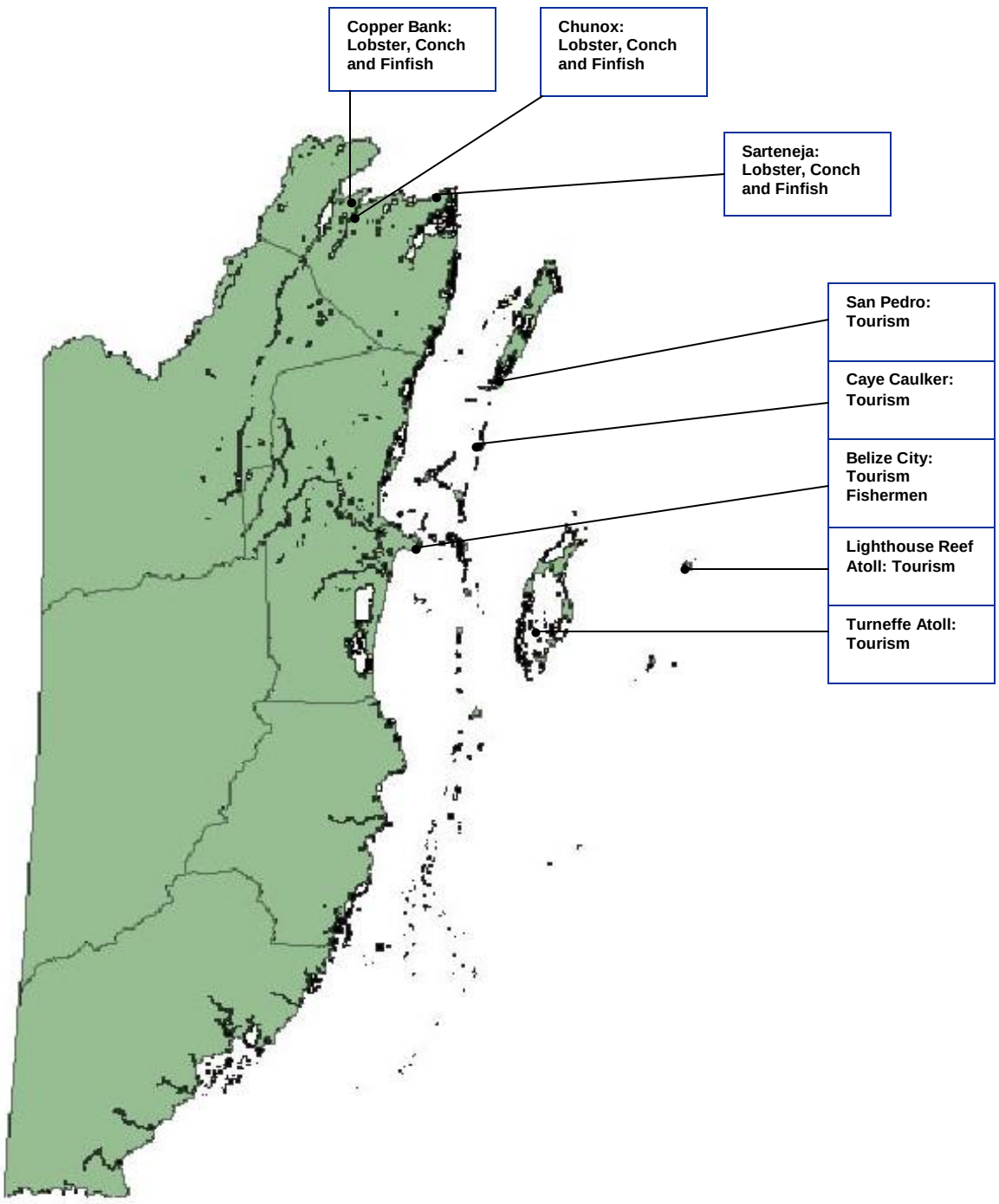
+ Positive Impact **-** Negative Impact

***Stakeholder Community Type (I):** Predominantly fishing community that utilizes Lighthouse Reef for its fish resources (Sarteneja, Chunox and Copper Bank)

Stakeholder Community Type (II): Predominantly tourism-based community, utilizing Lighthouse Reef for it tourism resources (San Pedro and Caye Caulker)

Table 10: Stakeholder Analysis for Half Moon Caye / Blue Hole Natural Monuments (cont.)				
Stakeholder	**Influence or Impact of Half Moon Caye / Blue Hole Natural Monuments on Stakeholder**		**Influence or Impact of Stakeholder on Half Moon Caye / Blue Hole Natural Monuments**	
BTIA	• Benefit from having Half Moon Caye and Blue Hole Natural Monuments as a major tourism venue, attracting visitors to the area	+	• Providing national and international marketing of HMCNM and BHNM • Support the conservation goals of HMCNM and BHNM	+ +
Visitors: Tourists	• Enjoy Half Moon Caye and Blue Hole Natural Monuments as a tourism destination • Benefit from education and awareness opportunities	+ +	• Entrance fee contributes towards the goal of sustainability • Provide marketing nationally and internationally by word of mouth, if happy with level of product • Presence deters fishing (and other illegal activities) within protected areas • Buy gifts and use facilities in Community Stakeholders type (II) • Negatively impact marine and terrestrial environments • Have a negative impact on wildlife behaviour – especially fish	+ + + + - -
Visitors: Researchers	• Benefit from being linked to protected areas, with support structure • Benefit from information on past research activities within protected areas	+ + + +	• Benefit from data gathered, greater knowledge of marine and terrestrial environments and species within area • Benefit from increased activity within area, assisting against illegal fishing activities • Possible impact of research activities on terrestrial / marine environments	+ + -
Visitors: Volunteers/Interns/ Expedition Groups	• Enjoy Half Moon Caye and Blue Hole Natural Monuments as a tourism destination • Benefit from education and awareness opportunities • Benefit from an adventurous site for project activities • Benefit from worthwhile project activities	+ + + +	• Provide a volunteer workforce for construction and maintenance projects requiring unskilled labour • Help raise awareness and profile of HMCNM and BHNM in country of origin • Large groups will negatively impact the fragile marine ecosystem and nesting birds during nesting season if not carefully controlled • Large, poorly managed groups may exhibit loud and anti-social behaviour to the detriment of enjoyment of other visitors • May impact water availability and quality – washing detergent for dishes clothes, personal hygiene, leaching into water table, and increase in sewage	+ + - - - -
Live-aboard Companies	• Benefit from protection of Half Moon Caye and Blue Hole Natural Monuments and their value as tourist attractions • Benefit from ability to moor in proximity to HMCNM / BHNM	+ +	• Support the conservation goals of HMCNM and BHNM • Impacts of sewage and detergent, bilge water. grey water and oil • Larger engines, so greater impacts of sedimentation and on mooring sites; Visual impact of larger vessels	+ - - -
Resorts of Lighthouse Reef Atoll	• Benefit from proximity to Half Moon Caye and Blue Hole Natural Monuments	+	• Support the conservation goals of HMCNM and BHNM • Providing marketing of HMCNM and BHNM at both national and international level • Impacts from potential dredging activities • Impact fish populations through mangrove clearance • Impacts of inadequate sewage disposal, grey water and detergents, possible impacts of insecticides • Impacts of run-off following land clearance, and associated sedimentation	+ + – – – –

Table 10: Stakeholder Analysis for Half Moon Caye / Blue Hole Natural Monuments (cont.)				
Stakeholder	**Influence or Impact of Half Moon Caye / Blue Hole Natural Monuments on Stakeholder**		**Influence or Impact of Stakeholder on Half Moon Caye / Blue Hole Natural Monuments**	
BAS Members	• A feeling of contribution and ownership towards biodiversity conservation	+	• Supportive of Half Moon Caye and Blue Hole Natural Monuments conservation objectives, and of BAS	+
General Belize Public (excluding primary stakeholder communities)	• Maintenance of fish, lobster and conch stocks • Environmental services • Cultural and aesthetic appreciation • Increased awareness through education	+ +		
Port Authority	• Liaison with BAS for assistance with logistics in maintaining lighthouse, lighthouse keeper and lighthouse keeper's assistant	+	• Lighthouse prevents accidental groundings of vessels in adjacent shipping lane • Lighthouse keeper harvests coconuts, preventing germination in some areas • Lighthouse keeper actively replants coconuts in some inappropriate areas, negatively impacting regeneration of littoral forest • Lighthouse keeper's assistant observed fishing commercially within Half Moon Caye Natural Monument (R. Graham, pers. com.). Using Half Moon Caye as a base for commercial fish operations	+ + – –
Protected Areas Conservation Trust	• Two of the protected areas within the National Protected Areas System that Pact was established to support		• Has financially contributed to enabling an improved level of management effectiveness through evaluated projects	
Government of Belize	• Blue Hole and Half Moon Caye Natural Monuments included within the National Protected Areas System Plan • Assists in demonstrating Belize Government's commitment to the conservation of natural resources, CCAD, CBD, MBRS, and national World Heritage sites • Income generation – these two protected areas attract visitors to Belize, and significant foreign revenue • Provides employment opportunities in stakeholder communities • Environmental services • Provides fisheries management through no-take regulations	+ + + + + +	• Political support (currently being strengthened through the NPAPSP) • Uncertainty of long term future commitment	+ -



Map 5: Principal Stakeholder Communities of Half Moon Caye and Blue Hole Natural Monuments
Belize Base Map: BERDS (Biodiversity and Environment Resources System)

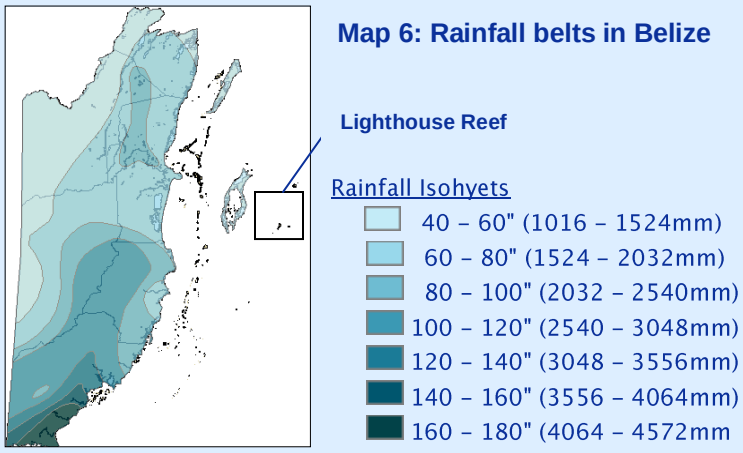
2.4 Physical Characteristics

2.4.1 Climate

Belize lies within the outer tropical geographical belt - the relatively high temperature and rainfall patterns associated with the tropics are one of the factors that promote and sustain the high levels of biodiversity within the region.

Rainfall

Lighthouse Reef Atoll is the most easterly of the three atolls of Belize, and is estimated to receive approximately the same rainfall as the coastal region adjacent to and including Belize City (Stoddart, 1962) - between 1524 – 2032mm (60" and 80") a year (Map 6). Rainfall data from Carrie Bow Cay, approximately 50km to the south west, suggests that rainfall may be higher, with an average rainfall of 2702mm (Caribbean Coral Reef Ecosystems Program, 2005; Figure 10).



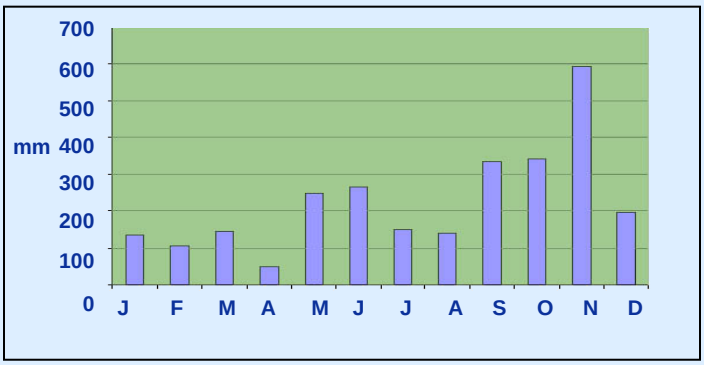


Figure 10: Rainfall

Rainfall varies throughout the year, with the highest rainfall occurring between June and December, peaking in November at 594mm, during the tropical storm season. The dry season has minimum rainfall levels of 47mm, recorded in April.

Carrie Bow Cay, 2002 - 2004

Data Source: Map 5: Map from BERDS (Biodiversity and Environmental Resource Data System)
Figure 10: Rainfall Data from Carrie Bow Cay, 2002 - 2004.

There is a pronounced dry season stretching from January through to the end of April, with minimum monthly rainfall of as low as 47mm in April, the driest month. This is followed by a wetter season (May to December with maximum monthly rainfalls in the region of 300 and 600mm, punctuated by a mini dry season in July/August. The majority of the rain falls within the

hurricane season, associated with passing tropical storms (particularly between September and November; Figure 10).

Temperature

Whilst no records have been forthcoming for Half Moon Caye itself, temperatures can be expected to follow the same patterns as other adjacent, such as Glovers Reef Atoll and Carrie Bow Cay (Tobacco Reef). Lying within the subtropics, annual temperatures on Carrie Bow Cay, slightly further south, average 27.1ºC, fluctuating throughout the year from a minimum of 23.5 ºC in January, during the cold fronts, and a maximum in September of 29.2 ºC (Figure 11; Table 11; Caribbean Coral Reef Ecosystems Program, 2005)

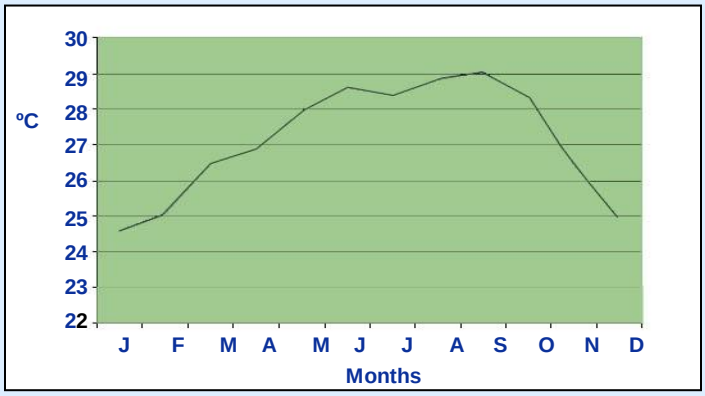


Figure 11: Mean Monthly Temperature, Carrie Bow Cay, 2002 - 2004

Month	Mean Temperature ºC 2002 - 2004	Mean Total Rainfall (mm) 2002 - 2004
January	24.61	136
February	25.08	106
March	26.47	146
April	26.88	47
May	27.96	248
June	28.60	264
July	28.39	149
August	28.83	140
September	29.06	334
October	28.30	342
November	26.45	594
December	24.95	196

Table 11: Mean Monthly Temperature and Rainfall, Carrie Bow Cay, 2002 - 2004

Data Source: Graph 4, Table 11: Caribbean Coral Reef Ecosystems Program, 2005: Carrie Bow Cay Meteorological Records, 2002 - 2004

Weather Systems

Belize is affected by three very distinct seasonal weather systems:

- ***Trade Winds*** – the predominant winds, blowing from the east and north-east
- ***Northers*** - high-pressure fronts moving down from the north, occurring between October and April
- ***Tropical Storms*** - occurring between June and November, originating in the mid-Atlantic

All three have an influence on the rainfall and temperature patterns, on the sea level, and on the currents around the Lighthouse Reef Atoll itself.

Tropical Storms

Tropical storms affect Belize every year, with the effects being felt particularly strongly on the 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, gathering strength until they hit land.

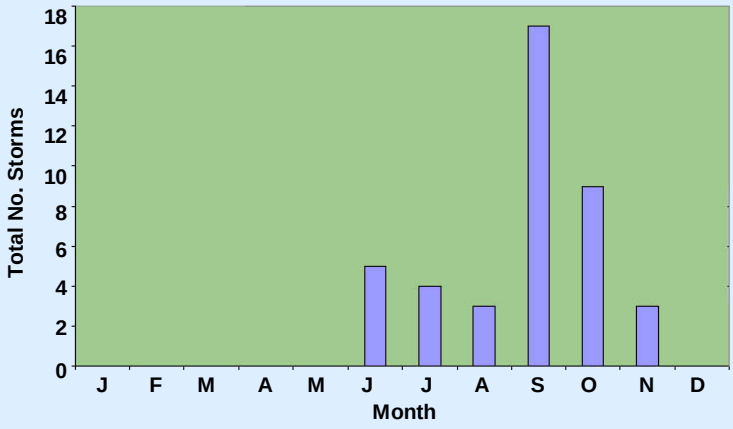
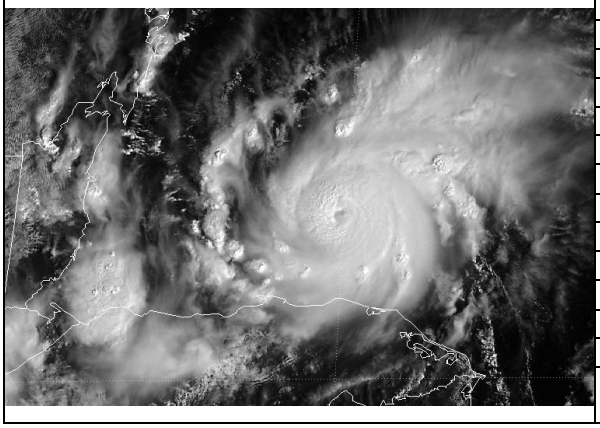


Figure 12: Tropical Storm frequency per month, from 1889 – 2000, making landfall in Belize

Data Source: National Meteorological Service of Belize, 2005. Data from 1889 - 2000

Whilst many hurricanes have a very focused path 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 12). 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 and the turbidity experienced after indicates the effects even distant hurricanes can have on the outer atolls, as they pass through the Caribbean Sea towards the Yucatan channel.

Table 12: Hurricanes Affecting Half Moon caye and Blue Hole Natural Monuments



Name	Year	Date Passed LHR
Unknown	1931	
Abby	1960	14th July
Anna	1961	23rd July
Hattie	1961	30th October
Edith (Tropical Storm)	1971	10th September
Fifi	1974	19th September
Greta	1978	19th September
Kyle (Tropical Storm)	1996	11th October
Mitch	1998	27th October
Keith	2000	30th October
Iris	2001	8th October
Ivan	2004	12th September

Photograph 4: Hurricane Iris
GOES Project, NASA-GSFC 14:45 UTC 8 October 2001


5


6


7


8

Half Moon Caye itself has been shaped and reshaped by hurricanes in the past. Direct effects include the storm surge that is associated with these events, with a local rise in sea level of several feet washing over the Caye, as described for both Hurricane 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 and contaminate ground water with salt. The strong wave action during hurricanes also results in erosion and 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) – it is now being undermined by wave action, suggesting substantial erosion of the beach. Erosion by the 1931 hurricane not only destroyed the beach, but also exposed the bedrock that can be seen today (Stoddart, 1962; Photographs 5 and 6). In 2004, during Hurricane Ivan, strong storm waves deposited a thick layer of coral rubble on the turtle nesting beach, preventing successful hatching (Photographs 7 and 8).

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.

Top to Bottom

Photographs 5 and 6: The exposed bedrock of the south east facing beach (Photo. 6: A. Gall)
Photograph 7: The sand cover of the south east facing turtle nesting beach, June 2004
Photograph 8: The same beach in December 2004, after Hurricane Ivan, showing the piled coral rubble (R. Graham)

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).

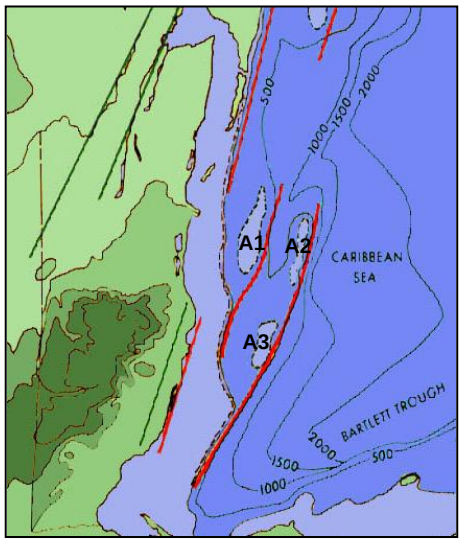
There is some debate on the effects of hurricanes on coral communities – coral reefs are considered to be relatively robust, until recently being capable of withstanding long-term change, with the ability to recover relatively rapidly from natural disturbances such as hurricanes. Studies in Honduras suggest that hurricanes cause complex impacts that may be both positive and negative (Halley, 2001). In some studies, devastation of the reef has been found to be very localized, and concentrated mainly in the reef crest areas, in the direct line of approach of the storm, with the back-reef and patch reefs of the lagoon showing less impact. Some theories suggest that storms remove much of the dead coral, assisting in the regeneration of the reef, and even helping to maintain the high biodiversity of the ecosystem. Mechanical damage to branching corals is also thought to disperse coral, seeding new colonies in areas where the fragments settle. Other theories suggest that hurricanes, which bring a cooler, deeper oceanic water influx onto the reef, may help mitigate coral bleaching by lowering the surface temperature of the water – Hurricane Mitch in 1998 is thought to have locally reduced the high water temperatures found elsewhere in the Caribbean by 4°C, resulting in a reduced incidence of coral bleaching around the Bay Islands, in comparison with other reef areas (Halley, 2001). Half Moon Caye, too, felt the effects of Hurricane Mitch, and may have had similar benefits, the incidence of coral bleaching being relatively low (Graham et. al., 2004).

The hurricanes and other tropical storms do, however, also have many negative impacts. Even distant hurricanes can cause high sedimentation levels, which can take many weeks to clear – effects from Hurricane Ivan in 2004 were still visible weeks later (Walker, pers. obs., Forman, pers. com.), as was the increase in turbidity at Hol Chan Marine Reserve after Hurricane Wilma, in 2005. This is thought to lead to greater stress on corals, making them more vulnerable to disease. The large storm waves of Hurricane Mitch in 1998 were shown to have a significant impact on the southern reefs of Belize (Bood, 2001), degrading reefs throughout the area through mechanical damage, with boulder corals being rolled out of place, and the fragmentation of elkhorn corals.

Hurricanes are seen as necessary natural phenomenon that have shaped the reefs throughout their existence. The current increasing human impacts seen on the reef (through overfishing, development, sedimentation, nutrient runoff, and pollution), are however placing increased stress on the resilience and recuperative powers of this ecosystem. These stresses, along with the increasing frequency of more destructive hurricanes, El Nino events, and the increasing incidence of coral bleaching, caused by elevated surface water temperatures (both attributed by many to climate change, associated with global warming), have caused significant reduction of healthy reef throughout the Caribbean and worldwide.

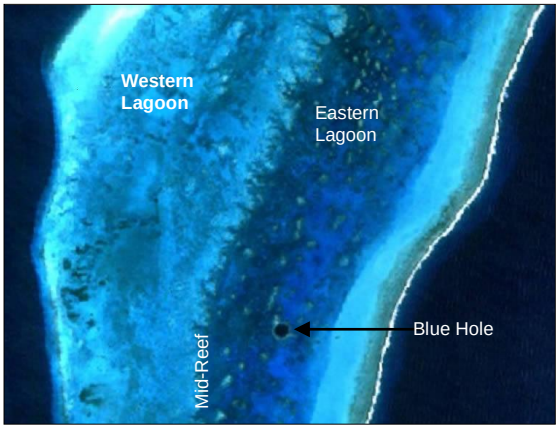
2.4.2 Geology and Atoll Structure

The main Barrier Reef sits on top of a prominent northeast-southwest fault, running parallel to the coast of Belize. A series of tilted submarine escarpments (major fault blocks caused as a result of the eastward subsidence of the Bartlett Trough during the Pliocene (Map 7)), have resulted in the development of three offshore atolls – two of these (Lighthouse Reef and Glover's Reef) being located on the third, most easterly escarpment furthest from the mainland. These two atolls are thought to have been formed in areas where limestone build-up has been at a rate equal to or greater than the subsidence caused by the movement on the faults, resulting in the formation of carbonate platforms surrounded by water that gets progressively deeper to the east, reaching 4000m.



Map 7: Fault and escarpment lines in Belize

Lighthouse Reef Atoll is the smallest of the three atolls of Belize, covering approximately 200km², being 35km long and up to 7.5km wide, with a coral grainstone and coral--red algae-Halimeda grainstone rim, enclosing a lagoon area of 112km². 2.9% of the area is land – with six sandy cayes within the atoll 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 appears to no longer exists.



Photograph 9: Section of Lighthouse Reef Atoll, showing the Blue Hole, and the linear middle reef separating the western and eastern lagoons

Evidence of the past tectonic activity that has given rise to the major fault blocks can be seen in the north-north-east trend alignment of the two atolls, and of the almost 20km long chain of 'middle reef' patch reefs of the Lighthouse Reef lagoon (Photograph 9), which 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. The lagoon floor itself is covered by patches of seagrass (*Thalassia testudinum, Syringodium filiforme)* and calcareous algae *(Penicillus sp., Halimeda sp., Udotea sp., Caulerpa* sp.), with patch reefs aligned along the middle reef.

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 14, overleaf). Development of the Atoll since then has been driven primarily by the eustatic rise in sea level.

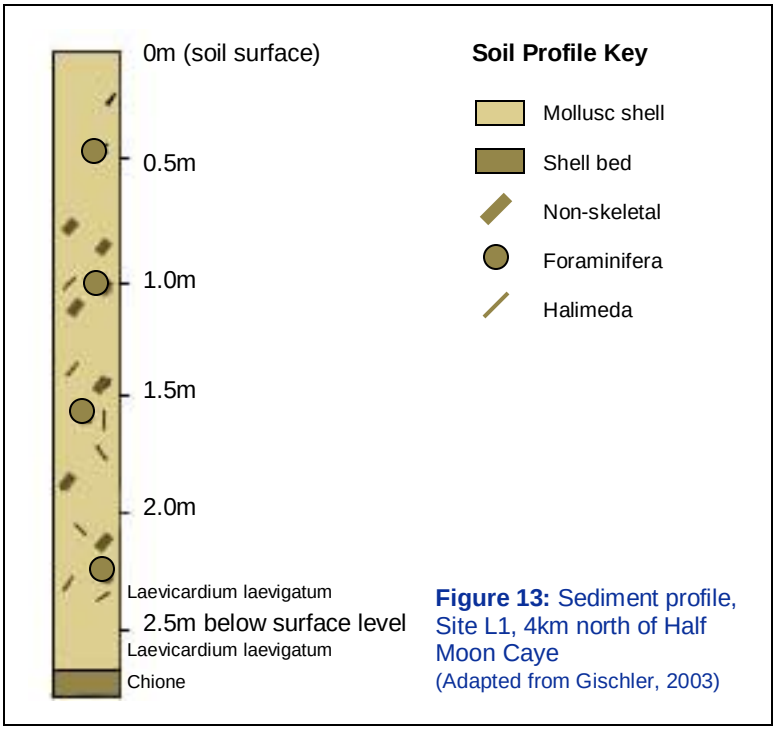
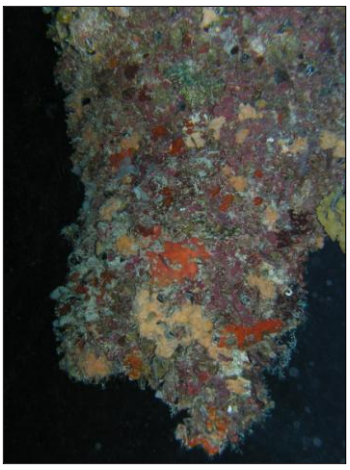


Figure 13: Sediment profile, Site L1, 4km north of Half Moon Caye
(Adapted from Gischler, 2003)

Sediment core analysis shows that the facies distribution within the lagoon is strongly asymmetrical. A sample taken approximately 4km north of Half Moon Caye, in the deeper eastern lagoon, gives an indication of the more recent geological history, with sediment formed from mollusc and foraminifera -*Halimeda* wackestone-packstone facies (grain-supported carbonate rock), to a depth of approximately 3m (Figure 13; Table 13; Gischler et. al., 2003).

Unlike the eastern lagoon, the western lagoon has a mixed peloidal/skeletal wackestone to grainstone facies, with no mud content.

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, and of a southward tectonic tilt during the Pleistocene, as indicated by the spiral patterning and tilting of many of the stalactites within the Hole. The presence of the Blue Hole, with sunken caves in its walls, and the numerous stalactites (Photograph 10), 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 once 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 tilting of the formations to an angle of 12° indicated by the lean on those stalactites formed before this event. More recent stalactites show the 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 during the period 11,500 to 10,200 BP, with a steady increase in sea level during recent geological time, inundating the Atoll with sea water (Jones et. al., 2000).



Photograph 10: Blue Hole stalactite
Photograph: E. Hickerson

Figure 14: Geological Development of Lighthouse Reef Atoll

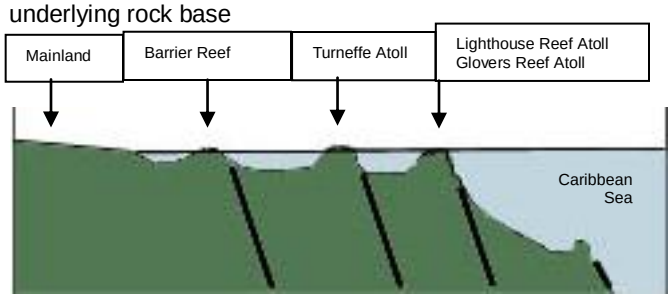
Time Period		
11- 75 million years ago or more ***Late Cretaceous – Early Tertiary tectonic activity***	Formation of the ridges on which the barrier reef and atolls will develop, through uplifting and faulting. Palaeozoic meta-sediments and meta-volcanics form the underlying rock base 	
8,000 years ago ***Water level 15m below current sea level***		Lighthouse Reef Atoll would have been a limestone island fringed by coral reef.
7,000 years ago ***Water level 10m below current sea level***		During the Holocene era, rising sea level led to the inundation of the central, lower channel, formed by the slipping of the north-north-east fault line. In this area, the increased salt content of the soil led to the establishment of mangroves, with increasing mangrove dominance with increasing inundation.
6,000 years ago ***Water level 7m below current sea level***		Increasing water depth leads to the formation of a mangrove-rimmed lagoon, with extensive *Halimeda* growth. The western portion of the Atoll is inundated, and dominated by mangroves
5,000 years ago ***Water level 5m below current sea level***		With sea levels rising to within 5m of current levels, the mangrove area is diminished, the central lagoon deepens, and coral reef begins to colonies the outer rims.
4,000 years ago ***Water level 3.5m below current sea level***		Much of the Atoll is flooded, and more closely resembles the Lighthouse Reef we know today. The remaining mangrove areas become gradually more inundated, leaving only the mangrove and sand cayes we see today.
Present ***Current sea level***		Lighthouse Reef Atoll as it is today, with six cayes
Adapted from: Gischler and Hudson, 1998 and Gischler 2003		

Table 13: Components of Core Samples from Lighthouse Reef
Mollusc Packstone: Holocene successions dominated by mollusc packstone and wackestone, consisting of primarily *Laevicardium laevigatum, Glycmeris sp., Arca sp.* and *Anadara sp.* Abundance of *Halimeda* decreases with decreasing age. Small branch *Porites* corals found occasionally
Halimeda packstone: Formed from Halimeda, molluscs and foraminifera, this occurs at the base of several cores
Shell beds: Bivalves at the base and lower sections of the carbonate sediments – primarily *Laevicardium laevigatum* and *Chione sp.,* both of which are indicative of an open, sandy substrate
Carbonate sediments: Dominated by packstone, with a high aragonite and magnesium content
Peat: Reddish brown to brown peat with long slender fibers, recognizable as mangrove prop roots and pneumataphores
Soil: Dark brown mudstone to greenish with plant remains
Core Base: Well cemented Pleistocene limestone up to 8m deep beneath marginal reef, with abundant calcite cement, coral, mollusc and *Halimeda* fragments

Soils

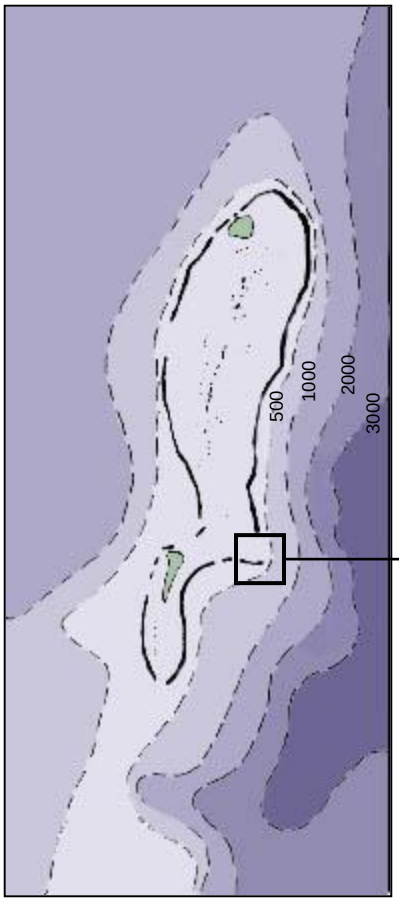
Half Moon Caye is the largest simple sand caye on Lighthouse Reef Atoll (and one of the largest in Belize), with a surface of coarse coral-algal sand with a varied fine coral debris content (Stoddart, 1962). The eastern section of the island is more or less cleared of vegetation, with a scarcely altered 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 over. The western portion of the island supports the littoral forest and beach ground cover, with a soil cover that is much higher in humus content, with much larger coral debris, forming a higher ridge up to 7 feet above sea level (Stoddart, 1962).

In the cleared areas, these sandy soils are formed primarily from coral, with a high limestone content. Additional minerals are deposited from sea water spray, and from the organic remains of coral polyps and seaweeds. Where there is a 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 foraging activities by hermit crabs has prevented a build-up of organic material.

2.4.3 Bathymetry

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

Within the Atoll itself, water depth reaches a maximum of 9m in the deeper eastward lagoon area, and 3m within the distinct shallower westward area. The division between the two is caused by slumping along the north-south mid-axis of the Atoll (Gischler, 2003; 2.4.2 Geology and Atoll Structure). Both Blue Hole and Half Moon Caye are situated in the deeper waters of the eastern half of the Atoll.



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

Both protected areas 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 was recently conducted to investigate the physical characteristics of the area (Ecochard et.al., 2003). This shows clearly the steep drop off to the south of Half Moon Caye, extending down beyond 1,000m (Map 8; Figure 15)

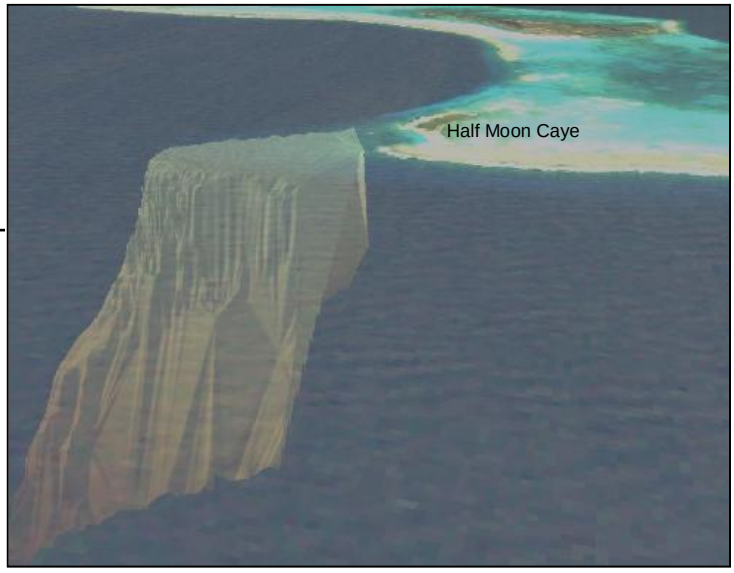


Figure 15: Bathymetry of spawning aggregation site.
Adapted from Ecochard et. al., 2003

The second focus for in-depth bathymetry studies has taken place within the Blue Hole Natural Monument – the Blue Hole itself is a natural sink hole with a centre depth estimated at 125m (just over 400 feet). This limestone feature 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 time line for rising sea levels during the last ice age, through the analysis of speleotherms and cave formations. 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). Towards 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 16). Features indicative of past exposure to air, such as flowstone formations, were found down to a depth of 97 meters (320 feet).

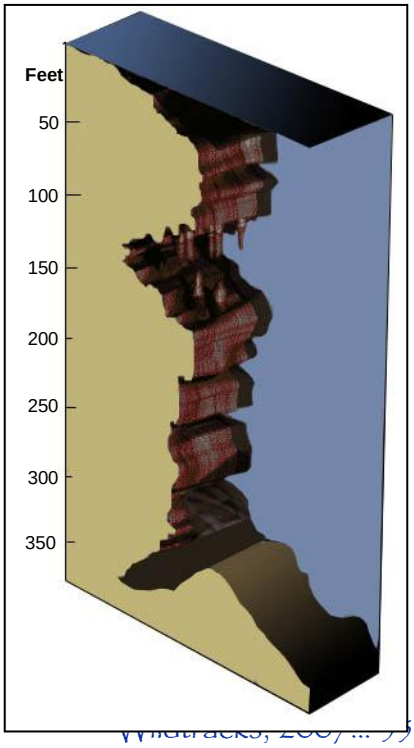
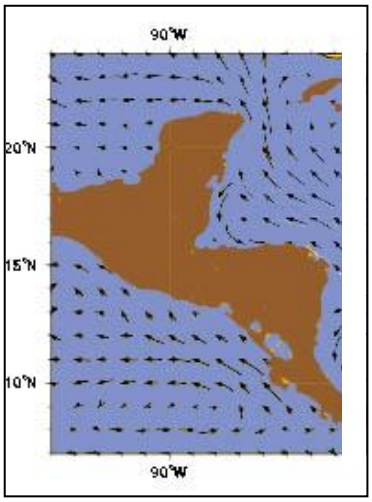


Figure 16: Cross section through Blue Hole, adapted from Furman and Mattin, 1997

2.4.4 Tides and Wave Movement

The main oceanic Caribbean current flows westwards from the Lesser Antilles then northwards through the Yucatan Channel, with an average flow rate of between 38 to 43 cm (15 to 17 inches) per second, and with localized gyres and counter-currents. One such counter current is created within the Gulf of Honduras area and throughout Belizean coastal waters, flowing southwards past the Belize coastline (Map 9; Stoddart, 1962). This creates a low-flow area between the atolls and the shore, with circulation being predominantly wind-driven.



Map 9: Ocean Currents

Surface Water Current Direction		
Month	**Current Direction**	
January	North or south	Dependent on wind direction
February	North	
March	North	
April	South	
May	South	
June	North	
July	North	
August	North	
September	North	
October	North	
November	North or south	Dependent on wind direction
December	North or south	Dependent on wind direction

Table 14: Surface Water Current Direction

Wave approach is controlled by the easterly / north-easterly trade winds, so is from the east-north-east (at 75°).The surface currents around the Atoll vary throughout the year, often also being wind-driven. During the norther season (November to January), when winds alternate between northerly and easterly, the north winds produce a south flowing current, whilst the easterly winds create a north flowing current (Table 14). 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). During February and March, currents flow northwards, with a reversal in April and May. Flow returns to northward between June and October, at a rate of 1.5 knots in June / July, increasing to 2 knots in September / October (Stoddart, 1962).

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

The tides and water currents of the area are important for the dispersion of planktonic larvae and potential recruitment between Atolls, but can also result in the spread diseases, as was shown by the rapid spread of disease in *Diadema antillarum* throughout the Caribbean region.

2.4.5 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, but as Belize Audubon Society begin implementation of the Mesoamerican Barrier Reef System Synoptic Monitoring Programme, more information will become available.

The most comprehensive monitoring of water parameters within adjacent areas in Belize has been conducted by the Caribbean Smithsonian Institute on Carrie Bow Cay, from 2000 to 2005, and ongoing. 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.

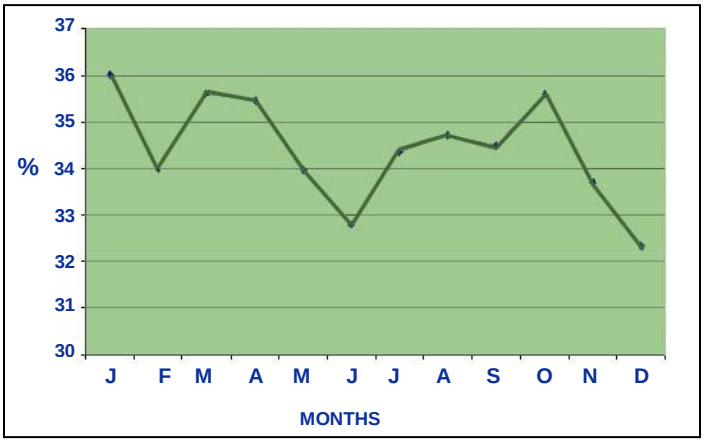


Figure 17: Salinity. Carrie Bow Cay, 2004
Data: Caribbean Coral Reef Ecosystems Program, 2005: Carrie Bow Cay Meteorological Records, 2002 - 2004

Salinity: 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 in comparison with 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 17).

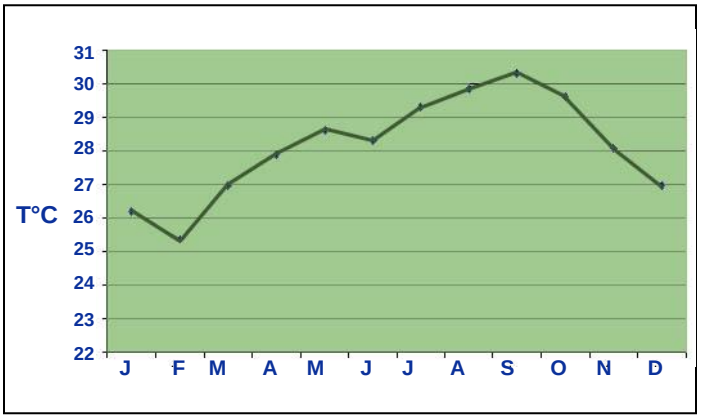


Figure 18: Water Temperature. Carrie Bow Cay, 2004
Data: Caribbean Coral Reef Ecosystems Program, 2005: Carrie Bow Cay Meteorological Records, 2002 - 2004

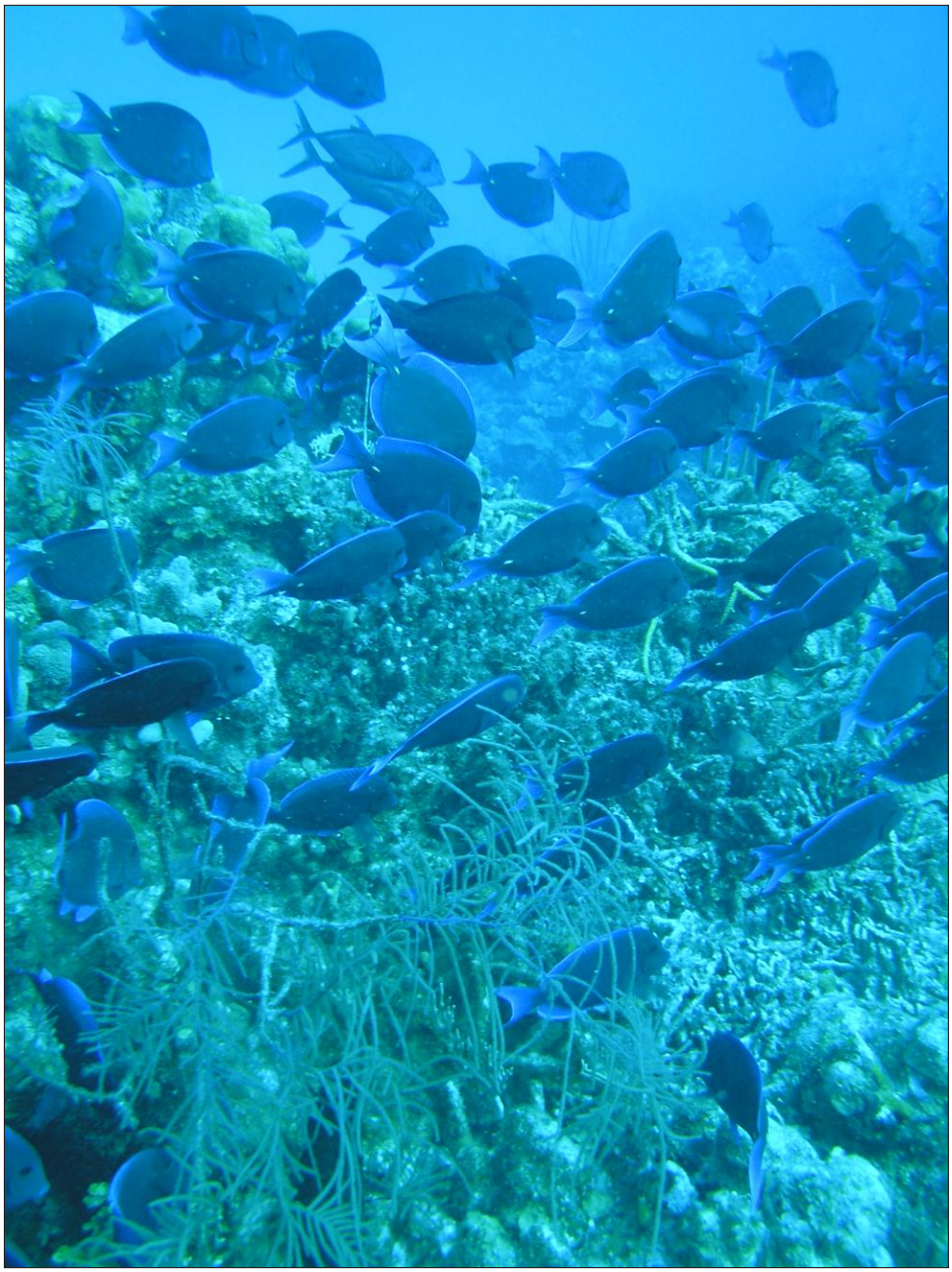
Water Temperature: A series of water temperatures logged from December 2000 to December 2001 showed that water temperature fluctuated from 23ºC to 31ºC. (Gischler, 2003). Readings from Carrie Bow Cay in 2004 show similar fluctuations, ranging from 25.37ºC during the north winds in February to 30.31ºC in September (Figure 18). Glover's Reef Atoll suffered from a temperature high of 32 ºC in September 1998, which resulted in mass bleaching of corals (Gibson, 2003), an event that was also reported from Half Moon Caye and elsewhere on the reef. Global climate change and the resulting increasing water temperatures are causing 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 ºC or more above the normal maximum, with a duration of at least two to three days.

pH: Whilst pH fluctuates naturally annually (Figure 19), there is concern that 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

Figure 19: Water pH. Carrie Bow Cay, 2004

Turbidity: As Lighthouse Reef Atoll lies far from the mainland, and therefore far from water runoff, visibility is generally good. The water does get more turbid, however, during 'northers' (cold fronts), and can take time to settle after hurricane category storms, as noted by several of the dive boat operators following the effects of Hurricane Ivan, in 2004 (Forman, pers. com.).

2.5 Biodiversity



Photograph 11: Blue Tangs (*Acanthurus coeruleus*) schooling on Half Moon Caye reef
Photograph: E. Hickerson

2.5.1 Ecosystems

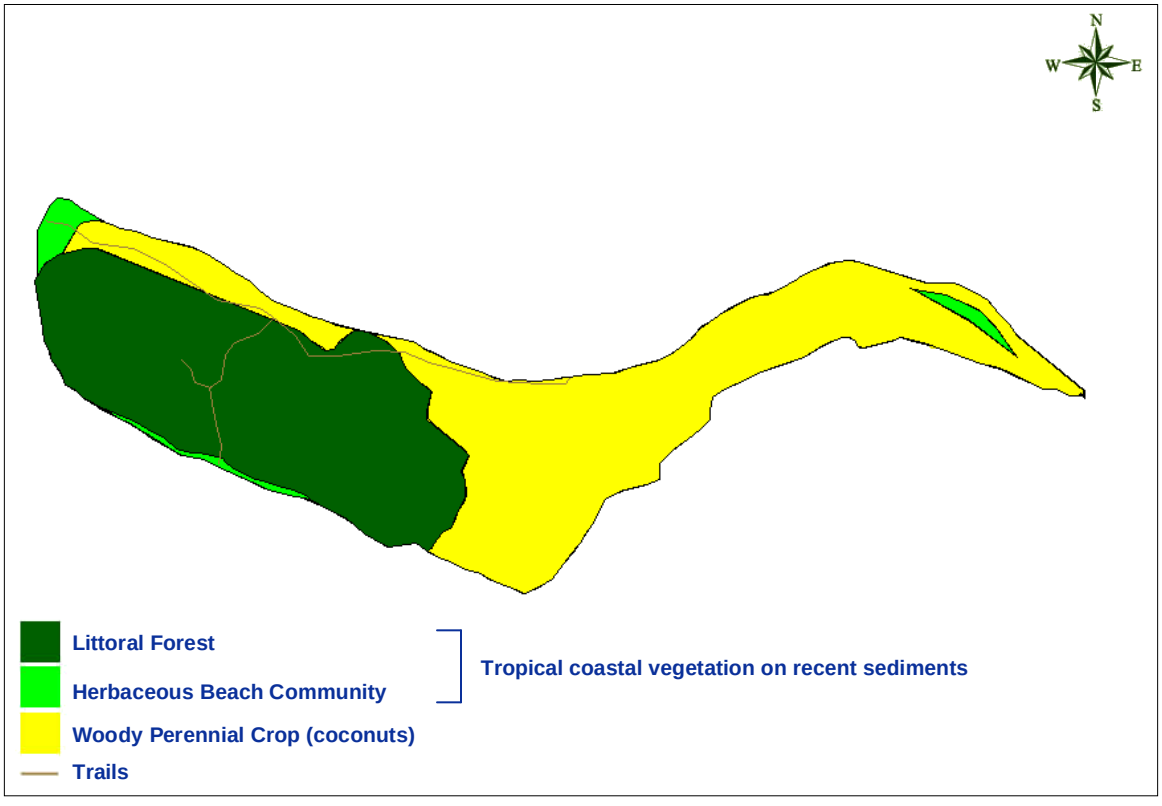
Terrestrial Ecosystems

Terrestrial ecosystems have been classified following the Central American Ecosystem project (Meerman and Sabido, 2004). Two terrestrial ecosystems currently occur on Half Moon Caye (Map 10):

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

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

Historically, it would appear that a further two ecosystems occurred on the island (**Coastal fringe *Rhizophora mangle* - dominated vegetation** and **Mixed mangrove scrub**), both of which were evidently locally eradicated by human activity. All four are described here, as coastal fringe mangrove is already in the early stages of becoming re-established, and it is quite likely that mixed mangrove scrub will also do so once appropriate management programmes are implemented and habitat restoration actions undertaken.



Map 10: Terrestrial Ecosystems of Half Moon Caye
Data: P. Walker, 2005; Arcview (UTM;NAD27)

Tropical coastal vegetation on recent sediments

A combination of Tropical littoral forest and Herbaceous beach communities

Belize Ecosystem Map legend code 69. Photograph 12, Photograph 13

The vegetation of the littoral forest of Half Moon Caye is by no means homogenous, but instead has quite distinct species assemblages that occur in relatively discrete areas – as noted and mapped in the earlier studies of Stoddart (1962). The distribution of some species assemblages appears to partially reflect topographical variation, though it is evident that past and present anthropogenic impacts (associated with the coconut plantation) have a far greater overall impact on distribution.

The canopy height of the littoral forest generally ranges from 6m to 10m, predominant tree species include *Cordia sebestena, Pithecellobium keyense, Bursera simaruba, Sideroxylon americanum, Pouteria campechiana,* and *Ficus citrifolia*. The Cordia, *Bursera* and Sideroxylon are of key importance in providing a nesting structure for red-footed booby and magnificent frigatebird nesting colony.

Cordia sebestena lies in 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 *Bursera simaruba* and *Sideroxylon americanum*. To the northeast of this belt is a species assemblage of *Bursera simaruba, Pouteria campechiana* and *Ficus citrifolia* - largely within a slightly lower-lying area where organic humus buildup is more evident. Northeast of this assemblage *Pouteria campechiana* forms an almost mono-specific stand

Photograph 12: Littoral Forest

Hurricanes and anthropogenic impacts have both had significant roles in shaping the present day littoral forest of Half Moon Caye. Whilst past hurricanes have dramatically affected the stature of the forest, reducing the canopy height by at least 5m from past records, such natural processes are in fact amongst the determinants of this forest type, and should not be considered a threat to the system as a whole – as long as not exacerbated by past, present or future anthropogenic impacts. Stoddart (1962) provides a good historical overview, stressing the dynamic nature of the littoral forest – changing in response to both natural and anthropogenic impacts. The invasive coconut (*Cocos nucifera*) is present throughout significant proportions of the littoral forest area.

The condition of the littoral forest on Half Moon Caye ranges from 'fair' to 'very good', with an overall rating of 'good' in this assessment - of the total area of 19 acres of remaining littoral forest, approximately 17 acres are considered to be in 'good' to 'very good' condition, with the remaining 2 acres assessed as 'fair'. Anthropogenic impacts upon this system are both historical and present. Between 1962 (Stoddart) and 1995 (Meerman), the saltwater palmetto *Thrinax radiata* was completely eradicated from the island as a direct result of over-harvesting of the trunks by the stakeholder population, though it should be noted that the current survey (2004) established that the island is now being successfully re-colonized by this species. Intensive searches located

one specimen of *Thrinax radiata* (at UTM 0443033E 1902017N) a 4-6 year old that escaped the 2004 fire, and which would appear to be a natural recolonization. Seed source is likely to have been Long Caye, transported in bird faeces. The Park Director located another (probably 2 year old) specimen close to the visitor toilet block – which he had heard reported as having been planted by BAS staff. This latter specimen had been damaged by fire from the burning of coconut debris, but is now recovering.

Of far greater impact upon the structure and overall composition of the littoral forest is the invasion by coconut trees from the plantation on the eastern portion of the island. Stoddart compiled records of the historical 'invasion' of HMC by coconuts, with first reports of coconut trees dating back to 1720; by 1830 a portion of the eastern tip of the island had been cleared and apparently planted with scattered coconuts – though "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. Whilst this active clearance continued into the 1960's, most subsequent and present day impacts are caused by the continued invasion by coconuts (with and without human assistance), and by ill-advised management activities (most specifically the controlled fire in 2004). The overall trend has been a decline in the extent of natural vegetation, with the apparent complete loss of some plant species. The eastern limit of the littoral forest has been pushed back approximately 110m and been largely replaced by coconut plantation. The *Bursera* / *Pouteria* species assemblage within the littoral forest appears to have colonized northwards approximately 20m into the previously herbaceous ecosystem. Coconuts have been planted (and / or invaded) along the entire northern coastline of the western half of the Caye and are now invading southwards into the northern limit of the littoral forest.

Despite this long history of anthropogenic impacts upon the condition and extent of the littoral forest of Half Moon Caye, it is still perhaps the most important tract of this ecosystem within Belize's protected area system. This ecosystem is highlighted under Belize's National Protected Areas Policy and System Plan (Meerman, 2005) as being significantly under-represented within the current protected areas – with only 8.6% of the national coverage being protected, as compared with the national target of 60%. Furthermore, only 4.1% of the littoral forest on Belize's cayes lies within protected areas – presenting a very significant shortfall in view of its importance to migratory birds, island specialists (such as the Allison's anole and the island leaf-toed gecko), and in helping anchor the nesting beaches for the critically endangered and endangered sea turtles. To further emphasize the very low level of protection currently afforded to Belize's insular littoral forests, of the 109 acres mapped as lying within protected areas (Meerman & Sabido, 2004, Meerman, 2005), 76 acres of that total were mapped as occurring on Half Moon Caye – a coverage of almost twice the area of the whole island. Actual coverage (as measured in the current survey) is approximately 19 acres. If this scale of mapping error (400%) for littoral forest is uniform, then it is quite possible that less than 30 acres of insular littoral forest lies within the protected area system.

Given that littoral forests tend to lie on some of the mostly highly valued real estate, prospects for significantly increasing the area under protection on the cayes are not good. Whilst it would not be unreasonable to question the long-term viability of such tiny tracts of insular littoral forest, it should be borne in mind that they have evolved and persisted over the eons with very limited connectivity between individual tracts – indicating a significant resilience to natural impacts, including hurricanes. It does however also further emphasize the critical need to maximize management effectiveness for Half Moon Caye's littoral forest, to reverse the long-term trend of removal and degradation, and implement a comprehensive habitat restoration programme. The importance of littoral forest patches on adjacent cayes, in terms of long-term ecosystem viability, cannot be overlooked.

Grouped within the same UNESCO ecosystem classification unit as littoral forest is the low herbaceous beach vegetation, typically found on the seaward edge of the littoral forest.

Photograph 13: Herbaceous Beach Community

Historically found on and above the splash zone of the beach, in a relatively narrow band backed by littoral forest, it is also able to colonize some of the areas previously cleared of littoral forest. Commonly encountered plants include *Cakile lanceolata, Canavalia rosea, Chamaesyce blodgetii, C. mesembrianthemifolia, Hymenocalis littoralis, Ipomoea pes-caprae, Sesuvium portulacastrum, Sporobolus virginicus, Sphagneticola trilobata* and *Tournefortia gnapheloides.* In some areas *Conocarpus erectus* appears to be re-establishing in areas that had been previously cleared. Species distribution is non-uniform throughout the beach vegetation zone, with various species being dominant in different areas. This appears to be a very dynamic and fragile system, with species such as *Stachytarpheta jamaicensis* having apparently disappeared completely since the surveys of Stoddart (1962) and Meerman (1995). Distributional pattern appears to reflect variations in aspect, wind exposure, drainage, humus content and human disturbance. It is clear from Stoddart's descriptions that the beach herbaceous community extent and species composition is intimately tied into the dynamics of sand accumulation and loss, natural processes associated with wave and storm action.

As with the littoral forest component of this clumped ecosystem category, the beach herbaceous vegetation is under very heavy threat in many areas in Belize – often being cleared completely to create white sandy beaches for tourism and residential developments. Even on Half Moon Caye, the herbaceous beach community has suffered clearance to enhance tourism appeal, and is also significantly impacted by invasive coconuts – the heavy palm leaf-fall causing physical damage to the delicate herbaceous layer, and smothering those plants not broken. The observed apparent local extinction of *Stachytarpheta jamaicensis* is almost certainly a direct result of such impacts from coconut trees, and was in fact predicted (Stoddart, 1962) as likely to experience a 'partial disappearance'. The 2004 attempt to clear coconut debris by controlled fire also had a very significant negative impact on the remaining ground flora – further emphasizing the importance of a slower, more methodical approach to the problem of controlling invasive coconuts. Whilst the overall condition of the littoral herbaceous and shrubby plant communities is assessed as being poor, tracts along the southwestern shore, the northwestern corner, and in a narrow band north of the lighthouse remain in good condition. Trampling by visitors could become a significant threat to this system, requiring continued careful visitor management to minimize impacts. As with the littoral forest, priority should be placed upon the restoration of impacted beach vegetation areas, and on facilitating their gradual extension over portions of historical coverage.

Woody Perennial Crops

Belize Ecosystem Map legend code 83

Photograph 14

Coconuts have been grown on Half Moon Caye as early as 1720, with extensive farming being initiated in the early 1900's. Presently coconuts occupy slightly over 50% of the island, including an area of approximately 1.8 acres in the northern edge of the littoral forest, which is being colonized and dominated by coconuts. Whilst the coconut plantation and white

Photograph 14: Woody Perennial Crop - Semi-cleared cocal

sandy beaches of the eastern portion of island are an important income source for the lighthouse keeper, and an important component of the tourism attraction, its insidious spread further and further into the remaining littoral forest is incompatible with the primary conservation objective of preserving and improving the condition of remaining natural vegetation. Active management actions are urgently needed to reverse the long-term trend of expansion of the coconut plantation (3.3 Conservation Strategies).

Historical ecosystems of Half Moon Caye Natural Monument:

Coastal fringe Rhizophora mangle – dominated forest

Belize Ecosystem Map legend code 50

Rhizophora mangle is known to have historically occurred on the northern shore of the western half of the Caye (J. Verde, pers. com.), but was extirpated prior to the 1960's and is now in the earliest stages of re-establishment. There can be little doubt that historically coastal fringe red mangrove occurred along much of the north and northwest beaches of Half Moon Caye, and probably also along significant portions of the more exposed coast on the southeast and easterly beaches. As in modern times, 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 island. 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 (presumably originating from Long Caye), none has yet become established there. Young plants had become established on 'Mitch Island' (K. Forman, pers. com.), but were subsequently buried under coral rubble moved by the wave action associated with the distant Hurricane Ivan (2004). Currently, mangrove propagules are becoming established on the southern beach (Pott, pers. com.). Recommended management actions, to assist the re-colonization of Half Moon Caye by red mangrove, include the planting of propagules that are found floating in the shallows along the northwest and southern coasts, in small clumps where they are washed up.

