Photographs: Glover's Atoll Resort / Dan Clark

Management Plan

Glover's Reef Marine Reserve World Heritage Site

2008 – 2013
DRAFT

Wildtracks /
Wildlife Conservation Society 2007

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1. Introduction

Background and Context

The Atlantic coast of Mesoamerica has the second longest barrier reef in the World, stretching from the Yucatan to the south of Belize. The Mesoamerican Barrier Reef is 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, Kramer and Kramer, 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).

Glover's Reef Atoll, an oval-shaped, 32 km long and 12 km wide, and the southernmost of Belize's three offshore atolls, is considered the prototypic atoll of the Caribbean. It is not only the best developed biologically, but also possesses the greatest diversity of reef types (Dahl et. al. 1974). Its deep lagoon is studded with about 850 patch reefs and pinnacles rising to the surface. Six sand cayes lie on the reef crest along its southeastern edge. The peripheral reef of the Atoll is broken in only three places by deep channels, allowing for the tidal flow of water between the lagoon and the open sea. A large grouper spawning site is located at the northeastern end of the Atoll.

The approximately 86,653 acre Glover's Reef Marine Reserve was established as a protected area in 1993 (SI 38 of 1993) under the Fisheries Act (Ch. 210), and encompasses the marine area of the Atoll, managed under the Fisheries Department of the Ministry of Agriculture and Fisheries. It is considered one of the highest priority areas in the Mesoamerican Caribbean Reef system, providing recruitment, nursery, feeding and dwelling areas for lobster, conch and finfish, and providing unique fish habitat in the interior lagoon (WWF, 2002). It is an important component of not only Belize's national marine protected areas system, but also at a regional and international level, being designated by UNESCO in 1996 as one of seven protected areas that together form the Belize Barrier Reef Reserve System – World Heritage Site.

The Glover's Reef Marine Reserve Statutory Instrument was updated in 2001 (SI 137 of 2001), and currently designates five different management zones: the General Use Zone, a Conservation Zone, a Wilderness Zone and a Seasonal Closure Zone, with each zone having regulations defining activities that can and can't be done. The protected area is considered to be within IUCN category IV – a Habitat/Species Management Area, with active management targeted at conservation through management intervention (IUCN, 1994).

Purpose and Scope of Plan

The management of Glover's Reef Marine Reserve is guided by its categorization as a Marine Reserve (under the Fisheries Act, 1983, amended 1987), being set aside to:

> *"afford special protection to the aquatic flora and fauna …and to protect and preserve the natural breeding grounds and habitats of aquatic life".*

Its designation as part of Belize's World Heritage Site (1996) also brings certain criteria to be taken into consideration during the development of the management plan.

Since the development of the first management plan in 1988, many legislative changes have taken place, including the declaration of the area as a Marine Reserve, the passing of the zoning regulations, and the subsequent amendments to these regulations. The uses of the protected area and the status of the resources have also changed. Furthermore, the knowledge base has improved substantially from the many years of research and data collection carried out since 1988. The programmes in this Plan therefore attempt to address the current status of the Atoll, and to reflect a more participatory approach to management.

The first draft of this Management Plan was prepared in 2003 following guidelines recommended by the CZM programme (CZMP 1996), and then updated in this document to fit within the framework required by the National Protected Area Policy and System Plan (NPAPSP, 2006). It includes general information on the physical and biological attributes of the reserve, documents the current uses and management problems, defines the goals and objectives of the marine reserve, summarises conservation planning, outlines specific management programmes, including the zoning plan, sets in place the means for measuring reserve effectiveness, and recommends an implementation schedule.

In line with both Fisheries Department and NPAPSP recommendations, this Management Plan has been prepared with the input of the various stakeholders of the Atoll through meetings with the Advisory Committee, and interviews with a wide variety of individuals, including fishermen, tourism sector, management staff and researchers, and seeks to protect the resources of the reserve while allowing economic benefit through sustainable fishing and tourism. The management programmes are based on the best available data and scientific knowledge, with the integration of conservation planning strategies, and fit within the scope of the current zoning scheme and regulations that govern the reserve.

The management plan, submitted to Fisheries Department, is designed to guide the management of the Marine Reserve through the next five years, providing a framework for both broad management activities as well as more specific research and monitoring activities. Detailed operational plans will be developed on an annual basis by the Fisheries Department, the Marine Reserve management agency, based on the framework provided by this management plan, and an annual review of implementation success will allow for adaptive management over the five year period.

2. Current Status

2.1 Location

Glover's Reef Marine Reserve is located on the most southern of the three atolls that form part of the Barrier Reef System, and lies approximately 45 kilometers east of the Belize mainland (75km southeast of Belize City) (Map 1; Fig. 1). Whilst separated from the main portion of the Belize Barrier Reef, this protected area is considered part of this important natural resource, and is one of seven protected areas included within the Belize Barrier Reef Reserve System - World Heritage Site.

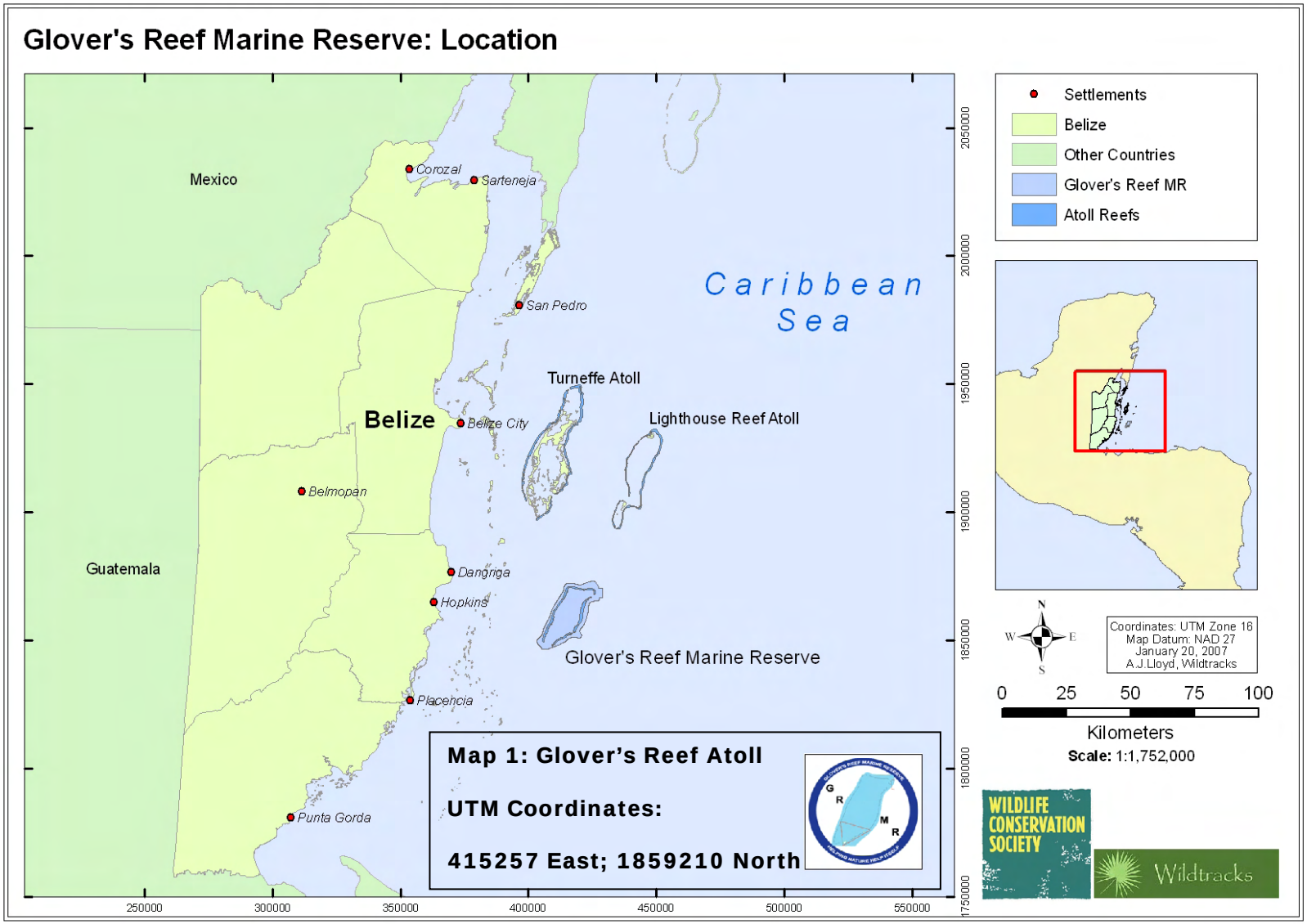
Figure 1: The three atolls of the Belize Barrier Reef (**NASA)**

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

The main stakeholders of the Atoll itself are the tourism and fishing industries, based both on the mainland, and on cayes within this and adjacent atolls. The Atoll is also visited by live-aboard dive boats.

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.

The fishing communities that impact the resources of the protected area are located primarily on the mainland, with the majority of boats originating from Sarteneja, Belize City, and Hopkins.