Mixed mangrove scrub

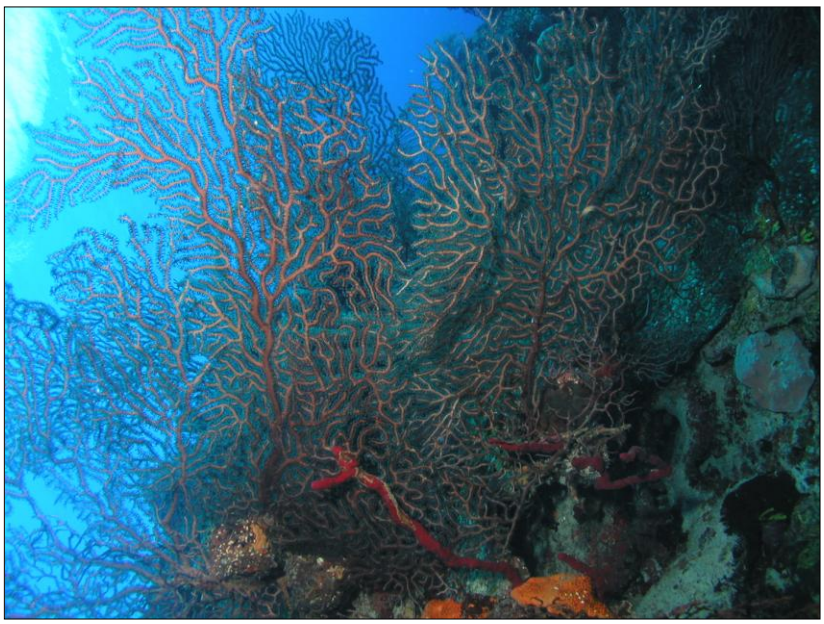
Belize Ecosystem Map legend code 49

An ecosystem that does not now occur on the island, 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 the areas where buttonwood (*Conocarpus erectus*) still occurs today, which includes the area damaged in the 2004 fire adjacent to the research building and possibly also on the western tip of the island in the area where *Laguncularia racemosa* was observed in this survey. Typically, all three mangrove species (*Avicennia germinans, Laguncularia racemosa* and *Rhizophora mangle*) occur in association with the mangrove associate *Conocarpus erectus*. Past impacts include the clearance of *Conocarpus erectus* by residents on Half Moon Caye (Stoddart, 1962), and it is likely that the true mangrove species suffered the same fate. Whilst a stand of *Laguncularia racemosa* was recorded during the current survey on the western tip of the island, a previous record (Meerman, 1995) of *Avicennia germinans* is now questioned (K. Forman, pers. com.) and discounted (pers. obs.) Mixed mangrove scrub often borders littoral forest - occurring on lower, less well drained soils.

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 & Dinerstein, 1998; Roberts, 2001) (Photograph 15).

The MBRS has four offshore coral atolls, the outermost of which is Lighthouse Reef, 80km from the mainland. Lighthouse Reef Atoll, created by scleractinian corals, is comprised of a well developed fore-reef more than 40 miles in length, enclosing a shallow lagoon, between 1 and 8m in depth containing numerous patch reefs. The Atoll has been identified by WWF 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 & Kramer, 2002).



Photograph 15: Coral Reef at Half Moon Caye
Photograph: R. Graham

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, which rises eastwards from the lagoon, north of Half Moon Caye, then plunges steeply down to the east into the deep, open Caribbean waters (Map 11). 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.

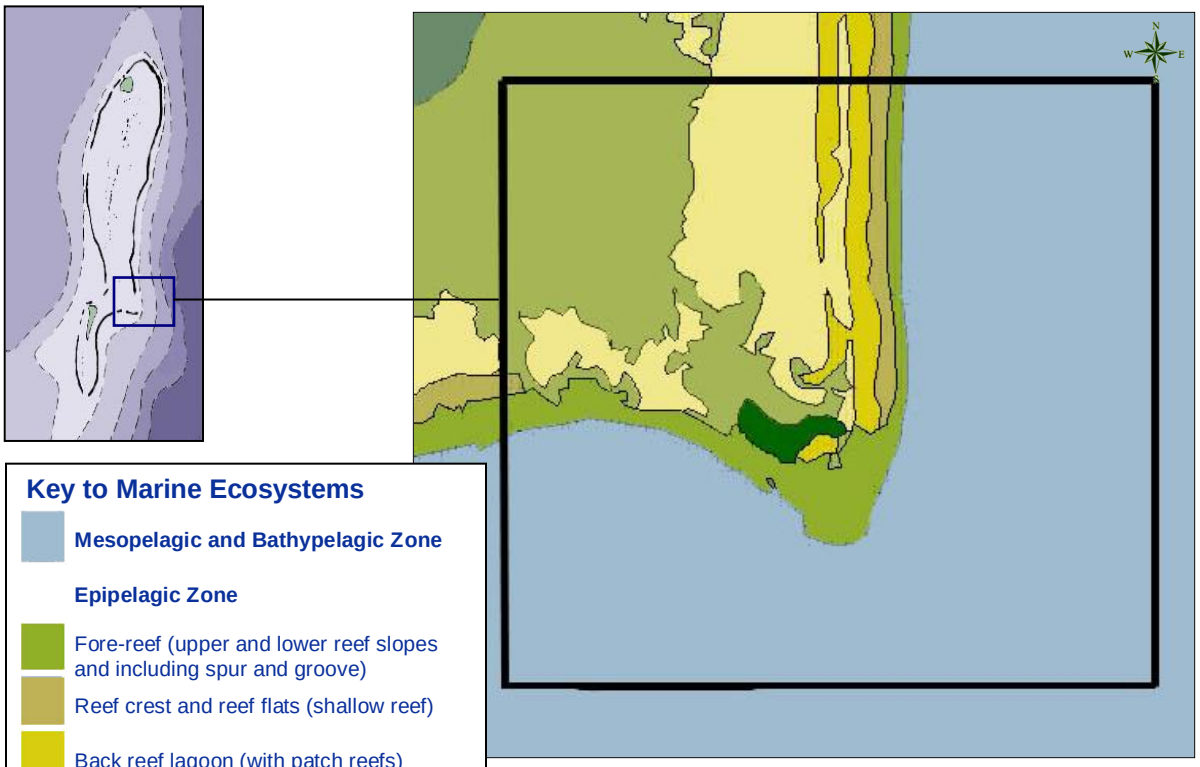
Mesopelagic / Bathypelagic Zone (200m to 2000m)

The Mesopelagic Zone, from 200m deep downwards, merging into the bathypelagic zone, which begins at the continental slope and extends beyond the protected area to reach a depth of 2000m. No work has yet been conducted in this zone, and little is known of the marine life that exists here, though whale sharks are known to pass by.

Epipelagic Zone (0m – 200m)

The Epipelagic Zone includes the shallow waters of the inner atoll, and the deeper waters of the outer atoll shelf, ranging from 0 to 200m. Within this zone there are an array of ecosystems that have evolved in response to 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:

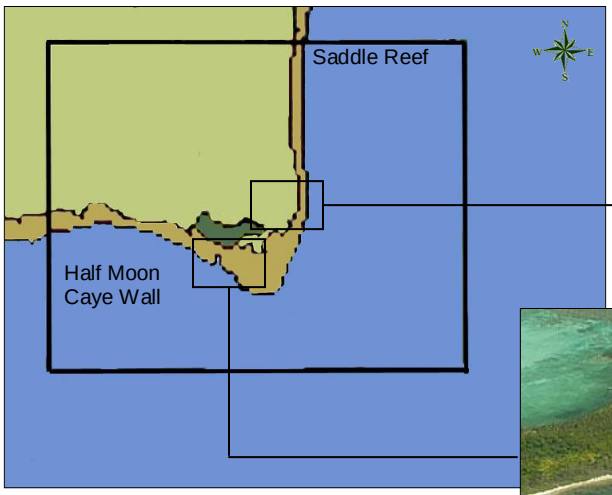
- Fore-reef (upper and lower reef slopes, including spur and grove topography)
- Reef crest and reef flats
- Back reef (with patch reefs)
- Seagrass
- Sparse algae / sand

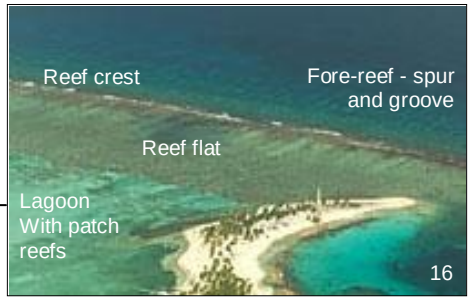


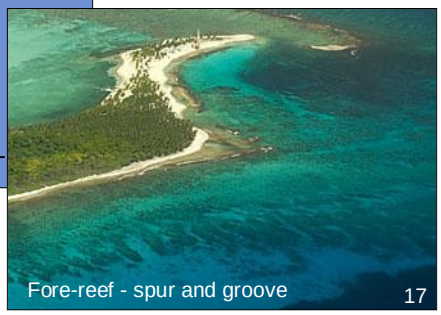
Map 11: Marine ecosystems of Half Moon Caye Natural Monument
Data: P. Walker, 2005 Arcview (UTM, NAD27); Meerman and Sabido, 2004

The Fore-reef

The fore-reef lies on the outer side of the reef crest, facing the sea, and includes the upper and lower reef slopes. Within Half Moon Caye Natural Monument, examples can be seen in the east and the south of the protected area, where the atoll rim falls away into the ocean (Map 12; Photographs 16 and 17)).







Map 12: Fore-reef, Half Moon Caye
Photographs 16 and 17: Reef ecosystems of Half Moon Caye

To the east of the protected area, Saddle Reef stretches northwards from Half Moon Caye to Harrier Wreck, and bears the brunt of the strong waves and currents that continually flow over the reef crest above (Stoddart, 1962). It is considered to be one of the most healthy examples of reef in Belize - the upper slope is steep at first to a depth of approximately 6m, then continues more gently down to about 12m, where an underwater ledge slopes gradually towards the drop-off, which starts at between 36 and 42m.

This drop-off continues vertically down to depths of approximately 800m. As is 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)***

Similar anecdotal descriptions have been given in more recent years, but whether this ledge still retains the *Acropora* community following the recent massive *Acropora* die-off (starting in the 1980's) is unknown. This is also true for *Agaricia agaricites,* which has been severely impacted by the more recent bleaching events.

This ledge stretches northwards outside the protected area and is popular with 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*). With the problems of marking the protected area boundary in the deeper waters on the outer side of the reef, there are enforcement issues that need to be addressed in this area.

To the south-west of Half Moon Caye, the rim is defined by a well-developed spur and groove formation - Half Moon Caye Natural Monument includes the world-renowned Half Moon Caye Wall to the south of the caye, 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 windward facing Saddle Reef. The calmer waters have led to this area being favoured by divers, with mooring points offshore to allow dive boats minimal impact access. However, not all vessels use these mooring points, still preferring to use their own anchors. There have also been occasions when larger vessels beyond the capacity of the mooring points have tied-up on these points, causing anchor drag and damage to the sea floor.

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 (Figures 20, 21), which appeared to be related to distance from the open ocean swells. The first was an *Acropora palmata* zone, similar to that on the eastern upper reef slope extending approximately 90m out from the southern shoreline of Half Moon Caye.

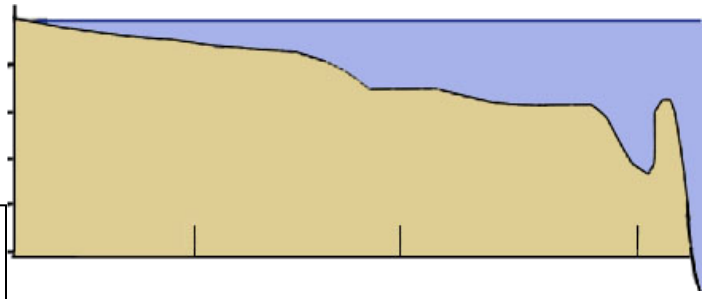


Figure 20: Profile of Fore-reef, south west of Half Moon Caye
(Adapted from CEDAM, 1989)

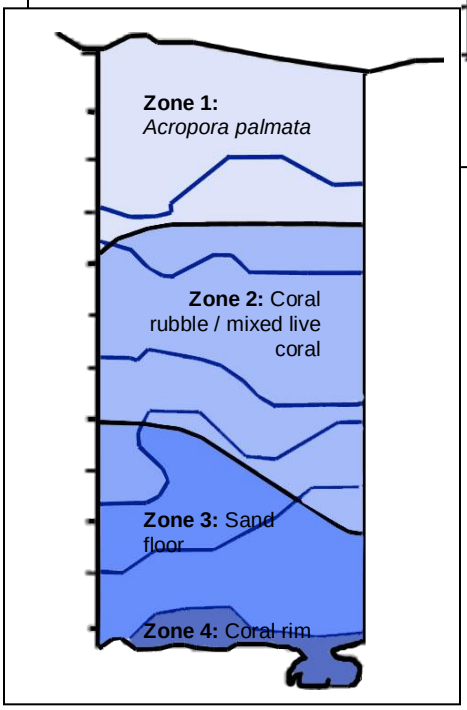


Figure 21: Zones of Fore-reef, south west of Half Moon Caye
(Adapted from CEDAM, 1989)

With increasing water depth, this gives 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 (Photograph 18).

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

Photograph 18: Brown garden eel (*Heterocongor halis*) of the barren sand zone, Half Moon Caye
Photograph: E. Hickerson

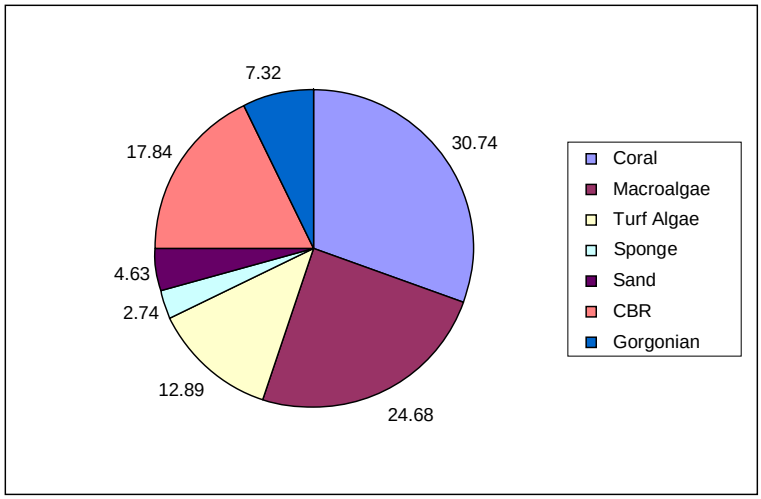


Figure 22: Percentage cover of major reef community categories on the Half Moon Caye Natural Monument fore-reef (Graham, 2004)

vertically downwards into the open sea (Meyer, in. lit., 1989).

More recently, the Rapid Marine Assessment also covered this fore-reef area (Graham et. al., 2004), which appears to support a healthy live coral population, with 36 species of scleractinian corals recorded. Coral cover ranges from 12% to 43% (Figure 22), with low levels of disease or bleaching, though there is evidence of decline when results from 2004 are compared with those of 1997 and 1999 (McField, 2001).

The *Montastraea annularis* complex dominates the coral community of the fore-reef, with a relative abundance of 39.73%, contributing 12.2% towards coral cover. Other species with a significant presence include *Agaricia agaricities* (15.93% relative coral composition), *Colpophyllia natans* (8.73% relative coral composition) and *Porites porites* (6.34% relative coral composition). Macroalgae and turf algae were also widely evident on the fore-reef, comprising a combined total of 37% cover. *Acropora cervicornis*, which has a relative coral composition of 2%, was the only species to show noticeable recent mortality (Graham et. al., 2004). Dominant macroalgae on the fore-reef at HMCNM included species of the following genus: *Halimeda, Dictyota,* and *Lobophora* (Graham et. al., 2004).

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

The Reef Crest and Reef Flats

The reef crest / reef flats area of the eastern reef has been highlighted for the breadth of both the living-coral reef crest zone and the adjacent reef flats (Photograph 16; Stoddart, 1962).The reef crest, forming the shallow rim of the atoll, lies behind the fore-reef, and on the windward side is composed of a dead, eroded reef rock of a predominantly *Acropora* framework, with a few robust staghorn (*Acropora cervicornis*), elkhorn (*Acropora palmata*), brain corals (*Diploria*) and red crustose coralline algae (*Lithothamnion sp.*). *Monterastrea annularis* predominates on the more sheltered inner reef flat, with *Thalassia testudinum* over a sandy bottom, and large examples of *Manicia areolata*, *Favia fragum* and *Siderastrea radians* (Stoddart, 1962). All these species are hardy enough to be able to withstand the breaking waves, constant strong current, and exposure at low tide.

Lagoon with Patch Reefs

Coral diversity decreases with increasing distance from the reef crest, the reef flat giving way to the lagoon area, with its sandy bottom (Photograph 16). A large number of small patch reefs of scleractinian corals are scattered throughout the shallow lagoon waters, forming in areas where a hard substrate exists long enough for establishment of the coral. 23 species of hard corals were identified on the patch reefs in HMCNM (Graham et. al., 2004).

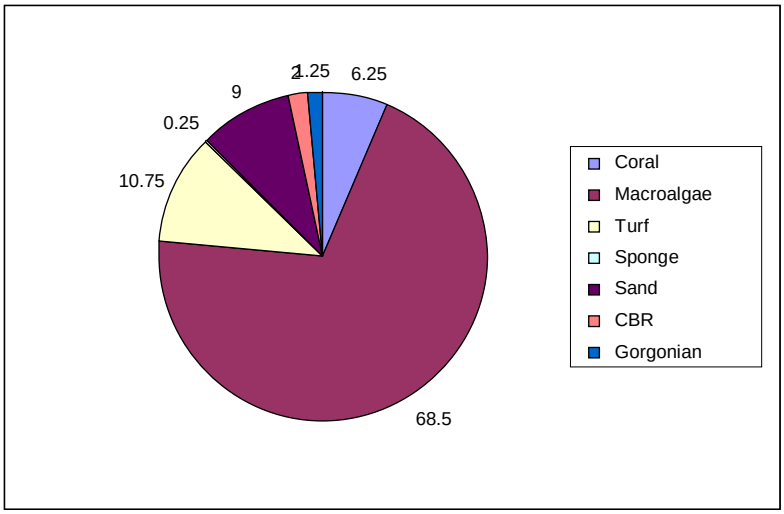
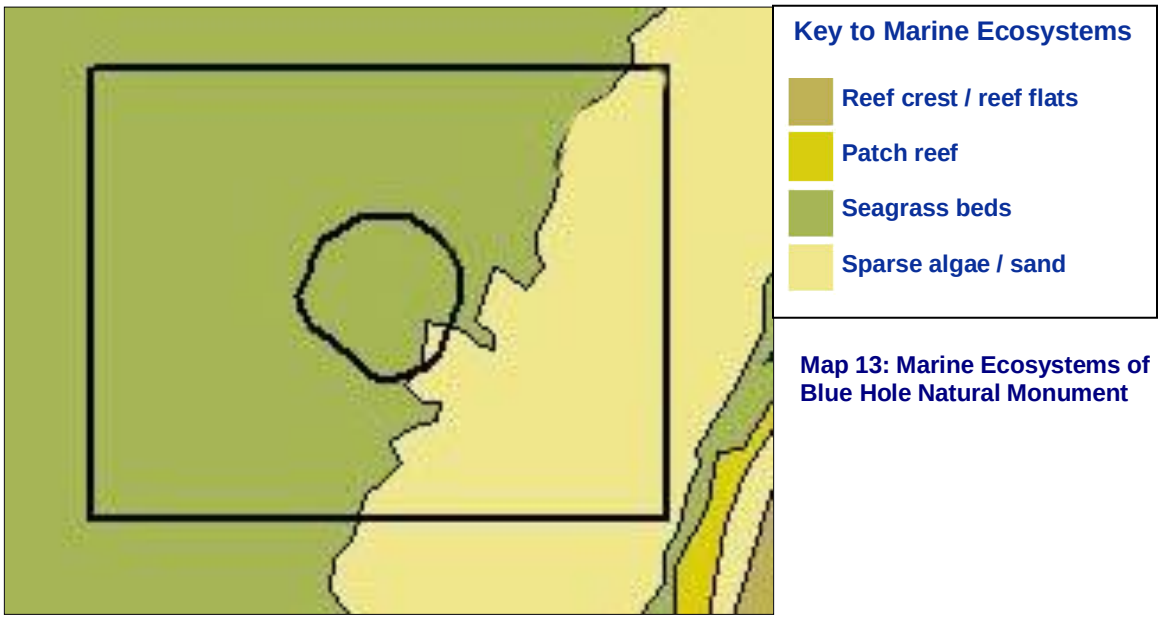


Figure 23: Percentage cover of major reef community categories on the Half Moon Caye Natural Monument patch reef (Graham et. al., 2004)

Patch reefs at both Natural Monuments were in poorer condition than the fore-reef sites, with reduced coral cover and higher algal overgrowth. Percentage coral cover on the patch reefs is variable, averaging 6.25%, with the largest contributor, *Montastrea annularis,* comprising 2.25%. In general, patch reefs were found to be dominated by macroalgae, with a large turf algae component - in total, algae accounted for over 79% cover (Figure 23).

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 (Map 13). 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 (Jones et. al. 2000) (Photograph 19). The hole is surrounded almost completely by a coral rim, which breaks the surface in places. Within the Blue Hole itself the collapsed cave system appears to support a limited amount of marine life, with filamentous algae, boring sponges cornflake algae and isolated gorgonians. Little biological work has been conducted here, and it has been highlighted for the potential of having unique assemblages of cryptic and endemic species (Kramer and Kramer, 2002).



Map 13: Marine Ecosystems of Blue Hole Natural Monument

Sharks have been reported within the Blue Hole by the majority of explorers, from Cousteau (1970) to the more recent reports from diving expeditions (Fuente, Villanueva, pers. com.), Bull, lemon, reef, hammerhead and blacktip sharks having been reported by dive operators using the site.

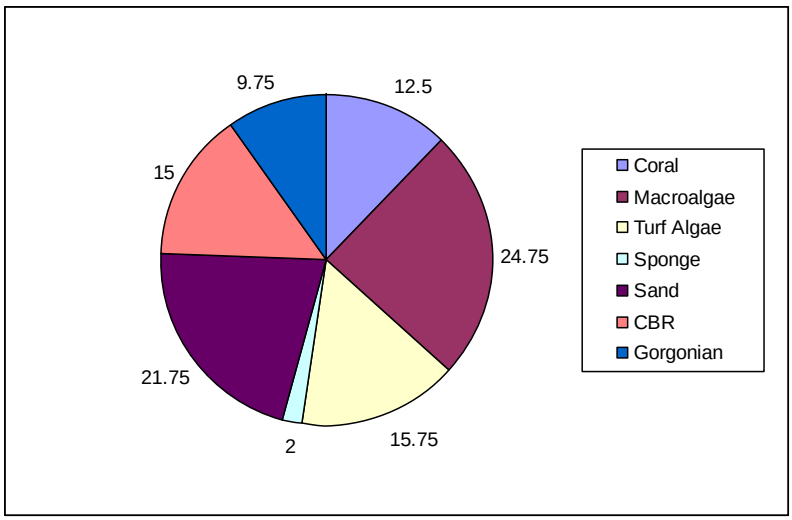
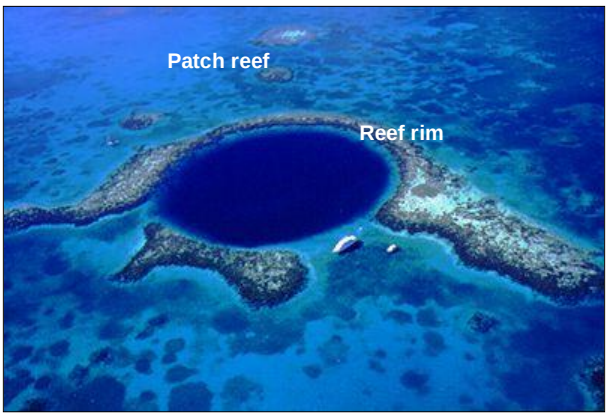


Figure 24: Percentage cover of major reef community categories on the Blue Hole Natural Monument reef (Graham, 2004)

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 being recorded. Coral cover averages 12.5%, while macroalgae and turf algae represent over 40% cover. *Montastrea annularis* complex was the predominant coral cover (Figure 24).



The Blue Hole coral reef shows impacts from boat and diver activities, with constant siltation action caused by dive boats maneuvering into and out of the current mooring points. Diver and snorkeler impacts are also thought to be causal factors in the high macroalgae coverages seen, though with the lack of a previous baseline, it is hard to make comparisons with former coral cover before the Blue Hole attracted the current levels of visitation.

Photograph 19: Reefs of the Blue Hole
Photograph: BAS

Reef Health

On a regional level, two thirds of wider Caribbean reefs are said to be at risk from human activities (Burke & Maidens, 2004), Nationally, 63% of reefs in Belize are considered to be 'at risk' (Reefbase, 2005), this slightly lower risk level being due in part to the small human population, and relatively low levels of coastal development. Lighthouse Reef is considered one of the most pristine reefs within the MBRS, being located far from the mainland, making access difficult and expensive for fishermen, and distancing it from land-based sources of pollution and sediment (McField, 2001). Many of the impacts threatening other reefs in the region do not, therefore, currently affect Lighthouse Reef – however is recognized that the reef is at risk from overfishing, hurricanes, coral bleaching, coral disease, the ramifications of adjacent caye development, and from the possibility of marine-based pollution.

In the wider Caribbean there has been a general ecological shift on reefs towards algal dominance in recent years, attributed to a number of impacts including a combination of

overfishing, population crash in the herbivorous sea urchin *Diadema antillarum* and other environmental stressors such as increasing sea surface temperature, sedimentation and pollution (Liddell WD & Ohlhorst SL, 1986). Though this shift has not been documented at Lighthouse Reef, the patch reefs of the adjacent Glover's Reef Atoll have show a 315% increase in algal cover over the last 25 years, with current patch reef averaging 80% algae and 20% hard coral cover. The more recent Rapid Marine Assessment of both Half Moon Caye and Blue Hole Natural Monument showed macroalgal cover increasing from 9.4% in 1997 to 24.68% in 2004 on the fore-reef, and an average of 68.5% macroalgae coverage on the patch reefs (Graham et. al., 2004) – still below that of Glover's Reef.

The vulnerability of the reef to marine impacts was particularly evident when a cargo ship ran aground on the reef in January 2005, one of several wrecks that are evidence of past shipping accidents – the Atoll being close to a main shipping channel, with the ever-present potential for direct damage and pollution from shipwrecks.

In 1995 and 1999 there were no *Diadema antillarum* recorded in any transects at Lighthouse Reef (1995 rapid assessment and Kramer & Bischof, 1999) however in 2004 this species was found to be present, albeit in low densities within HMCNM but not at BHNM (RMA, 2004).

The Belize Barrier Reef experienced mass coral bleaching for the first time in 1995 (McField, 1999), with recovery being considered good. However in Autumn of 1998, a second, more severe coral bleaching event occurred, with complete bleaching of almost all plate and head-forming corals down to 21m (Aronson *et al*, 2000), making it the worst recorded event to date in Belize. *Agaricia tenuifolia*, the dominant coral species on Belize's lagoonal reefs, underwent almost total mortality due to bleaching (Peckol *et al*, Aronson *et al*, 2000). Whilst it is not known specifically how this species fared on the outer atolls during this bleaching event, figures of percentage presence from 1997, 1999 and 2004 show a massive decline (though drawing conclusions from this in not possible, as this may have been due to site selection) (Table 15):

Species	% presence		
	1997 (McField, 2001)	1999 (McField, 2001)	2004 (Graham et. al., 2004)
Agaricia tenuifolia	92	92	8

Table 15: Percentage presence of *Agaricia tenuifolia* from 1997 to 2004

In 1999 the percentage of bleached corals at Lighthouse Reef was found to be between 2% and 27% at different fore-reef sites (McField, 2001). The only other study that has attempted to document coral bleaching and disease at Lighthouse Reef is the 2004 Rapid Marine Assessment, which recorded 8 incidents of bleaching during the surveys, on a variety of species.

Recovery has been slow, possibly due to the subsequent damage caused by Hurricane Mitch, a Category 5 storm, that passed south of the atoll, also in 1998 (Mumby, 1999), and impacted reefs along much of the coast for several days causing widespread coral destruction in fore reefs and outer atoll reefs (Aronson *et al*, 2000). This was just one of several hurricanes that have damaged reefs in Belize in recent years. Hurricane Mitch was followed in 2000 by Hurricane Keith, then Hurricane Iris in 2001. More recently, Hurricane Ivan caused storm waves that washed over the island. These storms have different paths, intensities, and impacts but they have all reduced coral cover at a number of locations (Aronson *et al*, 2000).In 1999 the percentage of diseased corals at Lighthouse Reef ranged between 0 and 15% at

Photograph 20: White plague disease on *Dendrogyra cylindrus*
Photograph: E. Hickerson

different fore-reef sites (Kramer & Bishchof, 1999). The coral areas surveyed during the 2004 Rapid Marine Assessment also exhibited very low incidence of disease - five corals were recorded with white plague disease (Photograph 20), on 4 different species (*Diplora labyrinthiformis, D. strigosa, Agaricia fragilis* and *Dendrogyra cylindrus*). One colony of *Acropora cervicornis* was observed to have white band disease, and a colony of *D. strigosa* was identified as having black band disease. Recent mortality of *Acropora cervicornis* was also noted - this may have been due to white-band disease which has been attacking *A. cervicornis* since the late 1980s. Once considered a dominant species on these reefs, this disease has almost eliminated *A. cervicornis* from reefs in the central shelf lagoon of Belize since the disease was first recorded (Aronson *et al*, 2000; Table 16).

Species	% presence		
	1997 (McField, 2001)	1999 (McField, 2001)	2004 (Graham et. al., 2004)
Acropora cervicornis	100	92	44

Table 16: Percentage presence of *Agaricia cervicornis* from 1997 to 2004

Evidence suggests that Lighthouse Reef has undergone dramatic ecological shifts in the last few decades in the same way as other Caribbean reefs. In 1962 the fore-reef was dominated by Acroporids and *Agaricia* species (Stoddart, 1962) but by 2004 algae was more prevalent on the fore-reef than live coral cover (Graham et al, 2004). *Montastrea annularis* had become the dominant coral species on the fore-reefs. Percentage cover has probably declined dramatically during those decades, since even in the period between 1997 and 2004 live coral cover on the fore-reef had been reduced from an average of 43.6% to 30.7% (McField, 2001; Graham et al, 2004).

Lighthouse Reef has experienced the same large-scale threats as other reefs in the region, including hurricanes, loss of herbivorous urchins, overfishing, coral disease and prolonged high sea surface temperatures in certain years, triggering mass bleaching (e.g. 1998; Table 17). All these impacts have contributed towards the phase shift from coral dominance to fleshy algal dominance on the reefs. This is particularly true of the vulnerable patch reefs within the lagoon which experience less flushing, less larval transport, greater fishing pressure and greater range of environmental conditions than the fore-reef.

Event	Year	Scale of event
Coral bleaching event	2005	Extent of bleaching unknown
Hurricane Ivan	2004	Increased turbidity, coral rubble deposited on southeast beach of Half Moon Caye
Hurricane Iris	2001	
Hurricane Keith	2000	
Hurricane Mitch	1998	Category 5, direct hit
Coral bleaching event	1998	Catastrophic bleaching
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 *Diadema antillarum* population	1983	Major Caribbean wide die-off

Table 17: Major events affecting reef health

At neighbouring Glovers Reef hard coral has declined by 75% on the patch reefs (McClanahan and Muthiaga, 1998) and the limited surveys of the Lighthouse Reef patch reefs point to a similar major change towards algal dominance. Loss of hard coral cover means loss of reef-builders, without which the reef is subject to erosion and cannot grow to compensate for this, a situation which leads first to reduction in habitat structure and eventually, in the worst cases, to a state from which the reef can never recover, once it has been eroded to a depth too far below current sea level.

Seagrass

The most important component of marine flora within the two protected areas 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 an 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).

Photograph 21: Manatee grass (*Syringodium filiforme*)
Photograph: E. Hickerson

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. Although fish abundance was not measured, it more fish were recorded at sites with lower boat activity, around Half Moon Caye and the site at the 'back' of the Blue Hole. Far fewer fish (none, on some transects) were observed where boat activity was greater, particularly at the entrances to the Blue Hole.

Two species of seagrass were recorded – **Turtle grass** (*Thalassia testudinum*) and **Manatee grass** (*Syringodium filiforme*) (Photograph 21). The majority of areas dominated by *Thalassia testudinum*, within the two protected areas are considered to be healthy, having reached their climax status, and being 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. This prevents as much light from penetrating to the seagrass, and can cause smothering of leaves.

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.

At present the seagrass is healthy however presence of macroalgae at certain sites suggests that disturbance is beginning to have an effect. Areas experiencing large volumes of boat traffic also experienced high levels of filamentous brown algae presence in the seagrass beds - an indicator of disturbance in seagrass beds, as the competitive balance shifts to faster growing primary producers. The presence of macroalgae changes the structure and stability of the beds, reducing the species-richness of the fish population, and making the beds less resistant to impacts such as hurricanes.

The recommendations of the Rapid Marine Assessment for monitoring suggest that any seagrass-monitoring programme that is established should look at seagrass density and density of macroalgae within seagrass beds as well as seagrass species composition. It would also be useful to monitor fish densities within the seagrass. Any changes in seagrass health can be used as early warning of problems such as nutrient enrichment or increased sedimentation.

2.5.2 Flora and Fauna

Terrestrial Flora

A total of 47 naturally occurring native species of plant, representing 33 families, have been reliably identified as currently occurring within the littoral forest and herbaceous beach community of Half Moon Caye (Table 18). A further two species (*Hamelia patens* and *Stachytarpheta jamaicensis*) recorded previously are now thought to no longer occur there. Additionally, three introduced species (coconut, almond and casuarinas) occur on the island.

This is quite a diverse species assemblage for this ecosystem type, especially in view of the distance of the Lighthouse Reef Atoll from other island and mainland populations. As previously noted (Stoddart, 1962), the flora of island ecosystems is dynamic in species occurrence and stature – changes often reflecting both natural cycles and anthropogenic impacts. Species of the littoral forest and of the herbaceous beach community play critical roles in the stabilization of the island, and in providing habitat for the fauna – including species that are endangered and / or have very limited distributions. Undoubtedly, national populations of several of the plant species found on Half Moon Caye have undergone significant decline in recent years, as coastal beaches are cleared and developed for tourism and residential use elsewhere in the Country. Insufficient data is currently available to assess this decline, or its impact upon the continued viability of plant populations. 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.

Photograph 22:
Tournefortia gnapheloides

Anthropogenic impacts have had huge impacts upon the flora of Half Moon Caye, historically causing the local extinction of the chit palm (*Thrinax radiata*) and red mangrove (*Rhizophora mangle*) and more recently, it is believed, of *Hamelia patens* and *Stachytarpheta jamaicensis.* Both the chit palm and the red mangrove are currently in the process of re-colonizing the island, though populations are still extremely small and tenuous. The introduced coconut palm continues to have a very major impact upon the flora of Half Moon Caye, the control and reversal of which is discussed in detail within the coconut control programme within this management plan.

Table 18: Plant Species of Half Moon Caye and Blue Natural Monuments		
Family	**Species**	**Common name**
Marine Species		
Hydrocheritaceea	*Thassalia testudinum*	Turtle grass
Potamogentonaceae	*Syringodium filiforme*	Manatee grass
Terrestrial Species		
Adiantaceae	*Acrostichum aureum*	
Aizoaceae	*Sesuvium portulacastrum*	Seaside pursane
Amaranthaceae	*Alternanthera flavescens*	
	Iresine diffusa	
Amaryllidaceae	*Hymenocallis littoralis*	Spider lily
Apocynaceae	*Echites umbellata*	vine
Arecaceae	*Cocos nucifera*	Coconut **
	Thrinax radiata	Chit, Salt-water Palmetto
Aristolochiaceae	*Aristolochia pentandra*	Aristolochia
Asteraceae	*Sphagneticola trilobata*	Creeping daisy
Boraginaceae	*Cordia sebestena*	Red-flowering zericote
	Tournefortia gnapheloides	
Brassicaceae	*Cakile lanceolata*	Caribbean sea rocket
Burseraceae	*Bursera simaruba*	Gumbo limbo
Capparaceae	*Capparis flexuosa*	
Casuarinaceae	*Casuarina equisetifolia*	Casuarina **
Combretaceae	*Conocarpus erecta*	Buttonwood
	Laguncularia racemosa	White Mangrove
	Terminalia catappa	Almond **
Convolvulaceae	*Ipomoea violacea*	
	Ipomoea pes-caprae	Beach morning glory
Cyperaceae	*Cyperus planifolius*	
	Fimbristylis cymosa	Hurricane grass
Euphorbiaceae	*Chamaesyce blodgettii*	Chicken weed
	Chamaesyce mesembrianthemifolia	Chicken weed
Fabaceae		
Mimosoideae	*Pithecellobium keyense*	Xo-coy, red fowl
Papilionoideae	*Canavalia rosea*	Seaside bean

Table 18: Plants Species of Half Moon Caye and Blue Hole Natural Monuments		
Family	**Species**	**Common name**
Fabaceae		
Papilionoideae	*Dalbergia ecastaphyllum*	Chaperno, dogwood
	Sophora tomentosa	
Lauraceae	*Cassytha filifirmis*	Jaundice tie-tie
Malvaceae	*Sida acuta*	Broomweed, chi-chi-be
Moraceae	*Ficus citrifolia*	Fig
Nyctaginaceae	*Neea psychotrioides*	Salat
Olacaceae	*Ximenia americana*	Sour plum
Passifloraceae	*Passiflora suberosa*	Passionflower
Phytolaccaceae	*Rivina humilis*	Tomatillo
Poaceae	*Cenchrus incertus*	
	Digitaria horizontalia	
	Eragrostris ciliaris	
	Sporobolus virginicus	Seashore dropseed
Polygonaceae	*Coccoloba uvifera*	Sea-grape
Rhizophoraceae	*Rhizophora mangle*	Red Mangrove
Rubiaceae	*Erithalis fruticosa*	Black torch, botoncillo
	Ernodea littoralis	Wild cherry
	Hamelia patens	Xcanan, Polly redhead *
	Spermacoce sp.	
Sapotaceae	*Pouteria campechiana*	Mamey cerilla, sapotilla
	Sideroxylon americanum	Mol-che
Solanaceae	*Solanum donianum*	Solanum
Surianaceae	*Suriana maritima*	Bay cedar
Verbenaceae	*Lippia nodiflora*	Beach Lippia
	Stachytarpheta jamaicensis	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

Fauna of Blue Hole and Half Moon Caye Natural Monuments

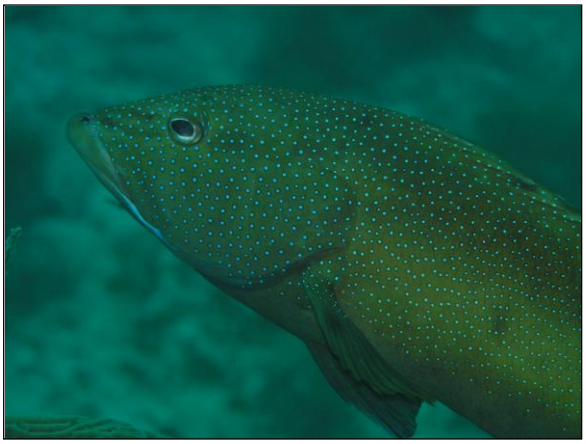
Fish Species

Of the 317 reef fish species recorded in Belize (ReefBase, 2006), 138 have been recorded at Half Moon Caye Natural Monument and Blue Hole Natural Monument, belonging to 42 families and 76 genera (Table 19). Lighthouse Reef has been identified as a highest priority conservation target for its outstanding fish diversity, a combination of the low human impact levels, the pristine nature of the reefs, and the connectivity with the open ocean, increasing the number of pelagic species present (Kramer and Kramer, 2002)

A number of surveys have been conducted within the protected areas - in 1995, a survey was undertaken at HMCNM for incorporation into the protected area's 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) have recorded 114 species within the Half Moon Caye Natural Monument. A rapid assessment of 11 fore-reef sites in the Southern half of Lighthouse Reef was conducted in 1999 using the AGRRA protocol (Kramer and Bischof, 1999), recording average fish densities ranging from between 20.5 and 64.0 individuals per hundred square metres.

Photograph 23: White margate (*Haemulon album*), Half Moon Caye
Photograph: E. Hickerson

Results of a BAS survey conducted in 2002 targeted at fin-fish populations demonstrated that fin-fish populations were dominated by Hogfish, Queen triggerfish, Mutton Snapper and Nassau Grouper, with 15% more fin-fish within HMCNM than in comparable habitats on Lighthouse Reef outside the protected area. For BHNM this figure was 12.8% in that year (Arana, 2002). More recently, the importance of the spawning aggregation sites of Lighthouse Reef (including the Half Moon Caye Elbow site) has been highlighted (Heyman and Requena, 2002) concentrating the reproductive activity of a number of species within a small area, thereby increasing the vulnerability of these species to external impacts – particularly overfishing. Also in 2002, The Nature Conservancy conducted further research on spawning aggregation sites by means of a tagging programme for a number of fish species using the spawning sites. They deployed both conventional and acoustic tags at the three sites. Each spawning aggregation site was fitted with an acoustic receiver, with an additional receiver on Long Caye Wall. The results of this research are not yet available.



The most recent survey at Half Moon Caye was conducted as part of the Rapid Marine Assessment in 2004, with a total of 134 species recorded. This survey highlighted the lack of abundant large predatory fish of the Lutjanid, Serranid and Carangid families (compared to other reefs in Belize), suggesting a depletion of these groups from over-fishing (Graham et.al, 2004). An additional four species of shark were also recorded (Graham, pers com.)

Photograph 24: Coney (*Cephalopholis fulvus*), Half Moon Caye
Photograph: E. Hickerson

The only survey of fish species in BHNM prior to the 2004 Rapid Marine Assessment were seven surveys compiled by REEF's expert divers, yielding a total of 85 species.

Of the 138 species identified in the two protected areas during the 2004 RMA, thirty-three species were considered commercial, and seven species are recognized as threatened (Critically Endangered, Endangered, or Vulnerable - IUCN, 2006). The most commercially valuable fish in the Caribbean are the snappers and groupers, targeted by fishermen and, like other large predatory fish species, popular with recreational divers. Hogfish, grunts, porgy and triggerfish may also be important for commercial fishing, whilst inshore pelagic fisheries may target mackerel, tuna, barracuda and sharks. They also play an important ecological role as higher-level carnivores in the food web of coral reef ecosystems. The majority of these species form spawning aggregations at predictable times and places, making them highly vulnerable to fishing pressure.

Within HMCNM there are 20 species that known to migrate seasonally to spawn in groups (Heyman and Requena, 2003). Three spawning aggregation sites are located on Lighthouse Reef, at Sandbore Caye, HMC Elbow and South Point Elbow. Only Half Moon Caye Elbow is within a managed protected area, though all spawning aggregation sites are protected by law (Statutory Instrument No. 161 of 2003). As the spawning events at these sites often represent most or all of the total annual reproductive output of the population, the reduction in population abundance caused by even moderate fishing pressure can have both ecological and socio-economic consequences. Evidence suggests that once a spawning aggregation has been 'fished out' it will be probably be permanently lost, as it is unlikely to reestablish itself. This situation has been recorded at the Caye Glory spawning aggregation site in Belize, where Nassau Grouper landings declined 4000 fold between 1968 and 2001 (Heyman, 2001). As these sites are often used by a number of species including groupers and snappers as well as jacks and grunts at different times throughout the year, their year-round protection could be key to maintaining the populations of numerous commercially important species.

The **Nassau Grouper**, *Epinephelus striatus* (IUCN status: Endangered), perhaps the most vulnerable of the species known to congregate at the spawning aggregation sites on Lighthouse Reef, was recorded on the Half Moon Caye wall and the back reef at Half Moon Caye (Graham et.al., 2004). Lighthouse Reef is an important site for this species, which congregates to form spawning aggregations at Half Moon Caye, Sandbore, and "El Nic" Southern Point (Heyman and Requena, 2002; BAS, 2006). This large species is commercially important and its national decline by more than 80% since the late 1970s has been attributed primarily to fishing pressure, particularly at spawning aggregation sites, where it is especially vulnerable. The Sandbore site has been identified as one of only two remaining viable sites remaining for the Nassau Grouper, of nine originally known locations (Paz and Grimshaw, 2001). In 2001, it was estimated to contain over 2000 individuals (Paz & Grimshaw 2001), with over 4,000 to 6,000 individuals counted at peak spawning time in 2002 (Heyman and Requena, 2002). First results from Sandbore for the 2006 BAS monitoring programme reported over 1,000 individuals. Fishermen have reported significant declines in numbers of Nassau Grouper at Sandbore over the last fifteen years, describing congregations of between 20,000 and 30,000 spawning individuals in the 1980's. Although the Sandbore site is outside the two protected areas, BAS does play an oversight role in protecting this resource, and the Nassau grouper individuals of the two protected areas are known to be highly mobile, and may travel 30km in one day to get to the spawning grounds in time for the mass spawning at the full moon (one tagged individual from Belize was known to move over 250km within the Mesoamerican reef system). (Sala et. al, 2001).

It has been estimated recently that one-third of all known Nassau grouper spawning aggregation sites in the Caribbean region have disappeared. A recent study estimated that under present management conditions, Nassau Grouper (once the second most commonly caught fish in Belize) will disappear from this country by the year 2013 (Paz and Grimshaw, 2001) More than half of Belize's 13 traditional Nassau grouper spawning sites are already considered to have collapsed, as reproduction-size aggregations no longer form. In 2002 a closed season was

introduced for the Nassau grouper, during its spawning season in Belize, which runs from 1st December – 31st March.

The Half Moon Caye spawning aggregation site is utilized by Nassau Grouper, but the maximum number observed in January 2002 was ten (Heyman and Requena, 2002), and only one in January 2006 (BAS) – there is no long term data available to be able to determine trends in the spawning population. However, this site is also important as a multi-species spawning aggregation site, with twenty species being recorded using the location for spawning activities over the course of the year (Heyman and Requena, 2002).

The huge **Goliath Grouper,** or Jewfish and **Black Grouper** (Photograph 25), another two species of the grouper family at risk (IUCN: Critically Endangered), were recorded on HMC wall and in the Blue Hole during the 2004 RMA. Like the other groupers, these species are commercially important species, both for fishing and tourism. The **Yellowfin Grouper** (IUCN: Near Threatened) has been recorded at both HMCNM and BHNM. The **Red Grouper**, a Near Threatened species has been recorded at HMCNM by REEF expert divers (REEF 1996) but was not identified in the most recent surveys. The **Tiger Grouper** and **Yellowmouth Grouper** were also recorded at HMCNM - these species are not considered to be threatened, but they are commercially valuable finfish species. Belize Audubon Society have recorded a reduction in Tiger Grouper spawning activity at South Point spawning aggregation site in 2004 compared to 2002 (Forman, pers. com.).

Photograph 25: Black Grouper (*Mycteroperca bonaci*), Blue Hole
Photograph: R. Graham

Two species of snapper found at HMCNM are listed as Vulnerable (IUCN, 2006); the **Mutton Snapper** and the **Cubera Snapper** were both recorded in all reef habitat types surveyed in the RMA and also in the seagrass. Seven other species of snapper were identified at HMCNM, some of these also using the multi-species spawning aggregation sites (the Mutton Snapper being recorded using the site at South Point and the Cubera Snapper using the site at Half Moon Caye (Heyman & Renquena, 2003)).

Photograph 26: Hogfish (*Lachnolaimus maximus)*
Photograph: E. Hickerson

The **Queen Triggerfish and Hogfish** (IUCN: Vulnerable; Photograph 26) were also recorded during the 2004 survey. Hogfish (IUCN: Vulnerable) were found in all reef habitat types at HMCNM and in the seagrass, 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).

The **Rainbow Parrotfish** (IUCN: Vulnerable), has not been recorded in the literature at HMCNM since 1995, though anecdotal reports suggest it may have been seen near Long Caye as recently as 2000 (Beveridge, pers. com.).There are questions as to whether it may have become locally extinct, as has happened at Glover's Reef (Mumby, pers comm.). Several other species of large parrotfish are present at HMCNM, these included the **Stoplight, Blue, Midnight** and **Queen Parrotfish**. These species have been shown to be a keystone species assemblage/guild,

vital in maintaining the health of the reef by controlling the rate of algal overgrowth through their grazing. Interviews with fishermen from Copper Bank show that over 34% of fishermen will include parrotfish (particularly **Blue** and **Midnight Parrotfish**) within the species they target, though few target these species specifically. 13% of respondents who fished parrotfish felt there had been a decline in parrotfish abundance (SWEET, pers.com., 2006).

The 'vulnerable' **Whitelined Toadfish** (*Sanopus greenfieldorum*) has only been recorded at Lighthouse Reef and Turneffe Atoll. There is little information on this cryptic species, which may be rare, or possibly endemic (Kramer & Kramer, 2002). It is thought to occur within the Blue Hole Natural Monument, though this is still to be confirmed.

Three species of elasmobranch were captured at HMCNM and one species at BHNM during the 2004 RMA. Other records come from visual observation or from interviews with fishers and divers. For these three species, HMCNM is likely to provide an important foraging ground as well as a reproductive ground for **Nurse Sharks**. For other species of sharks it is harder to assess the importance of the protected areas for their populations, as recorded frequencies were very low. Nurse sharks were found on the sandy seagrass flats and the patch reefs at HMCNM, some showed evidence of recent reproductive activity. **Caribbean Reef Sharks** were caught in seagrass areas at HMCNM and at BHNM within the Blue Hole. **Caribbean Sharpnose Sharks** were also recorded at HMCNM by being caught on the seagrass flats and at the patch reefs.

At least 14 elasmobranch species are thought to visit Lighthouse Reef atoll, according to evidence collected for the 2004 RMA. Presence of the **Whale Shark** at the atoll has been confirmed by information from an acoustic receiver (Graham, 2003) however this Vulnerable species is very unlikely to enter the protected areas, preferring deep water outside the atoll. Two species of hammerhead shark, the **Scalloped Hammerhead** and the **Great Hammerhead**, have been observed by tourguides and fishers at HMCNM and BHNM. The **Bull Shark**, a Near Threatened species was also reported by tourguides and fishers at both protected areas. Hammerheads and Bull Sharks are thought of as forereef and pelagic species but could possibly enter the atoll occasionally through reef passes.

There is evidence for the presence of the **Tiger Shark** and **Short Fin Mako** (both Near Threatened) within Lighthouse Reef (though these have not been recorded in the protected areas themselves), based on skeletal remains found there and reports from fishers, however the Tiger Shark rarely ventures over coral reefs and is more likely to be found outside the atoll (Deloach and Humann, 1999). Another Near Threatened species, the **Lemon Shark** has been observed by tourguides and fishers within the two protected areas. **Spotted Eagle Rays** have been observed in all reef habitats at HMCNM during the RMA, their status as a threatened species is unknown and they are listed as Data Deficient (IUCN, 2004). Several other elasmobranch species were recorded at and around the protected areas, including two deepwater species. The area may be important as a reproductive ground for the **Smooth Dogfish**, as one caught there recently was found to have 6 near-term pups.

Many of these elasmobranch species may be commercially important for fishing. Interviews with fishermen in stakeholder communities are currently underway and should help to elucidate the situation regarding shark fishing at Lighthouse Reef. At BHNM in particular the sharks are important for dive tourism and are actively encouraged to remain in the area by certain dive tour operators who 'chum' the water to give tourists an opportunity to watch the sharks feeding.

Colourful reef species are also commercially important for dive tourism. Angelfish, triggerfish, grunts and damselfish all help to enhance a sport dive. 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) – the large species such as rays and sharks, the large parrotfish, groupers and snappers, recorded in the two protected areas, therefore have a high value to dive tour operators due to their popularity with divers. Greatest diversity and abundance of reef fish were recorded on the Half Moon Caye Wall and fore-reef.

Table 19: Fish Species of Blue Hole and Half Moon Caye Natural Monuments			
Family	**Species**	**Common name**	**IUCN**
Acanthuridae	*Acanthurus bahianus*	Ocean surgeonfish	
	Acanthurus chirurgicus	Doctorfish	
	Acanthurus coerulus	Blue tang	
Aulostomidae	*Aulostomus maculatus*	Trumpetfish	
Balistidae	*Aluterus scriptus*	Scrawled filefish	
	Balistes vetula	Queen triggerfish	VU
	Cantherdermis sufflamen	Ocean triggerfish	
	Cantherhines macrocerus	Whitespotted filefish	
	Cantherhines pullus	Orangespotted filefish	
	Melichthys niger	Black durgon	
Belonidae	*Ablennes hiannes*	Flat needlefish	
Blenniidae	*Acanthemblemaria spinosa*	Spinyhead blenny	
Bothidae	*Bothus lunatus*	Peacock flounder	
Carangidae	*Caranx bartholomei*	Yellow jack	
	Caranx hippos	Crevalle jack	
	Caranx latus	Horse-eye jack	
	Caranx ruber	Bar jack	
Carcharhinidae	*Carcharhinus perezi*	Caribbean reef shark	NT
	Carcharhinus leucas	Bull Shark	LR/nt
	Negaprion brevisrostris	Lemon Shark	LR
	Rhizoprionodon porosus	Caribbean sharpnose shark	
Chaetodontidae	*Chaetodon capistratus*	Foureye butterflyfish	
	Chaetodon striatus	Banded butterflyfish	
	Chaetodon ocellatus	Spotfin butterflyfish	
Clinidae	*Chenopsis ocellata*	Bluethroat pikeblenny	
	Lucayablennius zingaro	Arrow blenny	
	Malacoctenus boehlkei	Diamond blenny	
Congridae	*Heteroconger halis*	Brown garden eel	
Dasyatidae	*Dasyatis americana*	Southern stingray	
Echeneidae	*Echeneis naucrates*	Sharksucker	
	Echeneis neucratoides	Whitefin sharksucker	
Elopidae	*Megalops atlanticus*	Tarpon	
Gerreidae	*Gerres cinereus*	Yellowfin mojarra	
Ginglymostomatidae	*Ginglymostoma cirratum*	Nurse shark	
Gobiidae	*Bathygobius soporator*	Frillfin goby	
	Coryphopterus personatus/hyalinus	Masked / glass goby	
	Ctenogobius saepepallens	Dash goby	
	Gobiosoma oceanops	Neon goby	
Gramistinidae	*Rypticus saponaceus*	Greater soapfish	
	Gramma loreto	Fairy basslet	
	Gramma melacara	Blackcap basslet	
Haemulidae	*Anostremus virginicus*	Porkfish	
	Haemulon album	White margate	
	Haemulon aurolineatum	Tomtate	
	Haemulon carbonarium	Caesar grunt	
	Haemulon flavolineatum	French grunt	
	Haemulon plumieri	White grunt	
	Haemulon sciurus	Bluestriped grunt	
Holocentridae	*Holocentrus adscensionis*	Squirrelfish	
	Holocentrus marianus	Longjaw squirrelfish	
	Holocentrus rufus	Longspine squirrelfish	
	Myripristis jacobus	Blackbar soldierfish	
Kyphosidae	*Kyphosus sectatrix*	Chub	

Table 19: Fish Species of Blue Hole and Half Moon Caye Natural Monuments			
Family	**Species**	**Common name**	**IUCN**
Labridae	*Bodianus rufus*	Spanish hogfish	
	Clepticus parrae	Creole wrasse	
	Halichoeres bivittatus	Slippery dick	
	Halichoeres garnoti	Yellowhead wrasse	
	Halichoeres maculipinna	Clown wrasse	
	Halichoeres radiatus	Puddingwife	
	Lachnolaimus maximus	Hogfish	VU
	Thalassoma bifasciatum	Bluehead wrasse	
	Xyrichtys martinicensis	Rosy razorfish	
Lutjanidae	*Lutjanus analis*	Mutton snapper	VU
	Lutjanus apodus	Schoolmaster	
	Lutjanus buccanella	Blackfin snapper	
	Lutjanus cyanopterus	Cubera snapper	VU
	Lutjanus griseus	Gray snapper	
	Lutjanus jocu	Dog snapper	
	Lutjanus mahogani	Mahogany snapper	
	Lutjanus synagris	Lane snapper	
	Ocyurus chrysurus	Yellowtail snapper	
Malacanthidae	*Malacanthus plumieri*	Sand tilefish	
Mullidae	*Mulloidiochthys martinicus*	Yellow goatfish	
	Pseudopeneus maculatus	Spotted goatfish	
Muraenidae	*Gymnothorax funebris*	Green moray	
	Gymnothorax miliaris	Goldentail moray	
	Gymnothorax moringa	Spotted moray	
Myliobatidae	*Aetobatus narinari*	Spotted eagle ray	NT
Opisthognatidae	*Opistognathus aurifrons*	Yellowhead jawfish	
Ostracidaee	*Lactophrys bicaudalis*	Spotted trunkfish	
	Lactophrys trigonus	Trunkfish	
	Lactophrys triqueter	Smooth trunkfish	
Pomacanthidae	*Centropyge argi*	Cherubfish	
	Holacanthus ciliaris	Queen angelfish	
	Holacanthus tricolor	Rock beauty	
	Pomacanthus arcuatus	Grey angelfish	
	Pomacanthus paru	French angelfish	
	Abudefduf saxatilis	Sergeant major	
	Chromis cyanea	Blue chromis	
	Chromis multilineata	Brown chromis	
	Microspathodon chrysurus	Yellowtail damselfish	
	Stegastes diencaeus	Longfin damselfish	
	Stegastes fuscus	Dusky damselfish	
	Stegastes leucosticus	Beaugregory	
	Stegastes partitus	Bicolor damselfish	
	Stegastes planifrons	Threespot damselfish	
	Stegastes variabilis	Cocoa damselfish	
	Heteropriacanthus cruentatus	Glasseye snapper	
	Priacanthus arenatus	Bigeye	
Scaridae	*Cryptotomus roseus*	Bluelip parrotfish	
	Scarus coelestinus	Midnight parrotfish	
	Scarus coeruleus	Blue parrotfish	
	Scarus croicensis	Striped parrotfish	
	Scarus taeniopterus	Princess parrotfish	
	Scarus vetula	Queen parrotfish	
	Sparisoma atomarium	Greenblotch parrotfish	
	Sparisoma aurofrenatum	Redband parrotfish	
	Sparisoma chrysopterum	Redtail parrotfish	

Table 19: Fish Species of Blue Hole and Half Moon Caye Natural Monuments			
Family	**Species**	**Common name**	**IUCN**
Scaridae (cont.)	*Sparisoma radians*	Bucktooth parrotfish	
	Sparisoma rubripinne	Yellowtail parrotfish	
	Sparisoma viridae	Stoplight parrotfish	
Sciaenidae	*Equetus punctatus*	Spotted drum	
Scombridae	*Acanthocybieum solandri*	Wahoo	
	Scomberomorus cavalla	King mackerel	
	Scomberomorus regala	Cero mackerel	
Scorpaenidae	*Scorpaena plumieri*	Spotted scorpionfish	
Serranidae	*Epinephelus adscensionis*	Rock hind	
	Epinephelus cruentatus	Graysby	
	Epinephelus fulvus	Coney	
	Epinephelus guttatus	Red hind	
	Epinephelus itajara	Goliath grouper	CR
	Epinephelus striatus	Nassau grouper	EN
	Hypoplectrus indigo	Indigo hamlet	
	Hypoplectrus nigricans	Black hamlet	
	Hypoplectrus puella	Barred hamlet	
	Hypoplectrus unicolor	Butter hamlet	
	Mycteroperca bonaci	Black grouper	CR
	Mycteroperca interstitialis	Yellowmouth grouper	
	Mycteroperca tigris	Tiger grouper	
	Mycteroperca venenosa	Yellowfin grouper	
	Serranus tabacarius	Tobaccofish	
	Serranus tigrinus	Harlequin bass	
Sparidae	*Calamus calamus*	Saucereye porgy	
Sphyraenidae	*Sphyraena barracuda*	Barracuda	
Sphyrnidae	*Sphyrna mokarran*	Great Hammerhead	
	Sphyrna lewini	Scalloped Hammerhead	LR
Tetraodontidae	*Canthigaster rostrata*	Sharpnose puffer	
	Diodon hystrix	Porcupinefish	
	Sphoeroides spengleri	Bandtail puffer	

Marine Invertebrates

In total, 67 species of Scleractinian coral (stony corals) have been recorded for Belize, with coral surveys on the fore-reef at Half Moon Caye Natural Monument in 1997 and 1999 demonstrating that Lighthouse Reef has some of the best coral coverage on the Belize Barrier Reef Reserve System (McField 2001). A 1999 study using the AGRRA protocol found that the percentage coral cover at 11 fore-reef sites at Lighthouse Reef ranged from 13.5% to 36.5%, with densities of stony corals with a minimum diameter of at least 25cm (average diameter from 39cm to 55cm) ranging from 7 to 10.5 colonies per ten square metres (Kramer & Bischof, 1999).