Glover's Reef Marine Reserve: Location
Mexico
Guatemala
Belize
Caribbean Sea
Corozal
Sarteneja
San Pedro
Belize City
Belmopan
Dangriga
Hopkins
Placencia
Punta Gorda
Turneffe Atoll
Lighthouse Reef Atoll
Glover's Reef Marine Reserve
Settlements
Belize
Other Countries
Glover's Reef MR
Atoll Reefs
Coordinates: UTM Zone 16
Map Datum: NAD 27
January 20, 2007
A.J.Lloyd, Wildtracks
0 25 50 75 100
Kilometers
Scale: 1:1,752,000
Map 1: Glover's Reef Atoll
UTM Coordinates:
415257 East; 1859210 North
250000 300000 350000 400000 450000 500000 550000
2050000 2000000 1950000 1900000 1850000 1800000 1750000
WILDLIFE CONSERVATION SOCIETY
Wildtracks

Facilities on Middle Caye, which is owned by Wildlife Conservation Society (WCS), provide a research base for scientific study of the Atoll, as well as being the location of the Fisheries Department operational headquarters for management of Glover's Reef. This partnership, between a government authority and a conservation NGO, provides the best opportunity for ensuring well-informed, science-based management of this marine protected area.

The land where the ranger station is located is leased by the Belize Fisheries Department for one dollar a year from WCS, providing a base of operations for the Fisheries Department from which to manage Glover's Reef Marine Reserve. The ranger station contains an office and residences for two rangers, a marine biologist and the reserve manager.

2.2 Regional Context

Glover's Reef Marine Reserve encompasses the marine portion of Glovers Reef Atoll, the southern-most of Belize's three atolls, and one of only four such atolls in the Western Hemisphere. It is part of the Mesoamerican 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*).

Glover's Reef is one of a serial nomination of seven sites that have been recognized as components of the Belize Barrier Reef System - World Heritage Site, as representative of the Belize Barrier Reef Reserve System, under criteria (iii), based on the classic examples of fringing, barrier and atoll reef types (Table 1).

Table 1: The Seven Protected Areas of the Belize Barrier Reef 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 south of Belize, 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 an estimated 1,420 km² of reef within its waters - 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** (the 'Cartagena Convention') 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 2).

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. Glover's Reef is rated as an ecoregional 'Highest Priority" (Kramer and Kramer, 2002), and is considered a critical component of high regional importance in the maintenance and conservation of the reef system.

The presence of the Northern Glover's Reef spawning aggregation adjacent to the Atoll is further evidence of its importance as a breeding area for commercial fin fish species - especially Nassau Grouper. A number of the cayes provide nesting sites for marine turtles, important to the survival of these marine reptiles within the region. But even on Glover's Reef Atoll, development is occurring on the cayes, reducing nesting success, 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 Glover's Reef has been affected, its relative 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 this Marine Reserve 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 2).

Table 2: International Conventions and Agreements of Relevance to Glover's Reef Marine Reserve	
Convention on Biological Diversity (Rio de Janeiro, 1992) Ratified in 1993	To conserve biological diversity to promote the sustainable use of its components, and encourage equitable sharing of benefits arising from the utilization of natural resources. ***Glover's Reef Marine Reserve provides 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. ***WCS initiatives within the stakeholder communities of Glover's Reef Marine Reserve are targeted for facilitation of sustainable economic and environmental development, with the support of Fisheries Department***
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 at Glover's Reef are shared regionally through MBRS and WCS.***
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. ***Glover's Reef provides 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. ***Glover's Reef has been accepted as one 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. ***Glover's Reef protects important feeding and nesting areas for sea turtles, including the Critically Endangered hawksbill***
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. ***Glover's Reef Atoll is one of the eastern-most locations in Belize, and therefore has a greater probability of being more affected by oceanic interactions than many other areas of coastal Belize***

2.3 National Context

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 Agriculture and Fisheries and Wildlife Conservation Society, and on community-based participation and equitable benefit from conservation efforts.

Glover's Reef Marine Reserve falls under the Fisheries Department of the Ministry of Agriculture and Fisheries, and is guided by The Fisheries Act (1948) and Fisheries Department policies. The Department is also responsible for enforcement of the no-take regulations of the marine reserve.

Also contributing to the conservation framework of Belize are a number of laws designed to protect wildlife and national heritage within Belize. The Fisheries Act, 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. 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 Glover's Reef, this is particularly important when ensuring that the impacts from development taking place on other cayes within the Glover's Reef Atoll are minimised.

Under the Ministry of Natural Resources, the Wildlife Protection Act provides protection for terrestrial wildlife and a number of marine species (West Indian Manatee, whales and dolphins), with the regulation of hunting and commercial extraction. The Protection of Mangroves regulations of 1989 provides for the protection of mangroves, with restrictions on mangrove alteration and / or clearance without permission.

The Port Authority has jurisdiction over both lighthouses at Glover's Reef, being mandated to ensure the safety of navigational channels through navigational aids (Belize Port Authority Act, revised, 2000). It also has a role in the monitoring of vessels using navigational channels and the removal of wrecks from the reef, which has recently come to the forefront, following the grounding of a cargo vessel on the eastern Lighthouse Reef Atoll reef crest.

Whilst the above are the legislative Acts most relevant to the Glover's Reef Marine Reserve, there are others - such as the Mines and Minerals Act (1989) and the Petroleum Act (1991), which regulate the exploration and extraction of all non-renewable resources, governing natural resources other than wildlife. These Acts regulate activities including dredging and prospecting.

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 3).

Table 3: Marine Protected Areas in Belize				
Protected Area	**Mgmt. / Co-mgmt**	**IUCN Category**	**SI**	**Area (Acres)**
Bacalar Chico National Park & Marine Reserve	Fisheries Dept.	IV	88 of 1996	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 and Silk Cayes Marine Reserve	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 Marine Reserve	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 Marine Reserves, including Glover's Reef, allow for general use, with some regulated extractive use. In addition, 11 spawning aggregation sites have been identified and declared under SI161 of 2003, one of these overlapping with the Glover's Reef Seasonal Closure Zone. The importance of Glover's Reef Marine Reserve, which contributes 14% towards the current total marine protected area (NPAPSP, 2005), is increased far beyond its size through the importance of the near-pristine state of the Glover's Reef Atoll.

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. A proposal from Fisheries Department for it's overall protected areas programme is currently being prepared for submission to this fund (Majil, 2007).

Caye development is regulated through the requirement for an Environmental Impact Assessment, resulting in the production of an Environmental Compliance Plan, approved and monitored by the Department of Environment.

2.3.2 Land and Sea Tenure

Under the Maritime Areas Act of 1992, Glover's Reef is included in Belize's territorial waters, as the Atoll lies within the 12 nautical mile territorial sea limit. The seabed is national land, and thus any construction in this region, such as piers, marinas, and seawalls, needs to be licensed by the Lands Department. Any mining, including beach sand mining or dredging activities, requires a license from the Geology & Petroleum Department. Belizean fishermen have fished the Atoll for many years, and have traditional rights to the fishing grounds in the area.

The six recognized cayes of the Atoll are all privately owned (Table 4), with the exception of a small southern portion of Southwest Caye II where the lighthouse is located. One of the cayes, Long Caye North, has been heavily eroded by Hurrican Mitch, which also cleared away the infrastructure and vegetation, and it is suggested that in future management plans, this should not be included in the list of cayes, unless its size increases again significantly.

Table 4: Caye Ownership

Caye	Ownership	Activity
Northeast Caye	Lomont Family	Tourism
Long Caye North	Lomont Family	Eroded by Hurr. Mitch
Long Caye - Northern	Slickrock Ltd.	Tourism
- Central	Off-the-Wall Dive Shop	Tourism
- Southern	F. Dodd	Being sold
Middle Caye	Wildlife Conservation Society	Research / Administration
Southwest Caye I	Usher Family	Tourism
Southwest Caye II	M. Feinstein	For sale
Southwest Caye II Lighthouse	Port Authority	Port Authority

As all six islands are located within the Conservation Zone of the marine reserve, the development that occurs on them needs to be compatible with the objectives of this Zone.

Figure 2: Aerial photograph of eastern Glover's Reef Atoll, including Middle Caye, Long Caye and Northeast Caye

Melanie McField, 2000 (Lighthawk Flight)

2.3.3 Evaluation of Protected Area

Global Importance

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

The Atoll is recognised for supporting extraordinarily high biological diversity and possessing the greatest range of reef types in the Caribbean Sea. The shallow protected waters of the Atoll's lagoon provide nursery and feeding habitats for at least three species of sea turtles, eight species of sharks and rays, more than twenty species of aggregating reef fish, and numerous species of coral. The benthic community of corals and sponges on the western wall of Glover's is considered among the most diverse and densely covered sites reported anywhere in the Caribbean, exhibiting 95% living cover and as many as 11 species per square meter (Gibson et. al., 2004).

The Atoll is known to protect at least ten species of international concern, recognized under the IUCN Redlist as Critically Endangered, Endangered or Vulnerable (IUCN, 2006), and possibly more.

The northeastern corner of the Atoll is the site of one of the Caribbean's largest and last remaining Nassau grouper spawning aggregations, a spectacular biological phenomenon with cultural and economic importance that is severely threatened across the Caribbean (Gibson et. al. 2004). The protection of the large grouper spawning aggregation site in the north east of the Atoll is important for the maintenance of the endangered Nassau grouper (*Epinephelus striatus*), as well as the near threatened yellowfin grouper (*Mycteroperca venenosa*) (Kramer and Kramer, 2002), and mutton snapper (*Lutjanus analis*). The endemic Belize Atoll gecko, *Phyllodactylus insularis,* has been recorded from two of the cayes within the Atoll, and may be present on the others.

National Importance

The Atoll is also of economic importance to Belize as a lobster, conch and fin-fish resource for traditional fishermen from fishing communities - particularly Sarteneja, Dangriga and Hopkins, on the mainland, and the zoning of the different marine areas has been developed to sustain the active fishing industry. Fly-fishing industries also utilise the extensive flats of the Atoll, famous for their bonefish and permit. The spur and groove formations of the outer reef structure are world-famous for their spectacular diving opportunities, and encircle a shallow lagoon that is dotted with more than 800 patch reefs. These sheltered waters benefit Belize's growing number of tourism operations based from both the cayes and the mainland, attracting snorkelers and divers, as well as providing the perfect environment for kayaking packages (Figure 3).

Figure 3: The beauty of the coral reef provides an important natural resource for the economy of Belize

Environmental Services of the Protected Areas

Other than the specific values of the protected areas, the coral reef and seagrass ecosystems present in the protected area also provides various ecosystem services (Table 5).

Table 5: Ecosystem Services of Glover's Reef Marine Reserve	
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 area itself is a no-take zones, they ensure that there are viable populations of commercial species for subsistence and commercial fishing
Cultural	Coral reefs in the protected area 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 area 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 (Figure 4). 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 248,000, of which 48% are urban dwellers (CSO, 2000 census) (Figure 5). Population densities are low, with 10 persons per sq. km., concentrated mostly within the coastal plain, Belize River 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.

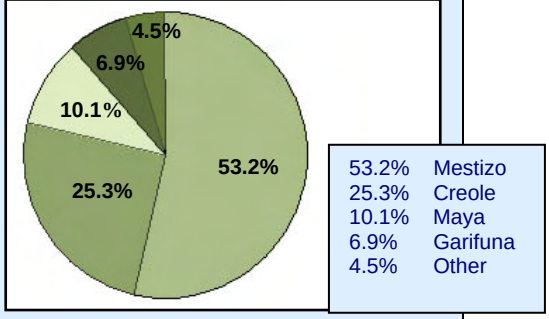


Figure 4: Ethnic Groups of Belize

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.

Whilst the economy of Belize as a whole has been based largely on agriculture, with banana, sugar and citrus (Figure 5), 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).

Figure 5: 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

The fishing sector utilizing Glover's 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 Glover's Reef fishermen originate from the Sarteneja, Dangriga and Hopkins, with a small number of fishermen from Belize City. These fishermen use hand lines for finfish (primarily the fishermen from Dangriga and Hopkins), and 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 Glover's Reef Atoll are divers, kayakers, and fly fishermen, staying on the Atoll at one of the four tourism operations based from the cayes. Figures for 2006 show that tourism income from reserve entrance fees exceeded Bz$42,800 (Figure 6; Fisheries Dept.).

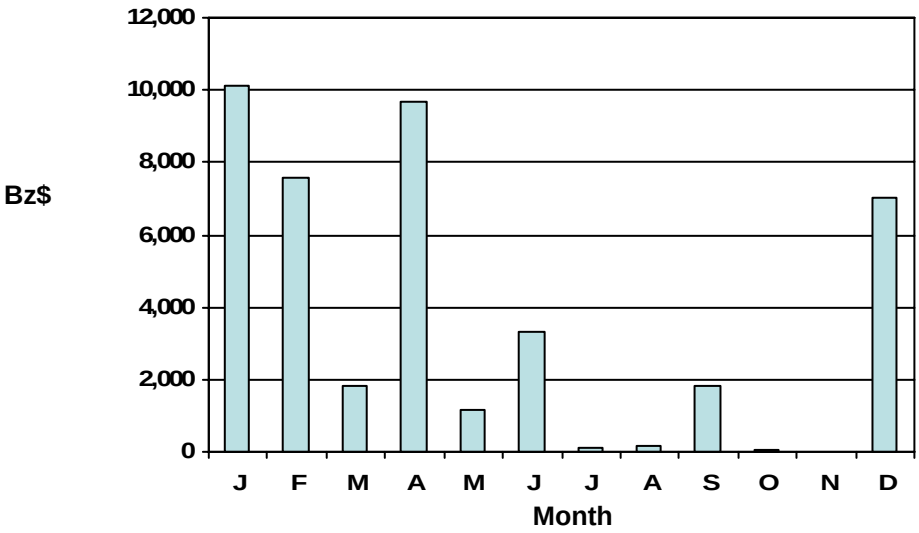


Figure 6: Income from tourism fees, 2006 (Fisheries Department 2007)

A number of communities have been highlighted as being major stakeholders in the protected area, through fishing or tourism (Table 6), and a basic stakeholder analysis identifies other stakeholder interests and impacts (Table 7). A full socio-economic assessment of stakeholder communities was completed in 2005 (Gibson et. al, 2005), covering socio-economic parameters in the stakeholder communities, as well as areas such as local values and beliefs about marine resources, and understanding of impacts.

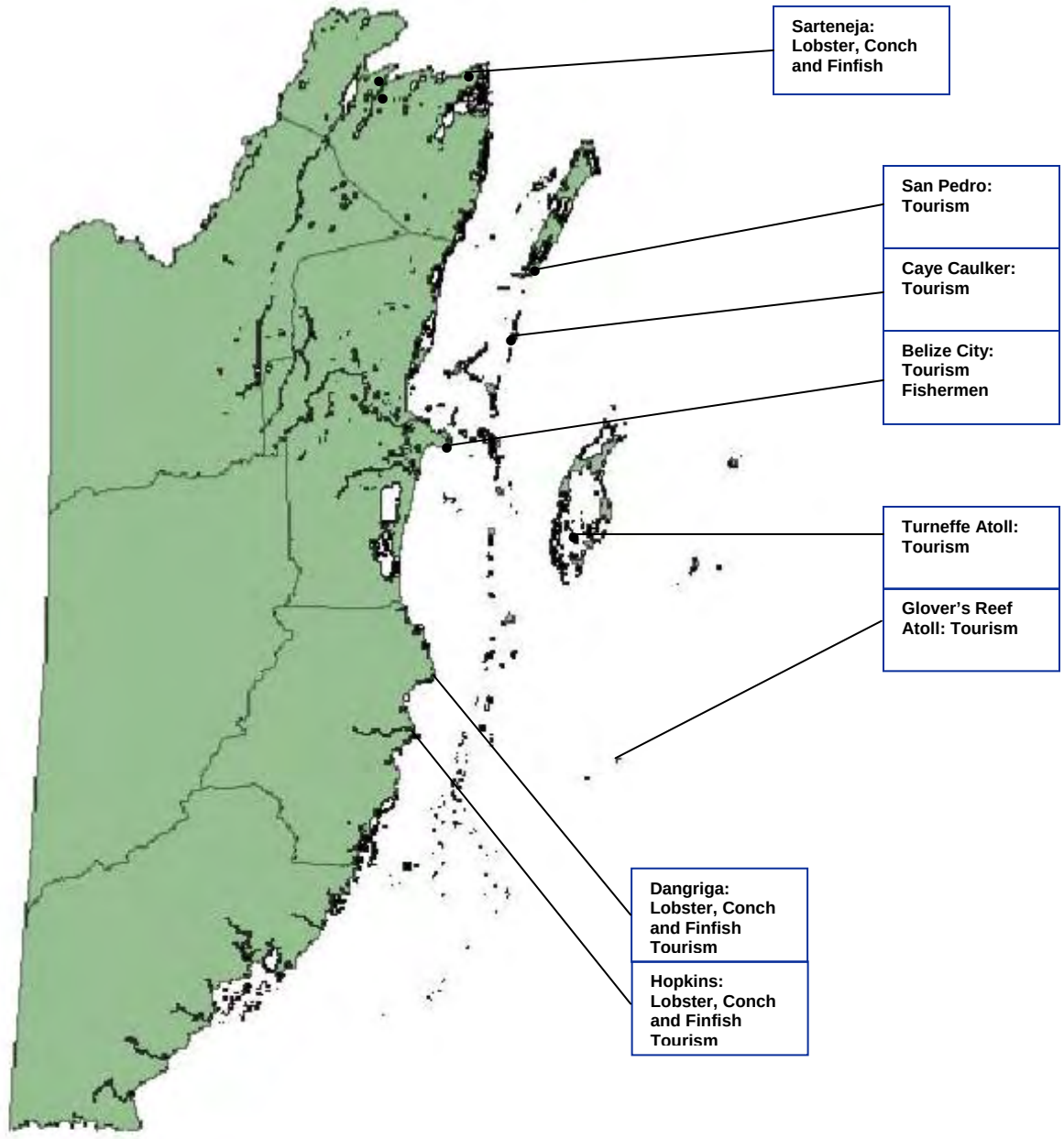
Table 6: Stakeholder Communities of Glover's Reef Marine Reserve