The 2004 Rapid Marine Assessment recorded 48 species of scleractinian coral of 24 genera within the two protected areas, with variable percentage coral cover (Table 20). The highest coral cover recorded was on the Half Moon Caye fore-reef, averaging 30.74%, a decrease from the average of 43.6% recorded in earlier studies in 1997 by Mcfield. Patch reefs were observed to be in the poorest condition, showing the lowest percentage coral cover of 6.25% (Graham et. al., 2004). Corals of the Blue Hole showed an average percentage cover of 12.5%, partly a reflection of the impacts of dive boats, divers and snorkelers

Table 20: Coral Species of Blue Hole and Half Moon Caye Natural Monuments (Graham et. al., 2004)

Species	Half Moon Caye				Blue Hole Reef
	Fore-reef	Reef shelf	Backreef	Patch Reef	
Acropora cervicornis	x		x	x	x
Acropora palmata		x		x	
Acropora prolifera	x				
Agarcia sp.					x
Agaricia agaricites	x	x	x	x	x
Agaricia fragilis	x	x			x
Agaricia grahamae	x			x	x
Agaricia lamarcki	x				
Agaricia tenuifolia	x		x		
Colpophyllia natans	x			x	x
Dendrogyra cylindrus		x			
Dichocoenia stokesi	x	x			
Diploria clivosa					x
Diploria labyrinthiformis	x	x	x	x	x
Diploria strigosa	x	x	x	x	x
Eusmilia fastigiata	x	x		x	x
Favia fragum			x	x	x
Isophyllastrea rigida		x			
Isophyllia sinuosa				x	x
Leptoseris cucullata	x	x			x
Madracis decactis	x			x	
Madracis mirabilis	x				
Madracis pharensis	x				
Madracis senaria					x
Manicini areolata	x				
Meandrina meandrites	x	x			
Millepora alcicornis	x	x		x	x
Millepora complanata		x			
Monterasraea annularis	x	x	x	x	x
Monterasraea annularis complex	x		x	x	x
Montastraea cavernosa	x	x		x	x
Montastraea faveolata	x			x	x
Montastraea franksi	x			x	x
Mussa angulosa	x				
Mycetophyllia alicae	x				
Mycetophyllia ferox	x				
Mycetophyllia lamarckiana	x				
Porites astreoides	x		x	x	x
Porites branneri			x		
Porites colonensis	x				

Table 20: Coral Species of Blue Hole and Half Moon Caye Natural Monuments (Graham et. al., 2004)					
Species	**Half Moon Caye**				**Blue Hole Reef**
	Fore-reef	**Reef Shelf**	**Backreef**	**Patch Reef**	
Porites furcata	x		x		x
Porites porites	x	x		x	x
Scolymia sp.	x		x		x
Siderastrea radians			x	x	
Siderastrea siderea	x	x	x	x	x
Siderastrea stellata	x			x	x
Solenastrea bournoni		x			
Stephanocoenia intersepta	x			x	
Total Number Species	**36**	**18**	**14**	**23**	**26**

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 Blue Hole has been highlighted as a site likely to harbour cave-dwelling marine invertebrate species so far unknown to science (WWF, 2002), such as the Novocriniidae copepods discovered in submerged caves elsewhere in Belize (Huys et. al., 1998)

There are two invertebrate species of commercial importance to the Lighthouse Reef fishery - the **Caribbean Spiny Lobster** (*Panulirus argus*) and **Queen conch** (*Strombus gigas*) (Photograph 27), both of which are fished extensively throughout Belize.

The Caribbean Spiny Lobster fishery is the largest capture fishery in Belize, with production representing over 45% of total capture fisheries production, and an export value of US$6.75 million (CSO, 2004). Lobster landings peaked in 1981 at 1,000 metric tones, but has fallen to 278 metric tones in 2004. (FAO, 2005). Whilst production appears to have stabilized at between 222MT (2000) and 278MT (2004), there are concerns for the continued sustainability of the lobster fishing industry. Numbers of lobster at Lighthouse Reef appear to be very low, few being observed within the protected areas during BAS monitoring (Forman, pers. com.) nor during the Rapid Marine Assessment (Graham et. al., 2004). Whilst there is continued optimism that lobsters are being harvested at just above sustainable level (Gillet, 2003), there is, however, also concern that the average size per lobster appears to be declining, and the catch per fishermen is no longer sufficient to support a fisherman and his family (anecdotal reports, Sarteneja, 2005). During community consultations with lobster fishermen, one participant stated that they felt that there would not be sufficient lobster or conch to sustain the community of Sarteneja - a community with over 80% of families being directly reliant on the lobster fishing industry - by 2010, (Sarteneja community consultation, 2005).

The Queen Conch fishery is already considered to have collapsed, though anecdotal information suggests that the 2005 season showed record catches for Lighthouse Reef Atoll. Half Moon Caye Natural Monument and the area directly to the north are recognized as important nursery areas for this species, and efforts are being made to encourage fishermen to respect the size restrictions and no-

Photograph 27: Queen Conch (*Strombus gigas*) at Half Moon Caye
Photograph: E. Hickerson

take regulations of the protected area, though training and participation in monitoring activities. Conch landings peaked at 562MT in 1972, and have declined since then to an estimated 241MT in 2004 (FAO, 2005). Reports from the 1960's suggest that conch were so numerous that they had to be swept aside to land boats on the Caye. However, even as far back as 1996, there was evidence that the national population consisted primarily of juveniles. This was confirmed for Half Moon Caye and Blue Hole Natural Monuments with conch surveys from 1999 onwards demonstrating a drastic decline in the adult population. In sixteen sites surveyed in 1999, 82.5% of the conch observed were juvenile. Whilst there is a good management presence at Half Moon Caye, preventing incursions by fishermen, there is no such presence at Blue Hole Natural Monument. Fishermen regularly enter the protected area to harvest conch, reflected by the 2002 survey results which showed that no conch at all were observed within the boundaries. Whilst conch were observed within Half Moon Caye, 100% were juveniles.

The Queen Conch 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. Belize has been placed in the Category (ii) list of countries, as an expression of concern as to the viability of the national conch fishery, and instigating a rigid requirement for implementation of an assessment and monitoring procedure. Findings of the initial report to CITES in 2003 following a national assessment of conch stocks highlighted the importance of the marine protected area no-take zones, and the protection of the deep water conch stocks to the continued viability of the conch fishery (Fisheries Dept. 2005).

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.

Conch (*Strombus gigas*)
- Shell length should exceed 7 inches.
- Market clean weight should exceed 3 ounces.
- Closed season is from July 1st -September 30th.

Figure 25: **Regulations for Fisheries Management**

There is legislation in place to try and ensure that both lobster and conch resources are sustainable (Figure 25), but unless enforcement can be improved, both 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.

Photograph 28: Sponge
Photograph 29: Banded coral shrimp (*Stenopus hispidus*)
Photograph 30: Red encrusting sponge (*Monanchora barbadensis*)
Photograph 31: Sponge brittle star (*Ophiothrix suensonii*)
Photographs: E. Hickerson

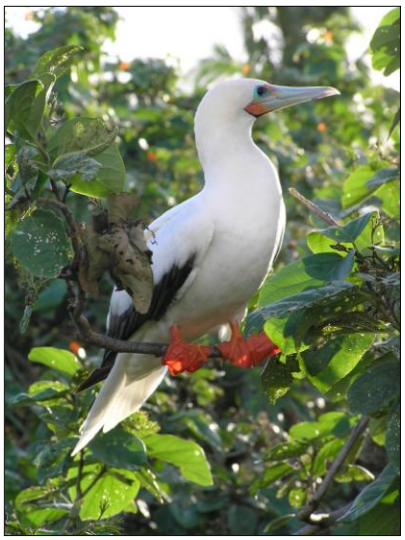
Birds

The bird fauna of Half Moon Caye is composed of a few resident species – the red-footed booby (*Sula sula*), magnificent frigatebird (*Fregata magnificens*), white-crowned parrot (*Columba leucocephala*), cinnamon hummingbird (*Amazilia rutila*), osprey (*Pandion haliaetus*) and great-tailed grackle (*Quiscalis mexicanus*). The black catbird has been recorded as resident on Half Moon Caye many years ago, and is recorded from the adjacent Long Caye, but has not been reported in recent years. The 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 not be unreasonable to expect these species to establish or re-establish a presence on Half Moon Caye.

The resident population is supplemented by a seasonal influx of migratory species using the caye as a refueling point after being blown off course on their route southwards from North America to Central or South America to overwinter. The first comprehensive survey appears to have taken place in 1958, conducted by Verner, with 87 species being recorded. Several studies since then have increased the species inventory to 128 species, and provided benchmark figures for red-footed booby and magnificent frigatebird populations.

Photograph 32: Male Magnificent Frigatebirds (*Fregata magnificens*) displaying on Half Moon Caye
Photograph: E. Hickerson

The western half of the 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 the caye each year, the nesting season stretching through almost the entire year (Verner, 1961). Although the red-footed booby is widespread throughout the tropics, there are three geographically separate races, the Belize sub-species being *S. sula sula,* found throughout the western Caribbean. They concentrate in relatively few breeding colonies, most of which are unprotected. Half Moon Caye supports what is considered to be the only viable breeding colony in the western Caribbean, with the nearest other colony, on Little Cayman Island, currently threatened by housing developments and a proposed airport expansion (L. Jones, pers. com.).



Photograph 33: White phase of the Red-footed Booby (*Sula sula*), Half Moon Caye
Photograph: E. Hickerson

Because boobies of all species do not recognize humans as a threat, they have been easily exploited in the past, Half Moon Caye being no exception until a permanent BAS staff base was established on the island. Lighthouse keepers and fishermen would both stock up on eggs during the nesting season. 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 (*Ctenosaura similis*) also raids nests, taking eggs and young nestlings (Pomeroy, 1989). Interestingly, though, further studies showed no direct relationship between iguana locations and nesting trees, with iguanas as likely to rest on non-nesting trees as those with nests (Cross, 1992).

There have been several studies of the birds of Half Moon Caye, primarily focused on the red-footed booby colony (*Sula sula*). A preliminary study by Salvin in 1864 established the caye as a known red-footed booby nesting location, and

Verner, 1961, estimated the population at 3,500 (including immatures but not nestlings). Whilst survey 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). 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 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. Survey results are thought to have varied dependent on the time of year and the time available for nest counts. The low count in 1988 may have been affected by Hurricane Gilbert (Pomeroy, 1988; Cross, 1992), and the timing of the survey, at the start of the nesting season, is thought to have been the cause of the low number of nests in 1995 (Table 21).

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 21: Survey results for Red-footed booby nests

A survey of the nesting magnificent frigatebirds estimated the presence of seventy-one nests in 1991 (Cross, 1992), far more than the counts of twenty recorded by Verner (1965) and Pomeroy (1989), though this may have been because of the later start to the frigatebird nesting season (first eggs being laid in mid to late January).

The greatest direct threat to the nesting colony in 1991 was identified as the invasive rat population, though the potential danger of disturbance from increased visitation was also recognized (Cross, 1992). This 1991 survey provides an excellent baseline against which to measure future nesting numbers of both red-footed booby and magnificent frigatebird populations (Cross, 1992), but no comprehensive survey data appears to be available since 1991 (discounting the 1995 early-season count)..

Other than the nesting colony, Half Moon Caye National Monument is important as a migratory bird stopover refueling point and, being the most isolated of the three atolls, probably has 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, as has been seen particularly with night-flying migrants, which have been 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 to Half Moon, Glover's Reef, and Sapodilla Cayes, and from there to Guatemala and Honduras, where they again hook up with the mainland and its "infinite" resources.

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% overlap of migratory species. Of these, the blue-winged, golden-winged, yellow, blackburninan, cerulean, magnolia, mourning, prothonatory, worm-eating, Swainson's and hooded warblers are largely believed to fly trans-gulf, relying on making landfall on the Yucatan Peninsula (N. Bayly, pers. com.). 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 caye 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.)

Table 22: Bird Species of Half Moon Caye Natural Monument

Species		Status	Habitats	Endemism
Brown Booby	*Sula leucogaster*	uV	OC	
Red-footed Booby	*Sula sula*	vP	LF, OC	
Brown Pelican	*Pelecanus occidentalis*	cV	LF, BE, OC	
Magnificent Frigatebird	*Fregata magnificens*	vP	LF, BE, OC	
Least Bittern	*Ixobrychus exilis*	oT	LF	
Great Blue Heron	*Ardea herodias*	uV	BE	
Great Egret	*Ardea alba*	uV	BE	
Snowy Egret	*Egretta thula*	uV	BE	
Little Blue Heron	*Egretta caerulea*	uV	BE	
Tricolored Heron	*Egretta tricolor*	oV	BE	
Cattle Egret	*Bubulcus ibis*	fT	BE	
Green Heron	*Butorides virescens*	fV	LF, BE	
Yellow-crowned Night-Heron	*Nyctanassa violacea*	uT	LF, BE	
Blue-winged Teal	*Anas discors*	oT	OC	
Lesser Scaup	*Aythya affinis*	oT	OC	
Osprey	*Pandion haliaetus*	fP	LF, BE, OC	
Common Black-Hawk	*Buteogallus anthracinus*	x	LF	
Merlin	*Falco columbarius*	uT	LF, BE	
Peregrine Falcon	*Falco peregrinus*	fT	LF, BE, OC	
Sora	*Porzana carolina*	oT	LF	
American Coot	*Fulica americana*	oT	BE, OC	
Black-bellied Plover	*Pluvialis squatarola*	uW	BE	
Collared Plover	*Charadrius collaris*	F	BE	
Semipalmated Plover	*Charadrius semipalmatus*	oT	BE	
Killdeer	*Charadrius vociferus*	uT	BE	
Greater Yellowlegs	*Tringa melanoleuca*	uT	BE	
Willet	*Catoptrophorus semipalmatus*	oT	BE	
Spotted Sandpiper	*Actitis macularia*	cW	BE	
Ruddy Turnstone	*Arenaria interpres*	fW	BE	
Sanderling	*Calidris alba*	fW	BE	

Status

Legend

v = very common
c = common
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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

Habitat Preferences within HMCNP

Legend (Adapted from Jones and Vallely, 2001)

LF Littoral forest
BE Beaches
OC Ocean
O Overhead

Regional Endemics

Legend (L. Jones)

MA Middle America Endemic
NMA Northern Middle America Endemic

With input from Lee Jones, 2005

Table 22: Bird Species of Half Moon Caye Natural Monument / 2

Species		Status	Habitats	Endemism
Semipalmated Sandpiper	*Calidris pusilla*	oT	BE	
Western Sandpiper	*Calidris mauri*	oT	BE	
Least Sandpiper	*Calidris minutilla*	uT	BE	
Wilson's Snipe	*Gallinago delicata*	oT	LF, BE	
Laughing Gull	*Larus atricilla*	uV	BE, OC	
Ring-billed Gull	*Larus delawarensis*	oW	BE, OC	
Herring Gull		oW	BE, OC	
Royal Tern	*Sterna maxima*	cV	BE, OC	
Sandwich Tern	*Sterna sandvicensis*	uV	BE, OC	
Bridled Tern	*Sterna anaethetus*	oV	OC	
White-crowned Pigeon	*Columba leucocephala*	fS	LF	
Yellow-billed Cuckoo	*Coccyzus americanus*	fT	LF	
Smooth-billed Ani	*Crotophaga ani*	x	LF	
Groove-billed Ani	*Crotophaga sulcirostris*	oW	LF	
Lesser Nighthawk	*Chordeiles acutipennis*	uT	LF	
Yucatan Nightjar	*Caprimulgus badius*	x	LF	MA
Chimney Swift	*Chaetura pelagica*	uT	O	
Green-breasted Mango	*Anthracothorax prevostii*	fS?	LF	
Cinnamon Hummingbird	*Amazilia rutila*	fP	LF	
Ruby-throated Hummingbird	*Archilochus colubris*	uT	LF	
Ringed Kingfisher	*Ceryle torquata*		LA	
Belted Kingfisher	*Ceryle alcyon*	fW	BE	
Yellow-bellied Sapsucker	*Sphyrapicus varius*	oT	LF	
Caribbean Elaenia	*Elaenia martinica*	x	LF	
Eastern Wood-Pewee	*Contopus virens*	vT	LF	
Yellow-bellied Flycatcher	*Empidonax flaviventris*	cT	LF	
Acadian Flycatcher	*Empidonax virescens*	cT	LF	
Willow Flycatcher	*Empidonax traillii*	fT	LF	
Great Crested Flycatcher	*Myiarchus crinitus*	cT	LF	
Sulphur-bellied Flycatcher	*Myiodynastes luteiventris*	oT	LF	
Piratic Flycatcher	*Legatus leucophalus*	oT	BFL, AG	

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Habitat Preferences within HMCNP

Legend (Adapted from Jones and Vallely, 2001)

LF Littoral forest
BE Beaches
OC Ocean
O Overhead

Regional Endemics

Legend (L. Jones)

MA Middle America Endemic
NMA Northern Middle America Endemic

With input from Lee Jones, 2005

Table 22: Bird Species of Half Moon Caye Natural Monument / 3				
Eastern Kingbird	*Tyrannus tyrannus*	cT	LF	
White-eyed Vireo	*Vireo griseus*	cT	LF	
Yellow-throated Vireo	*Vireo flavifrons*	fT	LF	
Philadelphia Vireo	*Vireo philadelphicus*	uT	LF	
Red-eyed Vireo	*Vireo olivaceus*	cT	LF	
Yellow-green Vireo	*Vireo flavoviridis*	oT	LF	
Black-whiskered Vireo	*Vireo altiloquus*	x	LF	
Purple Martin	*Progne subis*	cT	O	
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	uT	O	
Bank Swallow	*Riparia riparia*	uT	O	
Cliff Swallow	*Petrochelidon pyrrhonota*	uT	O	
Barn Swallow	*Hirundo rustica*	cT	O	
Veery	*Catharus fuscescens*	fT	LF	
Gray-cheeked Thrush	*Catharus minimus*	uT	LF	
Swainson's Thrush	*Catharus ustulatus*	cT	LF	
Wood Thrush	*Hylocichla mustelina*	cT	LF	
Gray Catbird	*Dumetella carolinensis*	vT	LF	
Black Catbird	*Melanoptila glabrirostris*	F	LF	
Cedar Waxwing	*Bombycilla cedrorum*	oT	LF	
Blue-winged Warbler	*Vermivora pinus*	oT	LF	
Golden-winged Warbler	*Vermivora chrysoptera*	oT	LF	
Tennessee Warbler	*Vermivora peregrina*	vT	LF	
Nashville Warbler	*Vermivora ruficapilla*	x	LF	
Northern Parula	*Parula americana*	cW	LF	
Yellow Warbler	*Dendroica petechia*	cW	LF	
Chestnut-sided Warbler	*Dendroica pensylvanica*	cT	LF	
Magnolia Warbler	*Dendroica magnolia*	cT	LF	
Cape May Warbler	*Dendroica tigrina*	uT	LF	
Black-throated Blue Warbler	*Dendroica caerulescens*	uT	LF	
Yellow-rumped Warbler	*Dendroica coronata*	uT	LF	
Black-throated Green Warbler	*Dendroica virens*	fT	LF	
Blackburnian Warbler	*Dendroica fusca*	uT	LF	
Yellow-throated Warbler	*Dendroica dominica*	cW	LF	
Prairie Warbler	*Dendroica discolor*	uW	LF	
Palm Warbler	*Dendroica palmarum*	cW	LF	

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Habitat Preferences within HMCNP

Legend (Adapted from Jones and Vallely, 2001)

LF Littoral forest
BE Beaches
OC Ocean
O Overhead

Regional Endemics

Legend (L. Jones)

MA Middle America Endemic
NMA Northern Middle America Endemic

With input from Lee Jones, 2005

Table 22: Bird Species of Half Moon Caye Natural Monument / 4				
Species		**Status**	**Habitats**	**Endemism**
Bay-breasted Warbler	*Dendroica castanea*	uT	LF	
Cerulean Warbler	*Dendroica cerulea*	oT	LF	
Black-and-white Warbler	*Mniotilta varia*	cW	LF	
American Redstart	*Setophaga ruticilla*	vW	LF	
Prothonotary Warbler	*Protonotaria citrea*	fT	LF	
Worm-eating Warbler	*Helmitheros vermivorus*	fT	LF	
Swainson's Warbler	*Limnothlypis swainsonii*	oT	LF	
Ovenbird	*Seiurus aurocapilla*	cW	LF	
Northern Waterthrush	*Seiurus noveboracensis*	cT	BE	
Louisiana Waterthrush	*Seiurus motacilla*	uT	BE	
Kentucky Warbler	*Oporornis formosus*	uT	LF	
Connecticut Warbler	*Oporornis agilis*	x?		
Mourning Warbler	*Oporornis philadelphia*	uT	LF	
Common Yellowthroat	*Geothlypis trichas*	cW	LF	
Hooded Warbler	*Wilsonia citrine*	cW	LF	
Wilson's Warbler	*Wilsonia pusilla*	oT	LF	
Canada Warbler	*Wilsonia canadensis*	uT	LF	
Yellow-breasted Chat	*Icteria virens*	cT	LF	
Summer Tanager	*Piranga rubra*	cW	LF	
Scarlet Tanager	*Piranga olivacea*	cT	LF	
Chipping Sparrow	*Spizella passerina*	x	BE	
Grasshopper Sparrow	*Ammodramus savannarum*	x	BE	
White-throated Sparrow	*Zonotrichia albicollis*	x	BE	
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	cT	LF	
Blue Grosbeak	*Passerina caerulea*	cT	LF	
Indigo Bunting	*Passerina cyanea*	vT	LF	
Bobolink	*Dolichonyx oryzivorus*	oT	BE	
Great-tailed Grackle	*Quiscalus mexicanus*	vP	LF, BE	
Orchard Oriole	*Icterus spurious*	uT	LF	
Baltimore Oriole	*Icterus galbula*	cT	LF	
Painted Bunting	*Passerina ciris*	uT	LF	
Dickcissel	*Spiza americana*	uT	LF	

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Regional Endemics

Legend (L. Jones)

MA Middle America Endemic
NMA Northern Middle America Endemic

With input from Lee Jones, 2005

Herpetofauna

The herpetofauna of Half Moon Caye is comprised entirely of reptile species. No amphibians have been recorded there - the saline conditions, absence of freshwater sources, and distance from the mainland are the main determinants precluding their presence. Snakes are also absent from the Caye – in this case distance from mainland and Caye populations is the main factor in having prevented colonization by species found on locations closer to the mainland, including the Turneffe Atoll.

Ten reptile species have been recorded from Half Moon Caye, six of which are terrestrial residents of the littoral forest and three are marine turtles. Four of these species are now globally threatened - the three marine turtles (loggerhead, green and hawksbill) and the American crocodile. Additionally, the island leaf-toed gecko is rated as Near Threatened on Belize's National List of Critical Species (Meerman, 2005), whilst 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.

Former records of *Basiliscus vittatus* and *Anolis carolinensis* are considered erroneous and are discounted, (see discussion below), and it seems almost certain that both *Rhinoclemmys areolata* and *Iguana iguana* were anthropogenically introduced to the Caye.

The **Loggerhead turtle** *(Caretta caretta)* is classified as endangered (IUCN, 2006). This species occurs throughout tropical, subtropical and temperate seas around the world. It is omnivorous, feeding on a wide range of marine invertebrates, seaweeds and turtle grass. Loggerheads are seen mating March through May along the outer reef and subsequently nest at Ambergris Cay, Glover's Reef, Lighthouse Reef, and at scattered locations throughout the offshore cayes from May through August. Nesting occurs at night, and usually at high tide. Females excavate nests on sandy beaches above high-water mark, and lay clutches of 60-200 eggs. A single female may lay several clutches during a single season. It is estimated that fewer than 40 loggerheads nest annually in Belize now. Nest counts (Smith, 1990) and recent staff observations (Chan, D., pers com) indicate that fewer than 10 Loggerhead nests are made annually now on Half Moon Caye – possibly representing nesting by only 2-3 individuals: a drastic decline from past numbers.

Photograph 34: Nesting Green Turtle (*Chelonia mydas*), Half Moon Caye
Photograph: Alex Lazarus

Green turtles *(Chelonia mydas)* are also classified as endangered (IUCN, 2006) (Photograph 34). The green turtle is primarily a tropical species ranging throughout the Atlantic, Pacific and Indian oceans, though is known to range into temperate seas at times. It is primarily herbivorous, feeding mostly upon 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, Half Moon Caye, Long Caye (Glover's Reef), Ambergris Caye, and the southern cayes. 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., 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.

The **hawksbill turtle** (*Eretmochelys imbricata*) is classified as critically endangered (IUCN, 2006), and is more restricted to the tropical portions of the Atlantic, Pacific and Indian oceans than the green turtle. It tends to be more confined to shallow waters than the other two species, and is known to venture into coastal lagoon and estuaries, where it feeds primarily upon marine invertebrates. This species has a protracted nesting season of 6 months or more – peaking in June and July, with the period between nesting seasons generally being 2-4 years (but may be as long as 10 years) (Chacon, D., 2004). Nesting occurs at night, generally at high tide, with a clutch size of 50-200 eggs. Nests are generally concealed in beach vegetation and, except for a faint asymmetrical crawl (ca. 0.7 m wide) leading to and from the ocean, there is seldom any obvious evidence of the visit. The loss of beach vegetation on Half Moon Caye may deter nesting females (Smith, et al., 1992). Whilst recent records are largely anecdotal, hawksbills are recorded as having nested on Half Moon Caye in 2004 (Majil, 2005). Previous uncertainties re. nesting here may reflect the fact that Hawksbill nests are harder to detect than the other species (as noted above), and the lack of continued monitoring of turtle nesting throughout the season

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. Significant changes in the coastline of Half Moon Caye also occurred as a result of extreme wave action associated with the distant Hurricane Mitch in 1998 – with the creation of "Mitch Island" from piled up coral rubble just off the easternmost tip of Half Moon Caye. 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 behaviour or even render nesting beaches inaccessible (Smith, et. al., 1992).

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 and Sandbore Caye within Lighthouse Reef Atoll, and the Bay Islands of Honduras. The populations on Lighthouse Reef Atoll and the Bay Islands of Honduras are effectively isolated from those on Cuba, and might well be genetically distinct. Its range and status in Belize merit inclusion within Belize's National List of Critical Species (Walker, P., pers. obs.). On Half Moon Caye it is relatively abundant, and is most easily observed on bare coconut trunks. It occurs 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. It was observed using both coconut debris on the ground, and the crown of coconut trees for retreat. Activity height (depending upon vegetation) ranges from 0.75m to 12m or more. It can rapidly change

colour from bright green to dull brown. Allison's anole juveniles on Half Moon Caye have evidently previously been misidentified as *Anolis carolinensis* (now discounted as occurring in Belize (Walker, pers. obs.; Lee, pers. com.), from which it differs in having an elongated ear opening.

The island leaf-toed gecko (*Phyllodactylus insularis*) (Photograph 35) 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.) as those specimens are attributed to *Pyllodactylus palmeus*. Its endemism is the justification for its inclusion on Belize's National List of Critical Species (Meerman, J.C., 2005). It is relatively abundant on Half Moon Caye, and occurs throughout the area occupied by 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 - to date in addition to the population on 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. There is little doubt that the distribution and abundance of this nocturnal gecko in Belize is significantly greater than previously reported.

Photograph 35: Island leaf-toed gecko (*Phyllodactylus insularis*), Half Moon Caye

The **Brown anole** (*Anolis sagrei*) is abundant on HMC, it is very variable in colouration 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. Whilst generally considered a human commensal, it does occur throughout the littoral forest of Half Moon Caye – and indeed on numerous uninhabited coastal islands. It would appear that these ecosystems are the natural habitat for the brown anole, and that its range has extended alongside that of the human population along the coastal plain.

Black iguanas (*Ctenosaura similis*) are common on the 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 (Photograph 36).

Photograph 36: Black iguana (*Ctenosaura similis*), Half Moon Caye

Green iguanas (*Iguana iguana*) are now uncommon on the Caye, and probably number just a few individuals. Specimens are extremely shy at this locality, and flee when approached. It is presumed that the species was anthropogenically introduced to the Caye and it appears that the population is now significantly lower than it had once been - and that it is likely to 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 possibly through declining availability of freshwater: Stoddart (1962) mapped standing water in a mudhole on the island, and commented that attempts appeared to have been made to fill it with coconut debris – 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 **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.).

Introduced Species

It seems almost certain that both *Rhinoclemmys areolata* and *Iguana iguana* were anthropogenically introduced to the Caye, though there may never be incontrovertible proof for *Iguana iguana.* Two specimens of *Rhinoclemmys areolata* have been observed, photographed and positively identified on the Caye in 2004 (Forman, pers. com.), with subjective indications that these specimens had recently been released onto the Caye by a tour operator (S. Rhamclam, pers. com). Whilst Half Moon Caye is not appropriate habitat for this species, it is conceivable that adults could survive there. Heavy predation and sub-optimal habitat conditions are likely to prevent full establishment of viable populations of these introduced species, their presence on the island is not desirable. Specimens of the apparently recently introduced *Rhinoclemmys areolata* should be captured when encountered, and taken to the mainland.

Iguana iguana has been present on HMCNM for several decades, having been positively identified there in the early 1960's. Being primarily associated with riparian and lacustrine forest habitats, the green iguana is not a species expected to be found on a small marine Caye distant from the mainland. This, and lack of authenticated records from other Belize Cayes, strongly supports the supposition that the species was introduced to the Caye as a food source by passing fishermen, or prior lighthouse keepers, possibly many decades ago. As noted above, it would appear that the population of *Iguana iguana* is in decline (during the December 2004 survey, only a single sub-adult specimen (2-3 yrs old) was observed); as negative impacts from this species upon the fauna and flora of the island have not been observed, it is proposed that active management actions towards the removal of this presumed introduced species are not implemented for the time being at least. If the few specimens of this species persist beyond the eradication of the rat population, and if it subsequently shows signs of renewed recruitment into the adult population (through lowered juvenile mortality), then its case should be reconsidered and consensus reached amongst professional biologists as to whether attempts should be made to eradicate it from the island.

Erroneous Records

A single specimen (UF 23924, Ref. Lee, 1996) of *Anolis carolinensis* is reported to have been collected on HMCNM in 1966. Meerman, J.C. (1996) reported that "a nice population inhabits the observation tower in the Booby colony" and collected several specimens of what he initially identified as *Anolis carolinensis,* but later determined them to more probably be juvenile specimens of *Anolis allisoni.* Lee, J.C. (1996, 2000) expresses considerable doubt about the presence of *Anolis carolinensis* on the Caye. Using the readily distinguishable feature of shape of ear opening (Stafford, P.J. & Meyer, J.R., 2000), significant attention was placed during the current survey on the resolution of the uncertainties associated with the 1996 report of the presence of *Anolis carolinensis* on Half Moon Caye. Of the 50+ specimens observed closely in the current survey, including three specimens on the observation tower and another on vegetation on Southern Beach, all had the elongated ear opening of *Anolis allisoni.* It is

concluded that if the 1996 specimen was indeed collected on HMCNM, that it represented a small introduced population that no longer occurs on the Caye. Meerman's (1996) records are therefore attributed as having been juvenile *Anolis allisoni.* Former records of *Basiliscus vittatus* and *Anolis carolinensis* are considered erroneous and are discounted.

Table 23: Herpetofauna Species of Half Moon Caye NM		IUCN Status
Chelonidae		
Loggerhead turtle	*Caretta caretta*	EN
Green turtle	*Chelonia mydas*	EN
Hawksbill turtle	*Eretmochelis imbricata*	CR
Emydidae		
Furrowed wood turtle	*Rhinoclemmys areolata*	
Gekkonidae		
Island leaf-toed gecko	*Phyllodactylus insularis*	
Iguanidae		
Black iguana, Wish-willy, Spiny-tailed iguana	*Ctenosaura similis*	
Green iguana, Bamboo chicken	*Iguana iguana*	
Polychrotidae		
Allison's anole, Giant anole	*Anolis allisoni*	
Brown Anole	*Anolis sagrei*	
Crocodylidae		
American crocodile	*Crocodylus acutus*	VU
IUCN Threatened Species Criteria **CR** Critically Endangered **EN** Endangered **VU** Vulnerable		

2.5.3 Past and Present Research

Despite the lack of any research facilities until the construction of the Miller Research Building, a significant amount of invaluable baseline research was undertaken on and around Half Moon Caye and the Blue Hole. Work encompassed geological surveys, surveys of the fauna and flora of the caye, and the surrounding coral formations. More recently, most research has been focused on reef assessments and fish spawning aggregations, with virtually no formal terrestrial research in the last decade.

A rapid assessment of the effects of coral bleaching followed the 1998 bleaching episode, and Belize Audubon Society is trying to establish and implement long term monitoring to look at the coral health of the atoll. This will follow the MBRS Synoptic monitoring programme protocols, covering seagrass and coral reef communities. Specific monitoring is also being developed for commercial fish species, lobster and conch, in liaison with Fisheries Department. There has been no specific research to assess any ecological shifts that may be taking place, as has been seen on other atolls. A baseline for monitoring visitor impacts was established for Half Moon Caye Wall in 1989 during a CEDAM International expedition, but with no follow-through. This data will, however, provide the baseline essential for future monitoring work.

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.

Terrestrial

1864 O. Salvin. 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 Jared Verner. 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 D. R. Stoddart. 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 D. R. Stoddart. 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).

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 programme. Veitch, D. (1997). Eradication of Rats from Half Moon Caye. Unpublished report for the Belize Audubon Society.

2006 Walker P. Current survey – rapid ecological assessment of vegetation and herpetofauna of Half Moon Caye; validation of existing data for use in management planning.

Marine

1962 D. R. Stoddart. Described much of the coral reef around Half Moon Caye, and on the rest of the Atoll.

1969 D. R. Stoddart. 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 P. Kramer and B. G. Bischof. Rapid assessment using AGRRA 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 M.D. McField. Surveyed coral response during and after the mass bleaching event of 1998.

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

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 and

2.6 Cultural and Socio-Economic Values

2.6.1 Community and Stakeholder Use

Lighthouse Reef Atoll includes five cayes that in 2000, supported a resident population of about 25 people (BAS, 2000), with one resort (Lighthouse Reef Resort, on Northern Two Cayes), one fishing camp, two attended lighthouses (on Sandbore and Half Moon Caye), and the HMCNM park management headquarters on Half Moon Caye). Live-aboards and day dive boats from San Pedro, Caye Caulker, Turneffe and Belize City also contribute towards the tourism based stakeholder interests, believed to be the primary economic interest of the Atoll. Over the past six years, from 2000 to 2006, development activity has increased, with Lighthouse Reef Resort currently being closed for redevelopment, and Long Cay being sub-divided into commercial and residential lots, with the first restaurant currently under construction. These developments, whilst increasing the economic benefits in maintaining or improving the state of the atoll reef, also bring with them the problems associated with coastal development (See section 3.2)

The second economic activity associated with Lighthouse Reef is fishing, primarily for lobster, conch and fin-fish. Nationally, the fisheries sector ranks third as a foreign exchange earner and earned over US$35 million in 2000.

The lobster fishery is the largest capture fishery in Belize, and lobster exports (US$6.75 million in 2003) and conch (US$1.85 million) have both increased from 1999 to 2000 (CSO, 2004). The impacts of increasing numbers of fishermen, the anticipated increasing numbers of hurricanes, and deterioration of the reef through greater incidence of disease and coral bleaching may well cause the decline of this industry in the near future.

During 2005, a total of 152 fishermen from 28 fishing boats were recorded using Lighthouse Reef (BAS, 2005). The majority of Lighthouse Reef fishermen are from Copper Bank, Chunox or Sarteneja, traveling to Lighthouse Reef from Belize City in sailing sloops with a crew of between seven and ten fishermen, and often one cook. Sailing from Belize City, they spend two days reaching the atoll, then stay out for six to twelve days, before returning to Belize City fishing cooperatives with full ice boxes.

Potential Areas of Conflict

Fishing within the Protected Area

There is an ‘honourable agreement’ that exists between the lighthouse keeper and the reserve wardens, allowing subsistence fishing within the protected area (D. Chan, 2005). The lighthouse keeper’s assistant, though, frequently fishes within the protected area for commercial sale, and has done so for years, which has produced some conflict with the coastal community fishermen, who see it as unfair that he should be able to maintain a fishing camp on Half Moon Caye and fish within the boundaries when all else are excluded. A second area of potential conflict is in relation to the spawning aggregations – the assistant lighthouse keeper was instrumental in showing BAS the location of the Half Moon Elbow spawning aggregation site. Once it was discovered that this site was within the Half Moon Caye Natural Monument, however, he was no longer allowed to fish there. He does, however, have permission from Fisheries Department to fish Southern Point spawning aggregation site (Forman, pers. com.).

There is also evidence of fishing within both the protected areas by the sailboat fishermen from the mainland, both during the day, and using underwater flashlights at night to cross into the protected areas. This is particularly so for the Blue Hole, which has little enforcement presence at outside of visitation hours. Lack of ability to see the boundary markers clearly has also created some conflict, as fishermen are unsure of protected area boundaries. A total of 22 arrests were

made during 2005, in conjunction with Fisheries Dept., leading to the confiscation of over 1,700lbs of illegally harvested conch.

There is a need to explore ways in which the traditional fishermen and the protected areas can co-exist and co-operate within the context of the Lighthouse Reef Atoll, the first steps have been taken within the framework of the current BAS management goals, through the OAK/AVINA funded 'Promoting the sustainable use of Lighthouse Reef Atoll' project, and through the recently formed Memorandum of Understanding signed with the Belize Fisherman's Cooperative Association in 2004.

With concerns for future pressure on the resources from continued fishing, BAS is considering investigating the feasibility of seeking stakeholder management of the entire Atoll, 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. Whilst privately owned lands were gradually integrated into the protected area through purchase or canceling leases, there has been an informal understanding that the lighthouse keeper could continue to harvest coconuts from the trees. It has long been recognized that the coconuts from the former plantations are invasive, and are continually 'pushing back' the boundaries of the natural vegetation. Reversal of the extremely negative trend of biodiversity loss caused by this invasion, and restoration of littoral forest and herbaceous beach vegetation on the western half of the island is of paramount importance if the biodiversity value of the terrestrial component of the protected area is to be maintained and restored. Under the coconut control plan, coconut trees will be left over much of the eastern half of the island, but it is recommended that they be sequentially and comprehensively removed from the western half of the island. This will inevitably reduce the overall harvest of coconuts that has become an expected 'right' of the lighthouse keeper. It will be very important for BAS and the Belize Port Authority to establish very open lines of communication, to explain the critical necessity of implementing the coconut control programme and to clearly explain the boundaries beyond which the forest restoration activities will not extend, and therefore where the lighthouse keeper may expect to retain the privilege of coconut harvest.

2.6.2 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 16$^{th/}$ 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, and the brick foundations of the replacement lighthouse are still present on Half Moon Caye (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 (Photograph 37). Some of the wrecks have now disappeared but many are still visible on the reef and several are used as dive sites (Table 24).

Photograph 37: 'Harrier Wreck', one of several wrecks visible on the Lighthouse Reef atoll rim

Table 24: Shipwrecks of Lighthouse Reef Atoll

Date	Name of Vessel	Information
1719	The Bangor	A galley lost off Sandbore Caye *en route* 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'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 8th 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.

Information from www.ambergriscaye.

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 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. Today, only one lighthouse keeper (Rudolf Allen) and his assistant (Philip Young) remain on the island, who continue to supplement their income by selling coconuts and marine products.

2.6.3 Tourism and Recreation Use

Under their designation as Natural Monuments, both protected areas are open for visitation. One of the goals under management is

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

Management Plan
Half Moon Caye Natural Monument and Blue Hole Monument 2008 – 2013
Goal 2

Tourism has fast become one of the major industries in Belize, contributing 15.6% towards the gross domestic product in 2002. It is also one of the main employers, estimated to provide employment for one in four people in 2002 (BTB, 2005). The major attractions for visitors are the cultural and natural resources, both marine and terrestrial.

Lighthouse Reef Atoll is one of Belize's major tourism attractions, bringing many people to Belize each year specifically to dive the internationally reknowned Blue Hole. The Half Moon Caye Wall, as well, is considered one of the best dive sites in Belize waters, and the impressive red-footed booby nesting colony on the caye itself is a resource appreciated by many bird watchers. 8,420 visitors are reported to have visited the Caye between January and December, 2005 (R. Pott, pers.com.), the majority as day visitors, arriving at Lighthouse Reef from San Pedro or Caye Caulker on one of the dive boats, diving Blue Hole, then stopping at the Caye for lunch, going on to dive Half Moon Caye Wall, the Aquarium and other sites around the Atoll, before heading back to the Ambergris Caye or Caye Caulker in the afternoon. The two-hour trip, often over rough waters, makes it an expensive day for divers, yet 6% of overnight visitors to Belize in 2004 did include Half Moon Caye on their itinerary.

Table 25: Tourism Statistics for Belize and for Half Moon Caye Natural Monument (BAS, 2005; Immigration Department)

	1998	1999	2000	2001	2002	2003	2004
Total Number Tourists	176,054	180,795	195,766	195,955	199,521	151,978	162,275
Half Moon Caye Natural Monument	7,310	7,940	12,317	10,071	10,207	7,141	9,803
% of Total Number of Tourists	4.15	4.39	6.29	5.14	5.12	4.70	6.0

Live-aboard dive boats also visit Half Moon Caye on a regular basis, using mooring sites to the south of the Caye, and staying at least one night. More recently, these moorings have been used by a number of smaller cruise ships, though this has caused problems as the cruise ships are much larger than the vessels for which the mooring points were installed.

There are occasionally also overnight visitors, who make use of the camp site, and Island Expeditions have established a camping base on the caye from which to run sea kayaking trips (Photograph 39).

Visitor facilities at Half Moon Caye are relatively basic, providing 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. Current levels of visitation are considered sustainable, though effects of tourism-related impacts are being seen on the reef and seagrass (see 3. Conservation Planning).

Photograph 38: Half Moon Caye Visitors Centre

Photograph 39: Island Expedition camping shelter and camp ground, Half Moon Caye

2.6.4 Other Economic Uses

There is a limited economic use of Half Moon Caye Natural Monument by the lighthouse keeper, who harvests coconuts, extracting the oil for sale in Belize City. This is accepted as a traditional activity, conducted under an unspoken agreement with BAS.

2.6.5 Education Use

The marine education programme is currently focused on several target groups and a number of activities. 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.

A wish to involve Lighthouse Reef fishermen in biodiversity monitoring activities has led to 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 a recognition of the need for training in alternative livelihoods within the stakeholder communities – primarily tourism-focused, 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.

There has been little scope, however, for education activities within the protected areas themselves, with the logistical problems of access and financial costs involved. 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.

On Half Moon Caye itself, the Visitors Centre provides information for the education of the constant flow of tourists that pass through the Caye. Belize Audubon Society also offers evening talks to the live-aboard dive boats that moor close to the caye, raising awareness of the organisation and its role in conservation in Belize, and the justifications behind the establishment of Blue Hole and Half Moon Caye Natural Monuments.

Photograph 40: Displays within the Visitor Centre, Half Moon Caye

Section Three

Conservation Planning

3. Conservation Planning

This conservation planning section looks at the species and ecosystems of concern, at the threats that impact them, and the strategies that can be used within the management of the area to abate these threats.

3.1 Conservation Targets

3.1.1 Identification of Conservation Targets

As a first step in the conservation planning process, eleven conservation targets were chosen, at a coarse enough scale to encompass the diverse guilds and individual species of conservation concern (Figure 26).

Ecosystem Level
- Coral Reef
- Seagrass
- Littoral Forest

Species Assemblages
- Commercial marine species
- Turtle species
- Lizard Species
- Nesting birds
- Shark species
- Parrotfish species
- Fish Spawning Aggregations

Physical Characteristics
- Blue Hole geology

Figure 26: Conservation Targets

Some of these are present in both the protected areas, whilst others are specific to one or the other. Conservation planning has been conducted for both protected areas separately (Figure 27).

Blue Hole	**Half Moon Caye**
Seagrass	Seagrass
Coral Reef	Coral Reef
Commercial Marine Species	Commercial Marine Species
Parrotfish	Parrotfish
Shark Species	Fish Spawning Aggregations
Blue Hole Geology	Marine Turtles
	Littoral Forest
	Nesting Bird Colony
	Lizard Species

Figure 27: Conservation Targets selected for each protected area

3.1.2 Blue Hole Natural Monument – Conservation Target Viability

Six conservation targets have been selected for the Blue Hole Natural Monument (Table 26).

Blue Hole Natural Monument
Conservation Target
Coral Reef
Seagrass
Commercial Marine Species
Parrotfish
Sharks
Sink Hole Geology

Table 26: Conservation Targets of Blue Hole Natural Monument

These have been chosen to assist in guiding conservation strategies at site level, and are indicative of the threats that are faced by the two protected areas. The justifications for target selection, and the nested targets represented, are discussed in Annex 1.

Table 27: Blue Hole: Viability Ranking for Conservation Targets

Conservation Target	Size	Condition	Landscape Context	Overall Viability Rank
Coral Reef	Good (3.5)	Fair (2.5)	Good (3.5)	**Good (3.17)**
Seagrass	Very Good (4)	Good (3.5)	Very Good (4)	**Very Good (3.83)**
Commercial Marine Species	Poor (1)	Poor (1)	Fair (2.5)	**Poor (1.50)**
Parrotfish	Good (3.5)	Fair (2.5)	Fair (2.5)	**Fair (2.83)**
Sharks	Good (3.5)	Good (3.5)	Fair (2.5)	**Good (3.17)**
Blue Hole Geology				**Very Good (4)**
Overall Viability Rating of Blue Hole				**Good (3.08)**

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)

The viability assessment for Blue Hole Natural Monument indicates that the overall health of the species and biological systems of the protected area is considered **GOOD.** The 'good' rather than 'very good' rating particularly reflects the increasing pressure on the commercial marine species within the Atoll, and in fact in Belize generally.

Under this system, the viability of one of the conservation targets – Commercial Marine Species (lobster, conch and fin-fish), is rated as 'Poor'; one target (Parrotfish) is rated as 'Fair"; two targets (Coral Reef and Sharks) are rated as 'Good', and the remaining two targets (Seagrass and Blue Hole Geology) have been rated as 'Very Good' (Table 27).

Viability goals for the five-year management period are allocated for each conservation target, and potential monitoring indicators identified, for the two protected areas (Table 28).

Conservation Target	Current Rating	Goal	Justification and Suggested Indicators
Seagrass	**Very Good**	**Very Good**	***Goal:*** To maintain seagrass and reduce further impacts of boat activity on the seagrass
			Potential Monitoring Indicators: % and distribution of seagrass cover; species composition; level of macroalgal cover; sedimentation rates
Coral Reef	**Good**	**Very Good**	***Goal:*** To maintain and improve current status of coral reef viability
			Potential Monitoring Indicators: Incidence of disease; % macroalgal cover, rugosity, % coral cover
Sharks	**Good**	**Good**	***Goal:*** To minimize anthropogenic impacts on shark populations within Blue Hole Natural Monument
			Potential Monitoring Indicators: Number of incidences of shark / human interaction (feeding, fishing) within BMNH
Commercial Marine Species	**Poor**	**Good**	***Goal:*** To reduce fishing pressure on the commercial marine species
			Potential Monitoring Indicators: Abundance of large predatory commercial species; Size and density of conch and lobster; ratio of juvenile:adult; LAMP protocol; Number of fishermen active on the Atoll
Parrotfish	**Fair**	**Good**	***Goal:*** To maintain and improve populations of parrotfish
			Potential Monitoring Indicators: Relative numbers of large parrotfish species
Sinkhole Geology	**Very Good**	**Very Good**	***Goal:*** To maintain the geological features of the Blue Hole in the current state
			Potential Monitoring Indicators: Damage to geological structures within sinkhole

Table 28: Viability Goals for Blue Hole Natural Monument

3.1.3 Half Moon Caye Natural Monument – Conservation Target Viability

Nine conservation targets – a combination of both terrestrial and marine components - have been selected for Half Moon Caye Natural Monument (Table 29).

Half Moon Caye
Seagrass
Coral Reef
Commercial Marine Species
Parrotfish
Fish Spawning Aggregations
Marine Turtles
Littoral Forest
Nesting Bird Colony
Lizard Species

Table 29: Conservation Targets selected for Half Moon Caye Natural Monument

The justification for target selection, and the nested targets represented, is discussed in Annex 1. Whilst the nesting bird colony and the lizard species can both be considered as nested targets within the littoral forest, they are treated separately as their primary threats differ in priority, scope and severity.

Table 30: Half Moon Caye: Viability Ranking for Conservation Targets

Conservation Target	Size	Condition	Landscape Context	Overall Viability Rank
Seagrass	Very Good (4)	Very Good (4)	Very Good (4)	**Very Good (4.00)**
Coral Reef	Good (3.5)	Good (3.5)	Good (3.5)	**Good (3.50)**
Parrotfish	Good (3.5)	Good (3.5)	Good (3.5)	**Good (3.50)**
Commercial Marine Species	Fair (2.5)	Fair (2.5)	Fair (2.5)	**Fair (2.50)**
Marine Turtles	Poor (1)	Fair (2.5)	Fair (2.5)	**Fair (2.00)**
Spawning Aggregation	Good (3.5)	Fair (2.5)	Poor (1)	**Fair (2.33)**
Littoral Forest	Good (3.5)	Good (3.5)	Fair (2.5)	**Good (3.17)**
Lizard Species	Good (3.5)	Good (3.5)	Fair (2.5)	**Good (3.17)**
Nesting Birds	Very Good (4)	Very Good (4)	Fair (2.5)	**Good (3.50)**
Overall Viability Rating of Half Moon Caye Natural Monument				**Good (3.07)**

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)

The viability assessment for Half Moon Caye Natural Monument indicates that the overall health of the species and biological systems of the protected area is considered **GOOD** (Table 30). As with the Blue Hole Natural Monument, the 'good' rather than 'very good' rating particularly reflects

the increasing pressure on the commercial marine species within the Atoll, and in fact in Belize generally as well as impacts of invasive coconuts and rats.

Under this analysis, the viability of three of the conservation targets – Commercial Marine Species (lobster, conch and fin-fish), Marine Turtles and Spawning Aggregations are rated as 'Fair'; five targets (Coral Reef, Parrotfish, Littoral Forest, Lizard Species and Nesting Birds) are rated as 'Good', and the remaining target (Seagrass) has been rated as 'Very Good'.

Conservation Target	Current Rating	Goal	Justification and Suggested Indicators
Seagrass	**Very Good**	**Very Good**	***Goal:*** To maintain current status, and reduce impacts of boat activity near the beaches
			Potential Monitoring Indicators: % and distribution of seagrass cover; species composition; level of macroalgal cover; sedimentation rates
Coral Reef	**Good**	**Very Good**	***Goal:*** To maintain and improve current status of coral reef viability
			Potential Monitoring Indicators: Incidence of disease; % macroalgal cover; % coral cover
Parrotfish	**Good**	**Very Good**	***Goal:*** To maintain and improve populations of parrotfish
			Potential Monitoring Indicators: Relative numbers of large parrotfish species
Commercial Marine Species	**Fair**	**Good**	***Goal:*** To reduce fishing pressure on the commercial marine species
			Potential Monitoring Indicators: Abundance of large predatory commercial species; Size and density of conch and lobster; Number of fishermen active on the Atoll
Marine Turtles	**Fair**	**Good**	***Goal:*** To improve nesting success
			Potential Monitoring Indicators: Number of nests per species; hatching success
Spawning Aggregation	**Fair**	**Good**	***Goal:*** To maintain and improve the viability of the spawning aggregation site
			Potential Monitoring Indicators: Number of illegal fishing incidents; number of species and individuals recorded during spawning aggregation monitoring
Nesting Birds	**Good**	**Very Good**	***Goal:*** To maintain viability of nesting colony
			Potential Monitoring Indicators: Number of nesting birds; fledging success
Littoral Forest	**Good**	**Very Good**	***Goal:*** To improve the viability of the littoral forest
			Potential Monitoring Indicators: Extent and condition of littoral forest; area and species composition of regenerating littoral forest, area and density of coconut trees within western portion of island.
Lizard Species	**Good**	**Very Good**	***Goal:*** To improve the viability of the lizard species
			Potential Monitoring Indicators: Population density, age structure and distribution of Island leaf-toed gecko and Allison's anole. Extent of littoral forest and abundance of rats on island – as proxy indicators of negative impacts.

Table 31: Viability Goals for Half Moon Caye Natural Monument

3.2 Threats to Biodiversity

A regional assessment of coral reef status suggests that two thirds of coral reefs in the Caribbean are threatened by human activities, one third of those being threatened by coastal development (WRI, 2005). Overfishing was recognized as affecting over 60% of the region's reefs, and marine based threats such as damage and pollution from ocean-going vessels was also recognized. On a global scale, rising sea temperatures are thought to be increasing the incidence of coral bleaching and possibly contributing to elevated levels of disease, with significant changes in coral reef populations within the last 30 years. The realization of the increasing degradation of this important ecosystem has led to the establishment of several regional conservation planning efforts focused on these reefs – the Mesoamerican Barrier Reef System project (MBRS) and the Ecoregional Conservation Planning for the Mesoamerican Caribbean Reef (WWF) being two.

At a regional level, the Belize Barrier Reef is considered to have a low impact rating, with Belize's small population and slow coastal development. A number of major concerns have been identified, however, under the WWF Ecoregional Conservation Planning for the Mesoamerican Caribbean Reef (Kramer and Kramer, 2002):

- **Coastal habitat degradation or conversion**
- **Declining water quality**
- **Declining or depleted fisheries**
- **Direct and indirect impacts from diver and boat activity**
- **Increased stress due to oceanographic and climato-meterological phenomena**

This Ecoregional Conservation Planning exercise recognized that, with the distance from the mainland, the probability of Lighthouse Reef Atoll being impacted by land-based threats such as agricultural contamination was considered ***not significant***.

Marine-based threats for the Atoll were identified as habitat fragmentation, loss or disruption of nursery grounds, degraded water quality (including point and non-point pollution, changes in temperature, pH, and DO, sedimentation and siltation) and excessive recreational impacts. These impacts were rated as ***low***.

Marine biota threats were focused on high species mortality and population decreases, loss of species richness or diversity, poor recruitment, shifts in trophic or community structures, increased incidence of disease, impacts associated with increased frequency of natural events (hurricanes, El Nin□o etc.), competition, infestation or predation from exotic species, and unsustainable or illegal fishing practices. This was rated as ***medium*** under the WWF assessment (Kramer and Kramer, 2002).

Several more site-specific threat assessments have been conducted of the Lighthouse Reef Atoll (and by association, Blue Hole and Half Moon Caye Natural Monuments) - in 2004 the World Resources Institute, mapped areas of concern on Lighthouse Reef Atoll highlighted during a stakeholder workshop as part of their Reefs at Risk project (WRI, 2005). Whilst this assessment was not all-inclusive, nor site-specific to the two protected areas, it does capture the major threats facing the Atoll as a whole, highlighting the following impacts:

- **Development of cayes**
- **Over-fishing and illegal fishing**
- **Boat and anchor damage**
- **Diver and snorkeler damage**

This overlaps with the WWF assessment, but distinguishes between diver and boat activity.

1.Overfishing and illegal fishing

Whilst the presence of prime commercial species such as grouper and snapper indicate that marine resources are relatively healthy by regional standards, the pressure on marine stocks is increasing, with an increasing number of fishermen, and incursions from neighbouring countries.

- Overfishing of commercial marine species, resulting in reduced catch per unit effort and a shift in the community and population structures
    - Overfishing for lobster, conch and commercial species of fin-fish,
    - Losses of by-catches from long lines, including marine turtles
    - Illegal fishing within protected areas and spawning aggregation sites
    - Reduction in coral grazers, particularly the large parrotfish species, resulting in algal invasion and reduction in coral productivity and resilience
    - Overfishing in the mangrove nursery areas adjacent to Long and Northern Caye
    - Damage to coral from fishing activities
    - Commercial fishing by the lighthouse keeper's assistant within the pa
    - Fishing by boats from Honduras,

2. Introduced Species

Introduced species, whether introduced deliberately or accidentally, have the potential to cause significant impacts to the natural wildlife on Half Moon Caye

- Rats
- Coconuts
- Domestic animals (esp. dogs, cats and chickens)
- Green iguana
- Furrowed wood turtle

3. Development on Adjacent Cayes

Ecosystem conversion: Increasing development of the two largest cayes – Long Caye and Northern Caye – and the sale of house lots, construction activities, development of service facilities such as restaurants, and predicted increase in residents is causing concern for the natural vegetation of the cayes, the sustainability of the important mangrove areas, and the health of the adjacent coral reef. Whilst this has been highlighted as an existing threat, the following impacts

- Changes in coastal morphological processes, beach erosion, sedimentation of natural and navigational channels and reefs, and fragmentation and stress of terrestrial, coastal and reef systems
    - Clearance of vegetation on Long and Northern Cayes for coastal development, leading to coastal erosion
    - Sedimentation following dredging activities west of Long Caye
- Changes in the composition of species and the introduction of exotics
    - Decline of key species – large predators and herbivorous fish species such as *Diadema antillarum* and parrotfish
    - Die-off identified in *Acropora* species
- Increased consumption of ground water leading to changes in ecosystem functions and water supplies
    - Increased development of both Long and Northern Caye, leading to increased number of residents and visitors, and increased water consumption
    - Increase in visitation to Half moon Caye and use of facilities, leading to increase in water demand
    -

Nutrient enrichment - can have serious impacts on coral, causing algal overgrowth. The Belize Coastal Threats Atlas suggests that land-based impacts don't spread as far from the coast as Lighthouse Reef. However, the potential impact from tourism develops within the Atoll are mapped. (WRI, 2005). Sedimentation from dredging activities and the ever-present threat of oil spills from international tankers is also of serious concern.

- Loss of productivity due to nitrification and/or chemical contamination of reefs and seagrass beds, potentially causing massive kills and/or threats to aquatic organisms
    - Inadequate sewage capacity on Half Moon Caye, leading to contamination of adjacent water
    - Blackwater contamination from moored vessels on the Atoll
    - Solid waste from moored vessels within the Atoll
    - Oil-contaminated bilge water from vessels within the Atoll
    - Greywater contamination from Long and Northern Caye developments and from moored vessels
    - Pollution (detergents, insecticide sprays etc.) from developments on the cayes

4. Direct and indirect impacts from boat activity

Primarily in areas with intensive boat and diver activity, through boat groundings, collisions, propeller impacts and anchor damage. Small scale but widespread direct damage to coral also occurs during commercial fishing for lobster.

- Anchor damage to sea grass and coral caused by lack of mooring buoys (or lack of sufficient mooring buoys) in prime dive sites both inside and outside protected area
- Collisions and groundings due to lack of awareness in boat captains of location of least impacting boat channels within Atoll
- Propeller damage to seagrass in shallow water areas as a result of lack of awareness of need to protect seagrass viability
- Damage to coral rim of Blue Hole by dive boats – esp. kicking up of sediment during mooring process
- Pollution from detergents, oil, bilge water from live-aboards; shark chumming

5. Direct and indirect impacts from visitors

Both terrestrial and marine impacts have been identified from visitor activities:

- Terrestrial
  - Visitor impacts on turtle nesting beach
- Marine
  - Mechanical damage from divers and snorkelers (esp. coral rim of Blue Hole and patch reefs)
  - Sedimentation effects on coral from sand kicked up by divers
  - Chumming of fish and sharks, leading to alteration of natural behaviour, changes in species composition, distribution, territorial habits, and in some cases death from a diet radically different from the natural diet
  - Increased organic matter concentrated in a single area, leading potentially to increased algal growth
  - Potential danger of aggressive behaviour towards divers and snorkelers

6. Impacts from Adjacent Shipping Lines

Despite the two lighthouses on the Atoll, there have been a number of shipwrecks on the eastern rim of the Atoll. To date none have resulted in major coral degradation, but with increased fuel transportation by sea, there is also an increase in the potential for devastating impacts from oil / fuel spillages. Passing ships (both cargo and passenger ships) also contribute to contamination of the water

- Grounding of vessels on the reef and possible resultant oil / fuel spillage
- Blackwater contamination from passing ships in adjacent shipping lane, and from moored vessels on the Atoll
- Solid waste from passing ships in adjacent shipping lane, and from vessels within the Atoll
- Oil-contaminated bilge water from vessels both within the Atoll and passing

7. Increased Stress Due to Oceanographic and Climato-meterological Phenomena

Unpredictable and global phenomena associated with rising sea temperatures, leading to increased frequency of coral bleaching and disease. In early 2006, UNESCO met to review the threats of climate change to a number of World Heritage Sites – including the Belize Barrier Reef Reserve System, and are to put forward their recommendations at the annual World Heritage Committee meeting in July, 2006

- Increased storm activity, with associated storm surges, rubble deposition and wave damage
- Degradation of coral reefs due to increased water temperatures and coral bleaching

8. Other Impacts

Harvesting of Black Coral

- Tourism demand and high market price for black coral jewelry

Threat Assessment for Half Moon Caye and Blue Hole Natural Monuments

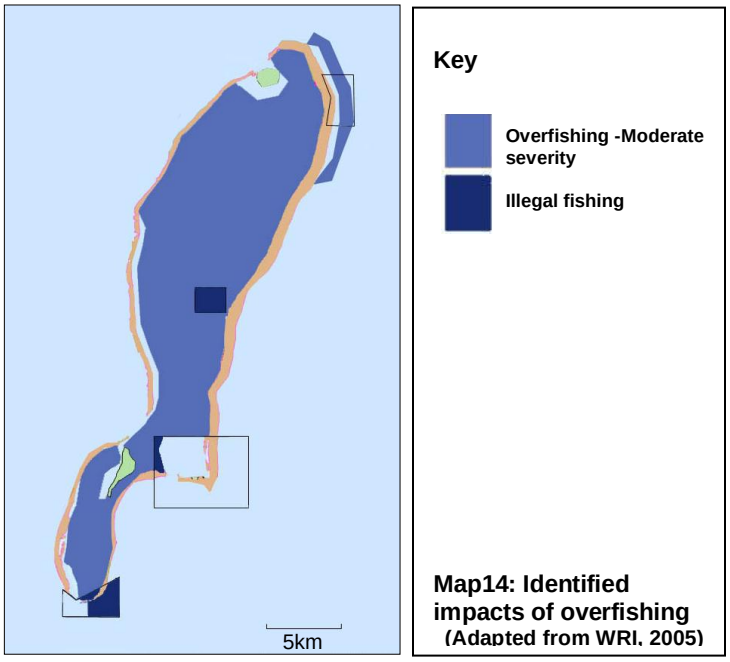
A full threat analysis was conducted for this current conservation planning process, incorporating the regional, national and site specific approaches, with input from BAS staff and a wide range of stakeholders, based on the WCS Living Landscapes programme (Annex 1). The high level of connectivity for current-transported impacts with other areas of Belize and the wider Caribbean has led to a need to take into consideration not just threats to the two protected areas, but also to the Atoll as a whole, as well as oceanic impacts and trans-boundary issues.