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. Largest number of fishermen utilizing natural resources of Glover's Reef.
Dangriga	E16 0370200 N18 1876300 (Approx. 42km ESE)	8,814**	Garifuna	Small number of fishing skiffs, focused on Glover's Reef Atoll Local tourism
Hopkins	E16 0363200 N 18 1864680 (Approx. 46km E)	1,027**	Garifuna	Small number of skiffs, focused on Glover's Reef Atoll. Tourism developments (eg. Hamanasi)
Belize City	E16 373850 N19 35160 (Approx. 76km NW)	59,400***	Multi-cultural	Main port and population centre. Tour operators and fishermen using Glover's Reef

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

Table 7: Stakeholder Analysis for Glover's Reef Marine Reserve				
Stakeholder	**Influence or Impact of Glover's Reef Marine Reserve on Stakeholder**		**Influence or Impact of Stakeholder on Glover's Reef Marine Reserve**	
Community Stakeholder Sarteneja, Dangriga, Hopkins,	• Protection of fish, lobster and conch resources within the Conservation Zone ensuring continued viability of fishery • Protection of spawning aggregation site, ensuring continued viability of fishery • Exclusion from traditional fishing areas	+ + -	• Low level of cooperation or openly antagonistic towards protected areas • Illegal fishing within the Conservation area • Illegal fishing within the SPAG area • Fishing impacts within protected areas (including damage to coral) • Anchor damage to reef	- - - - -
Tour Guides (including tour boat captains)	• Benefit from having Glover's Reef as a major venue for dive- and kayak-associated tourism • Employment in Atoll-based tourism initiatives • Income from using Glover's Reef for tourism	+ + +	• Support the conservation goals of Glover's Reef Marine Reserve • 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)	+ + + - -
Atoll-based Tourism Initiatives	• Benefit from having Glover's Reef Marine Reserve as a major venue for dive-, kayak- and fly-fishing associated tourism • Income from using Glover's Reef as a tourism destination	+ +	• Support the conservation goals of Glover's Reef Marine Reserve • Provide interpretation for visitors, facilitating overall visitor appreciation • If guides are well trained, assist with visitor management within the protected areas through in-depth briefings • If guides are poorly trained, can result in poor visitor management and increased impact on corals and associated fauna, anchor damage etc. • Potenial imapcts from pesticide / herbicide use • Potenial imapcts from nutrient runoff	+ + + - - -
Local / National Tour Operators	• Benefit from having Glover's Reef Marine Reserve as a major venue for dive- and kayak-associated tourism • Income from using Glover's Reef as a tourism destination	+ +	• Provide marketing at a national level, and send visitors to Glover's Reef, increasing sustainability • Support the conservation goals of Glover's Reef Marine Reserve • Increase the potential for exceeding the carrying capacity of the protected area	+ + -
International Tour Operators	• Benefit from havingGlover's Reef Marine Reserve 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 Glover's Reef Marine Reserve	+ +
BTIA	• Benefit from having Glover's Reef Atoll as a major tourism venue, attracting visitors to the area	+	• Providing national and international marketing of Glover's Reef Atoll • Support the conservation goals of Glover's Reef Marine Reserve	+ +
General Belize Public (excluding primary stakeholder communities)	• Maintenance of fish, lobster and conch stocks • Environmental services • Cultural and aesthetic appreciation • Increased awareness through education	+ + + +	• Support of the general public will strengthen the position of protected area • Lack of support may increase chances of dereservation	+ -

Table 7: Stakeholder Analysis for Glover's Reef Marine Reserve (cont.)				
Stakeholder	**Influence or Impact of Glover's Reef Marine Reserve on Stakeholder**		**Influence or Impact of Stakeholder on Glover's Reef Marine Reserve**	
Visitors: Tourists	• Enjoy Glover's Reef Marine Reserve as a tourism destination • Benefit from education and awareness opportunities	+ +	• Entrance fee contributes towards the goal of sustainability • Provide marketing nationally and internationally by word of mouth, if happy with level of product • Presence deters fishing (and other illegal activities) within protected area • Negatively impact marine and terrestrial environments	+ + + -
Visitors: Researchers	• Benefit from being linked to Glover's Reef Marine Reserve • Benefit from information on past research activities within protected areas • Benefit from partnership between WCS and Fisheries Department • Benefit from access to a virtually pristine reef environment	+ + + +	• 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	+ + -
Live-aboard Companies	• Benefit from protection of Glover's Reef Atoll and its value as tourist attractions	+	• Support the conservation goals of Glovers Reef Marine Reserve • 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 • Anchor damage on mooring sites	+ - - -
Tourism Resorts of Glover's Reef Atoll	• Benefit from location within Glover's Reef Marine Reserve	+	• Support the conservation goals of Glover's Reef Marine Reserve • Providing marketing of Glover's Reef Marine Reserve 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 • Beach use impacts on turtle nesting	+ + – – – – - -
Port Authority	•		• Maintain lighthouse, reducing potential for boat groundings on the reef • Poor maintenance of lighthouse may increase potential for boat groundings on the reef	+ -
Government of Belize	• Glover's Reef Marine Reserve 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 of significant foreign revenue • Provides employment opportunities in stakeholder communities • Environmental services • Provides fisheries management	+ + + + + +	• Political support (currently being strengthened through the NPAPSP) • Uncertainty of long term future commitment	+ -



Map 2: Principal Stakeholder Communities of Glover's Reef Marine Reserve
Belize Base Map: BERDS (Biodiversity and Environment Resources System)

2.4 Physical Environment of Management Area

2.4.1 Climate

Rainfall

Glover's Reef Atoll is the most southerly 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 (Figure 7; Figure 8). Rainfall data from Glover's Reef shows that rainfall averages 1750mm per annum.

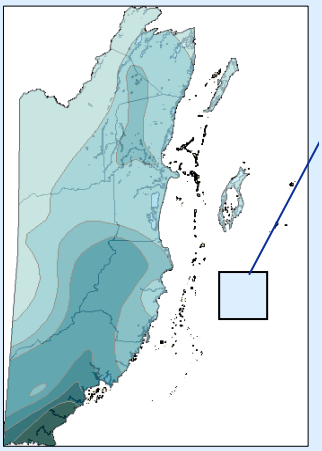
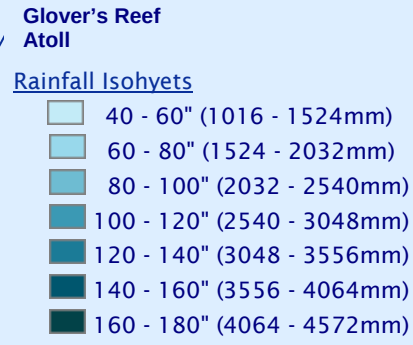


Figure 7: Rainfall belts in Belize



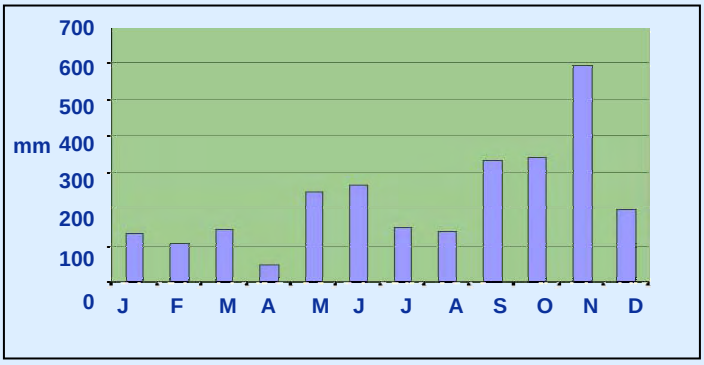


Figure 8: Rainfall

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: Fig. 7: Base Map from BERDS (Biodiversity and Environmental Resource Data System)
Fig. 8: 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 8.).

Temperature

Whilst continuous climatic data for Glover's Reef is not available, temperatures can be expected to follow the same patterns as other adjacent areas, such as Carrie Bow Cay (Tobacco Reef). Lying within the subtropics, annual temperatures on Carrie Bow Cay, slightly further west, 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 9; Table 8; Caribbean Coral Reef Ecosystems Program, 2005)

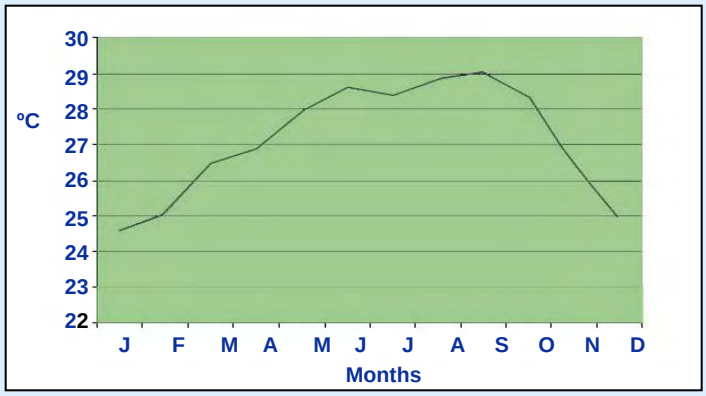


Figure 9: Mean Monthly Temperature, Carrie Bow Cay, 2002 - 2004

Month	Mean Temperature °C 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 8: Mean Monthly Temperature and Rainfall, Carrie Bow Cay, 2002 - 2004

Data Source: Fig. 8; Table7: 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 Glover's Reef Atoll itself.