The following summarizes the outputs of the most recent threat analyses (Kramer and Kramer, 2002; WRI, 2004), with additional input from stakeholders contacted during the development of the management plan – among them, BAS staff, fishermen, dive boat operators, the lighthouse keeper, and managers of developments on Northern and Long Cayes.

The threats are then assessed using the WCS Living Landscape threat analysis, rating proportion of area, severity, urgency, recovery and probability of the threat occurring (Annex 1)

Threat One: Fishing

Lighthouse Reef, whilst far from the mainland, is an important resource for a number of the coastal communities – primarily Copper Bank, Sarteneja and Chunox, with an estimated 73 fishermen using the area (Northern Fishing Cooperative, National Fishing Cooperative, 2003), Overfishing was identified as occurring throughout most of the Lighthouse Reef area (WRI, 2005 Walker, pers. obs.) (Map 14).



Map14: Identified impacts of overfishing (Adapted from WRI, 2005)

Whilst these are artisanal fisherman, free diving primarily for lobster and conch, and spear fishing fin-fish, the impact on the commercial marine species of the atoll has been immense, with an observed reduction in large predatory fish species (Graham et. al., 2004) and very reduced populations of lobster and conch - 69% of conch recorded in HMCNM in the 2002 BAS survey were juveniles, strongly indicating overfishing.

The composition of the fish community is skewed, with a low abundance of large, predatory fish (Graham et. al., 2004), and recruitment of all commercial species to the populations within HMCNM is considered to be affected by heavy fishing pressure outside the protected area, and illegal fishing within (Forman, 2002; pers. com. 2004). The large coastal sharks present in the waters around the Atoll (such as black tip, bull, tiger and hammerhead) are considered to be overfished both nationally and regionally, there are depressed numbers of commercial marine species generally, and a drastic decline in numbers of conch in particular throughout Belize (Gillet, 2003).

This is reflected in commercial marine species populations at Lighthouse Reef, with low proportions of reproductive adults recorded within the surveys (BAS, 2002). The protected areas are not sufficiently large to maintain populations of the commercial fin-fish species, and the isolation of the Atoll from other coral reef areas is considered to be a potential barrier to recruitment from outside the immediate Atoll area for fin-fish, with the possibility of local extinctions occurring if extractions continue at the current level (as may have happened with the Rainbow Parrotfish).

With the rapidly expanding population of fishermen active on the reef, it is recognized that these resources are not being managed for sustainability nor with optimal utilization (Gillet, 2003) - with the lobster fishery being already fully exploited (Carcamo, 2005), the conch fishery being in serious decline (McConney et. al., 2003), and with the national collapse of some of the spawning aggregation sites (Heyman et. al, 2005). This is further compounded by the harvest being spread too thinly amongst too many people (community consultations, Sarteneja, December, 2005).

Threat Two: Introduced Species

A globally recognized major threat to island biodiversity is that of introduced species - the extent and isolation of island populations often makes them particularly sensitive to predation, direct competition or disease transmission. Half Moon Caye is no exception – coconuts and ship rats pose very significant threats, with risks also associated with the presumed introduction of green iguanas and furrowed wood turtle, present on the caye.

Domestic livestock, along with casuarinas (Australian pine) and almonds also pose significant threats to the islands biodiversity and require immediate control / eradication actions. Human commensals such as the great-tailed grackle have colonized the island directly, but are still considered an invasive species as the population is likely to be maintained at high levels because of human presence and impacts upon the island.

Introduced Species	
Coconuts	Displacement and degradation of littoral forest and herbaceous beach communities
	Potential reduction of area available to nesting red-footed booby
	Increased vulnerability to hurricane damage, decreased regenerative ability of littoral forest
	Enhanced habitat for introduced rats – food supply & shelter

Introduced coconuts have already replaced the natural vegetation on more than 50% of the area of Half Moon Caye. As an invasive species, it continues to spread into the remaining natural vegetation which it gradually out-competes through direct competition for light, nutrients and water, as well as smothering the regenerating herbaceous and shrub layers. Natural vegetation has a far more extensive root system than do coconut groves, and is therefore far more effective in stabilizing sandy the sandy soils of islands against the impacts of tropical storms and hurricanes – invasive coconuts therefore increase the likely impacts from such storms. The considerable debris associated with leaf and nut fall from coconuts provides almost limitless cover and food supply for the introduced rats – rendering eradication efforts unlikely to be successful unless preceded by debris removal. If left unchecked, invasive coconuts will eventually remove any remaining biodiversity value of Half Moon Caye.

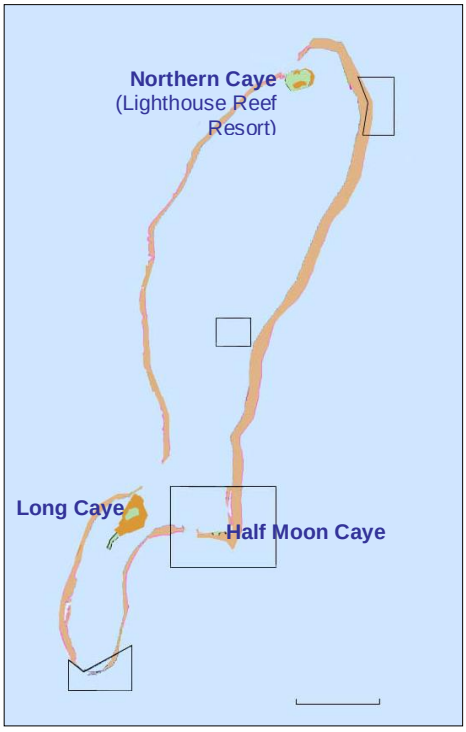
Introduced Species	
Rats	Presumed predation of eggs and nestlings of red-footed booby
	Presumed predation of turtle hatchlings
	Observed predation of lizard species
	Removal of seeds and seedlings of littoral forest species
Abundant literature documents the very negative impacts of introduced rats on island communities. In the absence of natural predators on Half Moon Caye, rats are present in enormous numbers, and undoubtedly impact both the fauna and the flora of the island – as well as having negative impacts on overnight tourism. Their continued presence on the island is incompatible with the primary roles of the protected area: it is of critical importance that the rat eradication plan is methodically implemented in tandem with the coconut control programme.	
Domestic Animals	Predation of eggs and nestlings of red-footed booby
	Predation of turtle eggs and disturbance of turtle nesting beach
	Predation of lizards. Damage to vegetation
Stoddart documented the presence of dogs, pigs and chickens associated with the Young family household on Half Moon Caye (Stoddart, 1962). Pomeroy (1989) too referred to a domestic cat that was seen within the littoral forest. Potential impacts from domestic animals includes disturbance of nesting turtles, physical damage to turtle nests and predation of turtle eggs and hatchlings, direct predation and disturbance of lizard and bird species, potential disease transmission to some species of native fauna, trampling and removal of herbaceous plants, and fouling of beaches and contamination of groundwater. The very negative impact of such livestock on the biodiversity of Half Moon Caye was recognized by BAS, and agreement was reached with lighthouse keepers for the removal of all livestock. This 'moratorium' has periodically been broken, with pet dogs being taken to the island by the lighthouse keeper – despite the known likelihood of very negative impacts upon the nesting marine turtles and resident fauna of the island. As fenced livestock (including dogs) around the lighthouse-keeper's house would be largely incompatible with tourism appreciation, it is extremely important that BAS, the Port Authority and the lighthouse keepers work together to ensure that pet dogs (and any other domestic animals) are not allowed on the island.	

Threat Three: Development Activities on Adjacent Cayes

One of the major threats to the integrity of the ecosystems of the two protected areas is the development activity occurring on two of the cayes within the Atoll – Northern Caye and Long Caye (Map 15). At present, these are primarily potential impacts, and may be mitigated to a certain extent by careful planning

This is a relatively wide-spanning category that encompasses impacts such as:

- Mangrove clearance
- Clearance of littoral forest
- Pollution
- Dredging and associated sedimentation



Key

Development areas of impact

Map 15: Identified impact areas of development
(Adapted from WRI, 2005)

Development Activities on Adjacent Cayes	
Mangrove Clearance	Removal of important habitat for many juveniles fish species
	Removal of caye protection from storm erosion
	Removal of filtration of water from inner inundated areas
	Removal of important habitat for migrating birds

Mangroves are key to the life cycles of many species of fish, including the parrotfish (highlighted for their critical role in maintaining coral health). Lighthouse Reef Atoll has little mangrove, making the small area present on the cayes that much more critical to the health of the Atoll. These mangrove areas can be affected not only directly, by clearance for development, but also indirectly, through the presence of structures such as breakwaters changing water flow and sediment deposition patterns, and through chronic stress from reduced air and water quality. Development plans for Long Caye show that the coastal mangroves are being retained, in recognition of their importance. However they may still be seriously impacted by adjacent development activity and associated water degradation. Advocating for careful development on Long Caye and Northern Caye is therefore crucial, and a collaborative partnership should be developed with the management bodies of both cayes for monitoring the state of the mangroves, using the protocols set out in the MBRS synoptic monitoring programme.

Development Activities on Adjacent Cayes	
Clearance of Littoral Forest	Removal of ecosystem that is under-represented within the Belize protected areas system
	Removal of important habitat for migrating birds
	Erosion of caye soils
	Removal of important habitat for lizards with limited distribution (Allison's anole, island leaf-toed gecko)
As with fringing red mangrove, littoral forest and herbaceous beach communities play a critical role in stabilizing island structure, reducing coastal erosion, beach loss and sedimentation. One of the most under-represented ecosystems within the protected area system of Belize, their loss is accelerating as the developmental value and demand for beach frontage escalates. This ecosystem is critical for nesting sea turtles, for the American crocodile, for two lizard species with extremely disjointed distributions, and for numerous bird species. Clearance on adjacent islands greatly reduces connectivity within an already seriously fragmented ecosystem, reducing the scope for gene-flow and recolonization after natural and anthropogenic impacts. It also greatly undermines the stability of the islands themselves, making them, and any infrastructure thereon, a great deal more susceptible to the impacts of hurricanes. The long-term sustainability of coastal tourism and residential developments can be made significantly more financially viable through the maintenance of this ecosystem.	
Pollution	Contamination of waters near cayes and throughout Atoll due to inappropriate sewage and grey water treatment, leading to eutrophication
	Inappropriate waste disposal
	Contamination of waters with runoff containing herbicides, insecticides or detergents
At present, there is little sign of the impacts of water contamination by excessive nutrients, and the majority of development plans reviewed for the cayes include adequate sewage treatment. Whilst development activities on Northern and Long Cayes are constrained to a certain extent by EIA approval through the Department of the Environment, and the Long Caye development includes a set of eco-guidelines for potential purchasers of residential lots, there is little guidance given in areas such as the above ground swimming pools, associated chemical use, wood preservatives, herbicides and pesticides - contamination of waters by biocides and detergents will become an increasing problem as more residential lots are developed on Northern and Long Cayes, affecting not only the waters adjacent to these cayes, but potentially all the fragile ecosystems of the Atoll. Very few resorts in Belize have adequate training in chemical storage, use, and spill response, or attempt to find environmentally friendly alternatives to more toxic options - availability of alternatives in Belize is also a limiting factor. Little thought, too, is generally given to problems of chemical contamination following flooding through storm events…such as pre-empting the problem by storing bulk chemicals on the mainland, ensuring only minimal amounts are kept on the cayes.	

Development Activities on Adjacent Cayes	
Dredging and Associated Sedimentation	Destruction of seagrass habitat, supporting many vertebrate and invertebrate species
	Sedimentation of coral, reducing coral viability
	Sedimentation of seagrass, reducing seagrass viability

If inappropriately managed, dredging activities within the Atoll will impact areas of conservation importance. Dredging activities are usually associated with development on the cayes, the two focal areas for development within the Atoll being Northern Caye and Long Caye. Limited dredging has been occurring in the waters adjacent to Long Caye – both this and the Northern Caye area are on the western side of the Atoll, with currents flowing east to west/south-west, so should have a minimal impact on the biodiversity of BHNM and HMCNM. However, water quality degradation and smothering of benthic flora and fauna by excessive sedimentation may be observed. Whilst the prevailing currents are from east to west, the presence of mangrove propagules on Half Moon Caye (presumed to have come from Long Caye) demonstrates that refracted or surface currents are also present, with the risk of sedimentation impacts from adjacent development activities.

In some countries, an environmental levy is placed on dredging operations in sensitive environments, to help offset the damage, and contribute towards monitoring of sensitive environments.

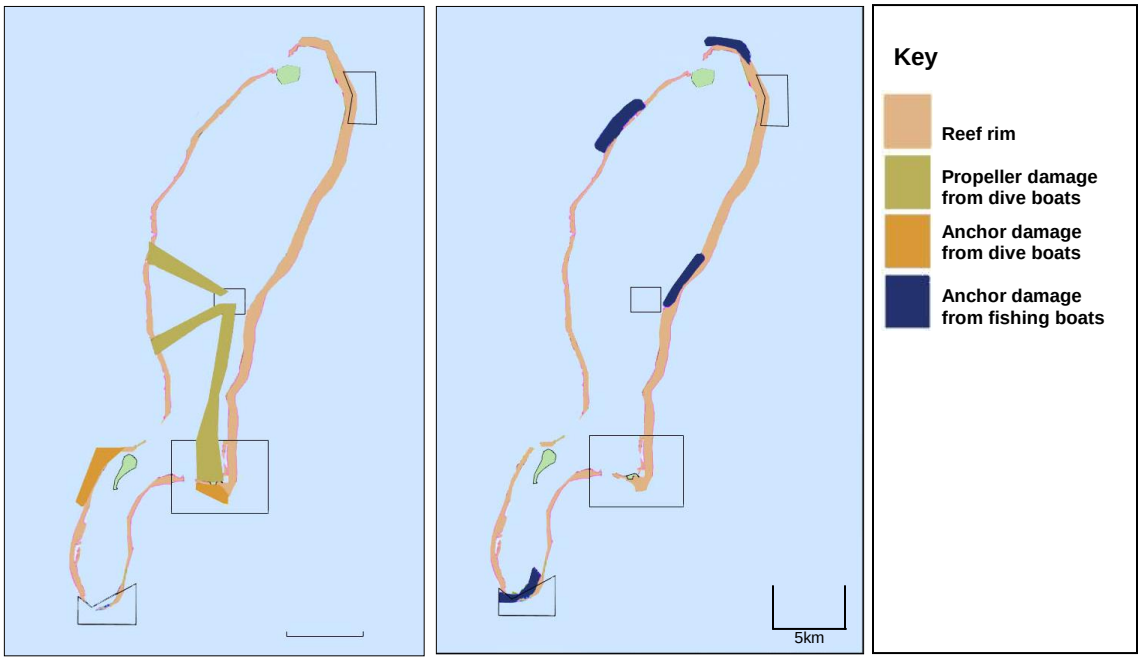
Freshwater Use	Drawing of excessive freshwater from the freshwater lens

Inappropriate use of excessive amounts of freshwater by an increased residential population can deplete the freshwater lens that supports the vegetation on the cayes, potentially leading to a reduction in the health of the littoral forest, mangrove and beach vegetation areas. Of particular importance is the maintenance of healthy mangroves, so critical to the life stages of many commercial and non-commercial marine species.

Threat Four: Impacts from Boats

Boats that visit Lighthouse Reef can be divided into two categories – those associated with the tourism industry (dive boats, live-aboards, independent sail boats, small cruise ships and supply boats for the tourism developments), and those associated with the fishing industry (primarily the traditional sail boats of the coastal fishing communities).

Both categories have similar impacts from mechanical damage from anchors, though the recent WRI threat assessment showed that the area of impact of anchor damage from fishing boats rarely overlaps with that of the tour boats (Maps 16 and 17).



Map 16: Identified impacts of dive boat anchors and propellers
(Adapted from WRI, 2005)

Map 17: Identified impacts of fishing boat anchors
(Adapted from WRI, 2005)

The Blue Hole is of specific concern, as there is considerable evidence that the movements of dive boats within the Hole whilst they manouver for mooring points is causing increased sedimentation of the coral rim, reducing the percentage live coral cover (Z. Walker, pers. obs., 2004).

Of more recent concern is the increased cruise industry presence within Belize. This is one of the fastest growing sectors of the travel industry. An increasing number of small cruise ships wish to include Lighthouse reef on their itinerary, but initial experience shows that current infrastructure (mooring points and land-based facilities) are insufficient to cope with the size of the vessels, and with the associated increased volume of people. The reef, too, is a very fragile ecosystem that will show deterioration with excessive use as a tourism venue.

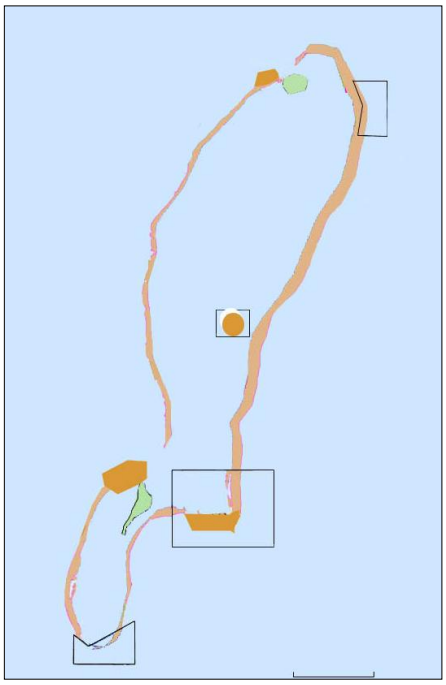
Threat Five: Impacts from Divers and Snorkelers

"In its most ideal form, tourism provides an incentive for governments, businesses and local communities to protect natural and cultural assets, as a way to raise revenue and improve standards of living by attracting tourists to a destination. One of the most rapidly growing segments of the tourism sector is the cruise industry. Although cruise tourism has the potential to overwhelm fragile destinations if not managed effectively, the industry is also a great potential ally for conservation, because many cruise passengers are attracted by the opportunity to experience new places and cultures".

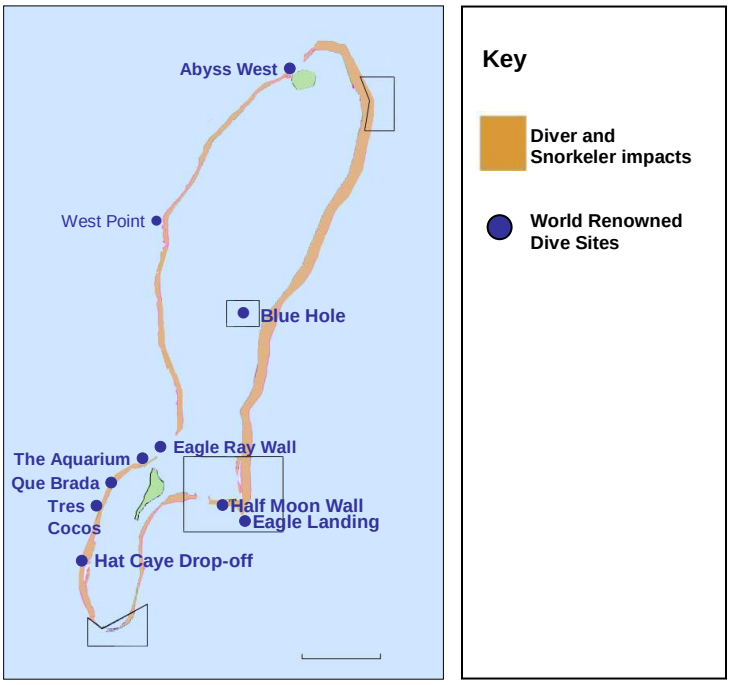
Russell A. Mittermeir, Director, Conservation International, 2006

At present, impacts from divers and snorkelers and associated boat activity are recognized as one of the greatest active threats both within and outside the two protected areas (Kramer and Kramer, 2002). The popular dive sites are increasingly impacted by diver activity – particularly mechanical damage from standing on or touching corals and sediment kicked up by flippers (Maps 18 and 19).

The coral rim of the Blue Hole in particular is showing signs of degradation from the impacts of diver and snorkeler numbers above the carrying capacity of the environment, with greatly decreased coral cover in comparison with other areas of the Atoll.



Map 18: Identified impacts of diving and snorkeling activities
(Adapted from WRI, 2005)



Map 19: Popular dive sites
(Adapted from Rinaldi, 2003;)

Another impact caused by the presence of divers is the practice of shark chumming at the Blue Hole by some of the dive boat operators. This activity has raised serious concerns in relation to the health of the sharks and the safety of the divers, and has become a contentious issue. At present, almost daily feeding sessions take place, attracting primarily Caribbean reef sharks, but also occasionally hammerheads, bull sharks, black tips and lemon sharks (Graham et. al., 2004). Whilst at present there is a ban on chumming in place (instigated by BAS in 2003), there is no enforcement, and the practice continues. The lack of consultation at all levels – with BAS on-site staff, tour operators and dive boat staff - prior to the implementation of the ban has increased the antagonism over this issue, with a stalemate in place and chumming continuing.

Many dive operators feel that companies that do chum for sharks are placing their tourists at unnecessary risk - experts caution that sharks 6 feet or longer should be considered potentially dangerous due to the damage they can cause to humans in a single bite. Among the species that grow to this size and have been known to attack humans are bull sharks and tiger sharks, both attracted by the chumming activity. Florida banned shark chumming throughout the state in 2002, to be followed by Hawaii and the Cayman Islands (Graham, 2004). Diver reaction to the shark congregations is to move closer to the coral crest, further impacting the health and viability of the reef in this area.

Threat Six: Impacts of Adjacent Shipping Lane

The shipping lane passes directly to the east of Half Moon Caye, with an ever-increasing flow of cargo and passenger vessels, from oil tankers to cruise ships. The latter are a component of the passenger vessel category, which make up 13% of the world shipping fleet. With the rapid rate of increase of cruise ship visitation to Belize, this sector has started to receive far more attention in terms of the threats they pose to the environment. For Half Moon Caye, any vessel traveling in the adjacent shipping lane, whether cruise ship or not, is a potential threat, though cruise ships tend to concentrate their activities within coastal areas, and have a higher volume of waste. The recent grounding of the LV Trader on the eastern rim of the atoll raised the profile of the threat – this was a limited impact in comparison to the possible consequences should the ship have been carrying oil or chemicals, and had broken apart on the reef.

The mechanical and physical impacts of groundings are not the only threats faced from vessels passing by in the shipping lane. During a typical one-week voyage, a large cruise ship (3,000 passengers and crew) is estimated to generate 210,000 gallons of sewage, 1 million gallons of greywater (wastewater from sinks, showers and laundries); more than 130 gallons of hazardous waste; 8 tons of solid waste; and 25,000 gallons of oily bilge water (Copeland, 2005). Whilst there are international laws in place to regulate pollution of the open seas by vessels such as these (principally the 1973 International Convention for the Prevention of Pollution from Ships – MARPOL), there are also known infringements of these regulations that suggest that ships will dump waste at sea – for example, in April 2002, Carnival Corporation was fined US$18 million for the deliberate falsification of oily bilge record books, whilst in July Royal Caribbean Cruises Ltd. was fined US$9 million and US$18 million during 1998 and 1999 respectively for discharging oil contaminated bilge waste. Incidents such as these, whether through human error, mechanical failure, negligence or deliberate, lead to skepticism about the waste handling of large ocean-going vessels. Cruise ships are self-regulated to a certain extent by the expectations of the passengers to be able to sail in unpolluted waters. Other components of international shipping have no such internal controls.

MARPOL
(International Convention for the Prevention of Pollution from Ships, 1973/1978)

This convention concerns the prevention of pollution from oil, bulk chemicals, dangerous goods, sewage, garbage and atmospheric pollution, and includes provisions such as requiring certain oil tankers to have double hulls.

Impacts can be from a variety of recognized sources from regular operations, and are normally characterized as blackwater, greywater, hazardous waste, solid waste and bilge water.

Blackwater

Sewage, waste water from toilets and medical facilities. Release of untreated or inadequately treated sewage close to the reef can cause bacterial and viral contamination of fisheries and shellfish, and excess nitrogen and phosphorus

Blackwater

A larger cruise ship (3,000 passengers and crew) generates an estimated 15,000 to 30,000 gallons per day of blackwater waste

can promote excessive algal growth, leading to eutrophication and great algal cover, reducing coral colonization.

Graywater

Wastewater from sinks, showers, galleys, laundry and cleaning activities, containing a variety of contaminants such as detergents, oil, grease, metals petroleum hydrocarbons, nutrients etc. This, as with blackwater, can cause excessive algal growth and eutrophication.

Greywater

A larger cruise ship (3,000 passengers and crew) generates an estimated 90,000 to 255,000 gallons per day of greywater waste

Hazardous Waste

A number of on-board activities can produce hazardous waste from photo-processing, dry-cleaning and repainting. A wide range of substances are included within this category – hydrocarbons, heavy metals, solvents, fluorescent and mercury vapour light bulbs, and batteries included, which whilst small in volume can be extremely toxic to marine organisms if they find their way into greywater, bilge water or solid waste.

Solid Waste

This category includes glass, paper, cardboard, aluminium, steel cans and plastics, much of which is incinerated on board, and the ash discharged at sea - it is estimated that 24% of solid waste generated by vessels worldwide comes from cruise ships. Inadequate incineration can lead to entanglement of marine mammals, fish sea turtles and birds with plastics and other solid waste.

Solid Waste

A larger cruise ship (3,000 passengers and crew) generates an estimated 8 tons of solid waste during a one-week cruise.

Bilge Water

A frequent problem on a ship is oil leakage, or oil byproducts from engines or from engine maintenance activities which, even in minute quantities, can kill fish or cause chronic effects. Much of this ends up in the bilge water, which may also contain other chemical contaminants. The bilge space, where this contaminated water accumulates, needs to be flushed out at regular intervals to maintain the vessels stability and eliminate potentially dangerous flammable vapours. To do so, the oil needs to be extracted, and then reused, offloaded at port or incinerated, using a separator or similar mechanism – failure to do so, or mechanical faults can result in untreated bilge water being emptied directly into the sea.

Bilge Water

A larger cruise ship (3,000 passengers and crew) generates an estimated 25,000 gallons of oily bilge water every week of operation

Ballast Water

Ballast water, used to stabilize vessels during transport, is often taken on in coastal waters in one region, then released in another, as cargo or passengers are loaded or unloaded, resulting in changes in the amount of compensating ballast required. This has resulted in the transport of plants, animals, viruses and bacteria into areas they would not normally occur. This is considered to be the major source of invasive species in US waters (Copeland, 2005).

This threat from current borne pollution from international shipping will be insignificant in comparison to the devastation that would occur should an oil tanker break up on the outer reef. There appears to be no emergency plan or preparation in place within BAS or the Lighthouse Reef Advisory Committee at present should a major incident occur, which could have the potential for being a major disaster for the entire atoll.

Table 32: Analysis of threats impacting BHNM/HMCNM (based on WCS Living Landscapes Programme)

Threat	Area Score	Severity Score	Urgency Score	Recovery score	Probability Score	Total Threat Score	Rank*
Fishing	4	3	3	2	1.00	60	**8**
Coconuts	4	2	3	2	1.00	40	**7**
Rats	4	1	3	2	1.00	20	**6**
Adjacent Shipping Lane	4	3	3	2	0.25	15	**5**
Domestic Animals	3	1	3	1	1.00	12	**4**
Boat Impacts	2	1	3	2	1.00	10	**2**
Dive/Visitor Impacts	2	1	3	2	1.00	10	**2**
Development on Cayes	2	1	2	2	0.50	4	**1**

Severity	**Rank**	**Urgency**	**Rank**
None or positive	0	Won't happen in > 10 years	0
Measurable effect on density or distribution	1	Could happen between 3 – 10 years	1
Substantial effect but local eradication unlikely	2	Could (or will) happen within 1 – 3 years	2
Local eradication a possibility	3	Threat is occurring now, and needs action	3
Proportion of Local Area Affected	**Rank**	**Recovery Time**	**Rank**
0	0	Immediate	0
1-10%	1	1-10 years	1
11-25%	2	11-100 years	2
26-50%	3	100+ years or never	3
>50%	4		
Probability of threat occurring		***Lowest threat score rank = 1**	
≤ 0.25	0.25		
0.26 – 0.50	0.50		
0.51 – 0.75	0.75		
0.76 – 1.00	1.00		

3.3 Priority Areas for Conservation Action

This management plan follows the national management plan framework, using a combination of the TNC 5-S conservation target viability ranking and the WCS threat analysis to establish the priority of conservation actions for the conservation targets highlighted for Blue Hole and Half Moon Caye Natural Monuments.

Through this analysis, the following prioritization order was developed for both the Blue Hole and Half Moon Caye Natural Monuments (Tables 33 and 34).

Table 33: Priority Areas of Action for the Blue Hole Natural Monument

Priority	Rank	Conservation Target	Primary Threat
High Priority	1	Commercial Marine Species	Fishing
	2	Coral Reef	Fishing / Boats
Medium Priority	3	Sharks	Fishing
	4	Parrotfish	Fishing
Lower Priority	5	Seagrass	Boats
Sinkhole Geology			Boats/Divers

Table 34: Priority Areas of Action for Half Moon Caye Natural Monument

Priority	Rank	Conservation Target	Primary Threat
High Priority	1	Spawning Aggregations	Fishing
	2	Nesting Birds	Introduced Species
	3	Lizard Species	Introduced Species
Medium Priority	4	Marine Turtles	Introduced species
	5	Littoral Forest	Introduced species
	6	Coral Reef	Fishing
	7	Parrotfish	Fishing
	8	Commercial Marine Species	Fishing
Lower Priority	9	Seagrass	Boats

3.4 Conservation Strategies

Strategies have been developed to reduce threats to all eleven identified conservation targets (Table 35), and are covered in detail in Annex 1, and incorporated into the Management Programmes.

Cross cutting Strategies

Primary cross cutting strategies for Half Moon Caye Natural Monument and Blue Hole Natural Monument	Seagrass	Coral Reef	Commercial Marine Species	Parrotfish	Spawning Aggregations	Marine Turtles	Littoral Forest	Nesting Bird Colony	Lizard Species	Shark Species	Sink Hole Geology
Finalization and implementation of Management Zones	■	■	■	■	■	■					
Increase BAS awareness of development activities within the atoll	■	■	■	■		■					
Increase awareness of impacts of sedimentation	■	■	■	■		■					
Ensure adequate wastewater and sewage disposal	■	■	■	■		■					
Patrol protected areas and enforce no-take legislation			■	■	■					■	
Lobby for stakeholder management of Lighthouse Reef	■	■	■	■							
Implement Rat Eradication Programme						■	■	■	■		
Ensure diver awareness of potential impacts		■	■	■		■					
Continue facilitating Alternative Livelihood projects			■	■	■	■					
Develop and implement Littoral Forest Recovery Programme							■	■	■		
Actively prevent further introduction of invasive species to HMCNM							■	■	■		
Designate specific mooring sites and boat channels	■	■									■
Work with dive boat operators to eliminate shark chumming										■	■
Increase awareness of the importance of marine protected areas to the fisheries industry			■								

Table 35: Primary cross cutting strategies for Half Moon Caye Natural Monument and Blue Hole Natural Monument

Section Four

Management Planning

4. Management Planning

4.1 Management and Organizational Background

The Blue Hole and Half Moon Caye Natural Monuments are co-managed by Belize Audubon Society (BAS), in partnership with the Forest Department. BAS is the non-governmental membership organisation responsible for the management of Blue Hole and Half Moon Caye Natural Monuments. Over the years, since its establishment in 1969, BAS has grown from a small entity to a leading conservation organisation within Belize, successfully co-managing nine of the 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 (Figure 28), BAS focuses on providing not only protection of wildlife and the environment, but also the provision of benefits to stakeholder communities.

Belize Audubon Society

Vision: Belize Audubon Society will be a strategic leader in building a nation in which people live in harmony with and benefit from the environment

Mission: The Belize Audubon Society is a non-governmental organization dedicated to the sustainable management or our natural resources through leadership and strategic partnerships with stakeholders in order to create a balance between people and the environment

Figure 28

BAS has had a co-management agreement with Forest Department for Half Moon Caye Natural Monument since 1982, and Blue Hole Natural Monument since 1999, through a series of renewed Memoranda of Understanding. Under these agreements, first signed in 1995, amended in 1999, and more recently renewed on in August, 2004, BAS is responsible for the management and maintenance of the parks, whilst the Forest Department (GoB) is responsible for law enforcement. The Department is also partially responsible for providing and maintaining boundary demarcation, signs, guard posts, and radio equipment – a responsibility shared with BAS under the most recent MoU. GoB is also required to give a set contribution per year into BAS, towards the management of the protected areas. Development and implementation of management plans and a means of monitoring the success of implementation for the protected area are the responsibility of BAS, following approval of these plans by Forest Department. Through this agreement, the Government also agrees to facilitate tax exemptions and other financial benefits for BAS.

Under the 2004 MoU, BAS is authorized through statutory instrument to collect entrance fees towards protected areas management (though not specifically towards Half Moon Caye or Blue Hole alone). Of these fees, 20% is paid to Forest Department, whilst BAS retains 80% (of which 10% is allocated specifically towards expenses related to infrastructure and security, considered as Forest Department's partial contribution in these areas).

Whilst originally for a five-year period, the MoU has become accepted as ongoing by both parties, the most recent agreement having been signed for 10 years, in recognition of the fact that the Belize Government doesn't at present have the resources to contemplate taking over management. In the event that Government wishes to resume management of the protected areas, there is a maximum of a two-year transition period to ensure that there is an adequate and effective handover period.

In December 2001, BAS developed an overall Strategic Plan for the organisation, addressing the need for organizational commitment in terms of implementation, and focus of purpose and direction – the result being a plan that emphasizes the organization's traditional strengths and provides a strong, logical framework within which the organization's programmes and activities can move from planning to implementation.

Within this Strategic Plan, the management of Blue Hole and Half Moon Caye Natural Monuments comes under the Integrated Resource Management Programme, which can be broken down into four different Programme Strategies that compliment and support each other (Table 36).

Table 36:
BAS Integrated Resources Management Programme
To effectively manage and advocate for BAS-managed protected areas through the establishment of strategic partnerships and the utilization of sound research

Programme Strategy	***Responsibility***
Protected Areas Management	Protected Areas Coordinator
Education	Education Director
Research and Monitoring	Research and Monitoring Coordinator
Environmental Advocacy	Advocacy Director

The day-to-day management of the Belize Audubon Society is the responsibility of the Executive Director and senior management staff. The Executive Director supervises the Programme and Protected Area Managers, who are in turn responsible for the effective implementation of the programme activities (Figure 29).

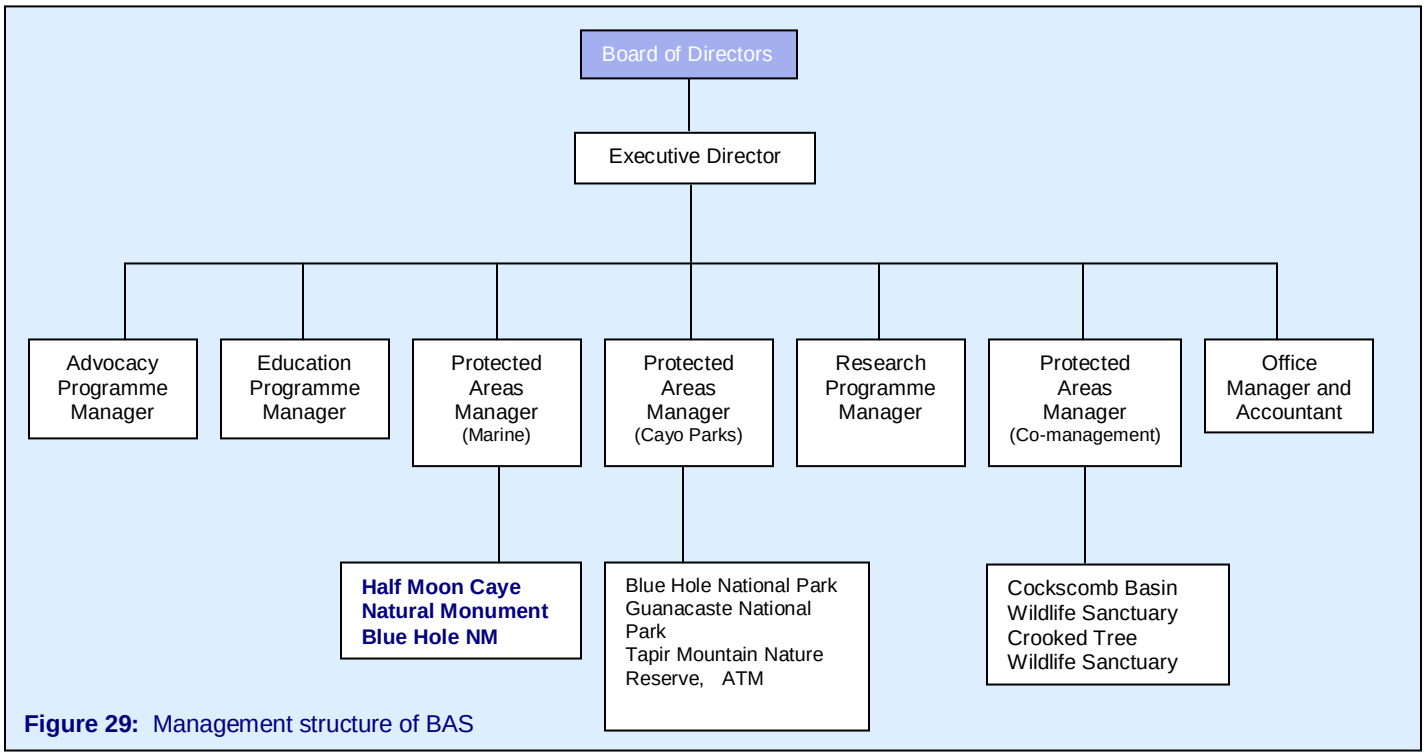


Figure 29: Management structure of BAS

Under this structure, much of the management of these two protected areas is conducted by the Marine Protected Area Manager from the BAS office in Belize City, with the support of the Programme Managers (Education, Research and Advocacy). A marine biologist also works alongside the park manager. Day to day activities (staff and volunteer supervision, patrolling, infrastructure maintenance and upkeep, fee collection etc.) are the responsibility of the on-site Park Director, supported by a boat captain and three park wardens. The Park Director is responsible to the Protected Area Manager.

The Marine Protected Area Manager (one of three protected area managers within BAS) is based in the Belize City office, and is at present responsible for all aspects of the two protected areas. He/she is also responsible for locating the funds for projects within his/her project area.

The Marine Protected Area Manager is assisted by the Community Liaison Officer (also based in the Belize City office), whose role is building awareness and capacity within the stakeholder communities towards a co-management structure, based on the models established at Cockscomb Basin and Crooked Tree Wildlife Sanctuaries. Developing strong links with the buffer communities, through capacity building, facilitation of sustainable development projects, and training to increase conservation awareness lies at the core of the BAS co-management strategy.

The Protected Area Manager and Park Director are also assisted by both the Education and Research Programme Managers, working from the Belize City office. These two programme managers are responsible for education and research activities in all the BAS-managed protected areas.

A Marine biologist, attached to the two protected areas, is tasked with conducting baseline research, and the development of biodiversity and water quality monitoring programmes, in liaison with Fisheries Department and the regional MBRS synoptic monitoring programme.

Within Belize Audubon Society, policy guidelines have been developed to assist in management structure and implementation.

For the successful management of Blue Hole and Half Moon Caye, and their development over the next five years, a number of key factors need to be incorporated into the planning phase (Figure 30).

Figure 30: Key factors that need to be incorporated into the Planning Phase

- **A protected area manager and on-site park director** who have a clear vision of the long term goals of the Blue Hole and Half Moon Caye Natural Monuments, achieved through the implementation of the six Management Programmes, are able to share this vision with the support team, and are dedicated to seeing the 5-year Management Plan succeed.
- **A multidisciplinary support team** on four levels:
  - The first is of Programme Managers based in the Belize City HQ, experienced in the development of specific key programmes – education, research, community liaison, funding, administration and advocacy - allowing the Project Coordinator to concentrate on the implementation of these programmes.
  - The second are the staff based on-site – the Park Director, marine biologist, wardens, and volunteers of the protected areas who are involved in the physical implementation of the Management Actions.
  - The third are members of the Lighthouse Reef Advisory Committee - supporters from the stakeholder community
  - The fourth is the Protected Areas Manager within Forest Department (GoB)

  The Park Manager must work closely with all four groups:
  - ensuring that there is close liaison with Project Managers and GoB in the implementation of the six programmes of the Management Plan.
  - ensuring that Park staff share the same vision and work towards the same goals in the implementation of the individual programmes
  - ensuring that the goal of community participation is taken into consideration at all times, through close, continuous and fully transparent liaison with stakeholder community members
- **An Institutional Leadership** in the form of Belize Audubon Society, providing leadership for the development and implementation of the Management Plan, and continuity should there be changes in personnel during the 5-year management plan process.
- **A Strategic Approach and Measures of Success,** that serves as the foundation for the success of the Management Plan, allowing constant review of the success of the management programmes, and flexibility for programme adaptation during the five year period covered by the Plan. It should always be remembered that circumstances change, new knowledge is gained and new threats may emerge, so conservation strategies need to evolve accordingly.
- **Adequate Funding** for the support of the implementation of Programme Activities under the Management Plan, and for the staff structure required to implement the Plan successfully
- **Collaboration with Key Partners,** both Government and non-Government, for support of the protected areas and the conservation goals and activities of the protected areas, and long term support from stakeholders, both local and non-local.
- **Continuity of Effort** over time – management planning should always look not only at the 5-year period of the Management Plan, but also beyond, to ensure the long term continuity of the Natural Monuments.

(Adapted from Landscape-Scale Conservation, TNC, 2003)

4.2 Review of Previous Management Plan

Past and current management objectives from the 1997 Management Plan for Half Moon Caye Natural Monument have been assessed, in close liaison with the park staff and marine biologist. Past objectives are categorized according to the perceived success of implementation (Table 37).

Overall, the level of implementation appears to be good, with 86% of the 1997 management objectives showing some measure of success. However, the management plan did not appear to adequately address the threat of illegal fishing within the protected areas, the effects of which are being seen in the lower than expected commercial species densities (R. Graham, pers. com.).

61% of the 1997 management objectives are considered to have partially succeeded, improving the management situation present in 1997, and 27% having fully succeeded. It is felt that there was insufficient consideration of the impact of illegal fishing and the need for effective patrolling within the objectives of the 1997 management plan, and this is one area where management cannot be said to have succeeded. Few objectives show no change or a worsening of the situation (5%), and all these are within the 'Resource and Enforcement' and 'Research and Monitoring' programmes, suggesting that there is currently a greater emphasis on tourism activities than on biodiversity protection. (Table 37, Table 38). Current analysis of the threats to the protected areas also suggests that there is a gap in recognition of the potential impacts of development on other cayes within the Atoll.

Table 37: Measures of Success of Implementation of the 1997 Management Plan for Half Moon Caye Natural Monument					
	Measures of Success of Implementation				Comments
Objectives/Actions	**Succeed**	**Improved**	**No Change**	**Worse**	
Resource Management and Enforcement Programme					
3 permanent wardens, establish regular patrols. 3 weeks on 1 week off (2 people on caye at any one time). One full time biologist					1 Park Manager, 5 on-site staff, 1 marine biologist, working 15 days on 1 week off. 2 staff are always on site at any one time. Patrolling has been cut back, and boats not always available – not effective.
Wardens have Fisheries and Park Warden empowerment					2 staff have training as police constables, 3 staff are in the process of being recognized as Fisheries wardens
Daily log recording law enforcement activities and noteworthy occurrences					An incident log is kept of law enforcement and noteworthy occurrences. A daily log is needed, to incorporate quantified area patrolled, distance covered
Terrestrial and marine area-based zoning					No zoning in place. Map of provisional zoning of terrestrial area of HMCNM produced by park director
Develop system of moorings close to dive sites					Buoys exist but are not maintained. Not sufficient for present boat activity. There is no formal policy on mooring
Permanent boundary markers – 4 on northern boundary, 2 on western boundary, 2 at entrance of southernmost channel, 1 on the shelf at southeast corner					At both natural monuments, boundary markers are in place, but for effective patrolling, more markers are required, as present buoys are too far apart to be seen from the fishing canoes. The channels need to be better marked, with same buoy colour and type.
Rat eradication programme					Rat eradication programme has been developed but not implemented. Rat population still a huge problem on HMC.
Study to determine whether coconuts should be removed at NW entrance to Booby sanctuary					Input from several sources (eg. Meerman, 1995), but no programme of coconut removal developed or implemented
Establish native tree nursery of seeds collected on HMC – plant out once coconuts have been removed					No native tree nursery established, and no planting of seedlings
Prohibit subsistence fishing within HMC by BAS wardens and lighthouse keeper					Theoretically there is no subsistence fishing by wardens, however they do get fish from the lighthouse keeper's assistant (Graham, pers. com.) There appears to be an informal, unwritten 'honourable agreement' that the lighthouse keeper should be able to take fish for the table (D. Chan, pers. com.). The lighthouse keeper's assistant and his two helpers, however, have been observed fishing within the protected area on a commercial scale, for sale in Belize City. May be having a major impact on fish populations of the protected area, and encouraging other fishermen to fish illegally in the area.
Protect birds and turtles from nest raiding by humans					No nest raiding taking place.
Control visitor behaviour so as not to interfere with bird nesting / turtle nesting behaviour					Good briefings given by tour guides when guests arrive on the island. Trails and observation platform allow good visitor management around bird colony.
Implement boat inspections to ensure no introduction of unwanted species					Wardens don't inspect boats, but don't allow dogs or other animals on the island. However, presence of *Rhynoclemmys areolata* demonstrates that enforcement isn't 100% effective. Supplies being brought in by Island Expeditions for camping expeditions are not checked for accidental introduced species.

Table 37: Measures of Success of Implementation of the 1997 Management Plan for Half Moon Caye Natural Monument (cont.)					
	Measures of Success of Implementation				Comments
Objectives	**Succeed**	**Improved**	**No Change**	**Worse**	
Prevent removal of objects from island or surrounding waters by tourists					Enforced, though some people still remove objects in their pockets. One sign informing visitors not to remove objects
Remove dogs currently on HMC					No dogs currently on island (2005 NB. Report in 2006 suggests that a dog may now be present on the caye)
Develop a research plan					List of research priorities, but not integrated into a research plan.
Develop repository for information					Data available in raw state at BAS, but not analyzed or written into reports. Hard to access
Identify key species and ecological systems for long term monitoring					Key species and ecological systems identified, but little baseline, and limited monitoring in place
Baseline on status and health of key species and ecological systems					Study in 1999 following coral bleaching, REA commissioned in 2004 / 2005. REA showed that knowledge of state of ecosystems is lacking
Identify research needs and opportunities					List of research needs is available (Forman, per. com.)
Encourage researchers to participate in integrated research program					Little research has been conducted on HMC since development of 1997 management plan. Possible research involvement being investigated in March 2005.
Establish guidelines for dissemination of information by participating scientists					General BAS research guidelines in place
Monitoring Sub-Programme					
Establish monitoring programme of key species and ecological systems					Using MBRS protocol for monitoring, but not quite running smoothly yet. Succeeded for lobster, conch, improved for commercial fin fish and corals, and no change for seagrass, turtles and indicator fish. Data analysis and reporting is either unavailable or hard to access
Adequate communication and logistical support for monitoring					Research building in place. When only two wardens on site, not sufficient support for monitoring, as wardens also need to patrol and receive visitors. Often a conflict with boat use – patrolling vs. monitoring (this will increase when wardens need to be present at the Blue Hole for collection of the new fees)
Disseminate monitoring information to management					Monitoring information given to management, though not evaluated and incorporated into management planning
Regular meetings to evaluate monitoring information and assess appropriate actions					No regular meetings
Human Use Programme					
Tourism and Recreation Sub-Programme					
Assure visitor activity is sustainable					Whilst the staff feel that visitor impact on reef and terrestrial areas of HMC appears to be sustainable (except for sewage disposal), initial observations from the Marine REA are that current tourism management is not ecologically sustainable (Graham, pers. com.)
Provide visitors with interpretive material					Signs are present in the terrestrial portion of HMC (however some information is incorrect), Visitors Centre display finished (but text still being developed)

Table 37: Measures of Success of Implementation of the 1997 Management Plan for Half Moon Caye Natural Monument					
	Measures of Success of Implementation				Comments
Objectives	**Succeed**	**Improved**	**No Change**	**Worse**	
Human Use Programme (cont.)					
Public Education and Interpretive Sub-programme					
Raise public consciousness in the protection of HMC					Increase in community consultations and educational outreach to stakeholder schools, some outreach to general public
Provide education, research and environmental monitoring programmes to students and general public					Informal programmes available but logistics make public participation difficult. Beach cleanups, student assistance with monitoring
Inform public of significance of HMC					Signs at Visitor's Centre indicate reasons for World Heritage status; leaflet provides information on HMC and Blue Hole. An improvement on past situation, but does not adequately address the need
Preserve history of HMC					History of HMC has been recorded
Infrastructure Development and Maintenance Programme					
Infrastructure Development Subprogramme					
Infrastructure to service visitors whilst protecting environment					Infrastructure has been put in place, but now insufficient toilet facilities, mooring buoys, dilapidated dock. Camping facilities good, observation tower in good condition. Considered to have succeeded for past usage levels, but not upgraded to cope with current usage levels
Secure and upgrade housing for wardens and resident biologist					Had succeeded, but now needs replacing/upgrading. Research building in place
Establish office area for wardens and biologist					No specific office area, research building in place
Work with Port Authority to upgrade condition of lighthouse					Lighthouse condition OK, functioning
Maintenance Sub-programme					
HMC staff will ensure that natural and constructed assets of HMC receive proper upkeep to ensure safe and efficient operation					Basic infrastructure maintenance by wardens, maintenance of marker and mooring buoys needed. Outboards receive full service every three months
Administration Programme					
Actively manage HMC, involving proper representation of all major stakeholders					HMC now fully staffed, though enforcement of protected area regulations appears to still be a problem. Lighthouse Reef Advisory Committee is now established
Establish adequate BAS presence					There are now thought to be sufficient staff at HMC for current level of activity, though enforcement of protected area regulations appears to still be a problem
Develop tighter coordination between all groups with interest in HMC in order to achieve conservation objectives					Better liaison is in place, but cooperation is a problem at times
Financial Programme					
Ensure the financial sustainability of HMCNM					Improved, but not sustainable

Table 38: Summary of Implementation of 1997 Management Plan				
	Succeeded	Improved	No Change	Worse
Total No. Objectives (of 41)	11	24	6	0
% of total	27%	58%	15%	0%
% +ve change	85%			
% -ve change or no change			15%	

Table 39: Programme Rating Table for Half Moon Caye 1997 Management Plan					
Programme	**Total no. Objectives**	**Succeeded**	**Improved**	**No Change**	**Worse**
Resource Management and Enforcement Programme	**15**	**5**	**5**	**5**	**0**
Research and Monitoring Programme	**11**	**2**	**8**	**1**	**0**
Human Use Programme	**6**	**1**	**5**	**0**	**0**
Infrastructure Development and Maintenance Programme	**5**	**3**	**2**	**0**	**0**
Administration Programme	**3**	**0**	**3**	**0**	**0**
Financial Programme	**1**	**0**	**1**	**0**	**0**
Total no. Objectives / Actions	**41**	**11**	**24**	**6**	**0**
% of total		**27%**	**58%**	**15%**	**0%**

4.3 Management Goals

Since the development of the goals set forward in the previous Half Moon Caye Natural Monument management plan (BAS, 1997), there has been a significant shift in the focus of management activities towards emphasis of the role of these marine protected areas in commercial marine resource management, and the participation of stakeholder communities in resource management.

Under the National Protected Areas Policy and System Plan, there is a move to standardize protected area categories with those of the global conservation community, following the IUCN system. Under this, Half Moon Caye Natural Monument is a Category II protected area, whilst Blue Hole Natural Monument is a Category III. This provides guidelines for activities that can take place within the protected areas, to be taken into account during the development of future goals and objectives.

Half Moon Caye Natural Monument	
CATEGORY II	National Park: protected area managed mainly for ecosystem protection and recreation
Definition	Natural area of land and/or sea, designated to: (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible. **IUCN Protected Area definitions**

Blue Hole Natural Monument	
CATEGORY III	Natural Monument: protected area managed mainly for conservation of specific natural features
Definition	Area containing one or more specific natural or natural/cultural feature which is of outstanding or unique value because of its inherent rarity, representative or aesthetic qualities or cultural significance. **IUCN Protected Area definitions**

For the purposes of the definition of management goals and the development of management programmes, Half Moon Caye and Blue Hole Natural Monuments are considered as a single conservation management unit.

Half Moon Caye Natural Monument and Blue Hole Natural Monument

Overall Management Vision:

To protect and preserve natural resources and nationally significant natural features of special interest or 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.

Following a thorough review of past management goals and objectives, their successes and failures, present limitations, the IUCN management categorization and the long-term vision of Belize Audubon Society for Blue Hole Natural Monument and Half Moon Caye Natural Monument, the following goals have been developed for the next five-year period:

Management Goals

1. To protect and maintain geology, marine and terrestrial ecosystems and associated biodiversity within two functional conservation areas, as integral parts of the National Protected Areas System Plan
2. To provide recreational and educational opportunities for Belizean and international visitors in a manner that is compatible with the natural environment
3. To protect and maintain natural resources and spawning aggregation sites important for the maintenance of traditional commercial fisheries on the Lighthouse Reef Atoll
4. To promote and facilitate active research and biodiversity monitoring activities towards provision of information for adaptive management
5. To further develop mechanisms to ensure long term financial sustainability

These goals and their associated management programme objectives and activities cannot be taken as discrete units, as they exist as a part of an integrated overall management concept. To succeed, all parts of the whole have to be addressed and acted upon, as actions of each management programme support the others.

4.4 Management Strategies

Within Lighthouse Reef Atoll, the high connectivity of the marine environment has led to the consensus that there is the requirement for not only on-site management strategies, but also a more holistic, atoll-based set of strategies. Taking this approach is in line with the Biosphere Reserve model developed by the UNESCO – Man and The Biosphere programme, which seeks to reconcile economic development, social development and environmental protection on a regional scale. Whilst Lighthouse Reef Atoll is very much a local scale, the same criteria apply:

- A multi-stakeholder approach
- An emphasis on the involvement and participation of local communities in management
- A platform for dialogue and a tool for conflict resolution
- The integration of traditional knowledge in ecosystem management
- Sound management supported by research
- Strengthening management through collaboration with other organisations of the Mesoamerican Barrier Reef System

During the development of this management plan, a number of site-specific issues were also identified as critical to the successful management of Half Moon Caye and Blue Hole Natural Monuments. These include:

- Maintaining the conservation, biodiversity and World Heritage values of the two protected areas
- Ensuring that tourism activities at the two protected areas are ecologically sustainable
- Mitigating external impacts to the biodiversity of the two protected areas – particularly fishing and caye development
- Ensuring stakeholder involvement in the management of the protected area, and equitable spread of opportunities.

A series of resource use guidelines have also been developed and implemented to address obligations under the National Park System Act, the major activities being carried out in these protected areas, and steps to be taken to avoid the destruction of the features/resources being used.

LEGAL RESTRICTIONS

The Blue Hole and Half Moon Caye Natural Monument were both designated under the 1981 National Parks System Act. 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 and remain in any nature reserve, wildlife sanctuary, or natural monument, except under the authority and in accordance with a permit issued by the prescribed officer on payment of the prescribed fee.
- Permanently or temporarily reside in or build any structure of whatever nature whether as a shelter or otherwise.

- Damage, destroy, or remove therein any species of flora.
- Hunt any species of wildlife.
- Remove any antiquity, cave formation, coral or other objects of cultural or national value.
- Quarry, dig or construct roads or trails.
- Deface or destroy any natural or cultural features or any signs or facilities provided for public use and enjoyment.
- Introduce organic or chemical pollutants to any water.
- Carry firearms, spears, traps or other means of hunting of fishing.
- Introduce exotic species of flora or fauna.
- Catch fish by any means whatsoever.

4.4.1 Management Constraints and Limitations

A brief overview of management effectiveness using the World Bank/WWF Management Effectiveness Tracking Tool (Stolton et. al. 2003) highlights several areas in which management is constrained or limited (Annex 2). Whilst no area is considered to be completely lacking effective management, seven areas were of concern through existing constraints and limitations:

- **Enforcement**

  Illegal fishing remains a problem – there is illegal fishing in both protected areas. BHNM is seldom patrolled outside visiting times, and night patrols are infrequent. The Lighthouse keeper's assistant is known to fish commercially within HMCNM, decreasing respect for the protected area from other fishermen.

  Staff capacity and resources are directed largely towards visitor management and fee collection, with the allocation of capacity and resources to enforcement being inadequate – there are insufficient staff for simultaneous fee collection and patrolling activities. Patrolling is limited by budget, and is given lower priority than visitor management and fee collection. Staff training as Fisheries Officers and Special Constables is ongoing, but high staff turnover results in these qualifications and training being lost. Good liaison with and support from Fisheries Dept for enforcement, but difficult logistics and delays in court appearances hinder convictions.

  Recommended Management Actions:
  Prioritize patrolling of reserves and enforcement of no-take regulations
  Commercial Marine Species Actions (CMS7 – CMS10)
  Natural Resource Management Programme

- **Research and Monitoring**

Whilst BAS has adopted various monitoring protocols, loss of data, gaps in the filling the position of marine biologist and high rate of staff turnover, and low priority of boat/fuel allocation impedes continuity of biodiversity monitoring. This results in limited knowledge of the state of the natural resources being managed, and little information on trends. Management is therefore not being based on good, scientific data, and there is an identified need to increase effectiveness of monitoring of conservation targets, and use of the data in adaptive management

Recommended Management Actions:

Conservation Planning Actions:
- Seagrass Actions (SG1 – SG4)
- Coral Reef Actions (CR1 – CR4)
- Commercial Marine Species Actions (CMS1 – CMS6)
- Parrotfish Actions (PF1 – PF5)
- Spawning Aggregation Actions (SA1 – SA5)
- Marine Turtle Actions (MT9 – MT11)
- Nesting Bird Colony Actions (NB1 – NB3)
- Lizard Species Actions (LZ1 – LZ2)
- Shark Actions (S1 – S8)

Research and Monitoring Programme

- **Personnel Management**

The high rate of staff turnover at all levels is a serious constraint to the achievement of management objectives. Partly the result of the remoteness of the LHR Atoll, the associated logistical problems, and the isolated work conditions, this results in a lack of long term continuity in resource management. This is of particular concern in areas of monitoring and enforcement, where an element of training is required to ensure staff have the capacity to implement activities within these programmes. Whilst the level of training both for monitoring and enforcement is considered good, the turnover results in a constant need for further training as new staff come on-board.

Staff motivation is also a significant problem, especially with the isolation, and antagonism from the fishermen. Improvement of communications between the fishing community, and their ongoing participation in monitoring activities may assist in relieving some of these pressures and increasing motivation. The goal for the end of the five year management period should be to engender improved, cooperative relations between staff and fishermen.

Recommended Management Actions:

Greater support for staff on-site
Improved staff facilities on Half Moon Caye
Increased number of staff at any one time on-site
Increased communication with fishermen on Lighthouse Reef Atoll

- **Co-ordination and Cooperation with State and Commercial Neighbours**

Liaison and coordination with Fisheries Department has increased, resulting in closer cooperation in the enforcement of no-take regulations at Half Moon Caye. Greater co-ordination is, however, required with the Management Authority – Forestry Department.

Increased communication is also recommended with adjacent landowners on the Northern and Long cayes, especially in view of the high threat rating given to development activities

on these cayes. A cooperative relationship needs to be established between BAS and developers / land owners, forming the basis for future collaborations.

Greater contact and coordination is required with the Port Authority, to ensure that future development of lighthouse facilities on Half Moon Caye conform to guidelines that minimise impacts on the environment. There is also a need to approach the problem of commercial fishing by the lighthouse keeper's assistant within Half Moon Caye Natural Monument, and to the current non-compliance with the no-dog policy.

Recommended Management Actions:
Increase liaison with Forestry Department
Increase liaison with Port Authority
Increase BAS awareness of development activities within Lighthouse Reef Atoll
Increase liaison and cooperation with landowners and developers on Northern and Long Cayes

- **Stakeholder Involvement in Management Decisions**

An advisory body for Lighthouse Reef Atoll exists, with representatives from all major stakeholders. However this body has no management authority, and is focused on the whole Atoll, not just the protected areas.

Stakeholder communities – particularly the fishermen - are increasingly involved in management activities (such as monitoring of commercial marine species) and discussions (and have had significant input into this management plan) but have no direct involvement in final management decisions.

Whilst the fishermen are consulted and can voice opinions at meetings, they feel they have no direct involvement in the resulting decision (even though decisions may be based on their input). There is increasing meeting-fatigue on the part of the fishermen, with many organisations seeking their presence at consultative meetings, but with little visible output from the consultation activities, and no apparent changes in management procedures following their recommendations.

In the past, antagonism has developed following the implementation of management decisions for Half Moon Caye and Blue Hole without adequate prior discussion or participation with the dive tour operators. The tourism sector needs to be engaged to a greater extent directly in decision making – especially in areas such as the finalization of the management zones, the number and positioning of mooring buoys, and the cessation of activities such as shark chumming. Without their active participation, zonation of the protected areas is unlikely to be successful.

There appears to be little involvement/consultation of the lighthouse keeper / assistant in management decisions for Half Moon Caye Natural Monument

Recommended Management Actions:
Lobby for stakeholder management of Lighthouse Reef Atoll
Ensure visible results from recommendations arising from community consultations, and feedback on areas of concern
Increase genuine stakeholder participation in management decisions and management activities where possible

- **Visitor Facilities**

  Staff consultations suggest that the current bathroom facilities are not adequate for current levels of visitations and may become damaging to the adjacent marine ecosystems. Tour operators consulted cited insufficient mooring buoys at dive sites (resulting in coral damage and increased sedimentation), and insufficient picnic facilities provide by BAS

  Recommended Management Actions:
  Increase number of bathroom facilities, and ensure they compliant with non-contamination of groundwater
  Increase number of mooring buoys, and site them in liaison with tourism sector
  Ensure visitor facilities are maintained

- **Monitoring and Evaluation of management activities against performance**

  There is some ad-hoc monitoring and evaluation, but no overall strategy and / or no regular collection or analysis of results – This is being addressed in the new management plan, which will seek to ensure that monitoring and evaluation will be used in adaptive management

An assessment of management effectiveness was conducted during management planning to highlight strengths and weaknesses…..Annex 2

4.4.2 Management Zones

The following outlines proposed management zones for both Half Moon Caye Natural Monument and Blue Hole Natural Monument, for tabling with stakeholder groups for discussion.

Proposed Management Zones - Half Moon Caye Natural Monument

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

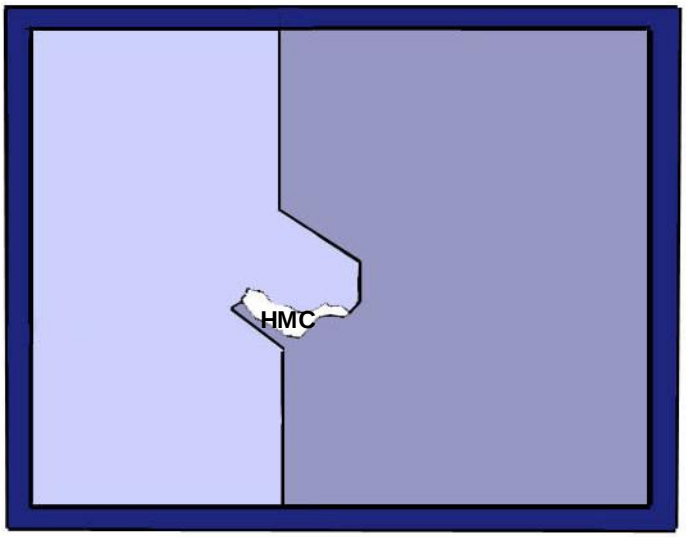
Conservation Criteria

- 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 divisions – 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 (Map 20), 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 (Map21).



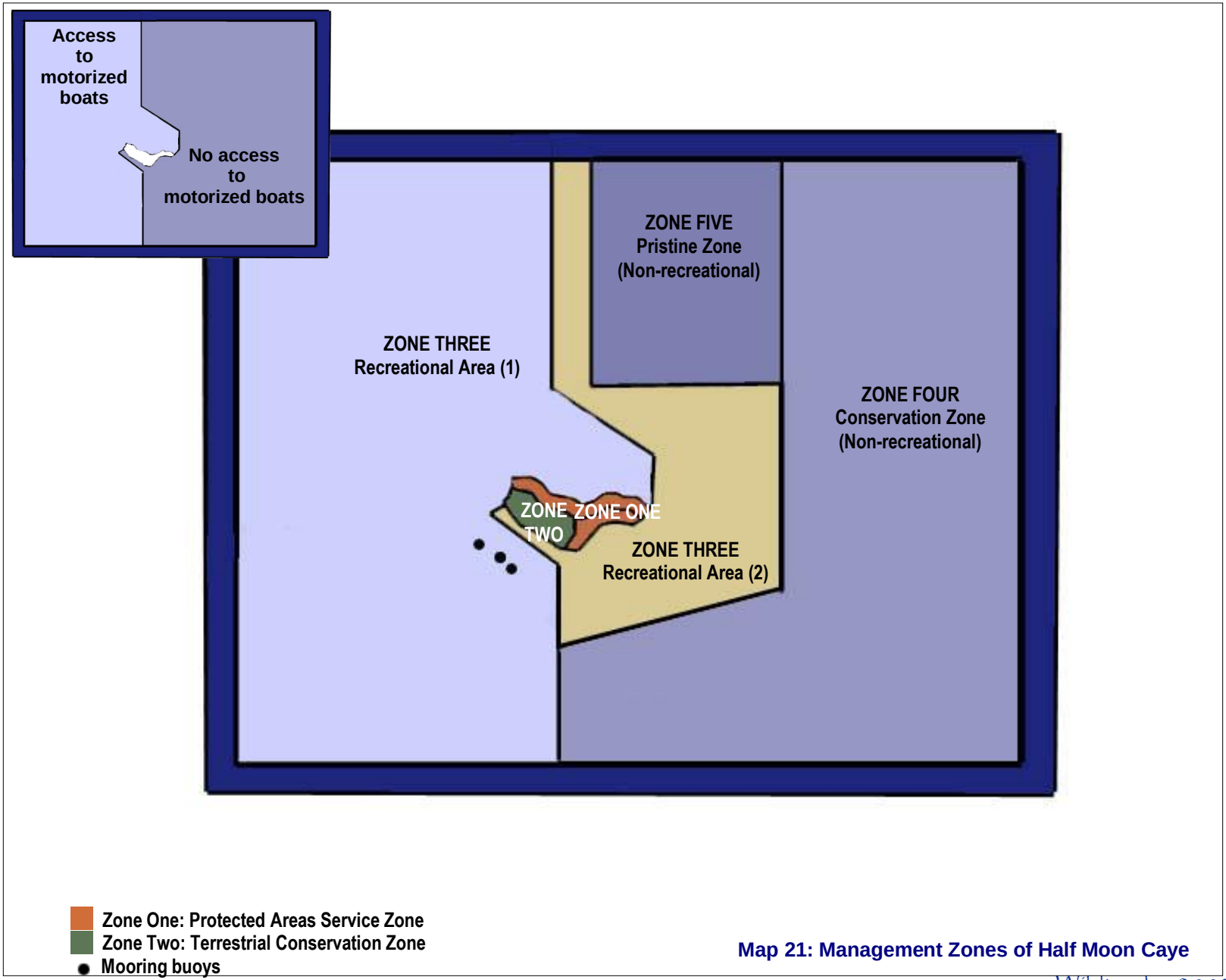
Map 20: Half Moon Caye Natural Monument showing boat access regulations.

Access to motorized boats

No access to motorized boats (unless authorized)

Buffer zone (access to motorized boats)

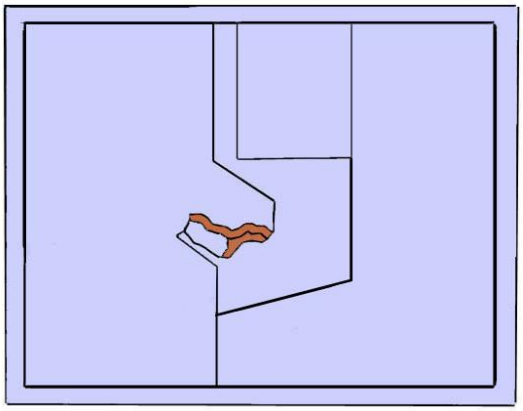
HMC Half Moon Caye



Map 21: Management Zones of Half Moon Caye

Table 40: Provisional 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,	• 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	• 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 • Continued traditional coconut harvesting activities by lighthouse keeper in defined areas • Prevent disturbance of turtles during nesting season
Zone Two	**Terrestrial Conservation Zone**	• 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	• Non-extractive use only • Regulated access for visitors, limited to existing trails • No further vegetation clearance • No camping or fires • No disturbance of wildlife • No replanting or harvesting of coconuts • Authorised education and research activities permitted
Zone Three	**Recreational Area 1** Snorkeling and diving (Access permitted for motorized boats)	• To protect and maintain biodiversity and ecosystem function • To provide an area for recreational diving and snorkeling.	• Non extractive use only • Recreational snorkeling and diving permitted • Boat mooring only at recognized mooring points • Education activities permitted • Authorised research activities permitted
	Recreational Area 2 Snorkeling and diving (No access permitted for motorized boats)	• 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.	• Non extractive use only • Recreational snorkeling and diving permitted • No access by unauthorized boats • Education activities permitted • Authorised research activities permitted
Zone Four	**Conservation Zone –** Open Sea	• To maintain and protect a representative sample of biodiversity and ecosystem function with minimal human impact. • To provide an area for research activities	• Non extractive use only • No recreational snorkeling or diving permitted • Authorised research activities permitted • No access by unauthorized boats
Zone Five	**Pristine Zone –** Representative area of back and fore reef	• To maintain and protect a representative sample of biodiversity and ecosystem function with minimal human impact.	• 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	• To minimize conflict with fishermen in areas where boundary is indistinct and enforcement a problem	• Non extractive use only • No recreational snorkeling and diving permitted • Authorised research activities permitted

Zone One: Protected Areas Service Zone



Map 22: Half Moon Caye - Zone 1

Zone 1: Protected Areas Service Zone

This includes both marine and terrestrial components, on and adjacent to Half Moon Caye. Present and future infrastructure is limited to this zone (except for observation tower, and currently includes:

- two boat docks,
- warden, research and lighthouse keeper accommodations, storerooms, two lighthouses (both old and new),
- interpretive centre and gift shop,
- picnic area,
- restroom facilities,
- camping area and showers

Zone One also includes a 100m offshore margin – a slow-boat zone with no snorkeling or diving permitted, allowing boat access to the caye with minimal impacts to the marine environment, and reduced risks for visitors.

Biodiversity concerns within this zone include:

Protection of turtles and turtle nesting beach during nesting season

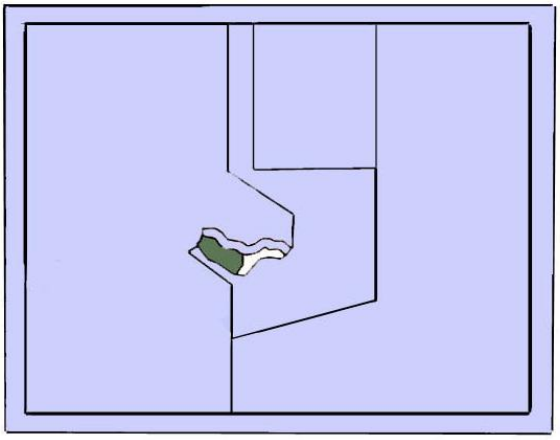
- Requirement for restricted access to south-east beach at nesting / hatching time to prevent disturbance of laying females, nests, and hatchlings
- Control of light pollution during nesting / hatching season
- Maintain no dog policy
- Investigation of impact of rats on hatchlings

Protection of shallow seagrass beds on north shore

- Requirement for all boats (including BAS boats) dock at designated sites
- No boats should be pulled up on beach west of main dock
- Slow boat zone in 100m north offshore margin
- More uniform and visible marking of boat access channels required, and increased awareness of these channels among boat operators

Zone One	Objective	Regulations/Guidelines
Protected Areas Service Zone Access routes, and core area with HMCNM infrastructure and facilities,	• 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	• Boats to follow designated, marked access routes • Boats to dock and disembark only at designated facilities • No boats to be hauled up on beach west of main dock • Camping permitted at camping site • Recreation allowed on designated beach areas • Recreational snorkeling and diving prohibited within 100m of north shore – slow boat zone • Continued traditional coconut harvesting activities by lighthouse keeper in defined areas • Prevent disturbance of turtles during nesting season

Zone Two: Terrestrial Conservation Zone



Map 23: Half Moon Caye Zone 2

Zone 2: Terrestrial Conservation Zone

The Terrestrial Conservation Zone covers the western half of Half Moon Caye (approximately 25.5 acres), and provides high level protection for terrestrial components of the protected area whilst also allowing visitor access for observation. The only visitor infrastructure within this zone consists of the limited trail system and the observation tower overlooking the bird nesting colony.

Biodiversity concerns within this zone include:

Protection of littoral forest and herbaceous beach community

- Removal of coconut debris (suppresses forest regeneration)
- Implement coconut eradication programme
- Replanting of *Thrinax radiate* and forest restoration
- No camping or fires permitted on beaches within this zone

Protection of bird nesting colony

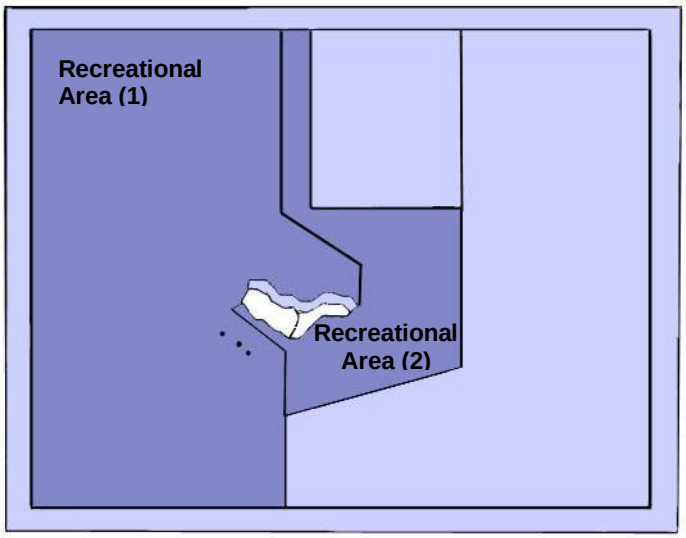
- Ensuring that birds and nests are not disturbed
- Long term monitoring of numbers of nests
- Maintenance of observation tower and trail system for visitor management
- Implementation of rat eradication programme

Protection of native caye lizard populations (*Anolis allisoni* and *Phyllodactylus insularis*)

- Maintain littoral forest cover
- Long term monitoring of populations
- Implementation of rat eradication programme

Zone Two	Objective	Regulations/Guidelines
Terrestrial Conservation Zone	• 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	• Regulated access for visitors, limited to existing trails • No further vegetation clearance • No camping or fires • No disturbance of wildlife • No replanting or harvesting of coconuts • Authorised education and research activities permitted

Zone Three: Recreational Zone



Map 24: Half Moon Caye Zone 3

Zone Three: Recreation Zones (1) and (2)

- **Mooring buoy**

Zone Three is entirely marine, and encompasses seagrass beds, patch reef, shallow reef, spur and groove reef, sparse algae and sand, and Caribbean open sea, and includes several world-recognised dive sites such as Half Moon Caye Wall, Eagle Landing It provides protection for biodiversity – including the Half Moon Caye spawning aggregation site and commercial marine species generally, providing a replenishment function for the rest of the Atoll.

The Recreational Zone allows for non-extractive recreational use of the protected area – primarily snorkeling, diving, and kayaking. This Zone is divided into two sub-zones:

Recreational Area (1)
Recreational Area (2)

Recreational Area (1): allows for access by motorized boats, and includes the access route to Zone One, permanent mooring buoys to the south of the caye.

Recreational Area (2): limits access of motorized boats to those authorized by the management authority for management or research activities. Non-motorised boats (such as recreational sail boats and kayaks) have access to this area.

Biodiversity concerns within this zone include:

Protection of seagrass beds

- Monitoring of seagrass status
- Minimising impacts of boat activity (anchor and propeller) on seagrass through use of designated, marked access routes and limiting mooring to specified sites
- Minimising bilge water and greywater impacts from day-trip and live-aboard dive boats
- Minimising impacts from sewage disposal on Half Moon Caye

Protection of coral reef ecosystems

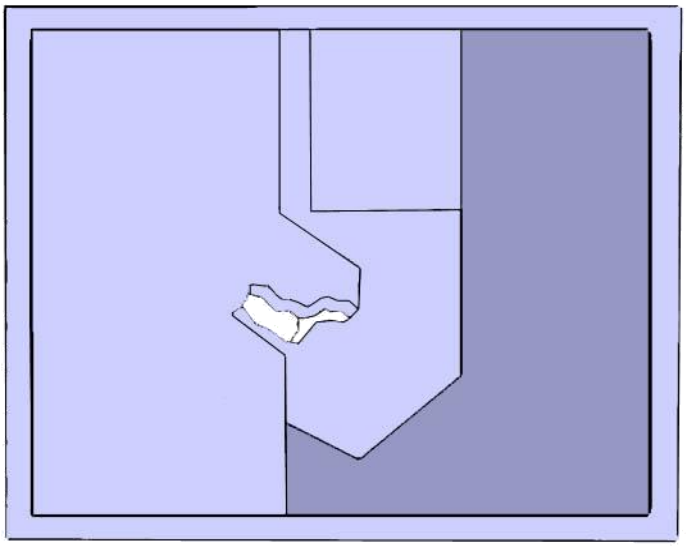
- Prevention of illegal fishing activities
- Minimising impacts of boat activity (anchor and propeller) on coral ecosystems through use of marked access routes and limiting mooring to specified sites
- Minimising impacts from divers and snorkelers
- Minimising bilge water and greywater impacts from day-trip and live-aboard dive boats
- Minimising impacts of sewage disposal on Half Moon Caye
- Advocating for 'best practices' development with land owners within the Atoll to minimize development impacts
- Monitoring of coral health

Conservation of commercial marine species

- Prevention of illegal fishing activities within the protected area
- Monitoring of commercial marine species
- Facilitation of alternative livelihoods for fishermen using Lighthouse Reef Atoll

Zone Three	Objective	Regulations/Guidelines
Recreational Area 1 Snorkeling and diving (Access permitted for motorized boats)	• To protect and maintain biodiversity and ecosystem function • To provide an area for recreational diving and snorkeling.	• Non extractive use only • Recreational snorkeling and diving permitted • Boat mooring only at recognized mooring points • Education activities permitted • Authorised research activities permitted
Recreational Area 2 Snorkeling and diving (No access permitted for motorized boats)	• 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.	• Non extractive use only • Recreational snorkeling and diving permitted • No access by unauthorized boats • Education activities permitted • Authorised research activities permitted

Zone Four: Conservation Zone



Map 25: Half Moon Caye Zone 4

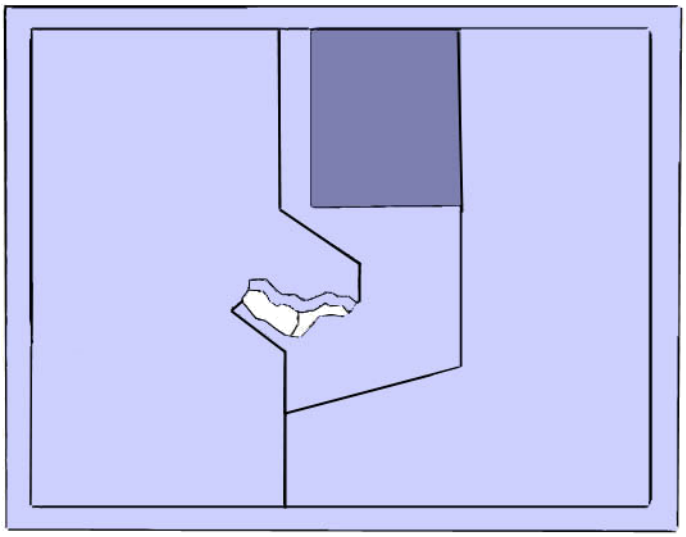
Zone Four: Conservation Zone

Zone Four has been established to conserve representative ecosystems of the Atoll with minimal impact from human activities. It is within the non-motorised boat area, and is open to authorized research, but closed to recreational activities. Research sampling is allowed within this zone, as is the installation of minimal impact research equipment that does not pose a threat to safety or navigation (such as stakes, data loggers, non-motorised water sampling and sediment sampling devices).

Biodiversity concerns are similar to those of Zone Three, but the level of protection is higher, with the increased restrictions on access.

Zone Four	Objective	Regulations/Guidelines
Conservation Zone – Open sea	• To maintain and protect a representative sample of biodiversity and ecosystem function with minimal human impact. • To provide an area for research activities	• Non extractive use only • No recreational snorkeling or diving permitted • Authorised research activities permitted • No access by unauthorized boats

Zone Five: Pristine Zone



Map 26: Half Moon Caye Zone 5

Zone Five: Pristine Zone

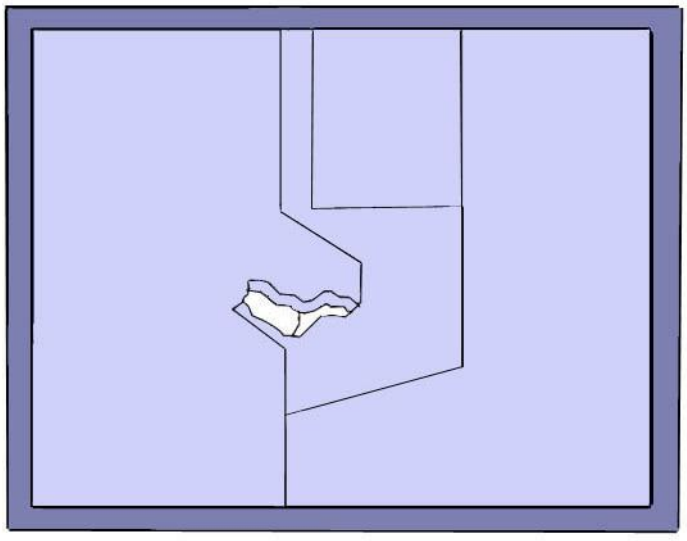
Zone Five, the Pristine Zone, has been established to give the highest level of protection for representative ecosystems of the Atoll, with no access to non-authorized boats.

Access is limited to management activities and minimal-impact management-driven research - research that is identified as a requirement for critical management issues, which does not involve the taking of animals, plants or marine products.

Biodiversity concerns within this Zone are similar to those for Zones Three and Four.

Zone Five	Objective	Regulations/Guidelines
Pristine Zone – Representative area of back and fore reef	• To maintain and protect a representative sample of biodiversity and ecosystem function with minimal human impact.	• Non extractive use only • No access by unauthorized boats • No recreational snorkeling or diving permitted • Restricted research permitted (no collection)

Zone Six: Buffer Zone



With problems of observing the boundaries of the protected area in terms of enforcement issues, a 200m buffer zone has been designated forming the inside perimeter, to facilitate implementation of no-fishing regulations.

Fishing within this buffer zone is not permitted, but recognised accidental incursions will receive a warning only and be advised of boundaries and regulations.

Map 27: Half Moon Caye Zone 6

Zone Six: Buffer Zone

Zone	Objective	Regulations/Guidelines
Buffer Zone – a 200m buffer zone that runs immediately inside the protected area boundary	• To minimize conflict with fishermen in areas where boundary is indistinct and enforcement a problem	• Non extractive use only • No recreational snorkeling and diving permitted • Authorised research activities permitted

Proposed Management Zones - Blue Hole Natural Monument

The Blue Hole has been designated as a Natural Monument and World Heritage Site to provide permanent protection to unique geological features of the sink hole, and to provide access for research and tourism (divers and snorkelers).

A number of issues have emerged during management planning that have been incorporated into the proposed zoning of the Blue Hole. These include:

- Increasing evidence of sediment impacts on coral from boats maneuvering within the Blue Hole
- Increased impacts on coral from divers and snorkelers
- Evidence of impacts on seagrass areas in boat access areas
- Shark chumming and associated diver impacts
- Safety concerns for sky diving activities associated with the Blue Hole

Developing zonation for the Blue Hole Natural Monument will need to take into account a number of criteria:

Conservation Criteria

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

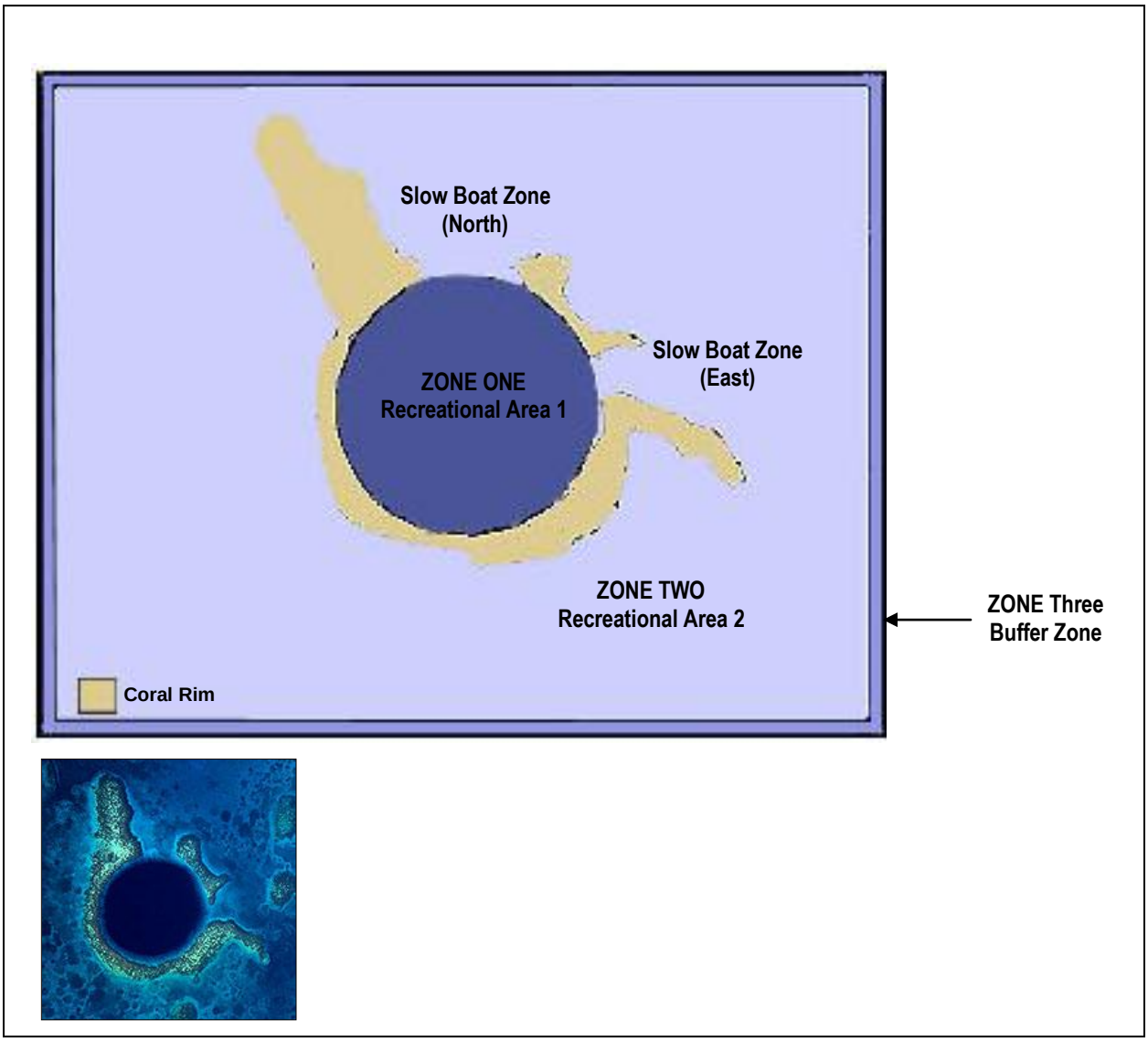
Human Use Criteria

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

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 (Map 28). The RMA established that there is significant degradation of coral reef health on the coral rim from dive boat-created sedimentation (Graham et. al, 2004), with the recommendation that alternate mooring locations in the northern and eastern channel should be investigated for use by the dive boats, removing them from the

Blue Hole itself. Further investigation and stakeholder consultations will be required to establish the exact location of safe and acceptable mooring options.

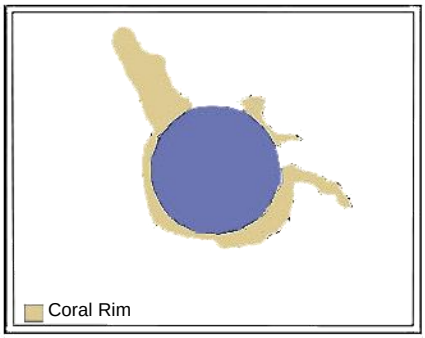
A second cause of decreasing coral health is considered to be poor diver skills and group management, resulting in the stirring up of silt, and increased incidence of contact with coral colonies. This can be addressed by ensuring that there is a requirement for divers to hold Advanced diver qualifications or above before being permitted to dive the Blue Hole. This would also be of benefit from a safety perspective.



Map 28: Provisional Zones of Blue Hole Natural Monument

Table 41: Summary of Provisional Blue Hole Natural Monument Management Zones			
Zone		**Objective**	**Regulations/Guidelines**
Zone One	**Recreational Area 1** The Blue Hole	• 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	• Non extractive use only • Recreational diving and snorkeling permitted • Recommended that 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 mooring within the Blue Hole • No fish/shark chumming • Authorised research activities permitted
Zone Two	**Recreational Area 2** Snorkeling and diving	• 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	• 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 points • No fish/shark chumming • Authorised research activities permitted
Zone Three	**Buffer Zone** – a 200m buffer zone that runs immediately inside the protected area boundary	• To minimize conflict with fishermen in areas where boundary is indistinct and enforcement a problem • To provide an area for research activities	• Non extractive use only • No recreational snorkeling and diving permitted • Authorised research activities permitted

Zone One: Recreational Area One



Map 29: Blue Hole Zone 1

Zone 1: Recreational Area 1

Recreational Area One encompasses the Blue Hole itself, considered to be one ot the world's foremost dive sites, and designated as a Natural Monument under Belize legislation, and as part of the Belize World Heritage Site, in recognition of its unique geological features. Largely unexplored in terms of biodiversity, it is possible that it may protect unique cryptofaunal assemblages, with as yet unidentified species.

At present, boats are permitted to tie on to permanent mooring points within the Blue Hole whilst their divers make the dive. The dive boats do cause damage to the coral rim as they manouveur into position to tie on, with both mechanical and sedimentation impacts leading to general degradation of the coral health. During northerly

winds, there is also a concern of boats being pushed against the reef These factors are further exacerbated by the limited number of mooring buoys, leading to boats using anchors within the Blue Hole. During the five-year timeframe of this management plan, discussions and consultations with dive operators should investigate the possibility of moving the mooring points out of the Blue Hole (as was apparently once the case).

Research sampling is allowed within this zone, as is the installation of minimal impact research equipment that does not pose a threat to safety or navigation (such as stakes, data loggers, non-motorised water sampling and sediment sampling devices).

Biodiversity /Geological concerns within this zone include:

Protection of geological features

- Mooring policy required (who can moor, who can set up mooring points), with enforcement
- Ensure that all boats using the Blue Hole use the required mooring facilities, and don't use anchors
- Move towards removing mooring sites from the Blue Hole itself to the northern and eastern entrances, through consultations and participatory planning with stakeholders
- Ensure divers are sufficiently well qualified (Advanced or above), and dive groups have the recommended ratio of qualified dive leaders to divers

Protection of biological features

- No resource extraction within the Blue Hole
- Enforce no-chumming regulations
- Create and enforce slow boat zones on northern and eastern entrance/exit to Blue Hole
- Monitoring of coral and seagrass status

Conservation of commercial marine species

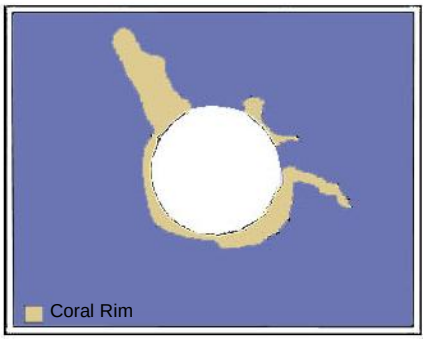
- Prevention of illegal fishing activities within the protected area
- Monitoring of commercial marine species
- Facilitation of alternative livelihoods for fishermen using Lighthouse Reef Atoll

Safety issues

- Ensure divers are sufficiently well qualified, and dive groups have the recommended ratio of qualified dive leaders to divers
- Ensure only activities approved by BAS are conducted within the protected area

Zone One	Objective	Regulations/Guidelines
Recreational Area 1 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 protect and maintain the geological features and ecosystems of the Blue Hole • To provide an area for research activities	• 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 routes • No mooring within the Blue Hole • No fish chumming • Authorised research activities permitted • Dive boats to slow on entry and exit to Blue Hole • Non extractive use only

Zone Two: Recreation Area Two



Map 30: Blue Hole Zone 2

Recreational Area Two

Whilst the majority of divers coming to the protected area come to dive the Blue Hole itself, Zone Two allows for shallow water recreational diving and snorkeling as well. Recreational Area Two also allows for the entrance and exit of boats to the Blue Hole, whilst mitigating the effects of the propellers on the seagrass beds within these zones through designated speed limits.

Research sampling is allowed within this zone, as is the installation of minimal impact research equipment that does not pose a threat to safety or navigation (such as stakes, data loggers, non-motorised water sampling and sediment sampling devices).

Biodiversity concerns within this zone include:

Protection of coral reef ecosystems

- Prevention of illegal fishing activities
- Minimising impacts of boat activity on coral ecosystems through designation as no access area to motorized vessels
- Minimising impacts from divers and snorkelers
- Monitoring of coral health

Mitigation of impacts to seagrass and coral

- Monitoring of seagrass status
- Implement slow boat zones on entrance and exit of Blue Hole
- Clearly marked routes for access and exit to the Blue Hole
- If mooring points are to be placed within either of these zones, ensure that there are sufficient buoys for the number of dive boats, in an area that minimises damage
- Minimising impacts of boat activity (anchor and propeller) on seagrass through use of designated, marked access routes and limiting mooring to specified sites
- Minimising bilge water and greywater impacts from day-trip and live-aboard dive boats
- Ensure that there is an adequate ratio of qualified dive leaders to snorkelers
- Ensure only activities approved by BAS are conducted within the protected area

Conservation of commercial marine species

- Prevention of illegal fishing activities within the protected area
- Monitoring of commercial marine species
- Facilitation of alternative livelihoods for fishermen using Lighthouse Reef Atoll

Zone Two	Objective	Regulations/Guidelines
Recreational Area Two Snorkeling and diving	• To protect and maintain biodiversity and ecosystem function • To provide an area for recreational diving and snorkeling. • To provide access to the Blue Hole	• 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 • Dive boats to slow on entry and exit to Blue Hole • Boats to follow designated, marked access routes • Boat mooring only at recognized points • No fish chumming • Authorised research activities permitted Non extractive use only

Zone Three: Buffer Zone

Map 31: Blue Hole Buffer Zone

With problems of observing the boundaries of the protected area in terms of enforcement issues, a 200m buffer zone has been designated forming the inside perimeter, to facilitate implementation of no-fishing regulations.

Research sampling is allowed within this zone, as is the installation of minimal impact research equipment that does not pose a threat to safety or navigation (such as stakes, data loggers, non-motorised water sampling and sediment sampling devices).

Fishing within this buffer zone is not permitted, but recognised accidental incursions will receive a warning only and be advised of boundaries and regulations.

Zone	Objective	Regulations/Guidelines
Buffer Zone – a 200m buffer zone that runs immediately inside the protected area boundary	• To minimize conflict with fishermen in areas where boundary is indistinct and enforcement a problem	• Non extractive use only • No recreational snorkeling and diving permitted • Authorised research activities permitted

4.4.3 Limits of Acceptable Change

With increasing visitation comes the potential for increasing impacts to the environment, presenting the ever-present dilemma of how a protected area can develop a sustainable financial income from tourism without causing 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 within the two protected areas for the mitigation of visitor impacts is 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.

- 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

The development of planning for visitor management, to ensure these values are maintained whilst visitor appreciation continues, has resulted in the development of two approaches have over the last few years:

- Carrying Capacity
- Limits of Acceptable Change

Carrying Capacity

The idea of 'carrying capacity' is to define what level of use triggers signs of environmental deterioration and visitor dissatisfaction, at which point an area is considered to have exceeded its carrying capacity level.

- **Benefits:** Wilderness managers would have a clear, unequivocal basis for restricting use once an area had reached its designated carrying capacity.
- **Drawbacks:** The lack of a clear and predictable relationship between use and impact. Hard to define 'how much use is too much'.

The coral reef ecosystem is particularly vulnerable to visitor impacts – both direct diver and snorkeler impacts and boat impacts (mechanical damage and water contamination), and indirect impacts from greywater and bilge water. Several studies have been completed in coral reef regions to try and identify suitable carrying capacities for the reef, with figures of between 5,000 and 6,000 dives per dive site per year (Hawkins et. al., 1997). Current figures suggest that visitation is still below 5,000 visitors per site pet year, as of 2005 (BAS, 2006). There are a number of determinants of a reef's capacity to withstand visitation impacts, which can determine the level of visitation that can be considered viable:

Size and shape of reef:

- Larger reefs can accommodate more divers and snorkelers than smaller ones
- Reefs with more irregular reef morphologies, with outcrops and patches, provide greater reef surface available to divers and snorkelers in a smaller area
- Areas of reef with high percentage of live coral are more easily damaged
- Irregular reef morphology will screen visitors from each other, reducing group contact and increasing visitor satisfaction

Composition of coral community:

- Visitation will cause damage, but damage extent depends on fragility of the coral colonies and percentage of live coral present
- Massive corals are less easily damaged than branching corals, which may be easily broken
- Reefs composed of large areas of soft corals are more resilient to diver impacts, and can accommodate more physical contact

Depth, currents and visibility:

- A deep reef, or one with a strong current is not as user friendly to divers
- Poor visibility will reduce visitor satisfaction

Level of experience of divers and snorkelers:

- Novice divers are more likely to cause impacts by standing on or touching reefs
- Experienced divers will have better buoyancy control and spatial awareness, and a greater understanding of the fragility of the reef ecosystem
-

Accessibility:

- Distance from the mainland

Attractions:

- Aesthetically pleasing dive sites will increase popularity with divers and snorkelers
- Attractants would include high coral diversity, large fish, large schools of fish, turtles, sharks, manta rays, caves and galleys
- Shortage of mooring points can be a problem in popular dive sites

Limits of Acceptable Change

'Limits of Acceptable Change' is a framework that can assist decision-making on the amount of change that can be accepted. It takes into account that change is an inevitable consequence of human use. Whilst the optimum management would be to retain pristine conditions, the reality is that once the area is opened for visitor use, resource conditions start to change – coral suffers greater breakage, and both coral and seagrass suffer increased sedimentation and increased algal growth

Natural resource managers found the setting of clear carrying capacities was more elusive than anticipated, due to the variability of the different parameters involved in the process, so the basic question became less one of 'how much use is too much?', and more one of 'how much change is too much.'

This has led to the development of the second conservation planning approach – the Limits of Acceptable Change (LAC) framework provides a means by which natural resource managers, whether terrestrial or marine based, can resolve the complex issues of minimizing visitor impacts (both biophysical and social) and maximizing visitor satisfaction through provision of the experiences they seek. At Blue Hole and Half Moon Caye Natural Monuments, there is a need to

separate LAC planning into terrestrial and marine, as the two have such different requirements and monitoring strategies.

Using Limits of Acceptable Change allows natural resource managers to set use levels based on the condition of the natural resource – a more measurable and immediate indicator than the esoteric relationship between use and impact. The answer to what constitutes 'acceptable change' remains a subjective one – requiring the viewpoints of not only the natural resource managers and the researchers, but also the visitors.

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. This is achieved through an eight step planning process.

Table 42: Steps in 'Limits of Acceptable Change' Planning for Half Moon Caye and Blue Hole Natural Monuments

Step 1	**Identify Area Concerns and Issues**	Identify the special features or qualities of the area Identify management problems or concerns that need to be addressed Identify issues visitors consider important in management Identify role the area plays in both regional and national context
Step 2	**Identify Visitor Requirements**	Identify visitor types Identify visitor impacts Identify visitor requirements
Step 3	**Define and Describe Management Zones**	Identify different management zones Identify natural resource condition appropriate to each zone
Step 4	**Select Indicators of Resource and Social Conditions**	Identify specific elements that are indicative of the overall status of appropriate conditions – resource indicators (eg. trail condition), and social indicators (eg. noise)
Step 5	**Inventory Existing Resource and Social Conditions**	Inventory condition and map location of specific indicators
Step 6	**Specify Standards for Resource and Social Conditions in each Management Zone**	Identify the range of conditions considered appropriate for each indicator, in each zone
Step 7	**Identify Management Actions and Alternatives**	Analysis of inventory data from Step 4 and issues and concerns from Step 1. Map locations where conditions are below acceptable change level, and identify management alternatives and actions to bring conditions up to standard
Step 8	**Implement actions and monitor conditions**	Implement management actions and monitor condition of indicators over time

An outline for ***Limits of Acceptable Change*** is developed for the Management Zones proposed for Half Moon Caye and Blue Hole Natural Monuments, to be built upon during the five year management period into a complete Limits of Acceptable Change Programme

Half Moon Caye and Blue Hole Natural Monuments
Limits of Acceptable Change Outline

Step One

Identify Areas of Concern and Issues of Concern

Areas and issues of concern are identified in this first step towards developing Limits of Acceptable Change – for example, features or values to be maintained or achieved, or specific locations of concern. (Table 43).

Also identified are the recreational opportunities available. Half Moon Caye Natural Monument, first designated to conserve the terrestrial bird nesting colony, and then enlarged to include one of the world's most acclaimed reef wall dive sites, is also recognised as part of Belize's World Heritage Site. As a Natural Monument, use is restricted to education, tourism and research.

The Blue Hole, an 'essential dive' location that provides the major attractant for visiting divers, and the pristine reputation of other dive sites on the Lighthouse Reef Atoll, including Half Moon Caye, draw over 8400 visitors in 2005.

Table 43: Identifying Areas and Issues of Concern - Overview

Identify the special features or qualities of the area	• Almost pristine coral reef with diverse fish community • Reputation as a top world dive site • Unique geological features • Nesting bird colony • Good representative example of littoral forest • Marine turtle nesting beach • Isolated location on Lighthouse Reef Atoll, considered one of the more pristine areas remaining on the Mesoamerican Barrier Reef, and one of only four atolls on the Mesoamerican Barrier Reef
Identify management problems or concerns that need to be addressed	• Minimise visitor impacts on coral reef and seagrass ecosystems • Minimise visitor impacts on nesting bird colony • Minimise visitor impacts on the vegetation of Half Moon Caye • Minimise impacts to the turtle nesting beach • Minimise boat impact on coral reef and seagrass ecosystems • Mitigate impacts from development on adjacent cayes • Ensure that illegal fishing doesn't take place within the protected areas
Identify issues visitors consider important in management	• World class dive sites – eg. Blue Hole, Half Moon Caye Wall, with excellent water clarity • Large fish (including sharks) • Healthy coral reef with species rich fish community • Uncrowded dive site • Charismatic species – turtles, large fish • Helpful and knowledgeable protected area staff
Identify role the area plays in both regional and national context	***Regional*** • Considered, as part of LHR, as one of the highest conservation priorities of the Mesoamerican Barrier Reef System (WWF, 2002) • Protects 10 or more globally threatened species, listed under IUCN Listing for 2004 ***National*** • Both protected areas form part of Belize's World Heritage Site • Important component of the Belize Barrier Reef Reserve System, highlighted as a conservation priority • A major tourism attraction, with over 8400 visitors in 2005.

Step Two

Identify Visitor Requirements

The requirements of visitors to the Blue Hole and Half Moon Caye Natural Monument are relatively restricted (Table 44).

Table 44: Visitor Requirements

Visitor Type	Potential Visitor Flow	Primary Reason for Visit	Secondary Reason for Visit	Acceptable Conditions	Level of Impact	Appropriate Zones
Divers	High	Dive the Blue Hole	Scenic values and Wildlife	Challenging dive conditions, pristine reef, limited contact with other groups whilst diving, abundant marine life	Low to Medium	**BHNM:** Zone 1; Zone 3 **HMCNM:** Zone 1**,** Zone 2, Zone 3
Snorkelers	Medium	Coral Reef	Scenic values and wildlife	Pristine conditions, limited contact with other groups, abundant marine life	Low to Medium	**BHNM:** Zone 3 **HMCNM:** Zone1, Zone 2, Zone 3
Cruise ship visitor	Low - Medium	Fun	Scenic values and wildlife	Abundant marine life	High	**BHNM:** Zone 1; Zone 3 **HMCNM:** Zone 1, Zone 2, Zone 3
Naturalist	Low	Coral reef, birds	Scenic values and wildlife	Pristine conditions, limited contact with other groups whilst diving / snorkeling. Good wildlife sightings, healthy reef	Low	**BHNM:** Zone 1; Zone 3 **HMCNM:** Zone 1, Zone 2, Zone 3
Researcher	Low	Scientific research	Scenic values and Wildlife	Pristine conditions where possible (depending on research interest). Limited contact with other visitor groups	Low – Medium (dependent on research field)	**BHNM:** Zone 1 - Zone 4 **HMCNM:** Zone 1 – Zone 6
Independent Yachts	Low	Coral Reef	Scenic values and Wildlife	Pristine conditions where possible. Limited contact with other visitors	Low	**BHNM:** Zone 1 - Zone 4 **HMCNM:** Zone 1, Zone 2, Zone 3
UB students	Very Low	Learning experience	Fun	Structured learning experience – wouldn't dive, may snorkel	Medium	**BHNM:** Zone 1; Zone 3 **HMCNM:** Zone 1, Zone 2, Zone 3
School students	Very Low	Learning experience	Fun	Structured learning experience – wouldn't dive, may snorkel	High	**BHNM:** Zone 1; Zone 3 **HMCNM:** Zone 1, Zone 2, Zone 3

Blue Hole Natural Monument

Define and Describe Management Zones

Once the visitor requirements have been identified, and the protected area has been zoned into management areas (Table 45), environment and visitor management techniques can be used to ensure that visitor expectations are met as far as possible, whilst also minimizing environmental impacts. This is achieved by the Limits of Acceptable Change Planning System.

Table 45: Summary of Blue Hole Natural Monument Zones, Objectives and Visitor Type

Zone		Objective	Visitor Type
Zone One	**Recreational Area 1** 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 protect and maintain the geological features and ecosystems of the Blue Hole	**All Visitors** **Particularly Divers**
Zone Two	**Slow Boat Zone** **North – Entrance** **East - Exit**	• To protect and maintain biodiversity and ecosystem function of the seagrass	**Access Only** **Researchers**
Zone Three	**Recreational Area 2** Snorkeling and diving (No access permitted for motorized boats)	• To protect and maintain biodiversity and ecosystem function • To provide an area for recreational diving and snorkeling.	**All Visitors**
Zone Four	**Conservation Zone –** No access permitted unless authorized	• To maintain and protect a representative sample of biodiversity and ecosystem function with minimal human impact. • To provide an area for research activities	**Researchers**
Zone Five	**Buffer Zone** – a 200m buffer zone that runs immediately inside the protected area boundary	• To minimize conflict with fishermen in areas where boundary is indistinct and enforcement a problem	**Researchers**

Half Moon Caye Natural Monument

Define and Describe Management Zones

Table 46: Summary of Half Moon Caye Natural Monument Zones, Objectives and Visitor Type

Zone		Objective	Visitor Type
Zone One	**Protected Areas Service Zone** Access routes, and core area with HMCNM infrastructure and facilities,	• 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	**All Visitors**
Zone Two	**Terrestrial Conservation Zone**	• 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	**All Visitors – Particularly Naturalists**
Zone Three	**Recreational Area 1** Snorkeling and diving (Access permitted for motorized boats)	• To protect and maintain biodiversity and ecosystem function • To provide an area for recreational diving and snorkeling.	**All Visitors Particularly Divers**
	Recreational Area 2 Snorkeling and diving (No access permitted for motorized boats)	• 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.	**All Visitors Particularly Snorkelers and Divers**
Zone Four	**Conservation Zone –** Open Sea	• To maintain and protect a representative sample of biodiversity and ecosystem function with minimal human impact. • To provide an area for research activities	**Researchers**
Zone Five	**Pristine Zone –** Representative area of back and fore reef	• To maintain and protect a representative sample of biodiversity and ecosystem function with minimal human impact.	**Researchers**
Zone Six	**Buffer Zone** – a 200m buffer zone that runs immediately inside the protected area boundary	• To minimize conflict with fishermen in areas where boundary is indistinct and enforcement a problem	**Researchers**

Table 47: Recreation Conditions for Blue Hole Natural Monument		
Management Zone	**Zone 1**	**Zone 2 (Recreational Zone)**
Resource Setting (General description)	Marine – sinkhole (estimated at 412 ft deep) with geological formations and possible unique cryptic species assemblages, rimmed by coral.	Shallow patch coral and the outer rim of the Blue Hole. Includes entrance and exit to Blue Hole – cuts through the coral rim with seagrass
Ecological Conditions	Coral rim is impacted by sedimentation from boat activity, and from diver damage, reducing the health of the coral. Potential damage to stalactites and stalagmites from anchor and diver damage. Alteration of fish behaviour due to shark chumming	The patch reef is not considered to be in good condition, with a percentage cover of live coral of 12.5% (as opposed to the 30.74% of Half Moon Caye). This fair condition is attributed partly to the shallow water, increasing stress on the corals, the decrease in natural grazers, and the impacts of divers and boats. The seagrass is generally in good condition, except in the areas of highest boat traffic, where there are higher levels of brown algae (thought to be indicative of higher boat activity)
Prevalence and duration of impact	The majority of dive boats enter the Blue Hole by mid-morning and have left by midday. Dive length is restricted by the dive depth, and the majority of divers are Advanced or higher, suggesting that their greater experience may reduce their negative impacts	Divers are generally in the area during the morning, most boats leaving before midday. This occurs between four and six days a week, with an average of …divers per boat. The majority of divers swim in Zone 1, dive impacts in Zone 2 are lower. Whilst there are divers outside of this time period, the numbers are reduced. Impacts from dive boats as they enter and leave the Blue Hole – an average of between four and seven dive boats regularly access the Blue Hole, though their presence in this zone is very brief.
Visibility of impacts	The coral rim of the Blue Hole was highlighted for increasing algal growth and sedimentation, attributed to boat and diver activity within the area. The congregation of sharks and large fish on the approach of the dive boats suggests conditioned behaviour from the observed chumming, which is known to increase the danger of potential shark bites to divers. Mooring buoys in place.	The low percentage live coral is visible to divers and snorkelers. There has been no assessment of diver damage. Lack of sufficient mooring buoys is also causing damage in some areas. Increased presence of filamentous brown algae, which reduces the structural value and stability of the seagrass beds. However this will not be visible to divers, as it is outside the area used for dives
Social Setting (General Description)	Primarily diving in groups from day dive boats. Popular dive, so frequently more than one dive boat at this location	Dive boats generally congregate within the area during the morning, though the majority of divers use Zone 1. This may change if mooring points are removed from the Blue Hole itself. No snorkeling or diving in this area. Other dive boats normally visible within the general area.
General level of encounters	With dive boats following a similar itinerary, the chance of there being more than one dive boat within the Blue Hole is high. This results in several groups of divers being in the water at the same time	With dive boats following a similar itinerary, the chance of there being more than one dive boat within the Blue Hole area is high. This results in several groups of divers and snorkelers being in the water at the same time. However the chance of encountering other groups in Zone 3 is probably less than that of Zone 1. No snorkeling or diving in this area. Other dive boats normally visible within the general area
Intergroup contacts	High – several groups will be in the water at the same time	Medium – several groups may be in the water at one time, but will not be concentrated in a single small area, as happens in Zone 1. The number of snorkelers is significantly smaller than divers. Other dive boats normally visible within the general area.
Zone Three is not open to recreational use		

Table 48: Recreation Conditions for Half Moon Caye Natural Monument			
Management Zone	**Zone 1**	**Zone 2**	**Zone 3 (1 and 2)**
Resource Setting (General description)	Terrestrial and Marine. Boat access routes and core administration area with facilities – Primarily modified environment, with natural storm impact alteration of shoreline	Terrestrial - Unmodified natural environment (Littoral Forest and Herbaceous Beach Community) with single trail and bird observation tower	Unmodified natural environment with a number of mooring buoys
Ecological Conditions	Marine – Shallow water *Thalassia* seagrass beds with minimal boat impacts on access routes (moderate propeller damage by docks). Some shading of seagrass by docks. Terrestrial – Highly modified conditions with clearance of natural vegetation to allow for facilities and picnic area. Some vegetation clearance on turtle nesting beach to south	Main impacts on the Littoral Forest and Herbaceous Beach Community are natural (storm related). User impacts on terrestrial ecosystems are regulated by the existence of a trail system. Impacts on nesting birds regulated by presence of guides, and use of the observation tower	Includes major dive sites (eg. Half Moon Wall) considered to be among the best in the world, with near pristine conditions and high biodiversity. Excellent water quality and few human impacts. Coral bleaching and disease incidence on LHR are lower than other areas of Belize
Prevalence and duration of impact	Majority of use is from day-trip dive boats, which arrive three or four times a week with groups of varying sizes, docking at the caye to allow visitors to disembark for lunch in the picnic area. Minimum number of visitors per boat averages ten, with up to … boats docking in one day	Compaction of soil; minimal trampling of trail-side vegetation. Disturbance of nesting birds appears to be minimal at current levels. No apparent impact to lizard populations. Visitors arrive daily – few overnight. Tend to be experienced divers (active, environmentally aware).	Diving in this zone takes place almost every day, either from day trip dive boats or live-aboards, with associated diver impacts. Possible impacts from grey water and bilge water from live aboards moored in the area. Alteration of behaviour patterns seen in some fish species suggesting chumming by some dive operators
Visibility of impacts	Highly modified environment, with clearance of natural vegetation. Administration and accommodation areas, with washing and bathroom facilities visible	Impacts are not readily apparent to most visitors	Majority of visitors consider the marine environment to be virtually pristine
Social Setting (General Description)	No opportunities for isolation and solitude.	Low opportunities for isolation and solitude – generally visited by groups during lunch break in diving itinerary	Low opportunities for isolation and solitude – usually more than one dive boat is on site at any one time, due to logistical time constraints. Live-aboards are usually moored within view as well.
General level of encounters	High – several (4 or 5) dive boats will be using the picnic area of Half Moon Caye at any one time	High – several (4 or 5) dive boats will be using Half Moon Caye at any one time, each with visitors wanting to see the bird colony	Moderate – the nature of the spur and groove reef, and level of visibility underwater may reduce group contact. There is a high probability of other dive boats being present, and requirement to use mooring buoys increases concentration of diving activity around mooring points
Intergroup contacts	High – several (4 or 5) dive boats will be using the picnic area of Half Moon Caye at any one time	High – several (4 or 5) dive boats will be using Half Moon Caye at any one time, each with visitors wanting to see the bird colony	High - Visual contact with other boats above water. Moderate below water.
Zones Four to Six are not open to recreational use			

Step Four: Indicator Selection

The Limits of Acceptable Change framework is based on the understanding that recreational use of an area will negatively impact the quality of both the natural resources and the quality of visitor experience. Standards can be set as to how much change is acceptable. Indicators allow managers to monitor the natural resources to ensure that these standards for both natural and social environments are not being passed, and to implement management measures before these limits are reached.

This is particularly important within the coral reef environment, with the fragility of the coral and the long recovery time if damage occurs. Indicators suggested for use within this framework can be drawn from those being implemented within the biodiversity monitoring programme, with sites selected to reflect visitor impacts. Indicators of greatest importance include:

Environmental Indicators

- **Water Quality Monitoring**

  Under the Healthy Reefs for Healthy People initiative, water quality indicators - temperature, salinity and turbidity – are key parameters for the maintenance of healthy reef and near-shore ecosystems. There is a need for an ongoing water quality monitoring programme at Lighthouse Reef Atoll, under the MBRS Synoptic Monitoring Programme, which should be supplemented with specific testing for sewage in areas of concern, such as run-off areas near Half Moon Caye itself, or by boat mooring buoys. See Management Programme B: Research and Monitoring Management Programme

- **Sedimentation**

  The implementation of long term monitoring of sedimentation in areas of high concern (eg. The Blue Hole) using sediment traps, and checked twice annually. See Management Programme B: Research and Monitoring Management Programme

- **Fish Abundance**

  Within the MBRS monitoring protocols, monitoring is for a limited range of species indicative of the general health of the reef. By ensuring that the location of transects include areas highlighted as 'of concern' in terms of tourism impacts, this monitoring programme should highlight any changes in species abundance in these areas. See Management Programme B: Research and Monitoring Management Programme

- **Coral Damage**

  MBRS protocols include monitoring for coral fragmentation, one of the indicators of diver impacts. See Management Programme B: Research and Monitoring Management Programme

- **Impact of Dive Boats**

  Impacts on seagrass should be monitored in areas of concern. See Management Programme B: Research and Monitoring Management Programme

- **Impacts of Shark Feeding**

  There is concern about the impacts of fish feeding activities carried out by dive operators on the majority of dive sites, including shark feeding at the Blue Hole. One of the management recommendations from many of the stakeholders is the cessation of such activities (in line with current regulations - that are not enforced). See Management Programme A: Natural Resource Management Programme

Social Indicators

- **Group Size**

  Monitoring of group size and diver:dive-leader ratio is crucial for management of resources, to ensure that guidelines are followed, and that Limits of Acceptable Change are not exceeded. See Management Programme B: Research and Monitoring Management Programme

- **Number of Dive Boats**

  Whilst not being included within the main suite of monitoring actions, monitoring of the number, type, size and capacity of dive boats visiting the protected areas, both on a day basis and overnight, is important for ensuring comprehensive understanding of protected area use, for inclusion in adaptive management. See Management Programme B: Research and Monitoring Management Programme

- **Visitor Experience**

  Visitor satisfaction, whether tourism or educational, is important in maintaining visitation as an economic sustainability mechanism, and should be monitored constantly, with adaptation of management procedures should visitor feedback suggest this is necessary. See Management Programme B: Research and Monitoring Management Programme

4.5 Management Programmes and Objectives

It should be borne in mind that the Programmes of a Management Plan are interconnected over space and time, supporting each other and forming a whole that is greater than the single parts. As such, Management Programmes cannot be considered individually, but must be seen in terms of a bigger picture – the integrated management of Blue Hole Natural Monument and Half Moon Caye Natural Monument, towards the final goal:

Half Moon Caye Natural Monument and Blue Hole Natural Monument

Overall Management Vision:

To protect and preserve natural resources and nationally significant natural features of special interest or 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.

There are six programmes within the overall Management Strategy for Half Moon Caye and Blue Hole Natural Monuments:

A. Natural Resource Management Programme
B. Research and Monitoring Programme
C. Community Participation Programme
D. Public Use Programme
E. Site and Infrastructure Management Programme
F. Administration Programme

When prioritizing activities within these programmes, the results of the Conservation Planning prioritization should be taken into account:

Priority Areas of Action for Half Moon Caye Natural Monument

Priority	Rank	Conservation Target	Primary Threat
High Priority	1	Spawning Aggregations	Fishing
	2	Nesting Birds	Introduced Species
	3	Lizard Species	Introduced Species
Medium Priority	4	Marine Turtles	Introduced species
	5	Littoral Forest	Introduced species
	6	Coral Reef	Fishing
	7	Parrotfish	Fishing
	8	Commercial Marine Species	Fishing
Lower Priority	9	Seagrass	Boats

…as should the leverage value of cross cutting strategies:

Primary cross cutting strategies for Half Moon Caye Natural Monument and Blue Hole Natural Monument	Seagrass	Coral Reef	Commercial Marine Species	Parrotfish	Spawning Aggregations	Marine Turtles	Littoral Forest	Nesting Bird Colony	Lizard Species	Shark Species	Sink Hole Geology	
Finalization and implementation of Management Zones												
Increase BAS awareness of development activities within the atoll												
Increase awareness of impacts of sedimentation												
Ensure adequate wastewater and sewage disposal												
Patrol protected areas and enforce no-take legislation												
Lobby for stakeholder management of Lighthouse Reef												
Implement Rat Eradication Programme												
Ensure diver awareness of potential impacts												
Continue facilitating Alternative Livelihood projects												
Develop and implement Littoral Forest Recovery Programme												
Actively prevent further introduction of invasive species to HMCNM												
Designate specific mooring sites and boat channels												
Work with dive boat operators to eliminate shark chumming												
Increase awareness of the importance of marine protected areas to the fisheries industry												

Wide ranging cross cutting issues (6 targets)	
Medium ranging cross cutting issues (4 targets)	
Narrow ranging cross cutting issues (1 to 3 targets)	

A. Natural Resource Management Programme

It has been recognized that the health of biodiversity within the two protected areas is inextricably linked to the overall biodiversity health of the entire Atoll. For that reason, it is necessary to take a more holistic view of the ecosystems of Lighthouse Reef Atoll, with many strategies and management activities targeted outside the protected areas boundaries.