Tropical Storms

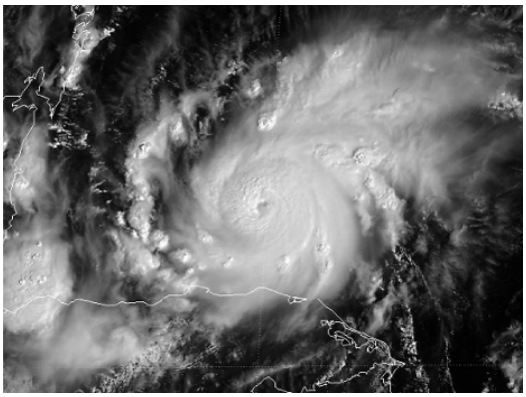
Tropical storms affect Belize every year, with the effects being felt particularly strongly on the atolls. Originating in the Atlantic Ocean over warm, tropical waters, these storms are non-frontal, developing highly organized circulations, and ranging in scale from tropical depressions and tropical 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.

Whilst many hurricanes have a very focused path of destruction, their effects are wide ranging, particularly at sea. Glover's Reef Marine Reserve has been affected on an almost annual basis by tropical storms, some of these reaching hurricane strength (Table 9). Of most note are some

of the stronger, more recent storms. Predictions are for increased frequency and strength of hurricanes in the next few years.

Table 9: Hurricanes Affecting Glover's Reef Marine Reserve

Figure 10: Hurricane Iris
GOES Project, NASA-GSFC 14:45 UTC 8 October, 2001



Name	Year	Date Passed GRMR
Unknown	1946	14th September
Unknown	1950	10th September
Jig (Tropical Storm)	1951	16th October
Faith	1966	1st September
Brenda (Tropical Storm)	1968	10th September
Laura	1971	November
Carrie (Tropical Storm)	1972	31st August
Dawn (Tropical Storm)	1972	10th September
Fifi	1974	18th September
Greta	1978	18th September
Josephine	1984	12th October
Daniel	1998	1st September
Mitch	1998	27th October
Keith	2000	30th October
Iris	2001	8th October
Ivan	2004	12th September

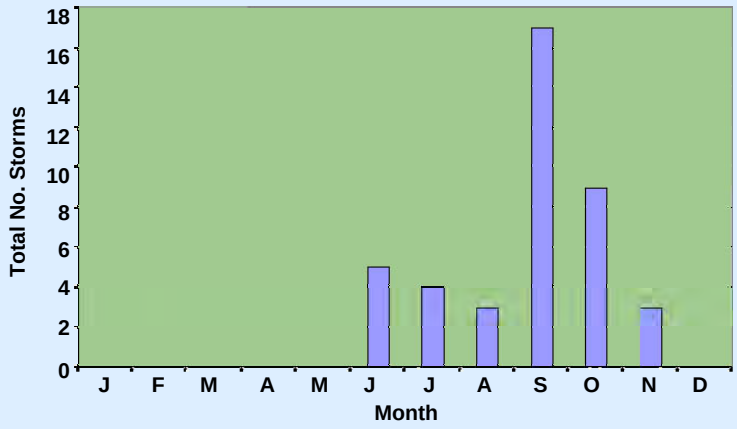


Figure 11: Tropical Storm frequency per month, from 1889 – 2000, making landfall in Belize

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

2.4.2 Geology

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, about seven million years ago (Schafersman 1972) (Figure 12)), 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.

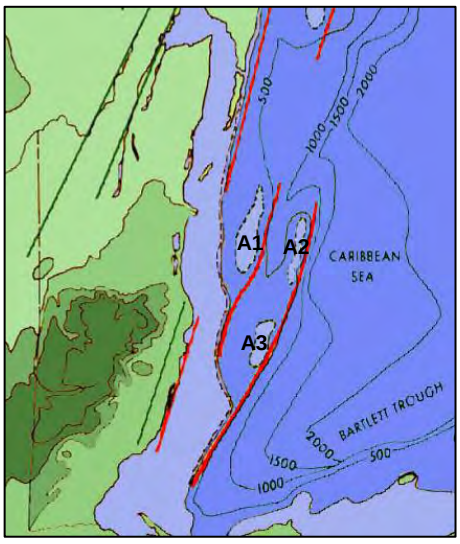


Figure 12: Fault and escarpment lines in Belize

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

Sediments from reef and fore reef are comprised of fragments of coral, red algae and *Halimeda*. In contrast, sediments of the back reef area contain more mollusk fragments and have lower percentages of *Halimeda* (Gischler 1994).

Sediments associated with the patch reefs are poorly sorted coarse-grained carbonates, composed primarily of *Halimeda*, coral, coralline algae, mollusc and other skeletal particles. The lagoon floor is muddy, composed of fine-grained carbonate sand, with the sand fraction rich in *Halimeda*, mollusc and foraminifer grains (James & Ginsburg 1979).

Soils

The Atoll's six cayes are composed mainly of coral rubble found on the windward sides, where ramparts of coral chunks have been formed. The five larger cayes have depressions in the middle, which often contain standing water in the rainy season. On the lagoon side, the cayes have fine sand and coral (Stoddart 1962).

2.4.3 Bathymetry

Glover's Reef Atoll lies on a limestone platform stretching north-south, formed by slumping of the escarpment ridge during tectonic activity. The water depths on the platform range from 0 to 500m. On the outer north and east facing margins of the Atoll, and the northern portion of the west margin, the water depth increases rapidly to between 500 and 1000 m. To the south and south west, the ridge continues at a maximum of 500 m (Fig. 12). Depths range from between 300 to 400 m to the west, between the barrier reef and the Atoll.

Within the Atoll itself, water depth in the inner lagoon averages 6 – 8 m deep. The platform slopes steeply from the lagoon ridge to the lagoon floor, which appears to be basin shaped. Two areas are up to 18 m deep in the north and in the south of the lagoon, separated by a higher area known as "Broken Ground" (Fig. 13) (Gishler & Lomando 1999).

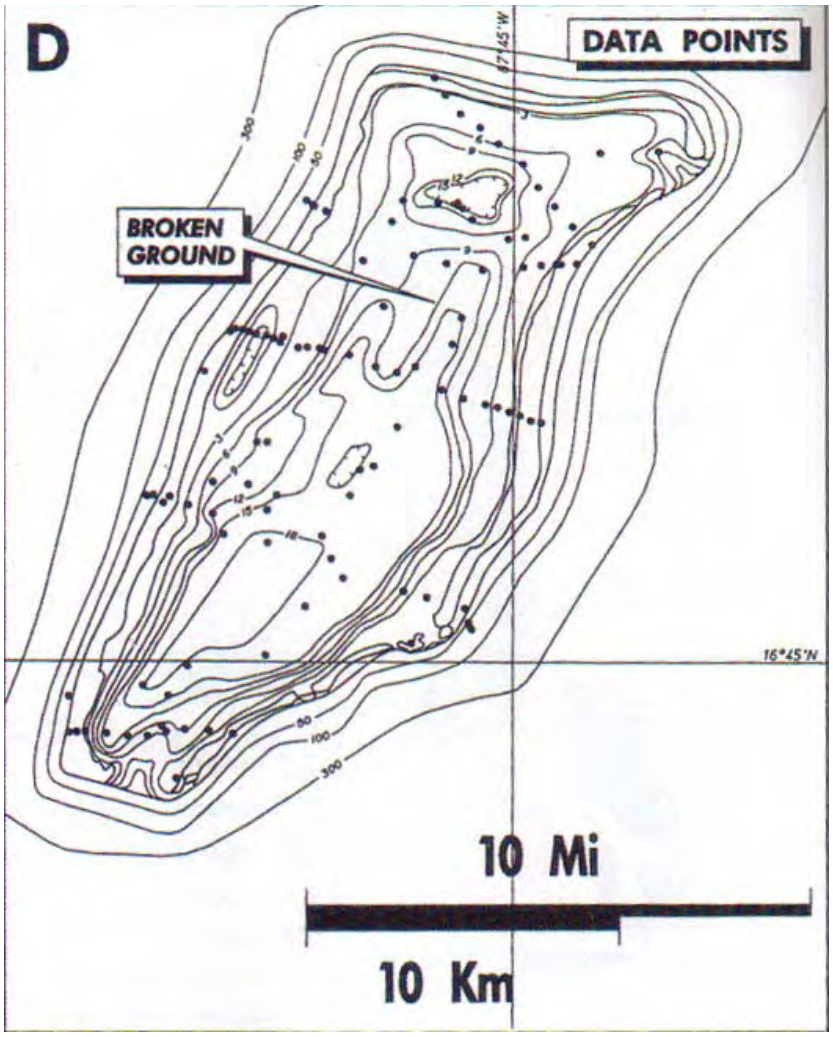


Figure 13: Map showing the depth contours within the atoll's lagoon Gishler & Lomando 1999

The lagoon of Glover's Reef is much deeper than the lagoons of Lighthouse Reef and Turneffe Islands atolls, and is studded with about 850 patch reefs (Gischler 1994), many of which rise very close to the surface.

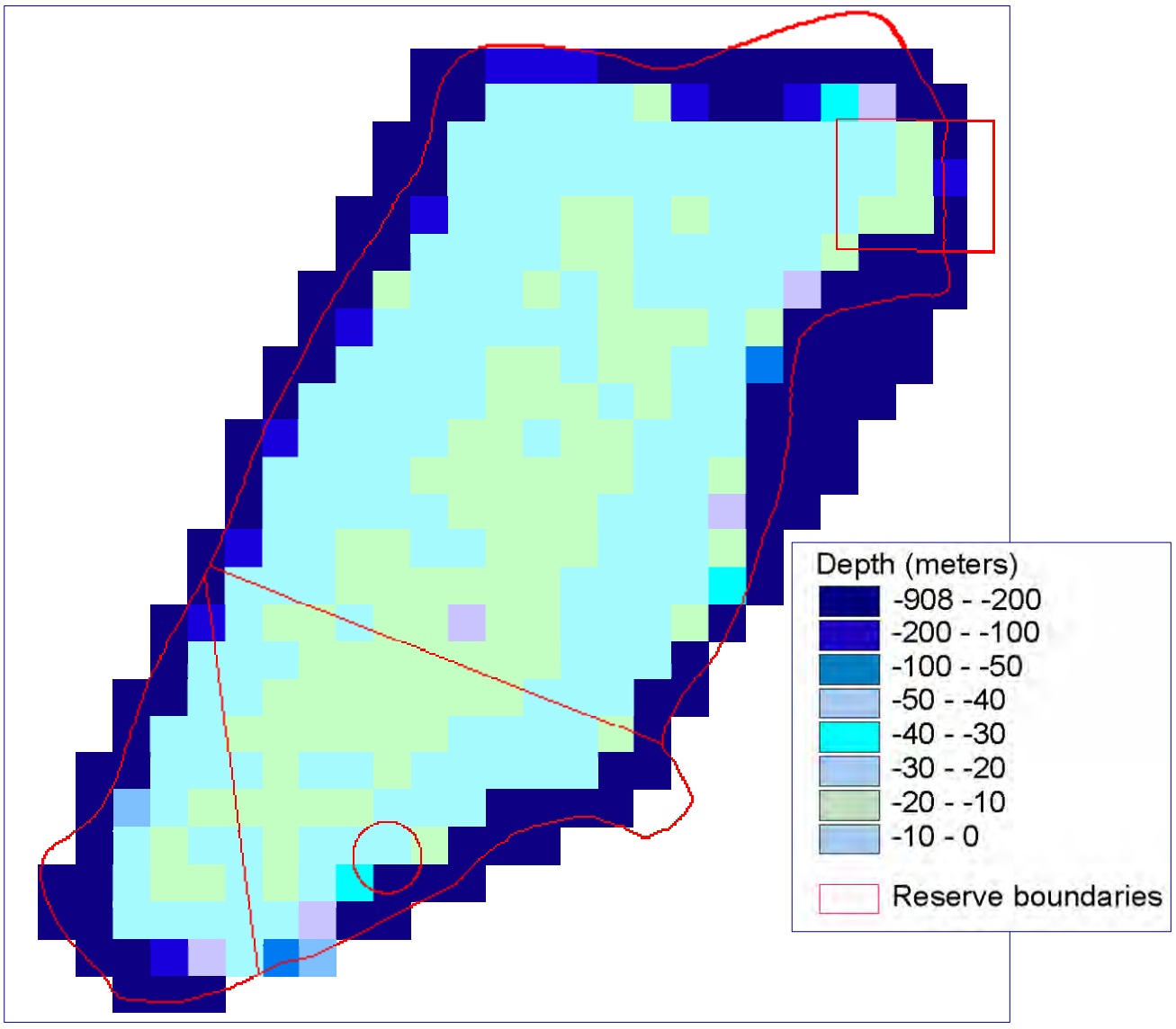


Figure 14: Bathymetry of Glover's Reef Atoll. WCS Living Seascapes, 2006

2.4.4 Tides and Water Movement

However, in the Gulf of Honduras area,. This gyre is stronger in the winter months, around the atolls. The main oceanic 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, where a counter-current is created, flowing southwards past the Belize coastline (Figure 15; Stoddart, 1962). This creates a low-flow area between the atolls and the shore, with circulation being predominantly wind-driven.

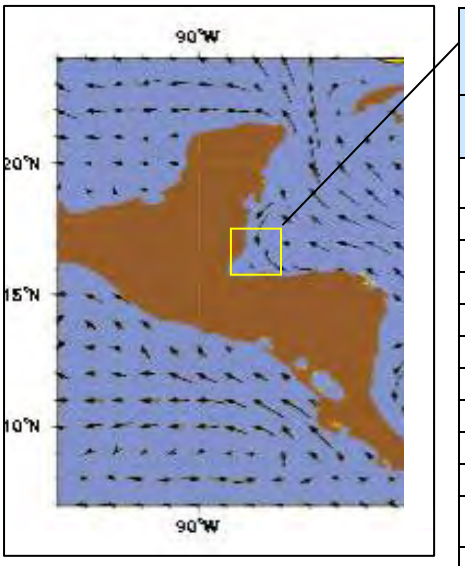


Figure 15: Ocean Currents

Surface Water Current Direction Adjacent to Glover's Reef

Adapted from Stoddart, 1962

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 10: 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 February and March the currents are mainly northward at a rate of about 1.5 knots. From June to August currents remain northward at the same rate, increasing to 2 knots during September and October (Table 10) (Stoddart 1962; Wallace 1975). Throughout Belize, the northerly winds are known to depress the water level by as much as a foot, for several days at a time during the early part of the year – this is true on the atolls as well, and 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 three main breaks in the reef are important tidal exchange channels, though even with these opening facilitating water flow into and out of the Atoll, the tidal range is only about 26 cm (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 of diseases, as was shown by the rapid spread of disease in *Diadema antillarum* throughout the Caribbean region. Knowledge of currents is essential in determining the transport of larvae, nutrients and pollutants. Acosta (1998) has carried out some current studies within the Atoll, using drifters. The general flow on the windward side of the atoll lagoon during rising tides and calm weather was to the south and southwest (Figure 16). With normal 15-knot winds from the east, the direction is more to the southwest. Flow was strongest in the major channels in the reef, and weakest on the lee of islands.

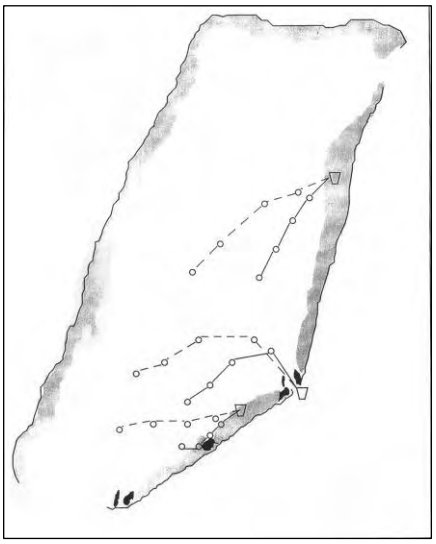


Figure 16: Map showing direction of drifters, demonstrating the southwesterly current within the Atoll

Acosta (1998)

2.4.5 Water Parameters

As the Atoll lagoon is relatively open to the sea, normal marine salinities prevail - salinities measured between October 1966 and May 1967 showed that surface water salinities ranged from 35.7 - 36.1 ppt to depths of 30 – 50 m, and appear well mixed (James & Ginsburg 1979). More recent salinity readings showed similar ranges of 36 to 36.7ppt in March 2005, and 35.6 to 36.4ppt in May 2005 (Table 10; Gibson and Hoare, 2006). With the higher evaporation rate of water from inside the Atoll, the salinity is, on average, 1ppt higher than the surrounding ocean, generally being 36ppt, as opposed to the 35ppt of the ocean (Gibson and Hoare, 2006).

The waters outside the atoll can be exceptionally clear, with visibility as high as 40 m at a depth of 10m inside the atoll is often turbid (James & Ginsburg 1979). Measures of visbility in 2005 showed some variation between March 2005 (with visibility at between 15 and 80 feet) and May (with variation from 19 to 100 feet). These results are as expected, as March generally is characterized by stronger currents and winds, resulting in rough seas and increased turbidity, whilst May is generally characterized by calmer weather and correspondingly higher visibility (Table 10; Gibson and Hoare, 2006)

Following the passage of hurricane Mitch in October 1998, Seawifs ocean colour images showed that large river plumes from Honduras extended out to the atoll (Andrefouet *et al.* 2002). Originally, the atoll was thought to be located beyond the influence of terrestrial run-off, but during major climatic events such as hurricanes, it is now known that such remote sites can be affected. Residents of the Atoll reported a significant increase in turbidity after hurricane Mitch.