Overall Objective:

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

Within this general objective, a number of conservation priorities have been highlighted:

- Improve protection of marine ecosystems within Blue Hole Natural Monument and Half Moon Caye Natural Monument
- Maintain geological formations within Blue Hole Natural Monument
- To improve protection of terrestrial ecosystems and associated biodiversity of Half Moon Caye
- Develop strategies for mitigating impacts on highlighted conservation targets of the two protected areas
- Work more closely with the fishermen, tour operators, and adjacent caye development managers towards a conservation plan for Lighthouse Reef Atoll

The Natural Resources Management Programme (**Programme A**) is divided into a number of sub-programmes:

- General Biodiversity Management
- Biodiversity Protection
- Specific Conservation Measures

…each of which has an associated series of activities.

A. Natural Resource Management Programme

General Biodiversity Management Sub-Programme			
Objective 1: Provide the framework for effective management of the protected area.			
			Activity
	Activity Group 1	Clearly demarcate the boundaries and management zones	**A1-A7**
	Activity Group 2	Strengthen communication and cooperation with other stakeholders of Lighthouse Reef Atoll	**A9-A11, A16-A17**
	Activity Group 3	Continue raising awareness in all stakeholders of the role of BAS, and the benefits of the protected areas	**A8, A13-A14**
	Activity Group 4	Strengthen ties with GoB, Port Authority, and other governmental and non governmental organisations	**A12, A15**
	Activity Group 5	Liaise with property owners of adjacent cayes at managerial level to engender support and cooperation	**A16**
	Activity Group 6	Integrate research and monitoring results into management process	**A18**

Biodiversity Protection Sub-Programme			
Objective 1: Patrolling and enforcement			
			Activity
	Activity Group 1	Increase effectiveness of patrolling and enforcement activities	**A19-A24**

Biodiversity Protection Sub-Programme			
Objective 2: Mitigation of impacts from development activities			
			Activity
	Activity Group 1	***Development on Half Moon Caye:*** Assess all impacts associated with current and potential infrastructure	**A25, A30**
	Activity Group 2	***Development on Adjacent Cayes:*** Monitor development on adjacent cayes; Ensure adequate representation in EIA process; Close liaison with owners and managers of adjacent cayes; Develop 'best practices' guidelines for small property owners, commercial managers and developers; Raise awareness of potential negatively impacting activities and methods for mitigation	**A26-A31**

Biodiversity Protection Sub-Programme			
Objective 3: Investigate Stakeholder Management of Lighthouse Reef			
			Activity
	Activity Group 1	Investigate the possibilities of stakeholder management of Lighthouse Reef	**A32-A35**
Objective 4: Mitigate Diver Impacts			
	Activity Group 1	Reduce visitor impact through implementation of management zones;	**A1, A3, A5**
		Development of 'best practices' guidelines for dive boats	**A36**
		Enforcement of protected areas regulations for visitors and tour guides	**A7, A23**
Objective 5: Protect against invasive species			
	Activity Group 1	Work closely with Port Authority, lighthouse keepers, boat captains and wardens to ensure no wildlife or pets are introduced to Half Moon Caye	**A37-A38**
		Implement coconut management plan	**A77**
		Implement rat eradication plan	**A39**
Objective 6: Continue facilitating alternative livelihood projects			
	Activity Group 1	Continue facilitating alternative livelihood mechanisms	**A40-A41**
Objective 7: Mitigate boat impacts			
	Activity Group 1	Define boat channels and mooring buoy system	**A42-A43**
Objective 8: Increase awareness of the importance of MPA's			
	Activity Group 1	Outreach and awareness to fishermen and associated stakeholder communities	**A44-A45**

Targeted Conservation Measures			
Target 1: Seagrass			
			Activity
	Activity Group 1	Develop baseline and monitoring of seagrass – see Research and Monitoring Programme	
	Activity Group 2	Develop and implement management zones	**A1-A7**
	Activity Group 3	Regulate boat impacts using specific marked channels and mooring buoys	**A42-A43**
	Activity Group 4	Mitigate land-based human impacts	**A25-A31**
Target 2: Coral Reef			
	Activity Group 1	Assess and monitor status of existing coral reef habitat – see Research and Monitoring Programme	
	Activity Group 2	Develop and implement management zones	**A1-A7**
	Activity Group 3	Regulate boat impacts using specific marked channels and mooring buoys	**A42-A43**
	Activity Group 4	Mitigate diver impacts to coral	**A36**
	Activity Group 4	Mitigate land-based human impacts	**A25-A31**
Target 3: Commercial Marine Species			
	Activity Group 1	Continue monitoring of commercial marine species – see Research and Monitoring Programme	
	Activity Group 2	Increase enforcement of no-take legislation within protected areas	A19-A24
	Activity Group 3	Increase awareness amongst stakeholders of the importance of marine protected areas to the fisheries industry	A53
	Activity Group 4	Continued facilitation of alternative income projects within the stakeholder communities	A40-A41
	Activity Group 5	Increased liaison with national and international fisheries sector	A48-A51
	Activity Group 6	Mitigate land-based human impacts	A25-A31
Target 4: Parrotfish			
	Activity Group 1	Develop and support initiatives to increase awareness of importance of parrotfish to reef health	A55-A56
	Activity Group 2	Continued facilitation of alternative income projects within the stakeholder communities	A40-A41
	Activity Group 3	Improve enforcement of no-fishing regulations within protected area	A19-A24
Target 5: Spawning Aggregations			
	Activity Group 1	Continue monitoring of spawning aggregation sites - see Research and Monitoring Programme	
	Activity Group 2	Improve enforcement of no-take legislation within protected areas	A19-A24
	Activity Group 3	Increase awareness of the importance of maintaining spawning aggregation sites	A58
	Activity Group 4	Mitigate land-based human impacts	A25-A31

Targeted Conservation Measures			
Target 6: Marine Turtles			
			Activity
	Activity Group 1	Develop and implement nesting beach plan	**A61-A64**
	Activity Group 2	Monitor turtle presence throughout Lighthouse Reef Atoll – see Research and Monitoring Programme	
	Activity Group 3	Increase public awareness	**A66-A70**
	Activity Group 4	Ensure protection of turtle nests	**A65**
	Activity Group 5	Reduction of risk of potential impact of lights through awareness programme	**A71-A72**
	Activity Group 6	Continued support of alternative livelihoods projects in stakeholder fishing communities	**A40-A41**
	Activity Group 7	Support of other national and international turtle conservation initiatives	**A74-A75**
Target 7: Littoral Forest			
	Activity Group 1	Develop and implement littoral forest recovery plan	**A76-A77**
	Activity Group 2	Actively prevent further introduction of exotic species to Half Moon Caye	**A37**
	Activity Group 3	Integrate rat eradication programme	**A39**
Target 8: Nesting Birds			
	Activity Group 1	Continue and improve monitoring of nesting birds – see Research and Monitoring Programme	
	Activity Group 2	Ensure visitor management to minimise disturbance – see Public Use	
	Activity Group 3	Ensure continued viability of Littoral Forest	**A76-A77**
	Activity Group 4	Actively prevent further introduction of exotic species to Half Moon Caye	**A37**
	Activity Group 5	Integrate rat eradication programme	**A39**
Target 9: Lizard Species			
	Activity Group 1	Develop baseline and monitoring for lizard species – see Research and Monitoring Programme	
	Activity Group 2	Ensure continued viability of Littoral Forest	**A76-A77**
	Activity Group 3	Actively prevent further introduction of exotic species to Half Moon Caye	**A37**
	Activity Group 4	Integrate rat eradication programme	**A39**
Target 10: Shark Species			
	Activity Group 1	Assess and monitor shark populations – see Research and Monitoring Programme	
	Activity Group 2	Increase awareness of sharks	**A80**
	Activity Group 3	Work with dive boat operators to eliminate the practice of shark feeding	**A81-A83**
	Activity Group 4	Liaison with other national and international organisation working on sharks	**A84**
	Activity Group 5	Improve enforcement of no-take legislation within the protected areas	**A19-A24**

Targeted Conservation Measures			
Target 11: Blue Hole Geology			
			Activity
	Activity Group 1	Information management	
	Activity Group 2	Enforce mooring regulations for dive boats using the Blue Hole	**A85**
	Activity Group 3	Investigate feasibility of removing dive boats from the Blue Hole	**A86**
Target 12: Filling national Ecosystem Coverage Gaps			
			Activity
	Activity Group 1	Investigate feasibility of increasing management to incorporate open sea area identified under the NPAPSP	**A87, A88**

A. Natural Resource Management Programme
General Biodiversity Management

Management Actions		Present Status	Desired Status	Year	People	Limitations/Requirements
A1	Ensure boundaries of both protected areas are clearly defined, with sufficient marker buoys to deter incursions	Boundary marker buoys are far apart, and can be hard for fishermen to see from dories	Boundaries clearly defined by sufficient, highly visible marker buoys	1st Year	Marine PA manager, Park Director,	BHNM requires at least 8 boundary marker buoys (currently has 4), which need to be larger and more obvious if possible. HMCNM also requires more boundary marker buoys
A2	Ensure all national shape files of the protected areas are correct	There is more than one shape file of the boundaries of Half Moon Caye Natural Monument in circulation…only one is correct	All national and regional mapping exercises use the correct shape file for Half Moon Caye Natural Monument	1st Year	Marine PA manager, BAS Research Coordinator LIC (Lands Department)	Need to check that the official map held by LIC (Lands Department) is the correct map, and if not, work with LIC to correct.
A3	Workshop with stakeholders to define Management Zones within protected areas	Previous Management Zones are not clearly defined nor implemented; greater stakeholder input required before finalization	Management zones for both protected areas defined and finalized through workshop with stakeholders, and implemented	1st Year	Executive Director, Marine PA manager, Marine Biologist, Protected Areas Officer (Forest Dept.), Protected Areas Officer (Fisheries Dept.) Park Director	Zones should be clear to visitors - adequate colour-coded, visible marker buoys. Create map and regulations leaflet to ensure awareness of stakeholders (A3)
A4	Ensure that at least one significant area of seagrass and each type of coral reef is included within a designated core 'preservation zone' at HMCM and BHNM	No zonation of protected area at present	Zonation to include seagrass and coral types within core 'preservation zone'	1st Year	Marine PA Manager, Park Director & Staff, Marine Biologist	
A5	Develop and distribute leaflet of new management zones to boat captains (both fishing and dive boats) and other stakeholders	No knowledge of current management zones	Full knowledge of future management zones and regulations per zone,	1st Year	Marine PA manager, Park Director, Community-liaison Officer,	Ensure full participation of stakeholders in finalization of management zones
A6	Staff awareness of zones, reasons for zoning, and activities permitted	No management zoning at present	Staff aware of management zones and activities permitted per zone, and enforce regulations	1st to 5th	Marine PA Manager, Park Director	Awareness through staff meetings
A7	Enforcement of management zone guidelines	No enforcement of current management zones guidelines	Enforcement of management zone guidelines	1st to 5th	Marine PA manager, Park Director, Park staff	
A8	Increase staff awareness of the critical role they and the protected areas play in maintenance of fisheries resources	Staff not always fully committed to their role in enforcement of no-take regulations within protected areas	Staff fully committed to their role in enforcement of no-take regulations within protected areas	1st to 5th	Executive Director, Marine PA Manager, Park Director & Staff, Marine Biologist, BAS Research Coordinator	Needs to be ongoing to have maximum effectiveness

A. Natural Resource Management Programme
General Biodiversity Management

Management Actions		Present Status	Desired Status	Year	People	Limitations/Requirements
A9	Continue establishing a working relationship with fishing stakeholders, based on stakeholder awareness and participation	BAS has not been working for long at engaging the fishing communities, and is still developing a working relationship. Previous relationship has been antagonistic over enforcement issues	Communities work in collaboration with BAS towards effective, participatory management of the marine pa's	1st to 5th	Marine PA Manager, Community-liaison Officer, Education Manager, Park Director, Fishermen, Fishing Cooperatives	Primary fishing stakeholder communities: Copper Bank, Chunox, Sarteneja
A10	Develop knowledge base and capacity of primary stakeholders (principally fishermen) for advisory role in management of protected areas	Fishermen, as a primary stakeholder sector, have been generally antagonistic towards protected area and objectives, and have limited knowledge base and capacity for management	Fishermen have knowledge and capacity to be supportive of objectives and goals of protected area management	1st to 5th	Marine PA Manager, Community Liaison Officer, Park Director	Leadership training for fishermen, and increased awareness through BAS outreach activities and community participation in monitoring
A11	Continue establishing a working relationship with tourism stakeholders, based on stakeholder awareness and participation	BAS has been working closely with the tourism industry, but relationship not yet truly participatory, with several perceived unilateral management decisions causing antagonism	Tourism stakeholders work in collaboration with BAS towards effective participatory management of protected areas	1st to 5th	Marine PA Manager, Community-liaison Officer, Marine Biologist, Park Director	Tourism stakeholders: Based primarily in San Pedro, Caye Caulker, Belize City,
A12	Continue liaising with Port Authority, and develop Memorandum of Agreement for Half Moon Caye	Little liaison between BAS and Port Authority, despite Port Authority's ownership and management of a portion of Half Moon Caye	Greater liaison between BAS and Port Authority, with agreement to ensure minimal environmental impacts from Port Authority activities and staff	1st to 5th	Executive Director, Marine PA Manager, Park Director, Port Authority	Port Authority sits on LHR Advisory Committee. Has informal arrangement of cooperation with BAS. Agreement and policy development on issues such as fishing within the protected area, introduced species (including dogs)
A13	Raise community awareness of the benefits of marine protected areas - particularly BHNM and HMCNM – eg species recruitment of commercial marine species etc.	Fishermen in particular don't see the benefits of marine protected areas	Fishermen see benefits of marine protected areas and are supportive of objectives and goals of protected area management	1st to 5th	Marine PA Manager, Community-liaison Officer, Education Officer, Park Director	Fishermen frequently say they have never been shown any proof or results that marine protected areas do work to their benefit
A14	Raise staff awareness of the benefits of marine protected areas - particularly BHNM and HMCNM - eg species recruitment of commercial marine species etc.	Ongoing – but staff not always fully committed to enforcement, possibly due to lack of full awareness of benefits	Ongoing and continuous staff awareness programme, and part of orientation for any new staff	1st to 5th	Marine PA Manager, Marine Biologist, Park Director & Staff,	

A. Natural Resource Management Programme

General Biodiversity Management

Management Actions		Present Status	Desired Status	Year	People	Limitations/Requirements
A15	Strengthen links with other organisations and Government agencies involved in marine protected areas management	Ongoing	Stronger links with other organisations and Government agencies involved in marine protected areas management	1st to 5th	Executive Director, Marine PA Manager, BAS Research Coordinator, Marine Biologist	Including Fisheries Department, MBRS, WCS, WWF initiatives (including the MAR initiative).
A16	Stimulate stakeholder participation in management and monitoring activities	Ongoing in some areas (eg. Fishermen and lobster and conch monitoring). Opportunities exist for participation in turtle nest monitoring, shark monitoring	Greater stakeholder participation in management and monitoring activities	1st to 5th	Marine PA Manager, Marine Biologist, Park Director	
A17	Investigate potential for stakeholder resource management of Lighthouse Reef Atoll	At present there is only limited atoll-wide management consultation through the LHR advisory committee	Active management of LHR atoll through recognition of a management role for stakeholders of the atoll, with participation from all stakeholders, and discussions with Forest, Fisheries, and Geology & Petroleum Departments towards implementation	1st to 5th	Executive Director, Marine PA Manager, Park Director, Marine Biologist,	Management success for HMCNM and BHNM relies on the health of the entire LHR Atoll. Prospective co-management body would include representatives of current and prospective developers, fishing and tourism stakeholders, GOB authorities
A18	Integrate natural resource research and monitoring results into adaptive management planning	There is little integration between natural resource research and monitoring, and management	Full integration of natural resource research and monitoring into adaptive management planning	1st to 5th	Marine PA Manager, Park Director, Marine Biologist, BAS Research Coordinator	

Biodiversity Protection

Biodiversity Protection: Patrolling and Enforcement

A19	Familiarization training for BAS staff on legislation regarding Fishing, Protected Areas, protected species, spawning aggregation sites and Nassau grouper.	New staff may not be familiar with relevant legislation	Staff fully aware of relevant legislation	1st to 5th	Marine PA Manager, Parks Director & Staff, Marine Biologist, Forest Dept., and Fisheries Dept	Needs to be brought into Orientation training for new staff throughout the management period
A20	Conduct frequent patrols of reserves including night patrols.	Some patrolling conducted but constrained by fuel costs, and seldom nocturnal patrols	Frequent patrols in reserves conducted at unpredictable times including night patrols.	1st to 5th	Park Director & Staff	Especially at start of lobster and conch seasons
A21	Conduct strict enforcement and reporting of illegal activities within protected areas	Ongoing. Enforcement of no-fishing regulations generally can be improved	Enforcement of regulations re. incursions into protected areas and other illegal fishing activities reported	1st to 5th	Marine PA Manager, Park Director & Staff, Forest and Fisheries Departments	Suggested that there should be investigation into feasibility of banning any fishing gear on boats within protected areas

A. Natural Resource Management Programme						
Biodiversity Protection						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
A22	Conduct enforcement and reporting of illegal activities at Spawning Aggregation sites in liaison with Forest and Fisheries Departments	Continue enforcement activities, in close liaison with Forest and Fisheries Department	Legislation is enforced and formal reports made of all enforcement actions taken. All enforcement is logged and followed up.	1st to 5th	Marine PA Manager, Park Director & Staff, Forest and Fisheries Departments	
A23	Increase effectiveness of patrolling and enforcement through training and equipment.	Wardens not sufficiently trained to be confident in encounters with illegal fishermen.	Wardens trained to be confident in encounters with illegal fishermen, with clear policy on dealing with encounters and enforcement issues	1st to 5th	Marine PA Manager, Park Director & Staff, Forest and Fisheries Departments	
A24	Develop mechanism / forum for rangers to be able to network with rangers from other protected areas to discuss problems, techniques etc.	Rangers isolated and can potentially lose sight of the importance of their role	Rangers part of a supportive national network with clear understanding of the value of their role and a mechanism for exchanging ideas.	1st to 5th	Marine PA Manager, Park Director & Staff	Subscribe to MPA News online http://depts.washington.edu/mpanews to facilitate discussion of management issues with international community of protected area managers.
Biodiversity Protection: Mitigation of impacts from development activities						
A25	Ensure that all development of infrastructure on Half Moon Caye is conducted after assessing potential environmental impacts	No formal assessment of potential impacts is conducted before infrastructural development takes place	An assessment of potential impacts is conducted before infrastructural development takes place (eg. Rebuilding docks etc.) to ensure minimising impacts	1st to 5th	Marine PA Manager, Marine Biologist, Park Director & Staff,	Assessment particularly with regard to impacts on seagrass, corals, water quality, nesting birds, lizard populations and littoral forest
A26	Explore best means of increasing positive liaison with caye developers and landowners - areas of conflict and mutual assistance Increase positive liaison with landowners	Some liaison with other inhabitants, landowners and developers of Lighthouse Reef Atoll, but not well developed, planned or strategic	Better liaison with other inhabitants, landowners and developers of Lighthouse Reef Atoll, promoting constructive partnerships, with active support from caye developers and landowners towards environmentally sensitive development of LHF	1st to 5th	Executive Director, Marine PA Manager, Park Director & Staff,	Through LHR Advisory Committee, workshops, individual discussions and communication, planned awareness activities at Half Moon Caye and other cayes; collaboration on 'Best Practices' guide
A27	Development of 'Best Practices Guidelines' for caye developers and owners to advise on wastewater management, chemical use and storage, etc.	Little liaison at present with caye developers and landowners. BAS reactive rather than proactive in mitigating development impacts	Development of 'Best Practices Guidelines' for caye developers and owners to advise on wastewater management, chemical use and storage, etc. Distribute to developers/property owners on the atoll, during workshop on mitigating impacts	1st to 2nd	Marine PA Manager, Park Director, Marine Biologist, Consultant	Pro-active assistance to developers, increasing awareness of coral reef seagrass, and mangrove environments, and methods of limiting development impacts (sedimentation - erosion following land clearance; wastewater, sewage and solid waste disposal)

A. Natural Resource Management Programme

Biodiversity Protection

Management Actions		Present Status	Desired Status	Year	People	Limitations/Requirements
Biodiversity Protection: Mitigation of impacts from development activities						
A28	Monitor land use of adjacent cayes	Little knowledge of land use and land use changes on adjacent cayes of LHR atoll	Land use on adjacent cayes mapped each year through over flight / satellite information, and discussions with developers / owners. Potential impacts through land use change flagged for management actions	1st to 5th	Marine PA Manager, Park Director & Staff, Marine Biologist	Lighthawk for overflight? CATHALAC satellite imagery
A29	Mitigate impacts of insect control programmes on adjacent cayes	Long Caye is planning to use insecticide spray (malathion?) to control insects	Collaboration between BAS and Long Caye to ensure mitigation plan for use of insecticide sprays	1st to 5th	Marine PA Manager, Park Director & Staff, Marine Biologist, Long Caye developers	Insecticides will have a very detrimental effect on fish species of the red mangrove on Long Caye, a critical nursery area for reef fish. Mitigation actions may include type of insecticide used, planning for runoff etc.
A30	Ensure adequate wastewater and sewage disposal on Half Moon Caye, adjacent cayes, and dive boats	Little knowledge of wastewater and sewage levels within the LHR Atoll system	Mitigation of effects of wastewater and sewage disposal within the LHR Atoll system	1st to 5th	Marine PA Manager, Park Director, Port Authority	Through development of Best Practices guide See also Infrastructure Management Programme:
A31	Implement research and monitoring actions associated with water quality	Research and monitoring poorly co-ordinated, and results not fed back into adaptive management	Research and monitoring exists, is well co-ordinated, and results feed back into adaptive management	1st to 5th	Marine PA Manager, Marine Biologist, Park Director	See Research and Monitoring
Biodiversity Protection: Investigate stakeholder management of Lighthouse Reef						
A32	Facilitate the formation of a stakeholder management group interested in investigating the possibilities of managing the resources of Lighthouse Reef Atoll	Advisory Committee exists, but not currently actively seeking management of LHR - will need to be play a more active role	BAS facilitated management committee formed to develop planning proposal for management of resources of LHR	1st to 2nd	Executive Director, Marine PA Manager, Park Director, Advocacy Officer, Forest and Fisheries Departments	Particularly the fishermen, dive operators, local developers and BAS, with representation from Forest Dept, Fisheries Dept, Port Authority. Possibly based on Advisory Committee?
A33	Facilitate the planning processes necessary for proposing stakeholder management of Lighthouse Reef Atoll	At present, there is no overall management plan or body for Lighthouse Reef Atoll	Proposal developed by management group for stakeholder management of Lighthouse Reef Atoll	1st to 5th	Executive Director, Marine PA Manager, Advocacy Officer, Forest Department and Fisheries Department	
A34	Lobby for stakeholder management of Lighthouse Reef Atoll	Management of LHR resources is not taking place outside of the protected areas	Management of LHR resources by a group that represents the stakeholders who use these resources	1st to 5th	Executive Director, Marine PA Manager, Advocacy Officer, Forest, and Fisheries Dt	Tourism & residential and fishing sector stakeholders,

A. Natural Resource Management Programme						
Biodiversity Protection						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Biodiversity Protection: Investigate stakeholder management of Lighthouse Reef						
A35	Develop 5-yr plan for management of LHR Atoll	No management plan exists at present for LHR Atoll	5-yr management plan for LHR Atoll	3rd to 5th	Marine PA Manager, Park Director & Staff, Forest, and Fisheries Depts., Consultant	
Biodiversity Protection: Mitigate diver impacts						
A36	Ensure diver awareness of potential impacts to reef and coral	No active BAS involvement in diver awareness	Standards are set in leaflet/poster to ensure that divers are aware of actions they can take for minimizing impacts to corals, even if their dive leaders do not cover this well. Accreditation scheme ensures divers can choose dive operators recognised for good dive practices.	1st Year	Marine PA Manager & Staff, Marine Biologist	Diver impacts highlighted as one of the threats to the reef, causing mechanical damage, sedimentation, and through alteration of fish behaviour through fish and shark feeding See also Public Use
Biodiversity Protection: Protect against invasive species						
A37	Close liaison with tour operators, Port Authorities and lighthouse keepers to prevent further introduction of species not native to HMCNM	Introduction of furrowed wood turtle suggests that there is insufficient awareness among tour guides of risks of introducing invasive species	Tour operators / guides aware of risks of introducing exotic species; no further introductions	1st to 5th	Marine PA Manager, Marine Biologist, Parks Director& Staff	
A38	Enforcement of strict 'no resident dog' policy on caye, in liaison with Port Authority. Enforcement of use-of-leash policy for dogs of day visitors.	Lighthouse Keeper has recently acquired a dog – in direct contravention of the no resident dog policy agreed with Port Authority.	Strict no resident dog policy adhered to. No dogs loose on island at any time.	1st to 5th	Executive Director, Marine PA Manager, Park Director & Staff, Forest Department, Port Authority	Current problem reflects in part wish to avoid conflict with the lighthouse keeper. Directive needs to come from Port Authority
A39	Implementation of Rat eradication plan	Rat eradication plan exists, but has not been implemented. Large population of rats is present on the Island. Known to prey on lizards	Rat eradication plan implemented and completed. No rats on the caye.	1st Year	Marine PA Manager, Park Director & Staff, Marine Biologist,	3 months Finance. Prioritization. Manpower. Need for sustained, concerted and comprehensive implementation. Veitch, 1997
Biodiversity Protection: Continue facilitating alternative livelihood projects						
A40	Continue facilitation of alternative income projects and skills training opportunities within the stakeholder communities	Supplemental training in tour guide specialties in progress (diving etc.)	Reduction in number of fishermen opportunistically taking sea turtle and other commercial marine species, reducing pressure on resources	1st Year	Marine PA Manager, Park Director, Community Liaison Officer	In socio-economic survey, only 12% of fishermen surveyed would change to an alternative income – most recognized that alternatives would not be able to provide the same level of income as fishing.

A. Natural Resource Management Programme						
Biodiversity Protection						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Biodiversity Protection: Continue facilitating alternative livelihood projects						
A41	Lobby for limiting fishing license allocation to traditional fishermen and fishing communities	Fishing licenses being issued to people from non-fishing backgrounds, or from other countries. The space left by fishermen switching to alternative livelihoods options is taken up by new fishermen	A limit is put on the number of fishing licenses being issued, relative to the harvest available	1st to 5th	Executive Director, Marine PA Manager, Advocacy Officer	Need to introduce limit to issuance of permits to prospective new fishermen, to maximize conservation benefits of alternative income projects.
Biodiversity Protection: Designate specific mooring sites and boat channels						
A42	Workshop with tour boat operators and live–aboards to define restricted boat channels and discuss mooring sites, to decrease boat impacts to seagrass and corals	No formal designation of boat channels, mooring sites and no-go areas. Some negative boat traffic impacts on seagrass at entrance to Blue Hole.	Boat traffic restricted to designated, well-marked boat channels and designated mooring sites. Moving towards exclusion of boat mooring within the Blue Hole itself	1st Year	Executing Director, Marine PA Manager, Park Director & Staff, Forest & Fisheries Departments	One to two-day workshop covering all management plan development issues. BAS needs to be an active member in the discussions, not just facilitate
A43	Ensure staff are aware that boats (including the BAS boat) should land only at the docks	Staff, researchers and fishermen sometimes beach the boats at Half Moon Caye, causing propeller and trampling damage to the seagrass in shallow water	Strict regulations on where boats can be beached, to minimise damage on shallow seagrass areas of Half Moon Caye	1st to 5th	Marine PA Manager, Park Director	Possible need to construct a static boat ramp (and marked approach channel) for use by staff and researchers.
Biodiversity Protection: Increase awareness of the importance of marine protected areas to the fisheries						
A44	Outreach to stakeholder communities increasing awareness of the importance of marine protected areas,	Outreach is ongoing. Fishermen still say that what they lack is proof of the benefits of marine protected areas. That they need figures that show there are positive benefits	Stakeholders, especially fishermen, fully informed and supportive of marine protected areas.	1st to 5th	Marine PA Manager, Park Director & Staff, Marine Biologist, Community-liaison Officer, Education Officer	Needs to be ongoing to have maximum effectiveness. Including data on densities of conch and lobster inside and outside functional reserves.
A45	Target fishermen with awareness materials and further training opportunities while they are at Lighthouse Reef	Liaison between BAS and fishermen is improving through the training opportunities being offered	Fishermen aware of importance of protected areas and locations of boundaries. Fishermen familiar with BAS staff and able to approach staff with questions.	1st to 5th	Marine PA Manager, Park Director & Staff, Marine Biologist, Community liaison Officer	Needs to be ongoing to have maximum effectiveness

A. Natural Resource Management Programme						
Specific Actions for Conservation Targets						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
A46	Ensure that monitoring and research actions associated with conservation planning and conservation targets are prioritized	Monitoring is not seen as a high priority and not management driven	Monitoring is prioritized as a management tool	1st to 5th	Executive Director, Marine PA Manager, Marine Biologist, Park Director & Staff	Requires a shift in attitude – research and monitoring should feed back into management, as a priority management action
Commercial Marine Species						
A47	Lobby for compliance of minimum size standards for conch by Northern Fishermen's Cooperative	Fishermen are consistently harvesting undersize conch reportedly for sale to Northern Fishermen's Cooperative	Northern Fishermen's Cooperative maintain strict control on size of conch accepted, and adhere to Fisheries quotas.	1st to 5th	Executive Director, Advocacy Officer, Marine PA Manager, Fisheries Department	In community consultations, fishermen say that they will sell conch to Northern as they are not strict about the lower size restrictions, and will take under-size conch
A48	Liaise with fisheries enforcement agencies in neighbouring countries	Little liaison with Honduras or Guatemala on problems associated with fishing by people from outside Belize. Including problem of Guatemalan tourism at Easter (16+ boats, with recreational fishing within protected area)	Greater liaison with fisheries agencies in neighbouring countries and collaboration on dealing with fishing incursions	1st to 5th	Executive Director, Marine PA Manager, Fisheries Department	Inconsistent policy implementation by previous minister. Need for enforcement of no-take policy at Easter – in collaboration with Guatemala Fisheries Dept.?
A49	Share data with other marine protected areas through Fisheries Department, MBRS	Lack of information sharing between protected areas regionally	BAS inputting to data sharing mechanisms nationally and regionally between marine protected areas	1st to 5th	Marine PA Manager, BAS Marine Biologist	
A50	Increased liaison with national and international fisheries sector	Little liaison with national and international fisheries sector	Increased liaison and support between national and international sector, at both management and field staff levels	1st to 5th	Marine PA Manager, Marine, Marine Biologist, BAS Research Coordinator	
A51	Greater liaison and collaboration with international marine protected area community	Little effort to liaise with international marine protected area community	Greater liaison and collaboration from the international marine protected area community	1st to 5th	Marine PA Manager, Marine Biologist, BAS Research Coordinator	Subscribe to MPA News online http://depts.washington.edu/mpanews to facilitate discussion of management issues with international community of protected area managers.

A. Natural Resource Management Programme						
Specific Actions for Conservation Targets						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Commercial Marine Species						
A52	Increase participation of fishermen in the management of the two protected areas	Participation in HMCNM and BHNM by stakeholders is increasing	Fishing stakeholders are participating in the management of the two protected areas, and are motivated to play an active role in conservation enforcement	1st to 5th	Marine PA Manager, Marine Parks Director and Staff, Marine Biologist, Community liaison Officer	
A53	Increase awareness of the fishermen of the reef and its fragility, fishing impacts, and the role functional protected areas play in maintenance of the fishing industry	Fishermen lack an understanding of the local and global threats to the reef, and ways in which their activities affect the health of the coral. They generally understand the concepts behind protected areas, but want scientific proof that the protected areas work	Fishermen understand how their activities affect the health of the coral, and also have a better understanding of global pressures on coral health Fishermen generally understand the concepts and cooperate towards the goal of functional protected areas	1st to 5th	Marine PA Manager, Marine Parks Director and Staff, Marine Biologist, Community liaison Officer	Lack of awareness was identified by tour guide trainee participants (Sarteneja fishermen) as a major block to persuasion of fishermen for need for sustainable fishing methods. Needs to be ongoing to have maximum effectiveness
A54	Encourage open channels of communication between fishermen and BAS staff	Communications between BAS staff and fishermen improving with involvement of fishermen in monitoring of commercial marine species, but needs to be extended to rest of LHR fishing stakeholders	Open communication with fishing stakeholders of LHR atoll	1st to 5th	Marine PA Manager, Parks Director & Staff, Marine Biologist, Community liaison Officer,	Needs to be ongoing to have maximum effectiveness
Parrotfish						
A55	Develop BAS initiatives to increase awareness of the importance of parrotfish to the health of the reef among key stakeholders – particularly fishermen	Awareness of parrotfish is growing, but needs reinforcing	Fishermen, dive operators, tour guides, developers and land owners of / using LHR are fully aware of the importance of parrotfish to the health of the reef	1st to 2nd	Marine PA Manager, Marine Biologist, Park Director, Education Officer, Community liaison Officer	Involvement of fishing sector stakeholders. Collaboration with other NGOs and Fisheries Dept. initiatives
A56	Support and compliment the BFCA / WCS initiative to halt parrotfish fishing	Awareness of parrotfish is growing, but needs reinforcing	Fishermen are fully aware of the importance of parrotfish to the health of the reef	1st to 2nd	Marine PA Manager, Marine Biologist, Park Director, BAS Research Coordinator	Involvement of fishing sector stakeholders
Spawning Aggregations						
A57	Include Spawning Aggregation sites in regular patrols, particularly at known spawning times.	Little specific patrolling or prioritization of Spawning Aggregation sites	Spawning aggregation sites patrolled frequently at unpredictable times with particular focus on times of highest spawning activity.	1st to 5th	Marine PA Manager, Marine Parks Director & Staff	In liaison with Fisheries and Forest Depts.

A. Natural Resource Management Programme						
Specific Actions for Conservation Targets						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Spawning Aggregations						
A58	Presentations and leaflets on importance of spawning aggregations developed and distributed in communities and to boats on Lighthouse Reef during patrols, in collaboration with other organisations working in similar area.	Some outreach to fishermen and fishing communities, but not focused specifically on spawning aggregations	Stakeholders, especially fishermen, fully informed and supportive of protection of spawning aggregation sites.	1st to 5th	Marine PA Manager, Park Director, Marine Biologist, Community liaison Officer	Liaison with Spawning Aggregation Working Group and other organisations to ensure collaborative efforts and reduce overlap in raising awareness of stakeholder communities of spawning aggregation sites.
A59	Liaise with The Society for the Conservation of Reef Fish Aggregations and submit data to its international database.	Little international collaboration	Greater liaison between BAS and international organisations	1st to 5th	Marine PA Manager, Marine Biologist, BAS Research Coordinator	
Marine Turtles						
A60	Identify limits of nesting beach and prevent visitor access	Unlimited access to beach during turtle nesting season	Access to beach controlled during nesting season	1st to 5th	Parks Director & Staff, Marine Biologist	
A61	Place information boards in nesting season to increase visitor awareness	Little information is given on the importance of Half Moon Caye as a turtle nesting site	Greater awareness of Half Moon Caye as a turtle nesting site	1st to 5th	Marine PA Manager, Parks Director, commissioned artist	Boards located on landward limit of nesting beach. Inform why access is limited
A62	Clear a 20-30' wide pathway through the hurricane debris, to allow access to upper nesting beach area.	Conch shells and coral debris deposited on nesting beach during 2004 hurricane season almost completely block access	Turtles able to access at least the upper beach area for nesting	1st to 5th	Marine PA Manager, Marine Parks Director & Staff, Marine Biologist	Volunteers?
A63	Investigate feasibility of clearing hurricane debris from nesting beach	Conch shells and coral debris deposited on nesting beach during 2004 hurricane season	Feasibility study on restoring beach conditions to those favourable for nesting	1st to 5th	Marine PA Manager, Parks Director & Staff	Report on study findings fed back into management activities. Volunteers?
A64	Investigate beach restoration activities, eg. feasibility of using breakers or other simple coastal engineering mechanism to rebuild beach	Conch shells and coral debris deposited on nesting beach during 2004 hurricane season	Beach restored to conditions favourable for nesting	1st to 2nd	Marine PA Manager, Marine Biologist, Consultant	A suggestion coming out of consultations with Sarteneja fishermen. Needs expert input from coastal engineer. If considered feasible, a possible volunteer project. Possible assistance from volunteers. See also Annex 1. Sea Turtles

A. Natural Resource Management Programme						
Specific Actions for Conservation Targets						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Marine Turtles						
A65	Ensure continued protection of turtle nests during nesting season	Ongoing - Nests protected by 24 hour presence of wardens	Continued nest protection	1st to 5th	Parks Director & Staff	In liaison with Fisheries and Forest Dept.
A66	Increase awareness of sea turtles nationally within Belize, and their critically endangered / endangered status	There is general knowledge of sea turtles within Belize, but little knowledge of their conservation status. Sea turtle meat and turtle shell souvenirs are still sold in Belize	Increased awareness and greater knowledge within Belize of sea turtles and their conservation status. Increased awareness of the need for protection – reduction in market for meat and souvenirs	1st to 5th	Marine PA Manager, Marine Biologist, Community liaison Officer, Education Officer	a) Targeting fishermen and coastal/caye communities in-particular, but also more general. b) Targeted at Belize public and tourists (eg. billboards in Belize City, possibility of advertising in buses, in Marine Terminal /Caye Caulker / San Pedro / Dive shops
A67	Increase awareness of laws and regulations concerning taking of sea turtles	Knowledge of laws and regulations re. taking of sea turtles is generally known, but needs reinforcing - Sea turtle meat and turtle shell souvenirs are still sold in Belize. Little liaison at present with other national initiatives	Increased awareness of sea turtle threats and conservation, Greater knowledge of laws and regulations re. taking of sea turtles Closer liaison with other conservation initiatives and other conservation organizations raising awareness of sea turtles	1st to 5th	Marine PA Manager, Marine Biologist, Community liaison Officer, Education Officer	Targeting fishermen and coastal/caye communities in-particular, but also more general. Submit article on sea turtle conservation, targeted at fishermen, for publishing in Belize Fishermen Cooperative Association newsletter Fishermen also still take young as pets.
A68	Increase awareness of CITES regulations concerning taking of sea turtle products out of the country	Greater awareness needed for tourists and customs staff concerning turtle products and CITES regulations	Posters at points of entry / exit to raise awareness. Enforcement of CITES regulations at point of departure	1st to 5th	Marine PA Manager, Marine Biologist, Community liaison Officer, Education Officer	However, there should also be consideration of recommendation for GoB to ban hunting of all turtles (**MT25)**
A69	Increase awareness amongst shark fishermen of status of turtles, and work towards reducing problems of turtle by-catch	Shark fishermen regularly catch turtles as part of their by-catch	Shark fishermen check nets and lines more frequently and reduce by-catch	1st to 5th	Marine PA Manager, Parks Director& Staff, Marine Biologist, Community liaison Officer	Recent reduction in shark fishing is thought by fishermen to have led to increase in numbers of immature Hawksbill turtles observed in 2005
A70	Marine turtles included in standardised presentation for live-aboards on reef conservation	Available on request	Evening presentation to live- aboards includes turtle identification and conservation	1st to 5th	Parks Director& Staff, Marine Biologist	

A. Natural Resource Management Programme						
Specific Actions for Conservation Targets						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Marine Turtles						
A71	Ensure all staff are aware of effects of light on turtle orientation – included in staff orientation	Staff do seem aware of the impacts of lights during turtle nesting	All staff are aware of the impacts of lights on turtle orientation	1st to 5th	Marine PA Manager, Parks Director	
A72	Include guidelines on sea-facing lighting in 'Best Practices' information for developers and land owners	BAS has little liaison with developers and land owners of adjacent cayes	Guidelines on sea-facing lighting developed as part of liaison with land owners and developers of adjacent cayes	1st to 5th	Marine PA Manager, Park Director, Community-liaison Officer, Marine Biologist, consultant	Included within' Best Practices Guidelines'
A73	Support moves to encourage GoB to ban all capture and trade in all species of sea turtles	At present there is restricted taking of sea turtles. An all-inclusive ban is recommended in CEP Belize Sea Turtle Recovery Plan (1992)	A change in legislation, extending the ban on the fishing of Hawksbill to include any turtle species	1st to 5th	BAS Board members, Executive Director, Marine PA Manager, BAS Research Coordinator	Belize is reducing the effectiveness of Mexico's 'no-hunting' legislation protecting sea turtles
A74	Liaise with regional and international turtle conservation initiatives	BAS doesn't focus on marine turtle conservation at this point in time	Closer liaison with regional turtle conservation initiatives	1st to 5th	BAS Research Coordinator, Marine PA Manager, Marine Biologist	Wider Caribbean Sea Turtle Conservation Network; Caribbean Conservation Corporation and Sea Turtle Survival League, WWF, WCS
A75	Support move for Belize to ratify Convention on Migratory Species	Belize has not yet ratified the Convention on Migratory Species	Belize ratifies the Convention on Migratory Species	1st to 5th	BAS Board members, BAS Executive Director, BAS Research Coordinator, Marine PA Manager, Marine Biologist	Also an action in Crooked Tree Wildlife Sanctuary Management Plan, for migratory birds
Littoral Forest						
A76	Zoned seed / seedling planting of selected species (from existing populations on HMCNM) within the buffer areas where coconut eradication has taken place	No rehabilitation taking place – extent of littoral forest is still being eroded, potential for development of single-species dominated stands.	Balanced re-establishment of littoral forest in areas reclaimed from recent degradation	1st to 5th	BAS Research Coordinator, Marine PA Manager, Park Director & Staff, Botanist.	Through planting seeds directly or transplanting seedlings, needs an outline plan for establishment of target species assemblages.

A. Natural Resource Management Programme						
Specific Actions for Conservation Targets						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Littoral Forest						
A77	Implement zoned and sequential coconut eradication programme in littoral forest and the buffer areas to the north and east - including removal of coconut debris	Inappropriate management of coconut removal in 2004. Detailed implementation plan included within this plan	Detailed management guidelines on coconut eradication, and implemented	1st to 5th	Marine PA Manager, Park Director & Staff, BAS Research Coordinator, Marine Biologist	Finance. Prioritization. Manpower. Need for sustained, concerted and comprehensive implementation. Volunteers?
A78	Control / restrict visitor access to littoral forest expansion areas and establish Limits of Acceptable Change Programme	No zoning of visitor access; No Limits of Acceptable Change Programme	Zoning of visitor access to allow undisturbed plant growth within the areas designated for rehabilitation. Limits of Acceptable Change Programme in place	1st to 5th	Park Director & Staff, BAS Research Coordinator, Marine Biologist	With particular reference to seaward impacts on littoral forest from visitor access / use on east southeast of caye. Also restrict camp fires and camping to camping area
Lizard Species						
A79	Ensure that staff and management have access to literature about the ecological requirements of the lizard species and the potential impact of habitat modification	Very limited information available	Literature available on ecological requirements of the lizard species and the potential impact of habitat modification	1st year	BAS Research Coordinator, Marine PA Manager	Limited herpetology capacity in Belize; input from herpetologist
Sharks						
A80	Monitor and record all incidents of shark-diver interaction in the Blue Hole through dive leader questionnaire	It is not known how many people have been touched by sharks in the Blue Hole	Reporting of shark bites and other shark-diver interactions by dive boat operators.	1st to 5th	Marine Biologist, Marine PA Manager, Parks Director & Staff	Dive leader questionnaire
A81	Consult with dive boat operators to discuss the practice of shark feeding, and determine a timeframe and mechanism to reduce and eliminate shark feeding	Current ban on shark feeding considered to have been introduced with little consultation with stakeholders, and is not enforced	Stakeholders meet to discuss merits and problems with shark feeding, consensus reached, and agree to phasing out shark feeding by a certain date.	1st Year	Executive Director, Marine PA Manager, Marine Biologist, Park Director, Forest & Fisheries Departments	Mixed feelings amongst tour boat operators, need to sensitize BTB and BTIA of tourism hazards associated with shark chumming – lessons learnt elsewhere. Problems of lack of long-term conservation and safety sustainability. Problems of conflict avoidance between BAS and stakeholders.

A. Natural Resource Management Programme						
Specific Actions for Conservation Targets						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Sharks						
A82	Following consultations, enforce the ban on shark feeding	Ban on shark feeding in place but not observed or enforced	Penalties for those operators who break the regulations	1st to 5th	Marine PA Manager, Park Director & Staff, Forest & Fisheries Departments	Reluctance to impose regulations on tour operators
A83	Include compliance with shark feeding ban as one of the criteria for qualifying for BAS accreditation scheme, for dive operators who follow a BAS code of conduct	Some dive boat operators regularly feed sharks while others do not support the practice	Best practice guidelines for dive operators established. Endorsement of 'eco-friendly' companies through accreditation scheme – annually revised	1st to 5th	Executive Director, Marine PA Manager, Park Director, Forest & Fisheries Departments,	Accreditation Scheme. Involve tourism sector in development and implementation - BTIA, BTB
A84	Liaise with national, regional and international organisations concerned with shark conservation	Little liaison or collaboration	Liaison and collaboration with national, regional and international organisations concerned with shark conservation	1st to 5th	Executive Director, Marine PA Manager, Park Director, Marine Biologist	
Blue Hole Geology						
A85	Enforce mooring regulations for dive boats using the Blue Hole	Insufficient mooring buoys, with resulting anchor damage within the Blue Hole	Enforce mooring regulations	1st to 5th	Park Director and Park Staff,	
A86	Stakeholder workshop to investigate feasibility of removing boats from the Blue Hole	Insufficient mooring buoys, with resulting anchor damage within the Blue Hole. Problem of shark feeding	Dive boats not permitted to enter Blue Hole	1st to 5th	Executive Director, Marine PA Manager, Park Director,	
Filling National Priority Ecosystem Gaps						
A87	Investigate the feasibility for extending BAS management to include the open sea ecosystem identified within the NPAPSP (2005)	The open sea has been identified as an important ecosystem gap, and it has been proposed under the NPAPSP that an area of open sea to the east of Lighthouse Reef be managed as a conservation area	Decision is made as to whether BAS considers it can, and wants, to take on conservation management of the area of open sea to the east of Lighthouse Reef highlighted under the NPAPSP	1st to 5th	BAS Board Forest Department Fisheries Department Executive Director, Marine PA Manager	The capacity of BAS to manage waters outside the Lighthouse Reef should be considered, especially as this area may include an active shipping lane
A88	Liaise with Forest and Fisheries Departmentsto establish the area of open sea to the east of Lighthouse Reef as a conservation area	It has been proposed under the NPAPSP that an area of open sea to the east of Lighthouse Reef be managed as a conservation area, covering an ecosystem gap.	Establishment of area of open sea to the east of Lighthouse Reef highlighted under the NPAPSP as a conservation area, managed under BAS	1st to 5th	BAS Board Forest Department Fisheries Department Executive Director, Marine PA Manager	Dependent on output of A87

B. Research and Monitoring Programme

Research and monitoring should play an integral role in the management of Half Moon Caye and Blue Hole Natural Monuments, ensuring that management decisions are based on the best scientific information available. Recently, however, little research has been undertaken within the two Natural Monuments, and logistical, financial and personnel constraints have prevented ongoing monitoring efforts.

Overall Objective:

To identify and address priority areas for research, and implement a robust and ongoing biodiversity monitoring programme to ensure informed conservation management of Half Moon Caye and Blue Natural Monuments

Several areas have been identified as priorities for research and monitoring activities, either through the development of conservation planning actions, or in response to specific research or monitoring requirements:

1. To develop a comprehensive biodiversity baseline on the state of biodiversity, building on the Rapid Marine Assessment (Graham et. al., 2004)
2. To ensure ongoing implementation of the overall biodiversity research and monitoring programme
3. To develop monitoring programme for Conservation Targets
4. To develop standards for the Limits of Acceptable Change Programme and implement dedicated LAC monitoring programme
5. To establish a comprehensive water quality monitoring program
6. To increase communication, cooperation and coordination between BAS and other conservation organisations and research institutions involved in research and monitoring on the Belize reef

Approval for research permits to support these activities is required, from both Forest and Fisheries Departments.

Baseline Information			
Develop comprehensive baseline information and framework required for effective management of biodiversity			
			Activity
	Activity Group 1	Develop an integrated database to contain links to all research, monitoring and socio-economic data	**B1-B3**
	Activity Group 2	***Baseline Data:*** Develop general baseline data for Half Moon Caye and Blue Hole Natural Monuments through surveys and mapping activities	**B4-B6**
	Activity Group 3	***Baseline Data:*** Develop baseline data for identified conservation targets for use in monitoring	**B7-B25**
	Activity Group 4	***Baseline Data:*** Develop baseline data for Limits of Acceptable Change programme	**B26-B29**
Monitoring Sub-Programme			
	Activity Group 1	Continue overall biodiversity monitoring programme	**B30-B31**
	Activity Group 2	Develop and implement monitoring programme for Abiotic Parameters	**B32-B34**
	Activity Group 3	Develop and implement monitoring programme for conservation targets	**B35-B46**
	Activity Group 4	Other monitoring priorities	**B47-B49**
	Activity Group 5	Develop and implement monitoring programme for measuring success of conservation management actions	**B50**
	Activity Group 6	Monitoring of socio-economic impacts	**B51**
	Activity Group 6	Develop and implement monitoring programme for Limits of Acceptable Change	**B52**
	Activity Group 7	Monitor identified threats	**B53-B68**
	Activity Group 8	Reporting	**B69-B70**
Research Sub-Programme			
	Activity Group 1	Active recruitment of researchers in identified priority research areas and provision of coordination and framework for research activities	**B71-72**
	Activity Group 2	Identify research priorities, in collaboration with Forest and Fisheries Departments	**B73-B79**
	Activity Group 3	Provide opportunities and training to Belize students in research techniques	**B80**
	Activity Group 4	Encourage participation of stakeholders in research	**B81**
Liaison and Collaboration Sub-Programme			
	Activity Group 1	Strengthen cross linkages with other organisations involved in research Belize and in the region	**B82-B91**
Training			
	Activity Group 1	Training in monitoring techniques for staff and participating stakeholders	**B92-B95**
Finance			
	Activity Group 1	Ensure prioritization of continued finance for research and monitoring activities	**B96**

B. Research and Monitoring Management Programme						
Baseline Information and Framework for Research						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
B1	Develop an integrated database for all research, monitoring and socio-economic data	Data collection is not centralized	Central repository of all Half Moon Caye / Blue Hole / Lighthouse Reef data in an organized, easily entered, easily accessible form. All research and monitoring data subject to peer review before general access	1st to 5th	Marine PA manager, Marine Biologist, BAS Data Manager	BERDS? But also off line in BAS Belize City office
B2	Ensure data protocol for regular back ups	Data has been lost from computer errors several times over the past five years, through not backing up	Data backed up on a daily / weekly basis	1st to 5th	Marine PA manager, Marine Biologist	Need to prioritise specific backup drive for marine research and monitoring data, as well as backing up on main computers
B3	Integrate research and monitoring results into management planning	There is little integration between research and management	Full integration of research into management	1st to 5th	Marine PA manager, Marine Biologist	
B4	Standardise baseline maps of coral and seagrass, and increase mapping data in areas of uncertainty	Several maps are in existence, but are not identical – all activities should be based on a single standardized map source	Standardized baseline maps with a dedicated project and shape files are used for all activities – research, monitoring and patrolling	1st	Marine PA manager, Marine Biologist, BAS Data Manager	Broadscale: CE Ecosystem Map (Meerman and Sabido, 2004) Fine Scale:
B5	Ensure all GPS used within the protected areas are set to the correct datum	Mapping errors have occurred in the past with use of the wrong datum	All GPS used by staff and researchers are set to the correct datum	1st to 5th	Marine PA manager, Marine Biologist, Park Director, BAS Research Manager	
B6	Install and maintain weather station for collection of meteorological data	No basic rainfall, temperature data exists	Met station installed and weather data kept up to date	1st to 5th	Marine PA manager, Marine Biologist, Park Director & Staff, BAS Research Manager	The optimum is an automated system, but there is the problem of power supply…dedicated solar system?

B. Research and Monitoring Management Programme						
Baseline Data Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Baseline Data: Seagrass						
B7	Identify and map extent of seagrass in both protected areas	Limited knowledge of distribution of seagrass, no mapping of seagrass	Knowledge of distribution of seagrass, including base map for GIS	1st	Marine Biologist, Park Director and staff,	Conservation Strategy **SG1** Aerial photography, satellite coverage and ground-truthing; Volunteer stakeholder members
B8	Assess status of existing seagrass habitat	Current seagrass status is only known from RMA	Knowledge of status in focal areas, through extension of RMA survey to cover other areas of the two protected areas	1st	Marine Biologist	Conservation Strategy **SG2;** Volunteer stakeholder members
B9	Identify and map areas of concern	General areas of concern are known, but not mapped or quantified	Areas of concern identified - map and baseline info of seagrass	1st	Marine PA manager, Marine Biologist, Park Director	Conservation Strategy **SG3;**
B10	Establish fixed monitoring transects (with controls), to monitor seasonal variation and detrimental impacts to seagrass	No fixed transects for seagrass monitoring in place, no knowledge of seasonal fluctuations or means of establishing whether the ecosystem is being negatively impacted	Fixed transects for seagrass monitoring in place in areas of concern	1st	Marine PA manager, Marine Biologist, Park Director	Conservation Strategy **SG4** Areas of concern identified in RMA include boat channels into Blue Hole and to docks on Half Moon Caye, and anchor points for dive boats and live-aboards.
Baseline Data: Coral Reef						
B11	Continue mapping of coral reef areas	Several maps of coral distribution exist, but differ	Finalised mapping of coral distribution, including base map for GIS	1st	Marine Biologist	Conservation Strategy **CR1** Aerial photography, satellite coverage and ground-truthing; Volunteer stakeholder members
B12	Assess status of existing coral reef ecosystems	Implementation of MBRS protocol	Standardisation of survey locations for future comparison. Probably need permanent transect markers.	1st to 5th	Marine Biologist	Conservation Strategy **CR2** Raw data from previous surveys is not held by BAS, increased liaison with researchers (BAS, Meyer, McField and Graham etc.) for standardization of survey locations for replication; Volunteer stakeholder members

B. Research and Monitoring Management Programme						
Baseline Data Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Baseline Data: Coral Reef						
B13	Identify coral reef areas of concern, and establish fixed monitoring transects	General areas of concern are known, but not mapped or quantified. No fixed coral reef monitoring transects in place	Areas of concern identified - map and baseline info on coral reef health in areas of concern. Coral reef fixed monitoring transects in place	1st to 5th	Marine PA Manager, Marine Biologist, Park Director	Conservation Strategy **CR3, CR4** Areas of concern identified in RMA include coral rim of Blue Hole and patch reefs on Half Moon Caye, and anchor points for dive boats and live-aboards. Volunteer stakeholder members. Relocate baseline transect and report from 1989 CEDAM survey
Baseline Data: Commercial Marine Species						
B14	Assess current status of lobster, conch and finfish within and outside the reserves.	Current status of commercial marine species at Lighthouse Reef within and outside reserves unclear, with no long-term data	Report produced on status of commercial marine species within and outside reserves to provide a baseline	1st to 2nd	Marine Biologist,	Conservation Strategy **CMS1** Using LAMP (lobster and conch) and MBRS (finfish) protocols. Requires at least one year of fieldwork by the same, trained observers to set the baseline.
Baseline Data: Parrotfish						
B15	Ensure knowledge of requirements of parrotfish is incorporated into management decisions -	No documented knowledge of parrotfish requirements on file at BAS	Good supporting literature on file on parrotfish species of LHR and their ecology available to managers	1st	Marine Biologist	Conservation Strategy **PF1** Conduct literature search to (territory, food requirements, need for multiple ecosystems during growth etc.). Ensure this is accessible to staff
B16	Develop baseline for each of the larger species of parrotfish in each protected area through surveys	No baseline for parrotfish populations (survey during RMA, 2005 provides some data. Need something more specific)	Baseline population statistics for parrotfish in both protected areas against which population changes can be measured	1st	Marine Biologist	Conservation Strategy **PF2** Rainbow, Midnight, Blue and Stoplight.
B17	Verify whether rainbow parrotfish still exist on Lighthouse Reef Atoll	Doubt raised by RMA as to whether rainbow parrotfish is still present at LHR	Knowledge of presence or absence of rainbow parrotfish at LHR	1st	Marine Biologist	Conservation Strategy **PF4**

B. Research and Monitoring Management Programme						
Baseline Data Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Baseline Data: Spawning Aggregations						
B18	Assess current status of spawning aggregations of each species throughout the year.	Current status of spawning aggregations known for some species but currently no consistent on-going monitoring.	Report produced on use of Spawning Aggregation sites by each species including numbers and timing of spawning – to provide a baseline	1st	Marine Biologist	Conservation Strategy **SA1** Requires one year of fieldwork by the same, trained observers, using TNC/MBRS protocols. Present lack of marine biologist has halted monitoring work
Baseline Data: Marine Turtles						
B19	Develop baseline of species of marine turtles using the protected areas - both marine use and nesting beach	Confused reports in literature on species using nesting beach. No firm baseline. No data on species using marine component of pas	Baseline of use of protected areas by marine turtle species, with	1st	Marine Biologist, Park Director	Seasonality of sightings, survey of nesting beaches during nesting season and identification of species
Baseline Data: Littoral Forest						
B20	Map in greater detail the distribution of natural terrestrial vegetation, and principal species assemblages	The detailed mapping by Fosberg et. al (1982) is now obsolete following habitat shift. There is a need for current detailed mapping	Detailed map of current ecosystems and species assemblages at Fosberg level of resolution	1st to 2nd	BAS Research Coordinator, Marine Biologist, Park Director, Botanist.	Very limited skills base in Belize re. reliable botanical identification. Individual specimens mapping for *Thrinax radiata* to monitor species re-establishment on the island.
Baseline Data: Nesting Birds						
B21	Map nesting trees and active nests (no. eggs. / nestlings / fledglings) on an annual basis	Need for a systematic approach to annual monitoring	Systematic approach to annual monitoring of nesting trees and number of nests	1st	Marine PA manager, BAS Research coordinator, Marine Biologist, Parks Director	**NB1** Training of wardens in monitoring techniques and protocol
Baseline Data: Lizard Species						
B22	Assess population structure and niche requirements, and map distribution of Allison's Anole and Leaf-toed Gecko on Half Moon Caye and presence/absence on other Cayes of Lighthouse Reef Atoll	No substantive knowledge of lizard populations or distribution data available	Knowledge of lizard population structure, niche requirements and distribution for use in conservation management planning	1st to 5th	Marine PA manager, BAS Research coordinator, Marine Biologist, Independent researcher	Conservation Strategy **LZ1** Information gap: Timing dependent on availability of external researcher

B. Research and Monitoring Management Programme						
Baseline Data Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Baseline Data: Lizard Species						
B23	Develop baseline and monitoring programme for lizard populations of Half Moon Caye and adjacent cayes. Population surveys: abundance, distribution and population dynamics	No baseline or monitoring programme for Allison's Anole or Leaf-toed Gecko. Quantitative data on the abundance, distribution and population dynamics of the lizard species is lacking.	Baseline or monitoring programme for Allison's Anole or Leaf-toed Gecko. Detailed data collected on the populations of these lizard species, sufficient to allow their monitoring over time.	1st to 5th	Marine PA manager, BAS Research coordinator, Independent researcher	Conservation Strategy **LZ2** Technical training. Finance. Prioritization. Manpower.
Baseline Data: Sharks						
B24	Assess current status of sharks in the Blue Hole	Some information is available on species using the Blue Hole but it has not been quantified.	A baseline of which species frequent the Blue Hole and their abundances.	1st to 2nd	Marine biologist, shark researcher	
Baseline Data: Blue Hole						
B25	Collate information on previous surveys on the geology of the Blue Hole	Several geological surveys have been conducted on the Blue Hole, but little of the information is available in the BAS library or in digital format	Library and digital copies of previous research on geology of Blue Hole are readily accessible	1st	Marine PA manager, Marine Biologist	Conservation Strategy **BH1**
Other Baselines						
B26	Develop indicators for measuring success of conservation planning actions	Conservation planning exists, but indicators are required to measure success of conservation planning actions	Indicators developed for monitoring of conservation planning	1st	Marine PA manager, Marine Biologist, BAS Research Manager	Develop from conservation strategies
B27	Develop baseline for status and extent of mangrove	No baseline exists at present	Baseline for status and extent of mangrove	1st	Marine Biologist	Mapping, assessment of status, with participation from Long Caye and Northern Caye
B28	Develop baselines and standards for Limits of Acceptable Change for natural and social resources	No limits are set yet for the Limits of Acceptable Change Programme	Baseline developed and standards set for Limits of Acceptable Change programme	1st	Marine PA manager, Marine Biologist	LF9 Also input from BAS Research coordinator
B29	Assess greywater / blackwater / bilge water output of boats using Blue Hole and Half Moon Caye Natural Monuments	No knowledge of greywater / blackwater / bilge water output of boats using Blue Hole and Half Moon Caye Natural Monuments	Annual updated report on greywater / blackwater / bilge water output of boats using Blue Hole and Half Moon Caye Natural Monuments, developed in collaboration with tour operators	1st to 5th	Marine PA manager, Marine Biologist,	An annual review

B. Research and Monitoring Management Programme						
Monitoring Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
General						
B30	Assess detergent and other chemical use on dive boats within Blue Hole and Half Moon Caye Natural Monuments	No knowledge of types or amounts of detergent and other chemical use on dive boats within Blue Hole and Half Moon Caye Natural Monuments	Annual updated report on types or amounts of detergent and other chemical use on dive boats within Blue Hole and Half Moon Caye Natural Monuments	1st to 5th	Marine PA manager, Marine Biologist,	An annual review
B31	Develop integrated monitoring programme for biodiversity, conservation planning and Limits of Acceptable Change	No integrated monitoring plan – no consistent data sets	Integrated monitoring programme developed and successfully implemented	1st to 5th	Marine PA manager, Marine Biologist,	See Monitoring Outline
Abiotic Parameters						
B32	**Water Quality:** Continue implementation of water quality monitoring programme using MBRS / Fisheries protocols	Ongoing water quality monitoring, in collaboration with Fisheries Department	Continued long term water quality monitoring with annual report of results	1st to 5th	Marine PA manager, Marine Biologist, Park Director	Water quality monitoring programme – MBRS protocol for salinity, turbidity and temperature. Specific nutrient testing in areas of concern. Other tests monthly
B33	**Sedimentation:** Implement long term monitoring of sedimentation	No knowledge of sedimentation rates in areas of concern (eg. At rim of Blue Hole)	Knowledge of sedimentation rates in areas of concern (eg. At rim of Blue Hole)	1st to 5th	Marine PA manager, Marine Biologist	Sediment traps, twice a year
B34	**Currents:** Monitor currents within LHR atoll at different times of year	Little knowledge of currents within LHR	Knowledge of water currents, including seasonal variation	1st to 5th	Marine PA manager, Marine Biologist	for use in management of oil spills etc., to increase knowledge of effect of development impacts, to predict mangrove dispersal, etc.
Monitoring: Seagrass						
B35	Implement MBRS seagrass monitoring protocols	No seagrass monitoring in place, no knowledge of seasonal fluctuations or means of establishing whether the ecosystem is being negatively impacted	Seagrass monitoring in place, knowledge of seasonal fluctuations, or means of establishing whether the ecosystem is being negatively impacted	1st to 5th	Marine PA manager, Marine Biologist	MBRS monitoring protocol includes % cover, abundance, species composition, standing crop, biomass and water depth, measured twice every year. Also of interest in areas of concern are seagrass density and species distribution, fish densities, and density of macroalgae. Conservation Strategy **SG4** See also B64 and B71

B. Research and Monitoring Management Programme						
Monitoring Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Monitoring: Coral Reef						
B36	Establish fixed monitoring transects and implement MBRS monitoring protocol to monitor state of coral reef	No consistent monitoring in place in areas of concern, no knowledge of seasonal fluctuations or means of establishing if the ecosystem is being negatively impacted	Coral reef monitoring in place, in areas of concern	1st to 5th	Marine Biologist	Conservation Strategy **CR4**
Monitoring: Commercial Marine Species						
B37	Implement monitoring programme using LAMP protocols	Some monitoring has been carried out but no reports of systematic monitoring and baseline is incomplete.	Regular monitoring carried out using standard protocol	1st to 5th	Marine Biologist	WCS LAMP protocols for conch, lobster and five species of fish. MBRS protocol for other species of fin fish
Monitoring: Parrotfish						
B38	Develop and implement monitoring programme to monitor parrotfish population changes in both protected areas	No specific monitoring of parrotfish populations	Long term monitoring programme in place measuring seasonal variations and long term population fluctuations	1st to 5th	Marine Biologist	Add to species monitored under the MBRS protocol. For the four larger parrotfish species – Rainbow, Midnight and Blue. Include also in dive leader and fishermen questionnaires
Monitoring: Spawning Aggregations						
B39	Implement spawning aggregation monitoring programme using MBRS protocols	Some monitoring has been carried out but no reports of systematic monitoring, and baseline is incomplete.	Regular monitoring carried out using standard protocol, and data submitted to Fisheries and MBRS	1st to 5th	Marine Biologist	Use TNC monitoring protocols, adopted by MBRS
Monitoring: Marine Turtles						
B40	Monitor nesting activity during nesting season	No standardized monitoring of nesting activity in place	Protocol for monitoring nesting activity in place, and implemented during nesting season	1st to 5th	Marine PA manager, Marine Biologist, Park Director	Recording of no. crawls, no. nests, no. and species of nesting females, no. hatchling during survey of beach between 19:00 and 20:00pm each night during nesting season. Whilst comprehensive night monitoring of hatching is probably impractical (unless with volunteers), it is feasible to excavate each nest following hatching to look at hatch success and embryo fatalities

B. Research and Monitoring Management Programme						
Monitoring Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Monitoring: Marine Turtles						
B41	Ensure all staff log turtle sightings – identification, location, habitat, size estimate, activity	No log kept at present	Log kept of all turtle sightings in HMCNP and BHNP	1st to 5th	Marine Biologist, Park Director	ID training required
Monitoring: Nesting Bird Species						
B42	Annual survey to estimate population size	Baseline provided through previous surveys, but not updated annually	Annual survey to estimate population size	1st to 5th	BAS Research coordinator, Park Director	Needs to be performed during the same month each year. Volunteer ornithologist? Consultant ornithologist?
Monitoring: Sharks						
B43	Record all incidental shark sightings	Shark sightings not systematically recorded	Records of shark sightings collated with species, location and date recorded.	1st to 5th	Marine Biologist, Park Director & staff	**S3** Requires training of staff in shark ID
B44	Work with WCS to gain more information on movements of sharks around Lighthouse Reef and in Belize waters generally.	WCS has installed acoustic receivers for monitoring shark movements	Analysis of information from acoustic study provided for BAS	1st to 5th	Marine PA manager, Marine Biologist,	**WCS. S4**
B45	Through regular discussions with dive boat operators monitor and record all incidents of shark-diver interaction in the Blue Hole	It is not known how many people have been touched by sharks in the Blue Hole	Reporting of shark bites and other shark-diver interactions by dive boat operators.	1st to 5th	Marine Biologist, Park Director & staff	**S6** **See also B72**
B46	Conduct monitoring of shark behaviour and abundance before, during and after feeding is eliminated and produce a report for distribution to stakeholders	No information on effects of shark feeding on shark behaviour at the Blue Hole	Information on effects of shark feeding on shark behaviour at the Blue Hole	1st to 5th	Marine PA Manager, Park Director, Marine Biologist, Shark Specialist	
Other Monitoring						
B47	Monitor incidence of disease in reef fish	During RMA, one or two cases of fungal diseased fish were noted on every dive. There is no monitoring to assess whether the incidence is increasing, decreasing or remaining stable	Monitoring of incidence of disease in reef fish incorporated into other monitoring	1st to 5th	Marine PA manager, Marine Biologist	

B. Research and Monitoring Management Programme						
Monitoring Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Other Monitoring						
B48	Monitor presence and status of red mangroves on Half Moon Caye	Red mangroves are trying to establish themselves on the shoreline of Half Moon Caye, but nor formal system is in place to monitor their success.	System in place to monitor the establishment of red mangroves on Half Moon Caye	1st to 5th	Marine PA manager, Marine Biologist, Park Director	Reports suggest that red mangroves once grew on Half Moon Caye, and seedlings are occasionally washed up and become established. Map extent and use MBRS mangrove monitoring protocol if mangrove becomes established
B49	Monitor presence and status of red mangroves on other cayes of LHR	Red mangroves on other cayes are not being monitored in a consistent manner	Presence, extent and status of red mangroves is being monitored on other cayes of LHR	1st to 5th	Marine Biologist, Park Director, BAS Research Manager	Red mangroves occur on some of the other cayes, but may be threatened by development activities. Mangrove is a critically important ecosystem on Lighthouse Reef - Important to monitor area, location and health, in close collaboration with property owners and developers
B50	Monitor indicators used to measure success of conservation planning actions	Conservation planning completed – but development of indicators to measure success still required	Conservation planning action indicators developed and implemented	1st	Marine PA manager, Marine Biologist, Park Director	Many of these indicators will overlap with those of other monitoring programmes
B51	Monitoring of socio-economic impacts of HMCNM / BHNM on stakeholder communities	No baseline socio-economic data generated by BAS (some exists with WCS, but for Glover's Reef		2nd and 4th years	Community Liaison Officer	SocMon…liaise with WCS (who have conducted the survey with Glover's Reef fishermen
B52	Development and implementation of monitoring for social conditions of Limits of Acceptable Change programme	Haphazard monitoring of visitor use and appreciation, no unified monitoring programme or protocols	Monitoring programme with set, timetabled protocols, for monitoring social conditions Limits of Acceptable Change goals	1st to 5th	Marine PA manager, Marine Biologist, Park Director	Fixed transects in areas of concern (seagrass and coral reef) included in MBRS surveys. Extraction of data from other monitoring activities; visitor monitoring programme

B. Research and Monitoring Management Programme						
Monitoring Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Current and Potential Threats						
Threat One: Fishing						
B53	Establish monitoring programme for illegal fishing activities within the protected areas	It is known that there is extensive fishing within the protected areas (especially BHNM, and by the lighthouse keepers assistant in HMCNM), but not the extent	Knowledge of the extent of illegal fishing activities within the protected areas	1st to 5th	Marine PA manager, Marine Biologist, Park Director	
B54	Keep record of enforcement activities and outcome	Enforcement activities are logged, but no annual report on outcome	Knowledge of success of enforcement activities	1st to 5th	Marine PA manager, Marine Biologist, Park Director	
B55	Continue monitoring of fish, lobster and conch catch within Lighthouse Reef Atoll	Ongoing monitoring of fish, lobster and conch catch is taking place in collaboration with the fishermen	Continued monitoring of fish, lobster and conch catch in collaboration with the fishermen	1st to 5th	Marine PA manager, Marine Biologist, Park Director	Both inside and outside protected areas, to allow comparison and integration of results into reporting
Threat Two: Introduced Species						
B56	Develop monitoring programme for number of rats	No knowledge of level of rat infestation	Knowledge of level of rat infestation and success of rat eradication programme during implementation	1st to 5th	Marine PA manager, Marine Biologist, Park Director, BAS Research coordinator	
B57	Monitor presence of introduced species – green iguanas, furrowed wood turtles, introduced trees	No reporting procedure in place	Knowledge of population levels of introduced species, breeding status, viability	1st to 5th	Marine PA manager, Marine Biologist, Park Director, BAS Research Manager	
Threat Three: Development Impacts						
B58	Monitor algae levels in seagrass adjacent to HMC, as an indicator of increased nutrient levels	No data on whether there are any effects of nutrient enrichment in the seagrass areas adjacent to Half Moon Caye and corals	Programme in place to monitor macroalgae levels in seagrass adjacent to Half Moon Caye and corals	1st to 5th	Marine PA Manager, Marine Biologist	Use graded visual % algal cover monitoring protocol (see Rapid Marine Assessment, Graham et. al. 2004)

B. Research and Monitoring Management Programme						
Monitoring Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Threat Three: Development Impacts						
B59	Monitor adjacent caye land use	Little knowledge of land use and land use changes on adjacent cayes of LHR atoll	Land use on adjacent cayes mapped each year through overflight / satellite information, and discussions with developers / owners. Potential impacts through land use change flagged for mitigating management actions	1st to 5th	Marine PA manager, Marine Biologist, Park Director, BAS Research coordinator	**SG19** Needs to be a collaborative effort between BAS and landowners / developers
B60	Investigate and map potential runoff sediment plumes from LHR cayes after first heavy rains of the wet season	No current monitoring of sediment runoff from LHR cayes	Annual monitoring of runoff sediment plumes from LHR cayes after first heavy rains of the wet season	1st to 5th	Marine PA manager, Marine Biologist, Park Director, BAS Research coordinator	Hard to do from the water - would require logistical timing with Lighthawk flights or similar, or liaison with flights to Northern Caye, when airstrip open…or satellite coverage
B61	Develop baseline and census number of residents and residential properties occupied or under construction on LHR cayes on an annual basis	No current monitoring of number of residents and residential properties on LHR cayes	Baseline and annual census of number of residents and residential properties on LHR cayes	1st to 5th	Marine PA manager, Marine Biologist, Park Director, CLO	
Threat Four: Boat Impacts						
B62	Monitor boat activity – number of day dive boats and live-aboards, small cruise ships, areas of activity	Daily log kept of visiting dive boats. No summarized results available of boat activity	Monthly and annual report on boat activity within the protected areas	1st to 5th	Marine PA manager, Park Director	Number of boats per month; Type of boats, Duration of stay; Number of passengers/ crew; Activities and location of activities;
B63	Monitor number of boats that use mooring buoys versus number of boats anchoring in Blue Hole and Half Moon Caye Natural Monuments	Anchor damage has been reported within both the Blue Hole and Half Moon Caye NM, but no information on number of boats using mooring buoys and number anchoring	Knowledge of usage of mooring buoys versus number of boats anchoring in the Blue Hole	1st to 5th	Marine PA manager, Park Director	Survey once a week? Once a month? Feed information back into management – number of mooring buoys required
B64	Monitor state of seagrass in identify high boat impacted areas (eg. Entrance to Blue Hole)	No seagrass monitoring in place	Seagrass monitoring in place in areas of concern, and information being used in management	1st to 5th	Marine PA manager, Marine Biologist,	See also
Threat Five: Impacts from Divers and Snorkelers						
B65	Monitor group size and diver:dive leader ratio in protected areas	No coordinated monitoring in place	Ongoing coordinated monitoring	1st to 5th	Marine PA manager, Marine Biologist,	

B. Research and Monitoring Management Programme						
Monitoring Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Threat Five: Impacts from Divers and Snorkelers						
B66	Use fixed transects to monitor impacts from divers and snorkelers in key diving sites and control areas	No knowledge of level of diver impacts in key diving locations	Knowledge of level of diver and snorkeler damage to reef, integrated into the LAC framework	1st to 5th	Marine PA manager, Marine Biologist	Use MBRS coral reef monitoring protocols. Integrate into Limits of Acceptable Change
B67	Monitor visitor satisfaction under the Limits of Acceptable Change programme	No comprehensive, continuing information on visitor satisfaction	Monitoring of visitor satisfaction under the Limits of Acceptable Change programme	1st to 5th	Marine PA manager, Marine Biologist, Park Director	
Threat Six: Impacts from Adjacent Shipping Lane						
B68	Monitor use of shipping lane, through records from Port Authority	No knowledge of volume or type of shipping using the sea adjacent to Lighthouse Reef Caye	Knowledge of volume or type of shipping using the sea adjacent to Lighthouse Reef Caye	1st to 5th	Marine PA Manager	In liaison with Port Authority
Reporting						
B69	Analyse monitoring data and prepare annual report	Reports not regularly produced	Annual report collates and presents data in a standardized format, available for all stakeholders and other interested parties	1st to 5th	Marine PA manager, Marine Biologist	Monitoring areas: Water quality; seagrass, spawning aggregations, conch, lobster and finfish abundance, mangrove area and health, turtle populations and turtle nests, sedimentation, water turbidity, coral and fish recruitment, currents, nesting bird colony numbers and success, tropical storms and storm damage
B70	Submit monitoring records to Fisheries and MBRS on an annual basis	Monitoring data scattered and some may have been lost.	Records of monitoring data kept at Half Moon Caye and at BAS office. Records regularly submitted to Fisheries Dept and MBRS	1st to 5th	Marine PA manager, Marine Biologist	

B. Research and Monitoring Management Programme						
Research Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
B71	Develop international research partners, to use LHR as a long-term study base	Currently little research, or continuity in monitoring, primarily due to lack of capacity	Increased capacity for research and monitoring through partnering with an international research organisation	1st to 5th	Executive Director, Marine PA manager, Marine Biologist	A long term research partner will also benefit the pas with greater enforcement, better staff morale, underwriting of boat and fuel costs, better science and greater continuity of monitoring. BAS would have to create better infrastructural conditions for visiting scientists as well as upgrade the logistical and fiscal frameworks. May require more facilities – could be located on Long Caye plot?
B72	Ensure all research activities have the necessary permits from Forest and Fisheries Dept.	Little independent research being conducted. Unclear regulations as to which permits are required	All independent research conducted with required permits	1st to 5th	Marine PA manager, Marine Biologist	Permit process could be streamlined through discussions with Forest and Fisheries Dept.
B73	Ensure baseline data is readily available for researchers	Little baseline available, and not easily accessible	Baseline data available and easily accessible	1st to 5th	Marine PA manager, Marine Biologist	
B74	Develop list of identified research priorities	List of identified research topics exists, but needs updating	Readily available list of identified research priorities	1st to 5th	Marine PA manager, Marine Biologist	
B75	**Littoral Forest:** Examine relative abundance and growth rates of *Thrinax radiata* in comparable littoral forests elsewhere in Belize, and determine whether and how assisted recolonization should be implemented	Very limited quantitative data on abundance of *Thrinax* in littoral forest	Quantitative data on abundance and growth rates of *Thrinax* in comparable littoral forest, to assist with recolonization plans	1st to 5th	Marine PA manager, BAS Research Coordinator, Marine Biologist Independent researcher	Reliant on interest from independent researcher
B76	**Nesting Birds:** Assess predator impacts on nesting populations	No knowledge of predator impacts on eggs and nestlings	Knowledge of predator impacts on eggs and nestlings, used in management planning	1st to 5th	Marine PA manager, BAS Research Coordinator, Marine Biologist, Independent researcher	Reliant on interest from independent researcher

B. Research and Monitoring Management Programme						
Research Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
B76	**Lizard Species:** Establish role of coconut plantation in the current ecology of these lizard populations	Limited knowledge of coconut plantation use by Allison's Anole and Leaf-toed Gecko	Greater knowledge of coconut plantation use by Allison's Anole and Leaf-toed Gecko	1st to 5th	Marine PA manager, BAS Research Coordinator, Independent researcher	Reliant on interest from independent researcher
B77	**Lizard Species:** Assess Great-tailed Grackle impact on lizard populations	High grackle population may be linked with increasing food waste from increased visitation, and thrive amongst coconut trees. Scale of predation on lizards not known	Knowledge of interface between Great-tailed Grackles and lizard populations	1st to 5th	Marine PA manager, BAS Research Coordinator, Independent researcher	Reliant on interest from independent researcher
B78	**Endemic Species:** Assessment of possible unique species assemblages in the Blue Hole	Little knowledge of biodiversity of the Blue Hole	Knowledge of biodiversity of Blue Hole and highlighting of any endemic species	1st to 5th	Marine PA manager, BAS Research Coordinator, Independent researcher	WWF report suggests that unique species assemblages may exist within the Blue Hole
B79	**Marine Turtles:** Investigate hatching success of marine turtles	Little knowledge of hatching success of marine turtles	Knowledge of hatching success of marine turtles	1st to 5th	Marine PA manager, Marine biologist, BAS Research Coordinator, Independent researcher	
B80	Provide opportunities and training for Belizean students in research	Limited opportunities available for Belizean students, poorly coordinated	Well coordinated opportunities for Belizean students to participate in research activities	1st to 5th	Marine PA manager, Marine biologist, BAS Research Coordinator	
B81	Provide opportunities and training for stakeholders in research and monitoring activities	A limited number of opportunities available for stakeholders to participate in research and monitoring	Well coordinated opportunities for stakeholders to participate in research and monitoring activities	1st to 5th	Marine PA manager, Marine biologist, BAS Research Coordinator, Community Liaison Officer	

B. Research and Monitoring Management Programme						
Research Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Liaison and Collaboration						
B82	Increase liaison with Forest Department re. research and monitoring	Limited liaison with Forest Department, due to marine setting. Could collaborate more	Greater liaison and collaboration with Forest Department	1st to 5th	Marine PA manager, Marine Biologist, BAS Research Manager	Research at either protected area requires a permit from Forest Department, and submission of report at end of project
B83	Continue improved liaison with Fisheries Department re. research and monitoring	Good liaison with Fisheries Department for monitoring and enforcement issues, and as MBRS country office	Continued good liaison with Fisheries Department for monitoring and enforcement issues, and for MBRS	1st to 5th	Marine PA manager, Marine Biologist, BAS Research Manager	
B84	Continue liaison with National Fishermen's Cooperative re. research and monitoring	Collaborative project implemented with National Fishermen's Cooperative	Continue working collaboratively with National Fishermen's Cooperative	1st to 5th	Marine PA manager, Marine Biologist	National Cooperative members losing motivation as Northern Cooperative members not keeping to fisheries regulations, so see no point in continuing monitoring
B85	Liaise more closely with Northern Fishermen's Cooperative re. research and monitoring	Little collaboration with Northern Fishermen's Cooperative	Greater collaboration towards management of fisheries resources	1st to 5th	Marine PA manager, Marine Biologist	Community consultations in Sarteneja report that fishermen allegedly take conch preferentially to Northern Cooperative as they will accept under-weight product
B86	Liaise and collaborate with organisations active in the conservation of the marine environment	Some collaboration, but could be more	Greater liaison and collaboration with organisations active in the conservation of the coral reef	1st to 5th	Executive Director, Marine PA manager, Marine Biologist, BAS Research Manager	Through the Healthy Reef Initiative (WWF, MBRS, World Bank. Summit Foundation and Perigree Environmental) www.healthyreefs.org
B87	Liaise and collaborate with MBRS with their synoptic monitoring programme and spawning aggregation monitoring programme	Some collaboration, but could be more	Greater liaison and collaboration with MBRS	1st to 5th	Executive Director, Marine PA manager, Marine Biologist, BAS Research Manager	Through the MBRS synoptic monitoring programme

B. Research and Monitoring Management Programme						
Liaison and Collaboration Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
B88	Liaise with WCS to share data on sharks at Lighthouse Reef	Little liaison and collaboration between organisations	Greater liaison, with data sharing on sharks of LHR	1st to 5th	Marine PA manager, Marine Biologist, BAS Research Manager	**S14**
B89	Increase liaison with international community of marine protected area managers.	Little effort to liaise with international marine protected area community	Greater liaison and collaboration from the international marine protected area community	1st to 5th	Marine PA manager, Marine Biologist	Subscribe to MPA News online http://depts.washington.edu/mpanews
B90	Liaise with The Society for the Conservation of Reef Fish Aggregations and submit data to its international database.	Little international collaboration	Greater liaison between BAS and international organisations	1st to 5th	Marine PA manager, Marine Biologist	
B91	Liaise and collaborate with the Caribbean Conservation Corporation and Sea Turtle Survival League	Little international collaboration	Greater liaison between BAS and international organisations	1st to 5th	Marine PA manager, Marine Biologist	
Training Sub-Programme						
B92	Train staff members in monitoring techniques and reasons for monitoring	High staff turnover and low motivation lead to low success rate in monitoring continuity	Continuous monitoring with new staff training and motivation a priority	1st to 5th	Marine PA manager, Marine Biologist	With more specific training in MBRS, LAMP and Spawning Aggregation monitoring
B93	**Marine Turtles:** Organise training workshop for staff and participating stakeholders in recognition of marine turtle species	Reports from stakeholders cannot currently be used as species identification cannot be verified. There is uncertainty over whether some marine turtle species have been seen on the atoll due to reporting by untrained observers	Staff and participating stakeholders trained in species identification, and producing reliable data BAS staff, dive leaders and fishermen able to correctly identify marine turtle species	1st to 5th	Marine PA manager, Marine Biologist, Community Liaison Officer	**S2** Produce laminated ID cards, and integrate with questionnaire. See also B97
B94	**Parrotfish:** Organise training workshop for staff and participating stakeholders in recognition of four large parrotfish species	Reports from stakeholders cannot currently be used as species identification cannot be verified. There is uncertainty over whether some parrotfish species have been seen on the atoll due to reporting by untrained observers	Staff and participating stakeholders trained in species identification, and producing reliable data BAS staff, dive leaders and fishermen able to correctly identify parrotfish species	1st to 5th	Marine PA manager, Marine Biologist, Community Liaison Officer	**S2** Produce laminated ID cards, and integrate with questionnaire. See also B97 - Rainbow, Midnight, Blue and Stoplight

B. Research and Monitoring Management Programme						
Training Sub-Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
B95	**Sharks:** Organise training workshop for staff and participating stakeholders in recognition of \shark species	Reports from stakeholders cannot currently be used, as species identification cannot be verified.	Staff and participating stakeholders trained in species identification, and producing reliable data BAS staff, dive leaders and fishermen able to correctly identify Caribbean shark species	1st to 5th	Marine PA manager, Marine Biologist, Community Liaison Officer	**S2** Produce laminated ID cards, and integrate with questionnaire. See also B97
Finance Sub-Programme						
B96	Ensure the prioritization of funding for the research and monitoring programme	Research and monitoring seldom prioritized	Prioritization of funding for the research and monitoring programme	1st to 5th	Marine PA manager, Marine Biologist,	
Other Activities						
B97	Liaise and collaborate with the Climate Change Office on caye and atoll vulnerability and increasing sea temperatures	Little collaboration at present with Climate Change Office	Greater liaison and collaboration with Climate Change Office	1st to 5th	Research Coordinator	
B98	Develop standardised procedures for assessing impacts directly following hurricanes	No standardised procedures or protocol exists at the moment	Standardised procedures or protocol is in place and is implemented if and when necessary, to update data on state of the protected area	1st to 5th	Marine PA manager, Marine Biologist,	

Marine Biodiversity Monitoring Plan

The aim of this monitoring plan is to provide information on how to interpret and use the results of the monitoring that is carried out in BHNM and HMCNM. In the past monitoring has been conducted however in most cases the data has not been analyzed and used by BAS to guide management, but simply sent to the relevant organisation (MBRS, Fisheries Department etc). The data gathered through this monitoring is important and useful to managers of the protected areas and, if analyzed properly can provide crucial feedback on the success or failure of management actions, on emerging problems and trends and on ecosystem health compared with similar ecosystems in the region. Staff should be aware that monitoring is not an activity carried out simply because of obligations to provide data to national or regional databases but that it can help to measure the effects of their work and to identify potential problems before they get out of control.

The monitoring programme will look at the following resources:

Resource	Protocol	Parameters
Core parameters	MBRS/SMP	Date, time of visit. Location name, Site ID, GPS coordinates. Collectors' names. Weather conditions, water and air temperature, rainfall, wind, sea state, salinity, light, turbidity, pH, DO, sedimentation, nutrients (to be analyzed in the laboratory), chlorophyll **a**. General site description (new Sites only), including depth range, relief, slope size, shape, features and orientation.
Corals	MBRS / SMP	Percentage algal cover, percentage coral cover by genus (and % cover gorgonians and sponges), coral colony size (height and average diameter), coral species diversity, mortality, bleaching, disease, *Diadema* abundance
Seagrass	MBRS / SMP / SeagrassNet and mapping	Percentage seagrass cover, abundance, species composition, standing crop and biomass, depth, presence of macroalgae, area extent.
Conch	LAMP	Density of conch, length, lip width and thickness in adults, presence of egg masses for conchs on sand
Lobster	LAMP	Density by species, sex, number of berried females, carapace length
Fish	MBRS / SMP Method 1 and parrotfish monitoring	Density and sizes (used for biomass estimations) of selected Caribbean key fish species, such as predators, herbivores, and “indicator” species, many of which are commercially exploited**.**
Spawning aggregations	TNC	Abundance, lengths
Mangrove	MBRS / SMP and mapping	Forest characterization/zonation, trunk diameter and height, community description, abundance and percentage cover, growth of saplings, area extent
Water quality and sedimentation	-	Salinity, temperature, turbidity, sedimentation levels
Sea turtles	Half Moon Caye sea turtle monitoring protocol	Species, tracks, number of nests, hatching success

Table 49: Resources to be monitored

Table 50: CORALS – MBRS Protocol				
Lighthouse Reef is a priority area for inclusion in the Synoptic Monitoring Programme. Reef habitats to be monitored: shallow, back reef (leeward); 1-5m depth; shallow fore-reef (windward) in 1-5m depth; and deep fore-reef habitats in 8-15m depth; identified areas of concern (dive locations)				
Monitoring Programmes: **Biodiversity Monitoring – B14, B37, B55** **Limits of Acceptable Change – n/a** **Conservation Planning – CMS1-CMS6**				
Parameter	**Use**	**Comments**	**Indicator limitations**	**Values**
Percentage algal cover (turf, coralline, macro)	Measures available space for corals, herbivory	Reefs that are healthier tend to have less macroalgae. Reef crest tends to have less than fore-reef.	Macroalgal abundance may vary seasonally. It can vary due to differences in herbivory or nutrients but it may not be easy to identify the exact cause.	Regional average (2001-02) = 25% Forereef =27% Reef crest = 19%
Percentage coral cover by genus (and % cover gorgonians and sponges)	Measures available habitat, coral colony condition.	Percentage live coral cover is a good indicator of overall reef health. It is a widely used indicator.	Not an early warning sign, high natural variability among reef, cause of coral cover loss not always easily identifiable.	Regional average (1999-2001) = 14% Forereef = 15% Reef crest = 11% (Caribbean average = 20%)
Coral colony size (height and average diameter)	Habitat structure / availability, proxy for coral age, condition and population structure	Provides information on reef rugosity. Can increase understanding of mortality.	Coral size varied naturally by species, reef type, depth and disturbance history. Not an early warning sign. May not change immediately after disturbance. Requires consistency among data collectors.	Regional average (1999-2001) = 60cm Forereef = 55cm Reef crest = 98cm

CORALS – MBRS protocol				
Parameter	**Use**	**Comments**	**Indicator limitations**	**Values**
Coral species diversity (in MBRS protocol the species of about 50 coral colonies is identified and this can be used to calculate diversity values)	The number and abundance of coral species.	A decline in coral species richness can indicate a decline in reef health and an indication of poor ecosystem integrity.	Richness will vary depending on reef type, method and level of past disturbance. Observers need to identify corals to species level	There are at least 67 coral species in the region. Number of species expected at a degraded site vs. a healthy site not known
Recent mortality, old mortality, standing dead	Recent: Decline in coral condition, evidence of disturbance	Recent: good indicator of significant recent disturbances, some recent mortality expected but once a baseline is established can help determine the magnitude of a severe disturbance event. Recent mortality occurs almost immediately after the disturbance. At popular dive sites the amount of recently broken or damaged coral will be a good indicator of the level of diving related impacts.	Recent: signal can vary with coral species, colony size, habitat type, type of disturbance and disturbance intensity / duration. Not an early warning signal. Requires consistency among trained observers.	Recent: Over 5% should be of concern. Regional average (1999-2001) = 2% but after bleaching events up to 70%
	Old: Past disturbance, coral colony condition	Old: a good signal of disturbances over time.	Old: signal varies with disturbance, depth and species. Some species retain their signal longer than others	Old: Regional average (1999-2001) = 24% Fore-reef = 21% Reef crest = 32%
	Standing: past disturbance, availability of reef habitat	Standing: Standing dead corals still provide habitat to other organisms and are an important signal of historic abundance / distribution.	Standing: species like *Acropora palmata* retain their standing dead signal longer while others like *Colpophyllia natans* may bioerode more quickly. Requires consistency among trained observers.	Standing: Regional average (1999-2001) = 7% Forereef = 3.4% Reef crest = 22.4%

CORALS – MBRS protocol				
Parameter	**Use**	**Comments**	**Indicator limitations**	**Values**
Coral bleaching	Stress of corals, potential disease, mortality	Does not necessarily result in mortality as corals may recover. Extent and intensity of bleaching can be measured.	Not an early warning signal, needs to be monitored over time to determine whether bleaching results in mortality. Varies with species, depth, physical environment and disturbance history.	Regional average (2000) = 9% but varies annually. Mass bleaching events occurred in 1995, 1998 and in some areas in 2005.
Coral diseases	Stress of corals, potential mortality	Important signal of coral condition. Susceptibility to specific disease varies with species.	Causes have not been identified for most diseases. Close examination needed for identification of disease type. Not an early warning signal.	Regional average (2000) = 8%, (2001) = 3%. Varies annually, may be higher after mass bleaching events.
***Diadema antillarum* abundance**	Levels of herbivory, suitable coral habitat, recovery of *Diadema antillarum*	Increase in abundance may indicate recovery after a massive die-off in 1983. *Diadema* reduce macroalgae and increase open settlement space for coral recruits. Reefs with more Diadema tend to have less macroalgae and may be healthier.	May be hard to measure total abundance because urchins are cryptic and less active in daytime.	Often more abundant on shallow reefs than fore-reefs. Regional average (1999 –2001) = 0.03/m^2
Other organization using MBRS protocol in Belize: Fisheries Dept., TIDE. Green Reef and WCS use AGGRA, which forms the basis for the MBRS protocol, so is comparable Green Reef also uses Reefcheck				

Table 51: SEAGRASS – MBRS protocol / SeagrassNet			
Seagrass habitats to be monitored: The seagrass bed with the most luxuriant or well-developed *Thalassia* community and an 'average' seagrass bed for the area; areas of concern (Boat impacted areas and near shore HMC areas)			
Monitoring Programmes: **Biodiversity Monitoring – B14, B37, B55** **Limits of Acceptable Change – n/a** **Conservation Planning – CMS1-CMS6**			
Parameter	**Measures**	**Comments**	**Indicator limitations**
Percentage seagrass cover	Habitat structure and availability	Indicator responds quickly to direct physical disturbances such as storms or propeller damage.	Seagrass beds are naturally patchy and a large sample size is needed to detect change due to anthropogenic impacts
Abundance	Available habitat, available space for herbivory		
Species composition	Diversity and species richness.	Shifts in species composition are often more sensitive indicators of ecosystem perturbation than changes in ecosystem function (*e.g.* production, decomposition and nutrient cycling), and changes in seagrass species may occur prior to the loss of critical seagrass habitat. Shifts in dominant species of seagrass meadows may also translate into differences in benthic-pelagic coupling and the quality of habitat for fish and other organisms.	At Lighthouse Reef, species diversity for seagrass is naturally low and this parameter may be more meaningful if combined with measures of algal species composition and abundance within the seagrass beds.
Standing crop & biomass	Productivity	Above and below ground biomass can be measured quickly. It is moderately responsive to impacts.	Destructive sampling technique. Repeated sampling in the exact same location could affect results.
Depth	Limits of range	Maximum depth can be a good indicator of change as it is a function of light penetration in the water column.	Depth of seagrass beds could vary due to changes in seabed topography – slopes etc or after physical disturbances of the seabed.
Percentage of macroalgae	Habitat structure, disturbance	High levels of macroalgae may indicate disturbance from boats or nutrient enrichment.	May be multiple reasons for increases in macroalgal abundance.
Area extent	Habitat availability changes over time	Changes in distribution of seagrass beds may indicate where impacts are occurring.	Expensive and technical to assess – needs satellite imagery or aerial photography.
Other organization using MBRS protocol in Belize: Fisheries Dept., TIDE. MBRS protocol is designed to feed into CARICOMP data collection			

Table 52: CONCH– LAMP protocol				
Conch habitats to be monitored: Sand flats and patch reefs				
Monitoring Programmes: **Biodiversity Monitoring – B14, B37, B55** **Limits of Acceptable Change – n/a** **Conservation Planning – CMS1-CMS6**				
Parameter	**Measures**	**Comments**	**Indicator limitations**	**Values**
Density of conch	Density			
Length	Size distribution of population	Males tend to be slightly smaller than females. The shell length increases at an average rate of nearly 75 mm (3 inches) a year in its active growing stage. With maturity, the shell thickens and the increase in length slows or ceases	Designed specifically for Glovers Reef	Mature conchs over: Harvestable outside reserve at: minimum 18cm
Lip width and thickness in adults	Age distribution within population	Lip thickness will increase with age.		
Presence of egg masses for conchs on sand	Reproductive activity	Will provide indication of whether this species is using the protected area for reproduction. Most spawning occurs in the warmer months.		
Other organization using LAMP protocol in Belize: WCS Designed to feed into CARICOMP data collection. Data is accepted by Fisheries Dept.				

Table 53: LOBSTER– LAMP protocol

Monitoring Programmes:

Biodiversity Monitoring – B14, B37, B55
Limits of Acceptable Change – n/a
Conservation Planning – CMS1-CMS6

Lobster habitats to be monitored: Shallow, back reef (leeward); 1-5m depth; shallow fore-reef (windward) in 1-5m depth; and deep fore-reef habitats in 8-15m depth; identified areas of concern (dive locations)

Parameter	Measures	Comments	Indicator limitations	Values
Density by species	Density	Species, density of lobster on fore-reef and patch reef	Designed specifically for Glovers Reef	
Sex	Sex ratio			
Number of berried females	Reproductive output			
Carapace length	Proportion of adults to juveniles.			Adults: > 7.8-8.3cm carapace length. Harvestable outside reserve at: minimum 7.6 cm (3 in) carapace length

Other organization using LAMP protocol in Belize: WCS
Designed to feed into CARICOMP data collection. Data is accepted by Fisheries Dept.

Table 54: FINFISH– MBRS protocol, Method I; LAMP protocol species			
Belt transects for defined species. Finfish habitats to be monitored: Seagrass,			
Monitoring Programmes: **Biodiversity Monitoring – B14, B16-B17, B37-B38, B55** **Limits of Acceptable Change – B28** **Conservation Planning – CMS1-CMS6**			
Parameter	**Use**	**Comments**	**Indicator limitations**
Density and size of selected Caribbean key fish species	Measures density and sizes of selected Caribbean key fish species – predators, herbivores and indicator species. Size is used for biomass estimation LAMP protocol species are included as specific commercial species indicators	**Species selected under MBRS protocol include:** Acanthuridae (Surgeonfish) Chaetodontidae (Butterflyfish) . Haemulidae (Grunts – over 5cm long) Lutjanidae (Snappers) Pomacanthidae (Angelfish) Scaridae (Parrotfish – over 5cm long) Serranidae – every species of genera - *Myctoperca* and *Epinephelus* Balistidae – Only the following species: *Balistes vetula* (Queen triggerfish) *Baslistes capriscus* (Grey triggerfish) *Melichthys niger* (Black durgon) *Aluterus scriptus* (Scrawled filefish) *Cantherines pulles* (Ornagespotted filefish *Cantherines macrocerus* (Whitespotted filefish) Also… *Bodianus rufus* (Spanish hogfish) *Caranax ruber* (Bar jack) *Lachnolaimus chrysurus* (Yellowtail damselfish) *Sphyraena barracuda* (Barracuda) **LAMP protocol species:** *Lutjanus analis* (Mutton Snapper) *Lachnolainus maximus* (Hogfish) *Balistes vetula* (Queen triggerfish) *Epinephelus striatus* (Nassau grouper) *Mycteroperca bonaci* (Black grouper)	Identification error in inexperienced observers, and in size estimation (total length). Method I is based on the AGGRA protocols, and has been adopted by CARICOMP. LAMP protocols were designed specifically for Glovers Reef, and focus on only five species. These can be incorporated into the MBRS protocol

Table 55: SPAWNING AGGREGATION – TNC Protocol			
Habitats to be monitored: 3 spawning aggregation sites. Half Moon Caye site has been highlighted for intensive monitoring under MBRS (more than 300 dives per year). El Nic and Sandbore are standard monitoring.			
Monitoring Programmes: **Biodiversity Monitoring – B18, B39** **Limits of Acceptable Change – n/a** **Conservation Planning – SA1-SA5**			
Parameter	**Measures**	**Comments**	**Indicator limitations**
Abundance	Viability of the spawning aggregation; species composition	It is recommended that monitoring is as intensive as resources allow, with greater focus on Nassau grouper at times of the year when it is spawning	Limited resources. Optimum for HMC site is 10 days per month until peaks are worked out (which phase of moon), then sampling just during peaks.
Lengths			
Other organization using TNC protocol in Belize: Fisheries Dept., WCS, Green Reef No database at present, but the SPAG working group are planning to develop one, to be managed by CZMA&I			

Table 56: MANGROVE– MBRS protocol			
Lighthouse Reef is considered a priority area for monitoring mangroves under the Synoptic Monitoring Programme. Mangrove habitats to be monitored: Coastal and fringing mangroves			
Monitoring Programmes: **Monitoring – B27, B48-B49** **Acceptable Change – B28 (n/a for 2006 status)** **Conservation Planning – n/a**			**Biodiversity** **Limits of**
Parameter	**Measures**	**Comments**	**Indicator limitations**
Forest characterization / zonation	DBH, Community description, abundance and percentage cover	Using Point Centered Quarter Method (PCQM), with 3 transects. MBRS data form	At present, no mangrove on Half Moon Caye – monitoring needs to be done on other cayes, which will require cooperation from landowners and developers
Community Composition	Species abundance	3 10m x 10m plots within representative area defined by PCQM transects. MBRS data form	
Growth of saplings	Recruitment		
Other organization using MBRS protocol in Belize: Fisheries Dept., TIDE			

Table 57: WATER QUALITY and SEDIMENTATION – MBRS protocol				
Habitats to be monitored: all, particularly areas of concern under the Limits of Acceptable Change programme				
Monitoring Programmes: **Biodiversity Monitoring – B32-B34** **Limits of Acceptable Change** **Conservation Planning**				
Parameter	**Measures**	**Comments**	**Indicator limitations**	**Values**
Salinity	Freshwater influx	Under the 'Healthy Reefs for Healthy People' initiative, water quality indicators including salinity are key parameters for the maintenance of healthy reef and nearshore ecosystems	Surface salinity may vary greatly with rainfall. Financial constraints – there should be a fixed automatic monitoring station	Full seawater in the Caribbean should be an average of 37.9 ppt.
Water temperature	Temperature fluctuation	Temperature is another key parameter for the maintenance of healthy reef and nearshore ecosystems, particularly important with reference to coral bleaching incidents	Financial constraints – there should be a fixed automatic monitoring station	Optimal coral growth is at between 25-29°C, with monthly averages that exceed 0.5°C above average are likely to result in coral bleaching
Turbidity	Water clarity	Water clarity in another key parameter for the maintenance of healthy reef and nearshore ecosystems. NB. A simple rule of thumb is that light can penetrate to ~2-3 times the Secchi depth.		Minimal turbidity – no change from natural conditions
Sedimentation levels	Sediment deposition rates	Results in increased sediment coverage of seagrass and coral	Fixed stations	Minimal sedimentation – no change from natural conditions

Table 58: MARINE TURTLES			
Turtle habitats to be monitored: Nesting beach, all aquatic habitats			
Monitoring Programmes: **Biodiversity Monitoring – B19, B40-B41, B73, B79 B93** **Limits of Acceptable Change - n/a** **Conservation Planning – MT9-MT11**			
Parameter	**Measures**	**Comments**	**Notes and Indicator limitations**
Turtle nesting beach	Number and species of individuals using beach, number of nests	Day patrols during nesting season – count tracks, record nests and false crawls Night patrols – at least every 3rd night during nesting season	Rubble currently covering beach – need to clear a gap to allow turtles onto higher sandy beach area Any turtles observed should not be disturbed, particularly prior to egg laying. Red lights should be used Each turtle should be photographed after egg laying has commenced for ID purposes
Hatching success	Nesting success	Emergence of hatchlings should be recorded, and estimation of numbers Return to each of the nests recorded during the season. Using latex gloves (turtle nests and eggs can contain a lot of bacteria including species that are potentially harmful to humans) carefully dig down to the nest chamber. Remove any live hatchlings to a bucket for closer examination and species ID. Dead hatchlings and embryos should be kept for genetic sampling Count and record the number of hatched eggs, intact eggs and dead hatchlings	If live hatchlings are found at night then they should be released immediately to facilitate maximum chances of survival. However, if the excavation is carried out during daylight, the hatchlings should be retained in an escape proof container (e.g. a bucket) containing some moist sand, which should be placed in a cool, dark and secure building until night fall, when they should be released, preferably on the beach from which they were collected. Daytime release will increase the chances of hatchlings being predated by diurnal fish and birds (e.g. frigate birds).
Species	Species, relative abundance, distribution within and around protected areas	A log should be kept of all incidental sightings of sea turtles in and around the protected areas. This should include information on date, time, location and species. Notes on behavioural observations should also be kept.	Incorrect ID – training required Including strategies for stakeholder involvement: B81, C8-C10

C. Community Participation Programme

Incorporating community participation is a key stone of BAS management ethos, with the involvement of all stakeholders – from the fishing communities of northern Belize to the tourism industry of San Pedro, Caye Caulker and the Lighthouse Reef Atoll itself.

Overall Objective:

Effective management of Blue Hole and Half Moon Caye Natural Monuments in which stakeholders participate and benefit.

Several activity areas have been identified as priorities for stakeholder involvement in management, and as mechanisms to increase stakeholder benefits.

1. Facilitation of development of stakeholder organisation, lobbying for management of Lighthouse Reef Atoll
2. To ensure ongoing implementation of stakeholder benefits strategies for fishing stakeholder
3. To develop collaboration with local landowners and developers of Lighthouse Reef Atoll
4. To ensure improved collaboration with tourism stakeholders

Community Participation - General			
			Activity
	Activity Group 1	Keep stakeholders informed about management issues	**C1**
	Activity Group 2	Develop mechanism(s) for stakeholder involvement in management decisions	**C2**
	Activity Group 3	Ensure participation of stakeholders in finalization of management zones	**C4-C5**
Management of Lighthouse Reef Atoll			
			Activity
	Activity Group 1	Facilitate development of management organisation for LHR	**C3**
Fisheries Stakeholder Participation			
	Activity Group 2	Further develop socio-economic benefits strategies for stakeholder communities	**C6-C7**
	Activity Group 3	Continue and increase stakeholder involvement in biodiversity monitoring	**C8-C10**
	Activity Group 4	Increase awareness of health of the reef and threats	**C10-C11**
	Activity Group 5	Continue conservation education programme in stakeholder schools	**C12**
Participation of Landowners and Developers			
	Activity Group 1	Increase liaison with landowners and developers on LHR, and participation in management and monitoring	**C13-C14**
Participation of Tour Operators and Visitors			
	Activity Group 1	Ensure participation in management decisions	**C15**
	Activity Group 4	Develop mechanisms for participation in biodiversity monitoring	**C16-C18**

C. Community Participation						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
General						
C1	Annual Workshop for members of each stakeholder village council and leading community fishermen of LHR, informing of management plan, annual operational plan, monitoring results etc.	Stakeholder members do not feel informed about management of HMCNM and BHNM, nor included in management decisions	Members of each stakeholder village council and leading community fishermen of LHR, informed of management plan, monitoring results etc.	1st to 5th	Executive Director, Marine PA Manager, Parks Director, Community Liaison Officer	
C2	Develop mechanisms for greater stakeholder participation in management and management decisions	Little input at present	Greater stakeholder participation in management and management decisions	1st and 2nd	Marine PA Manager, Parks Director, Community Liaison Officer	
C3	Facilitate the formation of a stakeholder management group interested in investigating the possibilities of managing the resources of Lighthouse Reef Atoll	Management group not yet formed - will need to be developed from interested stakeholders	BAS facilitated management committee formed to develop planning proposal for management of resources of LHR	1st and 2nd	Executive Director, Marine PA Manager, Community Liaison Officer, Parks Director	Forest Department; Fisheries Department. **CMS11**
C4	Workshop with stakeholders for discussion and flinalisation of management zones	No management zoning at present	Management zones developed with stakeholder input	1st	Executive Director, Marine PA Manager, Community Liaison Officer, Parks Director	One to two-day BAS-led workshop covering all management plan development issues, with specific reference to proposed management zoning
C5	Awareness of zones and permitted activities	No active management zoning at present	Awareness of zoning and regulations in the stakeholder communities and among the fishermen of LHR	1st	Marine PA Manager, Parks Director, Community Liaison Officer	Awareness through meetings, leaflet, individual discussions – **BEFORE** implementation. **CR8**
Fisheries Stakeholder Participation						
C6	Assess stakeholder communities for primary development needs, and facilitate the communities in provision of these requirements	Whilst Alternative Livelihood options are benefiting individuals, there is a n opportunity to benefit the stakeholder communities as a whole by tackling root problems	Facilitation of priority development issues	1st to 5th	Marine PA Manager, Community Liaison Officer	Eg. Lobbying for upgrade of road to Sarteneja; Location of funds for greater accommodation and restaurant infrastructure

C. Community Participation						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Fisheries Stakeholder Participation						
C7	Continue facilitation of alternative income projects and skills training opportunities within the fishing stakeholder communities to reduce pressure on the commercial marine species	Supplemental training in tour guide specialties in progress (diving etc.)	Reduction in number of fishermen opportunistically taking sea turtle and other commercial species, reducing pressure on resources	1st to 5th	Marine PA Manager, Community Liaison Officer	In socio-economic survey, only 12% of fishermen surveyed would change to an alternative income – most recognized that alternatives would not be able to provide the same level of income as fishing. However, all wanted alternatives for their children **CMS21**
C8	Stimulate stakeholder involvement in biodiversity monitoring	Increasing participation of stakeholders in biodiversity monitoring commercial marine species through training of fishermen, but the programme needs continuity in the long term. Lighthouse keepers are not active participants in monitoring, nor are staff and land owners from the adjacent cayes or tourism sector Some fishers trained as divers for lobster and conch surveys, and spawning aggregation monitoring	Trained fishermen actively involved in monitoring biodiversity. Active participation of Lighthouse Keepers, landowners of adjacent cayes, and tourism sector	1st to 5th	Marine PA Manager, Marine Biologist Community Liaison Officer	Involvement in monitoring of turtle nests, mangroves, water quality and catch of species that congregate in spawning aggregations. Provide training in identification of key species. For fishermen, log dives where appropriate towards dive master qualification as incentive. **SA4**
C9	Develop questionnaire for fishermen covering shark, turtle, ray and key parrotfish sightings	Little biodiversity information being gathered from fishermen	Information on key species being gathered from fishermen – participation in monitoring activities	1st to 5th	Marine PA Manager, Marine Biologist, Park Director, Community Liaison Officer	Fishermen requested to complete questionnaire on arrival at Half Moon Caye. Distribution of laminated ID sheet to fishing boats to ensure accurate ID. Training in identification of key species
C10	Target fishermen with awareness materials and further training opportunities while they are at Lighthouse Reef	Liaison between BAS and fishermen is improving through the training opportunities being offered	Fishermen aware of importance of protected areas and locations of boundaries. Fishermen familiar with BAS staff and able to approach staff with questions.	1st to 5th	Marine Biologist, Park Director, Community Liaison Officer	Training session in shark and turtle ID, on Half Moon Caye, to assist with surveys **CMS15**
C11	Use rainbow parrotfish as focal species to engage stakeholders and raise awareness of health of reef	Local stakeholders not aware of possible local extinction of rainbow parrotfish at LHR, nor of the importance of key herbivores	Stakeholders actively aware of rainbow parrotfish and report any sightings	1st to 5th	Marine PA Manager, Parks Director, Community Liaison Officer, Education Officer	Identified stakeholders for this action - Dive operators, dive guides, tourists, property owners, live-aboards, fishermen **PF5**

C. Community Participation						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Fisheries Stakeholder Participation						
C12	Conservation education programme for primary schools in local communities	Conservation education with primary schools in stakeholder communities to raise awareness is not continuous	Prioritization of conservation education in local community primary schools. Increase in school visits to all stakeholder communities	1st to 5th	Marine PA Manager, Community Liaison Officer, Education Officer	Possibly liaise with local NGO SWEET(Sarteneja) to form partnership and implement joint activities
Participation of Landowners and Developers on Adjacent Cayes						
C13	Increase positive liaison with landowners and increase participation in conservation goals and feelings of guardianship	Some liaison with other inhabitants, landowners and developers of Lighthouse Reef Atoll, but not well developed, planned or strategic. No involvement in biodiversity monitoring	Better liaison with other inhabitants, landowners and developers of Lighthouse Reef Atoll, promoting constructive partnerships, involvement in monitoring, and feelings of guardianship	1st to 5th	Executive Director, Marine PA Manager, Marine Biologist, Park Director	Through LHR Advisory Committee, workshops, individual discussions and communication, planned awareness activities at HMCNM, involvement in monitoring. **SG17**
C14	Stimulate stakeholder involvement in turtle nest monitoring on all cayes of LHR Atoll	Other landowners / developers / users of Lighthouse Reef are currently not involved in mapping and monitoring for turtle nests within the atoll	Co-coordinated mapping and monitoring of all turtle nests within the atoll, and involvement, with increased awareness among LHR landowners / users	1st to 5th	Marine PA manager, Marine Biologist, Park Director, CLO	Involvement of tourism developments, tour operators, fishermen in mapping and monitoring turtle sightings and turtle nests, increasing awareness.
Participation of Tour Operators and Visitors						
C15	Workshop with tour operators to develop guidelines for use of Blue Hole, including relocation of mooring buoys and stopping of shark chumming	Several changes are recommended for the management of Blue Hole, including relocation of mooring buoys and stopping of shark chumming, which need to be discussed with tour operators	Development of guidelines for use of the Blue Hole, with input from tour operators	1st	Executive Director, Marine PA Manager, Marine Biologist, Park Director, Community Liaison Officer	
C16	Develop questionnaire for dive leaders covering shark, turtle, ray and key parrotfish sightings	Little biodiversity information being gathered from dive leaders	Information on key species being gathered from dive leaders – participation in monitoring activities	1st to 5th	Marine PA Manager, Marine Biologist, Park Director	Dive leaders requested to complete questionnaire on arrival at Half Moon Caye. Distribution of laminated ID sheet to dive boats to ensure accurate ID
C17	Stimulate stakeholder involvement in monitoring of sharks through questionnaires for divers and dive leaders	Divers see sharks almost daily but BAS staff themselves rarely dive in the Blue Hole, and do not collect information on shark sightings	Information on numbers of sharks seen and basic behavioral patterns gathered through questionnaires for divers and dive leaders during lunch break on Half Moon Caye	1st to 5th	Marine Biologist, Park Director & staff	**S5** Questionnaires for visitors and diver leaders, with ID charts

C. Community Participation						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Participation of Tour Operators and Visitors						
C18	Stimulate stakeholder involvement by implementing questionnaire for visitor turtle sightings, linked to nesting beach information boards	No methods for logging turtle sightings by divers / snorkelers within the protected areas	Method to capture data from dive boats and live-aboards on turtle sightings, and encourage active participation of visitors	1st to 5th	Marine PA Manager, Marine Biologist, Park Director	Integrate with **MT17.** Need identification guides on boats, with intro from park staff when greeting at Blue Hole and Half Moon Caye, preferably before tourists go into water, to encourage divers to log sightings. Previous data presented to show that results are used. Need to segregate these results from those of staff and dive leaders as ID considered less reliable.

D. Public Use Programme

Both Blue Hole and Half Moon Caye Natural Monuments are internationally renowned tourism destinations, attracting large numbers of divers to Belize each year. As natural monuments, tourism access is one of the founding objectives for which they were established, and is also one of the major management requirements.

Overall Objective:

Effective management of public use of Blue Hole and Half Moon Caye Natural Monuments, in which stakeholders participate and benefit.

With its distance from the mainland and the need for specialized dive training, the number of tour operators using Blue Hole and Half Moon Caye is limited to a handful of companies primarily based out of San Pedro, Caye Caulker, and Belize City. Management of visitation has to be through close collaboration with these stakeholders, with greater active participation in management of public use. A series of guidelines have been developed for the two natural monuments to assist in providing a framework for tourism management:

GUIDELINES FOR RECREATIONAL ACTIVITIES

General Rules:

- 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 snorkeling and diving activities are asked 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 external 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.

Snorkeling:

Individuals engaged in snorkeling activities are required to adhere to the following guidelines:

- No more than 20 snorkelers will be allowed to be present at the same time in an area of 100 square yards.
- Snorkeling 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.

Diving:

Visitors wishing to engage in diving activities within the boundaries of the protected areas are asked to adhere to the following park guidelines:

- 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:

Visitors to Half Moon Caye Natural Monument wishing to carry out birding activities are asked to adhere to the following guidelines:

- 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.

Camping:

Visitors wishing to camp on Half Moon Caye Natural Monument are required to pay a fee of three dollars per night additional to their park visitation fee. The park staff has developed the following guidelines:

- Camping is restricted to the area delineated as camping grounds.
- Campers must bring their own food and water supply onto the island.
- Campfires are restricted to those areas identified by the staff.
- The campers on leaving must take all garbage/refuse off the island.
- As ground water and overhead catchments are utilized to provide restroom facilities, campers are asked to be mindful of water conservation measures.
- It is prohibited to remove shells, flora, fauna or coral specimens from the island even if these items may be dead or may be considered rubble.
- Campers are not allowed to fish within the delineated boundaries of the protected areas.
- No loud music or disorderly behavior will be tolerated in the protected areas.

One strategy to ensure greater compliance with guidelines is the development of a 'Best Practices' guide for tour operators and dive leaders, partly through workshops integrating feedback from these stakeholders.

With the time and resource limitations with distance from the mainland, educational use is limited, though education activities are conducted in stakeholder communities.

Strategies are developed for the following management areas:

- Visitor Management
- Visitor Awareness
- Education
- Illegal Use

Visitor Management			
	Activity Group 1	Develop awareness of management zoning and guidelines	**D1-D5**
	Activity Group 2	Increase good practices among dive parties	**D6-D11**
	Activity Group 3	Establish Limits of Acceptable Change programme and associated visitor monitoring activities	**D12-D15**
Visitor Awareness			
	Activity Group 1	Maintain on-site interpretive material	**D16-D119**
	Activity Group 2	Increase awareness of visitors on live-aboard boats	**D20**
Education Activities			
	Activity Group 1	Continue conservation education activities in stakeholder community schools	**D21**
	Activity Group 2	Collaborate and support other reef education programs and organisation efforts in Belize	**D22-D23**
Illegal Use			
	Activity Group 1	Ensure enforcement of no-take regulations	**D24-D25**

D. Public Use						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Visitor Management						
D1	Public awareness of and implementation of management zones	No management zoning at present	Management zones delineated, implemented and enforced	1st to 5th	Marine PA Manager, Park Director and staff	
D2	Workshop with tour boat operators and live–aboards re. boat impacts, and defining of restricted boat channels and mooring sites.	No formal designation of boat channels, mooring sites and no-go areas	Designation of boat channels, mooring sites and no-go areas, developed with respect to location of potential level of impact	1st	Marine PA Manager, Park Director	One to two-day workshop covering all management plan development issues with BAS an active member in the discussions, not just facilitate
D3	Workshop with tour operators to develop and implement stakeholder strategy guidelines for use of Blue Hole, over the 5 year management period	Several changes are recommended for the management of Blue Hole, including relocation of mooring buoys to outside the Blue Hole, designation of boat channels, and banning of shark chumming, following discussion and consensus with tour operators	Development of guidelines for use of the Blue Hole, with input from tour operators	1st	Marine PA Manager, Park Director	Developed during stakeholder workshop including relocation of mooring buoys to outside the Blue Hole. Needs to be a collaborative effort developed over the 5-year time scale of this management plan. Possible problem of air-time for divers if they have to travel from outside Hole first. Dive boat operators need to be convinced of the need, and incorporated into planning of new mooring sites. Also banning of shark chumming
D4	Ensure stakeholders area aware that motorized diving or other potentially impacting activities do not take place within the Blue Hole	No motorized aids (dive scooters etc.) are currently used by dive companies within the Blue Hole	No motorized aids (dive scooters etc.) are used by dive companies within the Blue Hole	1st to 5th	Park Director	**BH11**
D5	Ensure that present and future live-aboard and dive boat mooring points are above bare sound substrate where possible	Present mooring positions are above sand, but problems occurred when a larger "small" cruise ship used one of the buoys, pulling it out of position.	Where possible, live-aboard and dive boat moorings will be above bare sand substrate	1st to 5th	Marine PA Manager, Park Director	If larger vessels are going to moor at BAS mooring buoys, the anchoring mechanism needs to be reinforced to prevent drag **SG28**
D6	Development of 'Best Practices' guide for tour operators and dive leaders	BAS reactive rather than proactive in mitigating visitor related impacts	Development of 'Best Practices' guide for tour operators and dive leaders for distribution to dive operators	1st to 2nd	Executive Director, Marine PA Manager, Marine Biologist, Park Director	To include BAS policies developed at workshop – Management Zones and activities, Blue Hole mooring, fish chumming, boat channels, diver:dive leader ratios etc.