Measurements in 1966 and 1967 by James & Ginsburg (1979) showed that water temperatures ranged between 27 – 28°C, to a depth of 50 m. In mid September 1998, water temperatures soared to 32°C in some areas on the atoll, which resulted in mass bleaching of corals down to 30 m (Bright 1999). Readings in March and May, 2005 show significant differences, with

temperatures in March (during the Norther season) being lower, ranging from 26.2°C to 28.6°C, whilst readings in May ranged from 29.1°C to 30.5°C. (Table 11; Gibson and Hoare, 2006)

Data Set	Visibility (ft) (Range)	Salinity (ppt) (Range)	Conductivity (mS/cm) (Range)	Temperature (°C) (Range)
March 2005	40.0 (15 – 80)	36.2 (36 – 36.7)	54.8 (52.2 – 57.5)	27.6 (26.2 – 28.6)
May 2005	50.4 (19 – 100)	36.0 (35.6 – 36.4)	55.1 (54.1 – 59.2)	30.0 (29.1 – 30.5)

Table 11: Mean and range values of visibility, salinity, conductivity, and temperature (From: Gibson and Hoare, 2006)

More recent data on salinity, water temperature and turbidity will be made available through the long-term monitoring programme for the atoll (LAMP) recently initiated (Acosta 2001).

Preliminary studies have shown that Glover's has high nutrient levels, both in the lagoon and on the fore-reef (Mumby 1998). Nitrate levels were highest on the eastern fore-reef and on coral patch reefs. Levels of phosphorus were also significant in some areas, with absolute levels of Soluble Reactive Phosphorus (SRP) exceeding the empirical eutrophication level. Although similarly high SRP levels have been reported at many other atolls, the concentration is high when compared to other Caribbean fore-reefs. The cause of these high nutrient levels is not fully understood, but it has been suggested that they are possibly due to upwelling on the fore-reef and the decomposition of organic matter in the lagoon (Mumby 1998). As mentioned earlier, run-off from mainland watersheds is also a likely contributor.

More recent data shows that…

> "although monitoring of these parameters was completed for only one month, July 2005, and the results should be viewed as preliminary, they show that the values for DIN were 8.2 times higher than previous values found 15 years ago by Tomasko and Lapointe (1991). In addition, dissolved inorganic nitrate and orthophosphate were more than two times higher, and the N:P ratio was 3.2 times higher than values documented by the same study (Tomasko and LaPointe 1991). The current levels are indicative of coral reefs that are experiencing eutrophication and associated macroalgal blooms in other countries".
>
> Gibson and Hoare, 2006

With no long-term monitoring in place, however, it is not possible to place these most recent results (reported in Gibson and Hoare, 2006) in context, as these provide just a snapshot of nutrient levels on the Atoll. They are, however, sufficiently alarming that a long term monitoring plan should be prioritized to provide greater understanding of nutrient cycling on the Atoll.

2.5. Biodiversity of Management Area

2.5.1 Ecosystems

Whilst national ecosystem mapping gives a broad overview of the ecosystems to be found on Glover's Reef Atoll (Meerman, 2004), more intensive studies have provided a finer detail more useful for management planning (Mumby and Harborne,1999). Under this study, a classification scheme was developed which identifies eighteen different ecosystem categories within the Atoll:

Marine Ecosystems

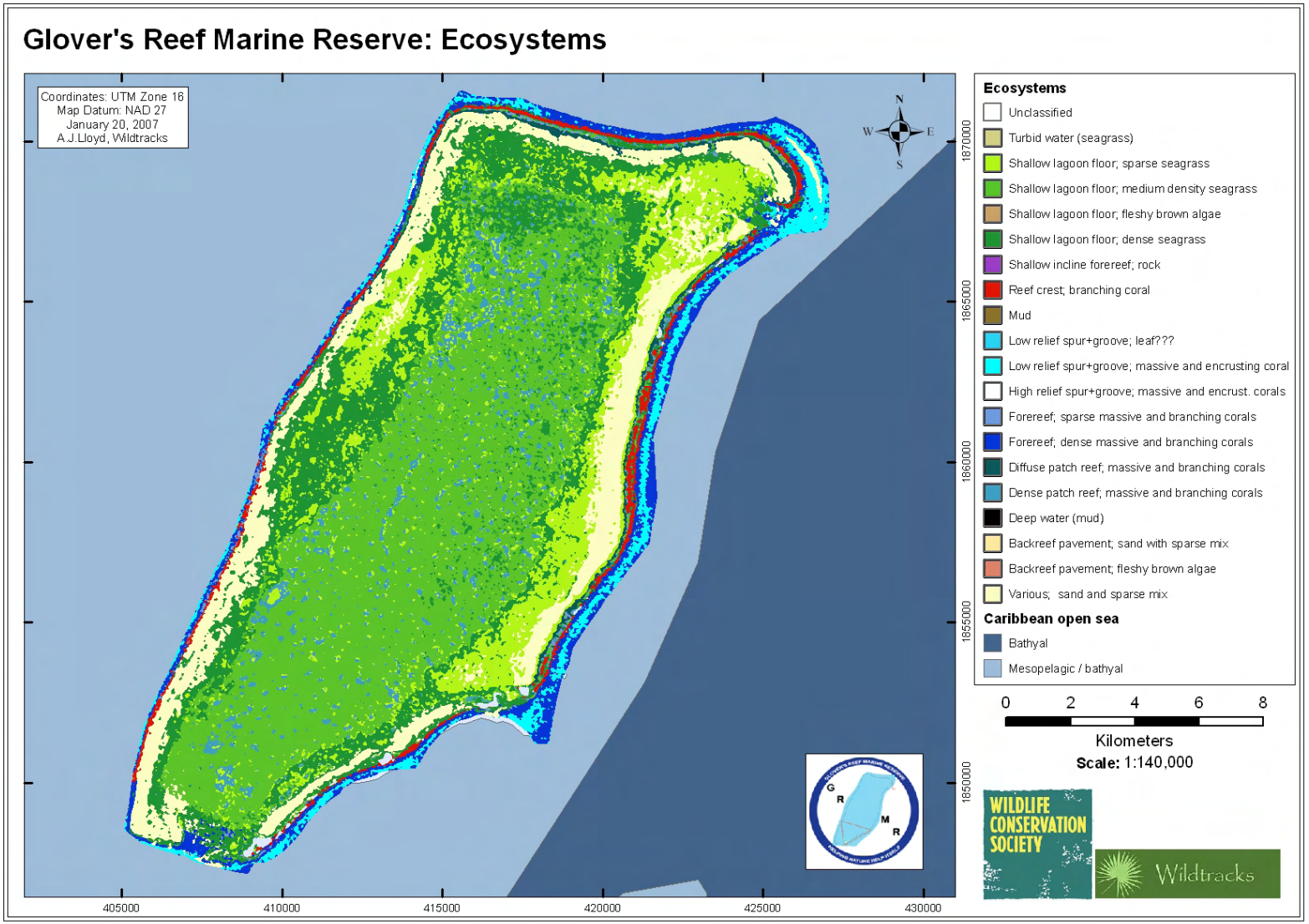
Glover's Reef Atoll is one of four atolls of the Mesoamerican Barrier Reef System (MBRS), the longest Barrier reef system in the Western hemisphere. Stretching from the Yucatan to the south of Belize, the Mesoamerican Barrier Reef is recognized as one of 233 ecoregions with biodiversity and representational values considered outstanding on a global scale, and recommended as a priority area for conservation (Olson & Dinerstein, 1998; Roberts, 2001, Kramer and Kramer, 2002).

Glover's Reef Atoll has been identified by WWF as the best developed coral atoll in the Western Atlantic, and a "***highest priority***" Ecoregional Biodiversity Priority Area (Kramer & Kramer, 2002). It lies 45km from the mainland and is surrounded on all sides by a sharply defined reef (Stoddart, 1962), with an interior lagoon that is highlighted for the high number and density of patch reefs (with over 800 recorded). Ecosystem mapping divides the Atoll ecosystems into six major ecosystem categories, each with a number of subcategories (Table 12; Map 3). These are further categorized by Mumby et. al. (Table 13).