D. Public Use						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Visitor Management						
D7	Ensure that live-aboards and dive boats are aware of 'Best Practices' guidelines re. wastewater, grey water and sewage, through BAS accrediting system	Issue of best practices for wastewater and sewage disposal not fully covered with live-aboard and dive boats that use HMC	Standards set in best practices leaflet to assist all live-aboards and tour operators to ensure they have adequate sewage, waste and grey water disposal	1st to 5th	Marine PA Manager, Park Director	**SG29**
D8	Ensure that staff deliver Best Practices introduction to independent boats (visitors) on arrival	Issue of best practices for wastewater and sewage disposal not fully covered when independent boats use HMC	Standards set in best practices leaflet to assist independent visiting boats to ensure they have adequate sewage, waste and grey water disposal	1st to 5th	Marine PA Manager, Park Director	**SG30**
D9	Provide orientation talk and signs to ensure correct visitor behaviour near the nesting colony	No orientation talk or information on arrival to caye on correct visitor behaviour near the nesting colony	Orientation talk and / or information on arrival to caye on correct visitor behaviour near the nesting colony	1st to 5th	Marine PA Manager, Marine Parks Director & Staff	
D10	Provide training for dive boat staff on protocols for leading groups to see nesting birds, and information on the birds	Little guidance given to dive groups visiting the caye on protocols	Guidance given to dive groups visiting the caye on protocols	1st to 5th	Marine PA Manager, Marine Parks Director & Staff, Education Officer	
D11	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	BAS impartial to different tour operators. No recognition at present of those dive operators who are attempting to ensure their visitors are following guidelines for minimizing impacts	Dive operations are recognised as approved by BAS for setting good standards. BAS approval / use of approval logo. Scheme is advertised through posters and leaflets to visitors on San Pedro and Caye Caulker	1st to 5th	Executive Director, Marine PA Manager, BTB, BTIA	Approved tour operators be accredited for awareness of impact mitigation in boat handling, tourist intro and management, wastewater management, Shark chumming activities would automatically exclude tour operator. Raise visitor awareness of accreditation system
D12	Laminated poster for mounting in dive boats, and leaflet for distribution on San Pedro and Caye Caulker, on good boat / dive practices for tour operators and tourists, to include minimizing impacts on ecosystems	Pre-dive talks on minimizing impacts to corals are not monitored for content, but are left to the discretion of the dive boat operators. Quality of information on good diving practices for tourists is dependent on tour operators. Poor dive leadership leads to greater impacts on the ecosystems	Dive standards set in laminated poster and on leaflet to ensure tourists are aware of good dive / snorkel practices in relation to ecosystem protection and actions they can take for minimizing impacts to corals, even if their dive leaders do not cover this well	1st to 5th	Marine PA Manager, Contracted layout artist	Poster and leaflet that includes good practices around coral, seagrass, fish. Posters also distributed in San Pedro and Caye Caulker **CR17**

D. Public Use						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Visitor Management						
D13	Establish Limits of Acceptable Change for trails within the littoral forest to assist with visitor management	No limits of acceptable change in place at present	Limits of Acceptable Change in place for trails within the littoral forest area	1st	Marine PA Manager, Park Director	With particular reference to seaward impacts on littoral forest from visitor access / use on east southeast of caye **LF9**
D14	Develop and implement visitor monitoring programme tied into Limits of Acceptable Change programme	Little visitor monitoring	Ongoing visitor monitoring programme with results feeding into adaptive management	1st to 5th	Marine PA Manager, Park Director, Marine Biologist / Research Coordinator	
D15	Continued control of visitor access to bird nesting colony through trail design, signs and observation tower	Visitor access is controlled by trail design, signs and observation tower	Continued visitor access controlled by trail design, signs and observation tower	1st to 5th	Marine PA Manager, Park Director	Sign for Observation Tower identifying bird species, with information, and requesting visitors to maintain low noise levels **NB4**
Visitor Awareness						
D16	Maintain Interpretive Centre	Interpretive Centre recently renovated	Continued maintenance of Interpretive Centre	1st to 5th	Marine PA Manager, Park Director	
D17	Place information boards on marine turtles in nesting season to increase visitor awareness	Little information is given on the importance of Half Moon Caye as a turtle nesting site	Greater awareness of Half Moon Caye as a turtle nesting site	1st to 5th	Marine PA Manager, Park Director, Commissioned artist	Boards located in front of nesting beach **MT2**
D18	Provide laminated self-guided trail leaflet for loan to visitors to nesting bird colony	Little information given to dive groups visiting Half Moon Caye trail system	Visitors able to use trail self-guided, and learn correct information	1st	Marine PA Manager, Park Director, Commissioned artist	
D19	Increase awareness of visitors of Blue Hole geological history through interpretive displays and leaflet	Interpretive displays in place but more information needed on geological significance of the Blue Hole	Tourists fully informed on geological significance of Blue Hole	1st to 5th	Marine PA Manager, Park Director, Commissioned artist	Leaflet combined information with diving best practices information for minimizing impact, and used as a mechanism for fundraising **BH10**
D20	Standardised evening presentation for live-aboards on reef conservation, to include turtles and how divers can be involved in monitoring	Available on request	Evening presentation to live-aboards includes turtle identification and conservation	1st to 5th	Marine PA Manager, Park Director	Integrate with **MT11. MT19**

D. Public Use						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Education						
D21	Increase awareness of coral reef in stakeholder communities	Some education activities in stakeholder schools	Continued education activities within targeted stakeholder schools	1st to 5th	Marine PA Manager, Park Director, Community Liaison Officer, Education Officer	Log dives if possible towards dive master qualification as incentive. **SA4**
D22	Collaborate with other national organisation involved in increasing awareness of the reef and marine biodiversity	Little collaboration with other national organisations, and duplication of efforts	Collaboration with other national organisations involved in increasing awareness of the reef	1st to 5th	Marine PA Manager, Marine Biologist, Community Liaison Officer	WCS, Wildlife Trust (manatees), BFCA
D23	Supporting efforts of local conservation organisations based within the stakeholder communities with similar education objectives	Little collaboration with other organisations, and duplication of efforts	Collaboration with other organisations involved in increasing awareness of the reef	1st to 5th	Marine PA Manager, Community Liaison Officer	Eg. Green Reef, SWEET
Illegal Use						
D24	Ensure enforcement of no-take regulations	Frequent incursions by fishermen for lobster, conch and fin fish. Lighthouse keeper's assistant fishing commercially within protected area	Effective enforcement in place	1st to 5th	Marine PA Manager, Park Director	In liaison with Forest and Fisheries Dept.
D25	Liaise with Guatemalan authorities to ensure compliance of Guatemalan visitors at Easter	16+ recreational boats arrive from Guatemala each Easter and fish within Half Moon Caye Natural Monument	Compliance of all visitors with protected area regulations	1st to 5th	Executive Director, Marine PA Manager, Park Director	

E. Site and Infrastructure Programme

Infrastructure purchase, construction and maintenance represents a major financial outgoing for Belize Audubon Society, with material costs, transport, frequent storm damage all contributing to the high expense in maintaining the two sites.

Overall Objective:

To ensure that the necessary infrastructure is present for the support of management activities within BHNM, HMCNM and the adjacent area

The Site and Infrastructure Management Programme is sub-divided into several section:

- General
- Current Infrastructure
- Future Infrastructure
- Specific Infrastructure Requirements

General			
	Activity Group 1	Maintenance of all structures	**E1**
	Activity Group 2	Assess liability issues	**E2-E3**
	Activity Group 3	Ensure sufficient infrastructure for management	**E4**
Current Infrastructure			
	Activity Group 1	Infrastructure for boats	**E5-E10**
	Activity Group 2	Water and Sewage	**E11-E15**
	Activity Group 3	Solid Waste Disposal	**E16-E19**
	Activity Group 4	Electricity	**E20**
	Activity Group 5	Communications	**E21-E22**
	Activity Group 6	Safety and Emergency Infrastructure	**E23-E27**
	Activity Group 7	Equipment	**E28-E31**
Future Infrastructure			
	Activity Group 1	Rapid response following storm damage	**E32**
	Activity Group 2	Upgrade buildings and camp site	**E33-E36**
Specific Infrastructure			
	Activity Group 1	Turtle Nesting Beach	**E37-E38**
	Activity Group 2	Nesting Bird Colony	**E39-E40**

E. Site and Infrastructure Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
General						
E1	Ensure maintenance of all structures	Visitor structures are well maintained. Staff structure could be better maintained	Annual maintenance of all structures	1st to 5th	Marine PA Manager, Park Director	Observation Tower base plates were in danger of rusting through during assessment. Needed repair
E2	Annual assessment of liability issues of Blue Hole Natural Monument annually	Potential liability issues are not adequately addressed	Liability issues are adequately addressed, and reassessed annually	1st to 5th	Marine PA Manager, Park Director	
E3	Annual assessment of liability issues of Half Moon Caye Natural Monument	Potential liability issues are not adequately addressed	Liability issues are adequately addressed, and reassessed annually	1st to 5th	Marine PA Manager, Park Director	
E4	Ensure sufficient resources and manpower for patrolling, monitoring and visitor management / fee collection	Current problem of boats (and staff) being overstretched trying to achieve all three operations with limited resources and manpower	Rationalisation of resources and manpower to ensure all three activity areas can be achieved	1st to 5th	Executive Director, Marine PA Manager	Restricted use of boats and outboards, with prioritization for fee collection results in decreased ability to complete other management objectives. Need more boats.
Specific Infrastructure						
Infrastructure for boats						
E5	Lobby for development of Mooring Policy	No Mooring Policy exists within Belize. Problems occur when larger vessels used inappropriate sized mooring, pulling it out of position.	National Mooring Policy to give guidelines for mooring points	2nd to 3rd	Executive Director, Marine PA Manager, Advocacy Officer	
E6	Workshop with tour boat operators and live–aboards re. boat impacts, and defining of restricted boat channels and mooring sites within HMCNM	No formal designation of boat channels, mooring sites and no-go areas	Designation of boat channels, mooring sites and no-go areas, developed with respect to location of coral	1st	Executive Director, Marine PA Manager, Park Director	One to two-day workshop covering all management plan development issues. BAS needs to be an active member in the discussions, not just facilitate. If larger vessels are going to moor at BAS mooring buoys, the anchoring mechanism needs to be reinforced to prevent drag. Should include Tourism sector stakeholders
E7	Restrict boat access within Blue Hole National Park to pre-designated channels marked with buoys, to ensure limited impact on coral rim	Some negative boat traffic impacts on coral rim of Blue Hole from boat activity	Boat traffic restricted to designated, well-marked boat channels within Blue Hole Natural Monument. Moving towards exclusion of boat mooring within the Blue Hole itself	1st to 5th	Marine PA Manager, Park Director	Developed during stakeholder workshop

E. Site and Infrastructure Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Specific Infrastructure for Boats						
E8	Ensure sufficient mooring sites are available at BHNM and off Half Moon Caye, following discussions with stakeholders; and that these are placed with minimal impact to seagrass, coral and other marine life	Anchor damage to coral and seagrass when insufficient mooring points are available. Mooring points for live-aboards need to be chosen to minimize impacts to seagrass, coral and other marine life	Sufficient mooring points, in locations that minimize impacts to seagrass, coral and other marine life	1st to 5th	Marine PA Manager, Park Director	Discussed at stakeholder workshop. Impacts of nutrient enrichment from live-aboard wastewater also needs to be taken into account
E9	Use colour-coded buoys – one colour for designated boat access channels, another for mooring buoys, and another for marking boundaries. Remove all temporary buoys	No coordinated marking system in use	Coordinated system of buoys for marking designated channels, mooring sites and protected area boundaries	1st to 5th	Marine PA Manager, Park Director	
E10	Ensure visitor dock is maintained, and sufficiently large for visitor requirements	Visitor dock is too small for number of dive boats visiting Half Moon Caye	Visitor dock is inadequate size for number of dive boats visiting Half Moon Caye	1st to 5th	Marine PA Manager, Park Director	
Water and Sewage						
E11	Consult hydrologist on water table and water flow on Half Moon Caye, and use this information to plan improvements to toilet and shower facilities and locations	No knowledge of hydrology, water table and water flow parameters of HMCNM	Knowledge of hydrology, water table and water flow parameters of HMCNM	1st Year	Marine PA Manager, Marine Biologist, Hydrologist	
E12	Ensure toilets and showers for HMCNM facilities (both staff and visitors) are designed and located to minimize risk of water contamination	Insufficient toilets for number of visitors. Need upgrading. No monitoring for groundwater contamination or leaching into sea	Toilets sufficient for visitor flow, and designed and located to minimize risk of water contamination	1st Year	Marine PA Manager, Marine Biologist, Hydrologist, Engineer	Need some expert advice on hydrology of HMC to determine locations. It has been suggested that composting toilets with capacity for 100 people per day may be the best option for mitigating effects of nutrient leaching
E13	Liaise with Port Authority to ensure that toilets and showers for lighthouse keeper's facilities are designed and located to minimize risk of water contamination	No data on whether lighthouse keeper's facilities are designed and located to minimize risk of water contamination	Liaison with Port Authority to ensure that lighthouse keeper's facilities are designed and located to minimize risk of water contamination	1st Year	Marine PA Manager, Marine Biologist, Hydrologist, Port Authority	

E. Site and Infrastructure Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Specific Infrastructure for Water and Sewage						
E14	Ensure that present and future live-aboard and dive boat mooring points are above bare sound substrate where possible	Present mooring positions are above sand, but problems occur when larger vessels used inappropriate sized mooring, pulling it out of position.	Where possible, live-aboard and dive boat moorings will be above bare sand substrate	1st to 5th	Marine PA Manager, Park Director,	If larger vessels are going to moor at BAS mooring buoys, the anchoring mechanism needs to be reinforced to prevent drag. Should include Tourism sector stakeholders
E15	Ensure implementation of water quality / indicator monitoring programme in areas of concern			1st to 5th	Marine Biologist	No monitoring of well water (salinity, E. coli). Monitoring of other water quality indicators
Solid Waste Disposal						
E16	Continue to request visitors to take their garbage with them	Signs request visitors to take garbage with them	Continue maintenance of signs, and replace when necessary	1st to 5th	Park Director and staff	
E17	Ensure implementation of monitoring programmes for garbage levels on trails and beach	No monitoring system in place for recording garbage levels on trails or beach	Monitoring system in place for recording garbage levels on trails or beach	1st to 5th	Marine Biologist, Park Director	Monitoring of garbage on trails through Limits of Acceptable Change programme. Data on type, origin and amount of garbage washed up on beach
E18	Monthly beach cleanup	Beach cleanups not conducted regularly	Beach cleanups conducted on a monthly basis	1st to 5th	Park Director and staff	Dive boat operators complain that there should be greater emphasis on beach cleanup, especially with increased entrance fees
E19	Ensure adequate planning for garbage – both left by visitors and beach debris	Garbage either burnt, or taken to Belize City by boat for disposal	Continued disposal of garbage	1st to 5th	Marine PA Manager, Park Director	
Electricity						
E20	Ensure adequate supply of electricity for management needs, and upkeep of system	If electricity is insufficient, safety aspects of managing the protected areas are compromised	Sufficient electricity for management requirements	1st to 5th	Marine PA Manager, Park Director	Lights for staff accommodation, radio communications etc.
Communications						
E21	Continued maintenance of radio communications system	Radio system provides communications with BAS office	Radio system continues to be maintained and operating	1st to 5th	Marine PA Manager, Park Director	
E22	Equip staff with emergency satphone for safety backup		Good communications for safety backup	1st to 5th	Marine PA Manager	

E. Site and Infrastructure Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Safety and Emergency Infrastructure						
E23	Ensure that at least one structure is hurricane-proof, for storage of equipment	At present, no hurricane proof structure at HMCNM	A hurricane proof structure at HMCNM	1st to 5th	Marine PA Manager	
E24	Reinforce present buildings for hurricane proofing (hurricane straps etc.)	Hurricane proofing of present buildings is inadequate	All buildings hurricane proofed retrospectively	1st to 5th	Marine PA Manager, Park Director	
E25	Ensure that all new structures are built to hurricane standards	Hurricane proofing of present buildings is inadequate	All buildings constructed to hurricane standards	1st to 5th	Marine PA Manager, Park Director	
E26	Ensure maintenance of all safety equipment, and staff training in use	Inadequate maintenance of safety equipment, insufficient staff training in use	Regular maintenance of safety equipment, prioritise replacement of failed equipment. Staff training	1st to 5th	Marine PA Manager, Park Director	Fire extinguishers, radios, satphone, flares, oxygen kit, medical kit etc.; First aid training for staff
E27	Provision of emergency rescue equipment	Ensure stretchers, full first aid kits, fire extinguishers etc. are present on HMCNM, and	HMCNM and BHNM staff adequately kitted for emergencies	1st to 5th	Marine PA Manager, Park Director	
Equipment						
E28	Ensure boats are insured, and fully equipped with GPS and base radio	Boat use at times invalidates any insurance. Staff feel that boats should be better equipped for both monitoring and safety purposes	Boat use is compliant with insurance clauses, and boats are fully equipped with GPS and base radio	1st to 5th	Executive Director, Marine PA Manager, Park Director	Boats are driven in past by unlicensed boat captains, invalidating any insurance
E29	Ensure equipment required for regular maintenance activities is on site	Equipment is not always available for maintenance activities, resulting in long delays	Equipment on-site for maintenance activities	1st to 5th	Marine PA Manager, Park Director,	Including GPS and digital camera for enforcement activities
E30	Ensure that all equipment is maintained	Equipment maintenance is not a high priority	Equipment well maintained and stored	1st to 5th	Marine PA Manager, Park Director	Proactive maintenance of outboards and other equipment
Future Infrastructure						
E31	Ensure rapid reconstruction of docks and other infrastructure after tropical storm damage	Being on the outer reef, LHR is open to frequent tropical storm damage, which can be destructive	Rapid reconstruction of infrastructure after tropical storm damage	1st to 5th	Marine PA Manager, Park Director	
E32	Upgrade present staff accommodation, Miller building, and storage facilities	Staff accommodation and storage facilities in need of upgrade	Staff accommodation and storage facilities upgraded	1st	Marine PA Manager, Park Director	Staff would like to see fuel storage facilities close to dock – need to assess possible environmental impacts
E33	Upgrade kitchen facilities in camping area	Kitchen in camping area is run down and in need of replacement	Presentable, useable kitchen area	1st to 2nd	Marine PA Manager, Park Director	

E. Site and Infrastructure Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Future Infrastructure						
E34	Upgrade dive shed / storage area	Dive shed / storage area in need of upgrade / rebuilding	Dive shed / storage area upgraded / rebuilt	1st	Marine PA Manager, Park Director	
E35	Improve office facilities at HMCNM / BHNM	Office facilities in need of upgrading	Better equipped office facilities	1st to 5th	Marine PA Manager, Park Director	
E36	Re-site staff bathroom facilities	Staff bathroom facilities in need of relocation and upgrade	Staff bathroom facilities relocated and upgraded	1st	Marine PA Manager, Park Director	
Specific Infrastructure						
Turtle Nesting Beach						
E37	Install informative signs to exclude visitors from nesting beach during nesting season	Visitors can access nesting beach during nesting season, with the potential to compact sand above the nests	Signs installed, excluding visitors from nesting beach during nesting season	1st to 5th	Marine PA Manager, Park Director	**Also see A: Natural Resource Management Programme – Specific Recommendations for Sea Turtles / Beach Replenishment**
E38	Ensure all external lights used on facilities at Half Moon Caye are of minimal impact to turtle nesting beach	Potential light impacts have not yet been assessed	All external lights used on facilities at Half Moon Caye (except lighthouse) are of minimal impact to turtle nesting beach	1st to 5th	Marine PA Manager, Park Director	No lighting on the nesting beach side of the caye; Also placing lights low to the ground, to prevent them shining over the beach, and allowing growth of natural vegetation to form barrier between facilities (incl. campsite) and beach
Nesting Bird Colony						
E39	Continued control of visitor access to nesting colony through trail design, signs and observation tower	Visitor access is controlled by trail design, signs and observation tower	Continued visitor access controlled by trail design, signs and observation tower	1st to 5th	Marine PA Manager, Park Director	Sign for Observation Tower identifying bird species, with information, and requesting visitors to maintain low noise levels
E40	Ensure that repairs to Observation Tower are timed for non-nesting season	Observation Tower repaired when required	Annual Observation Tower maintenance timed for the non-nesting season, and preventative rather than reactive	1st to 5th	Marine PA Manager, Park Director	

F. Administration Management Programme

Administration management is centralized, being conducted by the Belize Audubon Society office staff in Belize City.

Overall Objective:

To ensure that the necessary administration structure is in place for the support of management activities within BHNM, HMCNM and the adjacent area

The Administration Management Programme is sub-divided into several sections:

- General
- Staff Employment and Training
- Communications
- Volunteer Programme
- Issues and Concerns – Emergency Planning
- Marketing
- Monitoring

General			
	Activity Group 1	Policy issues	**F1**
	Activity Group 2	Human Resource Planning	**F2-F3**
	Activity Group 3	Financial Planning	**F4-F8**
	Activity Group 4	Operational Planning	**F9-F10**
	Activity Group 5	Reporting	**F11-F12**
Staff Employment and Training			
	Activity Group 1	Ensure there are sufficient staff for management	**F13**
	Activity Group 2	Ensure staff are adequately trained	**F14-F21**
Communications			
	Activity Group 1	Improve communications at site, local, national and international level	**F22-F26**
Volunteer Programme			
	Activity Group 1	Continue volunteer programme	**F27**
Issues and Concerns – Emergency Planning			
	Activity Group 1	Hurricane planning	**F28-F29**
	Activity Group 2	Shipwrecks and associated impacts	**F30**
	Activity Group 3	First Aid	**F31-F32**
	Activity Group 4	Emergency equipment	**F33**
	Activity Group 5	Liability	**F34-F35**

Marketing			
	Activity Group 1	Marketing internationally	**F36-F38**
	Activity Group 2	Marketing nationally	**F39-F40**
	Activity Group 3	Marketing to research institutions	**F41**
Monitoring			
	Activity Group 1	Measures of Success	**F42**
	Activity Group 2	Annual review of activities	**F43-F45**
	Activity Group 4	Review of management plan	**F46-F47**

F. Administration Management Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
General						
Administration						
F1	Maintain policy of no more buildings on Half Moon caye	Present policy is for no further infrastructure development	Maintain current infrastructure, but no increase on number of buildings	1st to 5th	Executive Director, Marine PA Manager	Replace infrastructure if and when necessary, but no new buildings
F2	Develop and implement Human Resource Development plan to maximise on present staff abilities	No Human Resource Development Plan in place at present	Human Resource Development Plan in place	1st	Marine PA Manager	
F3	Ensure accurate staff records of are maintained	Ongoing	Continued accurate staff records of are maintained	1st to 5th	Marine PA Manager, BAS office staff	
F4	Develop financial plan for HMCNM / BHNM for next five years to set course for economic sustainability	The next five years needs to be well planned for economic sustainability, particularly in view of increased visitation from cruise ship tourism	Good financial plan developed and implemented	1st	Marine PA Manager, Consultant	
F5	Prepare timely financial and management accounts and submit monthly	Reports prepared on a monthly basis and forwarded to Project Coordinator	Reports prepared on a monthly basis and forwarded to Project Coordinator	1st to 5th	Marine PA Manager, Park Director	
F6	Prepare quarterly report on use of annual budget, for submission to Executive Director and funding agencies	Quarterly budget report prepared and submitted to Executive Director and funding agencies at end of each Quarter	Quarterly budget report prepared and submitted to Executive Director and funding agencies. at end of each Quarter	1st to 5th	Marine PA Manager, Park Director, Accounts Manager	
F7	Ensure smooth and uninterrupted implementation of payroll associated activities	Ongoing	Continued smooth and uninterrupted implementation of payroll associated activities	1st to 5th	Executive Director, Marine PA Manager, Accounts Manager	
F8	Conduct a financial review / cost-benefit analysis of past programme activities and outcomes	Knowledge not available on cost-effectiveness of activity implementation	Knowledge of cost effectiveness of management activities, and knowledge used in development of future workplans	1st to 2nd	Marine PA Manager	
F9	Develop Operations Plan for forthcoming year, and submit each November	Workplan is developed for the forthcoming year	Workplan is developed for the forthcoming year	1st to 5th	Marine PA Manager, Park Director	
F10	Keep daily log of activities for HMCNM and BHNM, and prepare monthly report on enforcement activities, general situation report.	Ongoing	Daily log is completed, and summarized in monthly and annual reports of logged activities	1st to 5th	Marine PA Manager, Park Director	Enforcement activities, maintenance activities, number of visitors, ticket sales, and a general situation report.
F11	Prepare annual report	Reports prepared on an annual basis	Reports prepared on an annual basis	1st to 5th	Marine PA Manager, Park Director	Including fixed assets, with inventory of equipment

F. Administration Management Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
General						
F12	Conduct annual management effectiveness assessment and submit to PA administration authority	First Management Effectiveness assessment conducted in July 2006	Annual management effectiveness assessment and submitted to PA administration authority	1st to 5th	Marine PA Manager, Park Director	Should include stakeholders
Staff Employment and Training						
F13	Ensure there are sufficient staff for effective visitor and natural resource management and monitoring	Staff are overstretched with added requirement to be at Blue Hole to collect fees	Sufficient staff to fulfill all activities	1st to 5th	Executive Director, Marine PA Manager	
F14	Develop formal Orientation Package for all permanent staff, specific to HMCNM / BHNM	Orientation of staff is ongoing, but not on a formal basis	Formalised Orientation programme for permanent staff. Staff have baseline information on BAS, conservation, biodiversity of HMCNM / BHNM and necessary skills.	1st to 5th	Marine PA Manager, Park Director, Marine Biologist, Community Liaison Officer	Needs to include awareness of Management Zones and activities permitted in each zone
F15	Ensure marine biologist is fully trained in necessary monitoring protocols	High turnover in marine biologist position, with no skills transfer	Marine biologist is trained in necessary monitoring techniques and protocols as first priority on taking up the role	1st to 5th	Executive Director, Marine PA Manager	Training through apprenticeship with people using same protocols (eg. Fisheries, WCS) to ensure comparability of techniques/results
F16	Staff training in HMCNM / BHNM background, biodiversity	Staff have basic background information on BAS and HMCNM / BHNM but feel they should know more about the biodiversity of HMCNM / BHNM, and about other BAS protected areas open to visitors.	Staff able to discuss biodiversity of HMCNM / BHNM knowledgably with visitors, to respond to questions, and to promote other BAS protected areas, advise on what can be seen at each respective reserve. Greater knowledge of wildlife opportunities	1st to 5th	Marine PA Manager, Park Director, Marine Biologist	**LZ3**
F17	Staff training to PADI Advanced Level or above for staff involved in biodiversity monitoring	Some staff trained as divers, but staff turnover high	Sufficient staff trained as divers for assisting monitoring activities	1st to 5th	Marine PA Manager, Park Director	
F18	Hospitality training for staff	Staff employed as wardens yet find they are spending a large proportion of their time interacting with visitors and feel they need more training	Staff feel comfortable interacting with visitors and present professional approach to basic hospitality	1st to 5th	Marine PA Manager	
F19	Ensure that relevant staff are trained in simple accounting procedures, and use of computer	Staff feel they need further training in accounting and computer use	Training for staff involved in accounting and computer use	1st to 5th	Marine PA Manager	Also need access to computer in BAS Belize City office

F. Administration Management Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Staff Employment and Training						
F20	Staff training in conducting visitor surveys and biodiversity monitoring	Staff have no training in how to optimise information collection in visitor surveys	Information from visitor surveys as accurate, comprehensive as possible, and collected in an unobtrusive manner	1st to 5th	Marine PA Manager, Park Director, Marine Biologist	
F21	Staff training in and familiarisation with legislation	Staff not always fully aware of legislation they are trying to implement	Staff fully aware of legislation for protected areas and fisheries, enabling confident enforcement	1st to 5th	Marine PA Manager, Park Director	
Communications						
F22	Continue improvement of communication between HMCNM / BHNM and BAS/Belize City, greater liaison on future planning initiatives, problems etc.	Staff often feel isolated from mainland BAS structure	Better liaison between BAS Belize City and HMCNM / BHNM staff; staff feel more integrated into BAS structure by being better informed of limitations/ logistical problems that affect them;	1st to 5th	Executive Director, Marine PA Manager, Park Director	
F23	Improved communication with communities	Community liaison much improved with present Community Liaison Officer	Continued improved communications with communities	1st to 5th	Marine PA Manager, Park Director, Community Liaison Officer, Education Officer	
F24	Improved communication with tour operators and guides	Good communication with guides is still lacking	Increased opportunity for communication with tour guides through training and workshops	1st to 5th	Marine PA Manager, Park Director	
F25	Improved communication with landowners and developers of adjacent cayes	Communication, liaison and collaboration with landowners and developers of adjacent cayes could be improved	Improved communication with landowners and developers of adjacent cayes, with collaborative	1st to 5th	Executive Director, Marine PA Manager, Park Director	
F26	Continued communication and collaboration with other national and international organization active in Belize reef conservation	Ongoing communication and collaboration with other national and international organization active in Belize reef conservation	Continued communication and collaboration with other national and international organization active in Belize reef conservation	1st to 5th	Executive Director, Marine PA Manager, Park Director	
Volunteer Programme						
F27	Continue ongoing Volunteer programme	Ongoing volunteer programme at HMCNM / BHNM	Continue ongoing volunteer programme at HMCNM / BHNM	1st to 5th	Marine PA Manager, Park Director, Volunteer Coordinator	Volunteers are given support and encouragement, and integrated well into staff structure

F. Administration Management Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Issues and Concerns – Emergency Planning						
F28	Review hurricane plan for HMCNM / BHNM, and update if necessary	Hurricane Plan exists, but may need updating	Updated Hurricane Plan for HMCNM / BHNM	1st to 5th	Executive Director, Marine PA Manager, Park Director	
F29	Ensure that all staff are aware of hurricane procedures before start of each hurricane season	BAS hurricane procedures exist	All staff are aware of hurricane procedures before start of hurricane season	1st to 5th	Marine PA Manager, Park Director,	
F30	Develop emergency plan in liaison with Port Authority, DoE and Dept. of Geology and Petroleum in preparedness for potential shipwrecks / oil spills on Atoll	No emergency plan currently in place for potential shipwrecks and associated impacts	Emergency plan developed and in place, with necessary equipment available for mitigating effects of shipwrecks / oil spills	1st year	Executive Director, Marine PA Manager, Park Director	
F31	Ensure all staff trained in use of oxygen kit	When surveyed, none of the staff felt they had sufficient training to use the oxygen kit	All staff trained in use of oxygen kit	1st to 5th	Marine PA Manager, Park Director, Trainer	
F32	Ensure all staff have basic first aid training	High staff turnover, so not all staff are fully trained	All staff have basic first aid training	1st to 5th	Marine PA Manager, Park Director, Red Cross Trainer	Root problem is lack of motivation among staff leading to high staff turnover
F33	Ensure upkeep of all emergency and safety equipment	Staff felt there was not sufficient prioritization in ensuring safety equipment was working and up to date	All equipment well maintained and ready for use	1st to 5th	Marine PA Manager, Park Director, Park Staff	
F34	Assess safety issues of Half Moon Caye and develop plan to reduce threats	Staff feel that safety issues are not adequately addressed	Safety issues adequately addressed	1st year	Executive Director, Marine PA Manager, Park Director	Increased threat of hold-ups with increased daily takings at Half Moon Caye. Fishing boats have been held up by pirate skiffs
F35	Reassess liability issues within HMCNM / BHNM on an annual basis and provide feedback into development of annual workplan	Ongoing	Up-to-date knowledge of liability issues, with feedback into annual workplan	1st to 5th	Marine PA Manager, Park Director,	Including boat insurance issues, staff diving , visitor issues, Observation Tower, evacuation procedures, etc.
Marketing						
F36	Investigate ways of attracting more international visitors - and implementation	International visitation steadily increasing	Continue steady increase of international visitors, and market more widely	1st to 5th	Executive Director, Marine PA Manager, Publicity Officer?	
F37	Continue positive liaison with Island Expeditions	Ongoing use of caye by Island Expeditions, with some infrastructure development	Continued use of caye by Island Expeditions, with some infrastructure development	1st to 5th	Executive Director, Marine PA Manager, Parks Director	Continued good relations between Island Expedition and BAS

F. Administration Management Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Marketing						
F38	Liaison with international tour operators to promote HMCNM / BHNM	Place more emphasis on promoting HMCNM / BHNM through direct liaison with international tour operators	Increase tourism by promoting HMCNM / BHNM through direct liaison with international tour operators	1st to 5th	Executive Director, Marine PA Manager, Publicity Officer?	
F39	Liaison with BTIA/BTB to promote HMCNM / BHNM	Increase exposure of HMCNM / BHNM through BTB / BTIA	Increase tourism through increased exposure of HMCNM / BHNM through BTB / BTIA	1st to 5th	Executive Director, Marine PA Manager	
F40	Liaison with hotels and tour companies within Belize to promote HMCNM / BHNM	Place more emphasis on promoting HMCNM / BHNM through liaison with hotels and tour operators	Increase tourism by promoting HMCNM / BHNM through liaison with hotels and tour operators	1st to 5th	Executive Director, Marine PA Manager, Publicity Officer?	
F41	Actively market research opportunities to Universities and research institutions both nationally and internationally	Little marketing of research opportunities open to national and international research institutions	Marketing of research opportunities open to national and international research institutions	1st to 5th	Executive Director, Marine PA Manager, Marine Biologist	Focused on priority areas of research
Monitoring						
F42	Annual review of measures of success	No full review system at present in place for success of management strategies	1 week full review of measures of success of strategies and implementation prior to developing annual work plan	1st to 5th	Executive Director, Marine PA Manager, Park Director, Marine Biologist, Community Liaison Officer	
F43	Annual evaluation of operational plan	Review of current operational plan before developing new operational plan	Develop new operational plan with input on successes/failures of old workplan	1st to 5th	Executive Director, Marine PA Manager, Park Director, Marine Biologist, Community Liaison Officer	
F44	Annual review of education activities	Review of education activities over the past year before developing new operational plan	Develop new operational plan with input on successes/failures of education activities in old workplan	1st to 5th	Executive Director, Marine PA Manager, Park Director, Education Officer, Community Liaison Officer	
F45	Annual review of community participation activities	Review of community participation activities over the past year before developing new operational plan	Develop new operational plan with input on successes/failures of community participation activities in old workplan	1st to 5th	Executive Director, Marine PA Manager, Park Director, Education Officer, Community Liaison Officer, Marine Biologist	

F. Administration Management Programme						
Management Actions		**Present Status**	**Desired Status**	**Year**	**People**	**Limitations/Requirements**
Monitoring						
F46	Re-evaluate management plan after 2½ years	No re-evaluation of management plan currently takes place	Update information in all sections of Management Plan - including Environmental Assessment	3rd year	Executive Director, Marine PA Manager, Park Director, Marine Biologist, Education Officer, Community Liaison Officer	
F47	Re-evaluate management plan after 5 years	No standardised re-evaluation of management plan currently takes place	Update information in all sections of Management Plan - including Environmental Assessment	5th year	Executive Director, Marine PA Manager, Park Director, Marine Biologist, Education Officer, Community Liaison Officer	

4.5.1 Management Policies

Belize Audubon Society has a number of standard policies in place to assist management effectiveness, contained within the BAS Policy and Operations Manual (BAS, 2003). 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.

There are also other policies specific to staff at Half Moon Caye / Blue Hole Natural Monuments (Pott, pers. com.).

- Divers must be certified by a recognized certification body and BAS covers basic dive insurance for all divers under BAS' employ. Also an emergency oxygen kit is available while dive work is being conducted

- A standard operating procedure for the Marine Protected Areas Programme is to "Initiate evacuation procedure and evacuate all staff once a tropical depression enters within the grind line longitude 75^{o}West and is below latitude 20^{o}North. This is done as a precautionary measure.

- A first aid kit is maintained at the Park at all times, and at least one staff member is fully trained in First Aid and CPR. We also have one Member of staff trained in search and rescue at Sea to be done in conjunction with National Search and Rescue coordinating body

4.6 Management Actions

Management action matrices have been combined within the six Management Programmes, for continuity. An annual workplan is developed by the protected area manager incorporating appropriate activities outlined under the framework of the management plan, and additional activities highlighted during the annual monitoring and evaluation process (Table 59: the workplan for 2006/2007).

Management Actions - Workplan

Table 59: DRAFT WORKPLAN FOR HMCNM, AND BHNM - JANUARY TO DECEMBER 2006/7

Goal: To conserve in perpetuity the globally significant biodiversity on LHRA, in order to sustain multiple uses including tourism, fishing, research education and public appreciation.

ACTIVITIES	TASKS	JAN	FEB	MA	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Staff Responsible
ADMINISTRATION/MANAGEMENT														
Develop Annual Operational Plans														
	Complete operational plans for HMCNM & BHNM	■												MPAC
	Develop work schedules for staff	■												PD/MPAC
	Prepare following year's workplan								■	■				MPAC
	Prepare annual budget								■	■				MPAC
	Formulate a socio-economic map framework of buffer communities									■	■	■	■	MPAC/AED
Through the CAP process and utilizing the CPA														
	Gather information for development of Mgmt Plans	■	■	■	■	■	■							HMC Staff
	Formulate a DRAFT comprehensive long-term management plan for Blue Hole National Monument and revise the management plan for Half Moon Caye Natural Monument					■	■	■	■	■	■			MPAC/MB
	Develop a draft business/ sustainability plan for HMC & BHNM						■	■	■	■	■	■	■	
	Develop a master plan for HMC & BH						■	■	■	■	■	■	■	
	Refine specific objectives and responsibilities of Staff	■												MPAC
	Schedule and implement training activities for staff and volunteers/interns		■	■										MPAC
	Purchase and provide additional equipment to HMCNM	■	■	■	■	■	■	■	■	■	■	■	■	MPAC
	Schedule and facilitate community meetings			■			■			■			■	MPAC/MB/PD
	Liaise with Forestry and Fisheries Department concerning procedures in Policing of the reserves		■			■			■			■		MPAC

ACTIVITIES	TASKS	JAN	FEB	MA	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Staff Responsible
ADMINISTRATION/MANAGEMENT														
Through the CAP process and utilizing the CPA														
	Expand field/program staff to include additional Wardens													MPAC
	Develop concepts and proposals with AED for projects for HMC													MPAC/AED
Establish and maintain relationships with academic institutions														
	Draft and formalize MOUs with Fisheries Department and University of Belize													
	Formalize MOU with BFCA													MPAC/AED
Maintain reporting according to WHS guidelines														
	Write and submit reports to UNESCO according to WHS standards													MPAC
Participate in decision making through various committees														
	Attend various committee meetings with relevant organizations													MPAC/MB
Collaborate with Stakeholders														
	Schedule and facilitate stakeholders meeting													MPAC
To produce regular progress reports and evaluations and to maintain a system for regularizing reporting														
	Write monthly progress reports													MPAC
	Analyse research and monitoring data													MB
	Write monthly research reports													MB
	Write monthly progress reports													
	Conduct annual staff evaluations													MPAC
	Attend Coordinators Meeting													
	Attend Park Directors Meeting													

ACTIVITIES	TASKS	JAN	FEB	MA	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Staff Responsible
INFRASTRUCTURE & RECREATION														
To Improve and maintain the visitor experience at HMC														
Maintain the facilities at HMCNM														
	Maintain the Bird Trail													
	Maintain the Campsite and trails													
	Maintain Gift Shop													
	Maintain visitor and staff pier													
	Maintain staff house and facilities													
	Maintain Dive Shop/Store Room													MPAC
	Purchase equipment for tourism rental *UNEP													
	Maintain Visitor/interpretive center													
Upgrade existing infrastructure and construct new infrastructure to improve on the facilities and visitor experience at HMC														
	Upgrading of visitors pier													
	Construct eight stall bathroom/outdoor facility													
	Construction of concrete barbecue pits													
	Upgrade existing gift shop facilities													
	Upgrade the Research Building													
	Renovate the Visitor's Center													
SURVELLIANCE/ENFORCEMENT														
To enhance and maintain regular surveillance of HMC& BH and enforcement of fisheries regulations and other illegal activities contrary to that of the Parks System Act														
	Conduct regular patrols to HMC park boundaries													
	Conduct regular patrols to BHNM													
	Log all patrols													

ACTIVITIES	TASKS	JAN	FEB	MA	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Staff Responsible
RESEARCH/MONITORING														
To resume and continue the long-term research and monitoring program focused on collecting ecological and socio-economic data needed for management														
Fishers Survey														
	Continue to conduct the Fishers Survey and add to database	■	■	■	■	■	■	■	■	■	■	■	■	
	Continue collecting data on catch per unit effort (cpue)	■	■	■	■	■	■	■	■	■	■	■	■	
Determine the Carrying Capacity of HMCNM&BHNM														
	Determine carrying capacity/LAC framework		■	■	■	■								MPAC/MB
	Initiate a carrying capacity study			■	■	■	■	■	■	■	■	■	■	
	Formalize Carrying Capacity(intuitive) numbers for HMC & BH		■	■										PD/MPAC
Execute and strengthen Research Protocols														
	Initiate mangrove surveys	■	■			■				■				MB/RA
	Initiate seagrass monitoring	■	■			■				■				MB/RA
	Initiate reef fish surveys	■	■			■				■				MB/RA
	Initiate coral reef surveys	■	■			■				■				MB/RA
	Initiate sponge assessments and monitoring			■	■			■	■	■				MB/RA
	Initiate and conduct turtle assessments and monitoring		■	■										MB/RA
	Conduct SPAG monitoring *(COMPACT)	■	■	■	■	■	■						■	HMC staff
	Initiate vegetation survey	■	■					■						HMC staff
	Continue conch, lobster and finfish survey		■	■	■	■	■			■	■			MB/RA
	Conduct regular bird monitoring/counts	■	■		■			■			■		■	MB/RA
	Select water quality monitoring sites and start collecting and analyzing samples	■	■	■	■	■	■	■	■	■	■	■	■	MB/RA
Establish social and economic surveys			■											
	Draft surveys to gather data on improving visitors' experience		■											HMC staff
	Conduct surveys			■			■			■			■	

ACTIVITIES	TASKS	JAN	FEB	MA	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Staff Responsible
EDUCATION/OUTREACH														
Engage Tertiary Level institutions/stakeholder in environmental and ecological awareness programs														
	Organize and implement clean-up, birding activities for tertiary students													
	Liaise with Advocacy to schedule and conduct visits into buffer communities to give presentations													
	Conduct schedule/ stakeholder meetings and visits													
To engage fishermen in research activities and integrate them into the management of LHRA														
	Hire Fishermen/dive guides as casuals to assist in research													
CAPACITY BUILDING														
To enhance the capacity of HMC staff to effectively and efficiently manage HMC & BHNM														
	Conduct basic computer training													Wardens
	Participate in engine maintenance & repair training													HMC Staff
	Upgrade diving qualifications of staff													PD/MPAC
	Participate in disaster management training													HMC staff
	Participate in first aid training													HMC staff
	Participate in Natural Resource Management training													HMC staff
	Participate in Hospitality training													HMC staff

4.7 Monitoring and Review

Monitoring and review is essential in order to ensure that management is effective in achieving its objectives. This can be achieved through measurement of success:

- Measurement of Success:
    - the measurement of success of in implementing the management actions
    - the measurement of success of the conservation strategies in addressing the threats.

Two matrices are used to facilitate this process:

- the Measures of Success of Implementation (whether the actions have been implemented successfully)
- the Measures of Success of Status (whether the actions, following implementations, have positively altered the status of the situation - ie. Been successful).

These matrices form the basis for the annual review of the management plan, so time should be taken to complete each one fully and as accurately as possible, using data from the monitoring programme. If this is maintained on an annual basis, then should there be a change of manager, the handover should be a lot easier than has been in the past.

Included is an example of the suggested structure for both matrices (Table 60 and Table 61).

Table 60: A. Natural Resource Management Programme - Implementation

Measure of Success of Implementation

N.B. It is important to note that the numerical values ascribed to the measures of success are not scores, but indicators of the stage of implementation	1 No improvement on present status	**Comments:** Justification for Measure of Success score. Problems, concerns. Notes for inclusion in updated Management Plan
	2 Planning has started, but no implementation	
	3 Planning is completed, but no implementation	
	4 Implementation is started, but not yet completed	
	5 Implementation is completed or ongoing (continuous activities), activity has succeeded	

Management Activities		Measure of Success						**Comments:** Justification for Measure of Success score. Problems, concerns. Notes for inclusion in updated Management Plan
		Year						
	Activity	**1**	**2**	**3**	**4**	**5**	**Desired Status**	
General Biodiversity Management								
A1	Ensure boundaries of both protected areas are clearly defined, with sufficient marker buoys to deter incursions						Boundaries clearly defined by sufficient, highly visible marker buoys	
A2	Workshop with stakeholders to define Management Zones within protected areas						Management zones for both protected areas defined and finalised through workshop with stakeholders, and implemented	
A3	Develop and distribute leaflet of new management zones to boat captains (both fishing and dive boats) and other stakeholders						Full knowledge of future management zones and regulations per zone,	
A4	Develop capacity of primary stakeholders (principally fishermen) for advisory role in management of protected areas						Fishermen supportive of objectives and goals of protected area management	
A5	Continue establishing a working relationship with fishing stakeholders, based on stakeholder awareness and participation						Communities work in collaboration with BAS towards effective, participatory management of the marine pas	

Table 61: A. Natural Resource Management Programme - 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 (2004)	Status (2008)	Status (2009)	Status (2010)	Status (2011)	Status (2012)	Desired Status
	Activity							
General Biodiversity Management								
A1	Ensure boundaries of both protected areas are clearly defined, with sufficient marker buoys to deter incursions	Boundaries have been redefined several times in SIs, leading to uncertainties over actual location of boundaries, especially in Ben's Bluff area						Boundaries clearly defined by sufficient, highly visible marker buoys
A2	Workshop with stakeholders to define Management Zones within protected areas	Present Management Zones are not implemented and contradict use						Management zones for both protected areas defined and finalised through workshop with stakeholders, and implemented
A3	Develop and distribute leaflet of new management zones to boat captains (both fishing and dive boats) and other stakeholders	LAC members have a TOR, but feel they have no clearly defined role or task						Full knowledge of future management zones and regulations per zone,
A4	Develop capacity of primary stakeholders (principally fishermen) for advisory role in management of protected areas	Communities don't see the environmental benefits of CBWS						Fishermen supportive of objectives and goals of protected area management

4.8 Timeline

Activities within the annual workplan are scheduled using a timeline, against which implementation effectiveness can be measured. This ensures an orderly and planned implementation of activities throughout the year (Table 62). This workplan is developed by the Park Manager and Marine Protected Area Coordinator at the end of each year.

This workplan also enables Belize Audubon Society to budget the outlay required for the coming year, against activities the Society would like to achieve.

Table 62: Marine Protected Areas Programme Workplan

Objectives	Activity/Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Responsibility
ADMINISTRATION/Management														
Enhance internal and external reporting efficiency	Identify possible solutions to improving project financial report process.	■	■											MPAM/ED/FM
To provide logistic support to HMCNM staff to facilitate the implementation of Management and work plans.	Procure essential equipment and supplies.	■	■	■	■	■	■	■	■	■	■	■	■	MPAM
	Liaise with volunteer coordinator to enlist support of volunteers to fulfill work tasks.	■	■	■	■	■	■	■	■	■	■	■	■	MPAM\VC
	Contract casual labor to assist with labor tasks.		■	■			■	■		■		■	■	MPAM
	Prepare monthly reports and conduct periodic staff evaluations.	■	■	■	■	■	■	■	■	■	■	■	■	MPAM
To fulfill reporting obligations to international agencies and national co-managers.	Write and submit reports to UNESCO according to WHS standards.						■						■	MPAM
	Liaise with Forestry Dept. and provide periodic reports.			■			■			■			■	MPAM
To initiate activities with a view to financial sustainability.	Collaborate with Gift manager in identifying and developing improved products for HMC Gift shop.	■	■	■	■	■	■	■	■	■	■	■	■	MPAM\PD
	Liaise with current/potential income generating initiatives to pursue alternative revenue generation.	■			■					■				MPAM/ED
	Pursue opportunities to develop business plan for HMCNM and BHNM.	■	■	■	■	■	■	■	■	■	■	■	■	
		■	■	■	■	■	■	■	■	■	■	■	■	MPAM

Objectives	Activity/Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Responsibility
ADMINISTRATION/MANAGEMENT														
Build operational and management capacity	Identify suitable boat handling and maintenance training opportunities for staff.		■				■	■	■	■				MPAM
INFRASTRUCTURE DEVELOPMENT/MAINTENANCE														
Upgrade park infrastructure	Obtain necessary permits from Port and Forestry Dept and sourcing funding.	■	■											MPAM
	Construct new bathroom facilities.						■	■	■	■	■	■		PD/W
	Construct new visitor pier.			■	■	■	■	■	■					MPAM\Co-MPAM\PD
	Identify and hire contractor	■	■											
	Identify source of financing for power system				■	■	■	■	■					MPAM\ED
To maintain park infrastructure.	Maintain HMC infrastructure including trails, campsite, birdwatch tower, gift shop, staff housing, picnic facilities, visitor center, boats and visitor bathroom facilities.	■	■	■	■	■	■	■	■	■	■	■	■	MPAM\FD
	Develop and implement maintenance regime for moorings and marker buoys.	■		■			■			■			■	MPAM\PD\MB

Objectives	Activity/Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Responsibility
EDUCATION AND OUTREACH														
Engage fisher folks in management activities	Train fisher-folk as tour guides.[1]													MPAM
Demonstrate alternative resource use and livelihoods.	Conduct trip with stakeholders to demonstration-site for fisheries management.													MPAM\CLO
	Facilitate networking of fishers with tour operator and other initiative													MPAM\CLO
Increase awareness of the MPA role in support fisheries, biodiversity and recreational services.	Engage Live-aboards and other visitor groups in educational talks, presentations and guide terrestrial and under water guided tours													PD\W
	Prepare periodic pieces for Newsletter on activities within the Marine programme.													MPAM\EM
	Complete refurbishing Visitor Center													MB-EdM
	Conduct school education programmes targeting stakeholder communities													MPAM-MB-EdM
	Conduct marine protected areas importance education sessions during patrol encounters with fishers and visitors.													

ENFORCEMENT														
To streamline enforcement activities.	Liaise with Forestry and Fisheries Department concerning procedures in enforcement of the reserves.													MPAM
	Conduct patrols in priority threat areas.													PD\W
	Collect data on users and boats													

Objectives	Activity/Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Responsibility
ENFORCEMENT														
	Liaise with BN Coast Guard to build BAS capacity in seamanship, search and rescue. Forestry and Fisheries Department concerning procedures in enforcement of the reserves.						■			■				

RESEARCH AND MONITORING

Collect data for short term and long term management action	Implement SMP monitoring and commercial species monitoring.	■	■	■	■	■	■	■	■	■	■	■	■	MB
	Train fisher-folk for participation in commercial species monitoring	■	■	■			■							MPAM\MB
	Conduct SPAG monitoring	■	■	■			■							MPAM\MB
	Re-establish data collection for visitor use.	■	■	■	■	■	■	■	■	■	■	■	■	MB
	Partner with organizations to fill information gaps	■	■	■	■	■	■	■	■	■	■	■	■	MPAM\MB
	Liaise with Cooperatives to access resource extraction data for LHR	■	■	■	■	■	■	■	■	■	■	■	■	
	Initiate seagrass monitoring in collaboration with Seagrassnet	■	■											
	Initiate mangrove monitoring in collaboration with MBRS/Fisheries Dept.		■	■			■	■						

Objectives	Activity/Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Responsibility
ADVOCACY														
Improve stakeholder participation in management of LHR.	Revive LHR advisory committee meetings to discuss management issues.													MPAM\AM
Lobby for improve legislation for commercial species exploitation.	Attend FAB, CZAC and other meetings.													MPAM\AM
	Convey information in bi-annual seminars regarding fisheries and other biodiversity monitoring data to fishers and other stakeholders to reinforce need to improve management of fisheries.													MPAM\AM

Half Moon Caye/Blue Hole Natural Monument

Table 63: Implementation Plan

Activity	Objectives	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Resources	Possible Constraints
1. Monitoring Program															
Catch and effort	▪ Document the quantity of commercial fish extracted from the Park.													Entire Staff Volunteers	Fishermen cooperation. Availability of personnel and resources (fuel).
Birds survey	▪ Estimate the number of booby birds present at a given time. ▪ Document a species list ▪ Document migratory from foraging. ▪ Form a database that can be used for developing recommendation to future land developments.													Entire Staff Volunteers	Availability of personnel involved. Binoculars
Lobster	▪ To note population changes, over time, of the protected area against the harvested area. ▪ Collect data that would be used to improve management of the Reserve. ▪ Gather data that is comparable nationally and regionally													Entire Staff Volunteers	Availability of resources and personnel. Weather Conditions

Activity	Objectives	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Resources	Possible Constraints
1. Monitoring Program															
Conch	▪ To note population changes, over time, of the protected area against the harvested area. ▪ Collect data that would be used to improve management of the Reserve. ▪ Gather data that is comparable nationally and regionally.													Entire Staff Volunteers	Availability of resources and personnel. Weather Condition
Reef Fish and Coral Reef Surveys	▪ To record changes in number and species of the fish population and Coral reef communities along with recruitment population.													Entire Staff Volunteers	Availability of resources and personnel.
Mangrove and Seagrass Surveys	▪ To determine the health of mangrove and sea grass communities. ▪ To determined their densities and productivity of these communities.													Entire Staff and Volunteers	Availability of equipment and personnel
Spawning Aggregation Surveys	▪ To record changes of SPAG populations and compare data with previous years.													Entire Staff and volunteers	Availability of fuel, dive Tanks and funding.

Activity	Objectives	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Resources	Possible Constraints
1. Monitoring Program															
Turtle Monitoring Program	▪ Research the number of female turtles nesting in the N/M ▪ Identify the species and if tagged protect the nest to maximize the number of successful hatchlings.													Entire Staff Local and International Volunteers	Availability of personnel and personnel training. Funds for implementation of program that requires hosting volunteers. Fuel and traveling equipment.
2. Surveillance and Enforcement															
Surveillance and Enforcement	▪ Enforcement of fisheries regulations and other illegal activities both in the National Park. ▪ Enforcement of HMC & BH Statutory Instrument.													Entire staff	Availability of resources. Availability of personnel. Availability of fuel
3. Short Term Training															
Training for work activities	▪ Enhance the staff knowledge and capacity to perform their duties. ▪ To improve the quality of work produced at the Reserve.													Entire staff	Constraint financial resources. Availability of courses.
Basic computer training	▪ To get staff members acquainted with the various computer programs (word, excel) so as to develop their reporting and presentations skills														

Activity	Objectives	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Resources	Possible Constraints
3. Short Term Training															
Outboard engine maintenance and repair training	▪ To enhance the capacity of the rangers to dealt with and solve engine problems so as to ensure the longevity of the reserve engines														
4. Environmental/ Ecological Awareness Program															
	▪ Develop lectures featuring HMC & BH biological, historical and geological characteristics ▪ Field exercise will be designed for children in order to increase their awareness of the environment and apply knowledge gained at school.													Entire Staff Volunteers	Schedule of both HMC and the Schools not coinciding. Boats and fuel. Visual equipments Funding
5. Improve and upgrade infrastructure															
	▪ Enhance the island's capacity to deal with liquid waste ▪ Construction of barbecue pits ▪ Develop eco-tour facilities ▪ Upgrading of pier ▪ Enhance visitors accommodations														Funding
6. Internship Program															
	▪ Increase participant's awareness of both marine													Entire Staff	Funds for hosting of students.

	and terrestrial environment and apply any related knowledge gained at their institution. ▪ Provide hands-on experience on biological and physical data collection carried out at the NM.													Volunteers	Availability of materials for training/ field work.
7. Buoying Project															
	▪ Properly demarcate the boundaries of the NM. ▪ Establish proper mooring buoys within snorkel and dive areas of NP/MR.													Entire Staff Any outside help	Availability of funding and man power
8. Report Writing															
	▪ Report on progress and constraints within the reserve													Entire Staff MPAM	Availability of Resources Technical know how
9. Funding															
	▪ Seek funding opportunities to carry out activities in the implementation plan													Park Director MPAM	Time Constraints

4.9 Financing

BAS faces ongoing challenges in securing the necessary finances to continue and further develop its management of the protected areas under its custodianship. As with most participants in the conservation process in Belize, BAS has developed the management of the parks under its mandate, its staff and as an institution, largely upon external grants. 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.

In 2005, the protected area generated a revenue of Bz$448,360 – but the budget required for 2006 (Table 64) exceeds this, being Bz$580,947. Currently, therefore, revenue generation is not meeting expected budgeted expenditures. The shortfall for 2006 is met by four funding bodies – Oak Foundation, Protected Areas Conservation Trust, GEF/UNDP (COMPACT) and AVINA.

Table 64: Budget - Half Moon Caye / Blue Hole Natural Monuments

Budget (draft)

EXPENSE UNIT	Budget Total	*Total Amount Allocation by Donors* Unrestricted Funds	Oak Funds	GEF/SGP COMPACT Funds	PACT	AVINA
Salaries						
PAM Marine	35,349.00	5,349.00	30,000.00			
Park Director	42,840.00	21,000.00	21,840.00			
Assistant Park Director	18,907.00	18,907.00				
Marine Biologist	23,109.00	17,109.00				6,000.00
Boat Captain	12,480.00	541.00	6,919.00	5,020.00		2,000.00
Wardens(2)	20,575.00	20,575.00				
Social Security	6,125.00	6,125.00				
Insurance	1,108.56	1,109.00				
Severance	5,000.00	5,000.00				
Program Management	$ -					
Total Salaries	**165,494.00**	**95,715.00**	**58,759.00**	**5,020.00**		**8,000.00**
Transportation						
Staff travel	4,600.00	3,600.00		1,000.00		
Per diem/Accommodations	3,000.00	1,000.00	2,000.00			
Freight/Rental	500.00	500.00				
Boat Fuel	48,000.00	37,000.00	8,000.00	3,000.00		
Vehicle/Acc.	75,000.00					75,000.00
Boat license/Insurance	500.00	500.00				
Overseas Travel	4,500.00			4,500.00		
Program Management						
Total Transportation	**136,100.00**	**42,600.00**	**10,000.00**	**8,500.00**		**75,000.00**

BELIZE AUDUBON SOCIETY - Half Moon Caye / Blue Hole Natural Monuments						
EXPENSE UNIT	Budget Total	Unrestricted Funds	Oak Funds	GEF/SGP COMPACT Funds	PACT	AVINA
Office Expense						
Radio communications	1,500.00	1,500.00				
Professional fees/Audit	1,000.00	1,000.00				
Telephone/fax	3,000.00	3,000.00				
Postage	300.00	300.00				
Office Supplies	600.00	600.00				
Film and slides	1,000.00	1,000.00				
Sanitation	4,000.00	4,000.00				
Sundries	2,500.00	2,500.00				
Food Supplies	14,400.00	14,400.00				
Miscellaneous	1,200.00	1,200.00				
Utilities	3,000.00	3,000.00				
Promotional Materials	3,000.00	3,000.00				
Total Office Expense	**35,500.00**	**35,500.00**				
Maintenance & Upgrade						
Hotel Tax	25.00	25.00				
Buildings/Structures	20,000.00	10,000.00			10,000.00	
Trails	5,000.00	5,000.00				
Campsites	4,000.00	4,000.00				
Equipment/repair	10,000.00	5,000.00			5,000.00	
Docking Fees	3,300.00	3,300.00				
Boats	14,000.00	10,000		4,000.00		
Casual Labour	5,000.00	5,000.00				
Dive Equipment	2,000.00	500.00		1,500.00		
Total Maint./Upgrade	**63,325.00**	**42,825.00**		**5,500.00**	**15,000.00**	
BELIZE AUDUBON SOCIETY - Half Moon Caye / Blue Hole Natural Monuments						

EXPENSE UNIT	Budget Total	Unrestricted Funds	Oak Funds	GEF/SGP COMPACT Funds	PACT	AVINA
Research						
Monitoring of IRM Program	23,000.00			20,000.00	3,000.00	
Total Research	**23,000.00**			**20,000.00**	**3,000.00**	
Training						
Training/Staff Development	17,800.00	3,000.00			8,800.00	6,000.00
Total Training	**17,800.00**	**3,000.00**			**8,800.00**	**6,000.00**
Education & Advocacy						
Volunteer/Internship	4,000.00	4,000.00				
Total Ed & Advocacy	**4,000.00**	**4,000.00**				
Equipment						
Computers	3,000.00		3,000.00			
Dive Equipment	2,000.00	2,000.00				
Marker Buoys & Anchor	29,600.00				29,600.00	
Mooring Buoys	4,000.00				4,000.00	
Kayaks	4,000.00				4,000.00	
Monitoring Equipment	8,000.00			3,000.00	5,000.00	
Total Equipment	**50,600.00**	**2,000.00**	**3,000.00**	**3,000.00**	**42,600.00**	

BELIZE AUDUBON SOCIETY - Half Moon Caye / Blue Hole Natural Monuments						
EXPENSE UNIT	Budget Total	Unrestricted Funds	Oak Funds	GEF/SGP COMPACT Funds	PACT	AVINA
Others						
Uniforms	2,500.00	2,500.00				
Vacation Grant	10,628.00	10,627.81				
Consultancy	40,000.00					40,000.00
Emergency funds	3,000.00	3,000.00				
Outreach	29,000.00	1,000.00	11,000.00	17,000.00		
Total Others	**85,128.00**	**17,128.00**	**11,000.00**	**17,000.00**		**40,000.00**
GRAND TOTAL	**580,947.00**	**242,768.00**	**82,759.00**	**53,520.00**	**54,400.00**	**129,000.00**

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