Table 12: Ecosystems of Glover's Reef Atoll

Fore Reef	With sparse massive and encrusting corals
	With dense massive and encrusting corals
Patch Reef	Dense patch reef
	Diffuse patch reef
Other Reef	Reef crest
	Low relief spur and groove
Shallow Lagoon Floor	With sparse seagrass
	With medium density seagrass
	With dense seagrass
Other Habitats	Cayes
	Sand and sparse seagrass
Caribbean Open Sea	Bathyal
	Mesopelagic

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



Map 3: Ecosystems of Glover's Reef Marine Reserve (Living Seascapes, WCS, 2006)

Table 13: Ecosystems of Glover's Reef (after Mumby and Harborne, 1999)	
Marine Ecosystems	
Shallow lagoon floor - sparse seagrass	**Seagrass cover < 30%; Depth < 12m; Angle of slope ≤ 45°. This benthic class is dominated by sand and mud, with seagrass from the genera *Halodule, Halophila* and *Syringodium,* with low densities of *Thalassia.* Corals are usually absent, but algae of the genera *Batophora, Laurencia, Halimeda, Penicillus, Avrainvillea, Udotea* and *Cymopolia* are likely to be present.**
Shallow lagoon floor - medium density seagrass	**Seagrass cover: 30 - 70%; Depth < 12m; Angle of slope ≤ 45°. This benthic class is dominated by a sand or mud substrate, with seagrass from the genera *Syringodium* and *Thalassia.* Some corals may be present (*Manicina areolata, Siderastrea radians* and *Porites spp.*), and gorgonians from the genera *Pseudopterogorgia.* Algae of the genera *Laurencia, Halimeda, Penicillus, Avrainvillea, Udotea* and *Cymopolia* are likely to be present.**
Shallow lagoon floor - dense seagrass	**Seagrass cover: > 70%; Depth < 12m; Angle of slope ≤ 45°. This benthic class is dominated by a sand or mud substrate, with seagrass from the genera *Syringodium* and *Thalassia.* Algae of the genera *Laurencia, Halimeda, Penicillus, Avrainvillea, Udotea* and *Cymopolia* are likely to be present.**
Sand and sparse algae	**Over 90% of the lagoon floor is of coarse sediment (>1mm diameter) with some sparse algae, particularly green algae (calcified or non calcified), and red or brown branching algae.**
Diffuse patch reef	**Dispersed coral formations in the lagoon covering less than 30% of the benthos, surrounded either by seagrass, sand or algae. Although patch reefs are usually formed by hard corals, this category is also used for patches where the coral has died and another organism now dominates (such as the macroalgal dominated patch reefs.**
Dense patch reef	**Aggregated coral formations in the lagoon covering more than 70% of the benthos, surrounded either by seagrass, sand or algae. Although patch reefs are usually formed by hard corals, this category is also used for patches where the coral has died and another organism now dominates (such as the macroalgal dominated patch reefs. The patch is often surrounded by a halo of sand)**
Forereef – dense massive and encrusting corals	**An area of reef with an incline of between 0 and 45° on a substratum dominated by bedrock and sand, found seaward of the reef crest along the length of the fringing reef. Hard coral cover is > 5%, with this category – 'massive and encrusting corals' - forming a diverse community of species, the most common being *Montastraea annularis, M. cavernosa, Siderastrea sidereal, Dichocoenia stokesii, Agaracia agaricites, Porites* spp. *Diploria* spp. and *Millepora alcicornis.* Soft corals such as *Pseudoplexura* spp. and *Pseudopterogorgia* spp. are common, and fleshy brown algae, red branching algae and green calcified algae are abundant.**
Forereef - sparse massive and encrusting corals	**An area of reef with an incline of between 0 and 45° on a substratum dominated by bedrock and sand, found seaward of the reef crest along the length of the fringing reef. Hard coral cover is between 1 and 5%, with this category – 'massive and encrusting corals' - forming a diverse community of species, the most common being *Montastraea annularis, M. cavernosa, Siderastrea sidereal, Dichocoenia stokesii, Agaracia agaricites, Porites* spp. *Diploria* spp. and *Millepora alcicornis.* Soft corals such as *Pseudoplexura* spp. and *Pseudopterogorgia* spp. are common, and fleshy brown algae, red branching algae and green calcified algae are abundant.**
Low relief spur and groove	**Low relief spurs (with a height less than 5m), usually formed by accreting hard corals and calcified algae, whereas the grooves usually contain sand or bare bedrock. Most commonly located immediately seaward of, at right angles to, the reef crest. Wave energy can be high.**
Deep reef/wall/escarpment	**Described as an area of benthos with an angle < 45°, often associated with the drop off wall of the Atoll. Steep escarpments are also found throughout the lagoon.**
Reef crest	**This is the shallowest part of the reef, often emergent, and separates the forereef from the backreef and lagoon. The reef crest absorbs much of the wave energy, and is particularly important for maintaining the structure of the cayes within the Atoll. Where the reef crest is absent, breaks or 'cuts' occur.**

Table 13: Ecosystems of Glover's Reef (continued)	
Marine Ecosystems	
Reef channels	**Three reef channels occur on the windward side of the Atoll, connecting the lagoon waters directly with the open ocean. These are the North East Channel (1,400 yds wide), the Southwest Channel (approximately 1 mile wide) and the channel between Long Caye and Northeast Caye (about ¼ mile wide).**
Terrestrial	
Mangrove	***Rhizophora mangle* extends out from the shoreline of Middle Caye and Southwest Cayes, and *Avicennia germinans* is found on the western portion of Northeast Caye.**
Rubble beach	**Located primarily on the windward side of the cayes, with coral rubble deposits forming ridge or rampart of broken coral , which may be as much as 5ft high.**
Sandy beach	**These gently sloping, coral/algal fine sand beaches are located on the leeward side of the cayes.**
Caye littoral forest	**Characterized by species such as sea grape (*Coccoloba uvifera*), ziricote (*Cordia sebestena*) and gumbolimbo (*Bursera simaruba*), this forest type is found on the southeast side of Northeast Caye, with a small stand also being located on Middle Caye, interspersed with grassland, This ecosystem, whilst not occurring within the Marine Reserve itself, is highlighted as under-represented within the National Protected Areas System, and at reat threat from coastal development.**
Brackish pond	**Middle Caye, Northeast Caye and Southwest I Caye have small depressions in the central portion of the caye that fill with brackish water during the rainy season.**
Palm	**The littoral forest on the majority of the cayes has already been cleared, and the area planted with coconuts (originally the Panamanian tall variety, but with the onset of 'lethal yellow', many landowners have replanted with the more resistant Maypan variety – a hybrid between the Malaysian dwarf and the Panamanian tall coconut varieties. In some places, such as Northeast Caye, these form dense thickets.**

Peripheral Reefs

Stoddart (1962) classified the peripheral reefs of Glover's Reef into four main groups:

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

In general, a gradually sloping fore-reef extends to the drop-off, ranging from approximately 400m to 1.5 km wide, that runs perpendicular on the north and east windward sides of the Atoll, with a very well-developed spur and groove system. The edge of the drop-off lies at a depth of between 15-25 m, and is vertical in most areas, though a series of ledges or terraces occur at different depths below the drop-off.

The windward reef is characterized by first a *Porites* zone, followed by an *Annularis* zone, a *Porites-Lithothamnion* zone, then the reef crest of dead reef-rock encrusted with *A. agaricites*, *P. porites*, *Millepora*, and finally a well-defined spur-and-groove zone primarily of massive *A. palmata* colonies on the outer slope. In contrast, the leeward reef is comprised of a mixed *Cervicornis* zone, a mixed *Palmata* zone, followed by an *Annularis* zone to depths of 5 m that continues down to 10 m with taller and massive colonies in deeper water, and then long buttresses of *M. annularis* and pillars of *D. cylindrus* (Stoddart 1962).

James and Ginsburg (1979) described both the leeward and windward deep reefs of Glover's based on their observations to depths of 300 m from a research submersible. The deepest-growing hermatypic coral observed was a small *Agaricia fragilis* at 102 m on the eastern side of Glover's.

The reefs of Glovers were impacted by the coral bleaching event in 1995 (McField (2001)). Three sites surveyed on the Atoll in October and November 1995, representing patch reef, back reef and fore reef, showed 44%, 27%, and 61% of the reefs affected, respectively. When these sites were re-surveyed in May 1996, the degree of bleaching had decreased to 6%, 7% and 12%, repectively (McField, 2001).

Glovers' reefs were again severely impacted by both a mass bleaching event and hurricane Mitch in 1998, and again in 2005 (Table 14).

Table 14: Local and Regional Hurricane Impacts

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
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

Hurricane Mitch, the fourth strongest storm documented this century with winds of 290 km/hr, passed about 120 miles southeast of Glover's Reef during the last days of October 1998. Preliminary reports described extensive damage to the windward eastern and northern fore-reefs, with both branching and massive corals affected down to a depth of 10 m. Many of the corals remaining were severely abraded, with little living tissue remaining. Coral mortality was estimated to be 60 – 70% (Bright 1999).

Investigations by Kramer & Kramer (2000) indicated that shallow (1–3 m) reef and deep (8 –17 m) fore reef sites on Glovers experienced the most disturbance of Belize's three atolls. Shallow windward reefs suffered severe hurricane damage and recent mortality, while bleaching and diseases were more prevalent on the leeward reefs. These reefs still displayed remnant bleaching (mainly 'pale') up to 10 months after the mass-bleaching event recorded in September 1998. They also reported a consistently high incidence of coral disease on the Glovers fore reefs compared to other fore reef sites surveyed in Belize. In relation to damage from hurricane Mitch, the east facing shallow reef sites sustained the greatest damage, with the NE Glover's survey site having the highest degree of damage in the entire Mesoamerican barrier reef region. In addition, exposed deep fore reef sites on Glovers had higher than average damage, consisting primarily of knocked over or broken corals. This region had coral recruitment reduced by 80% (Mumby 1999). Glovers also showed higher levels of recent coral mortality than the other two atolls; this was especially high for the East Glovers site, located on the fore reef near Middle Caye. Total mortality was higher on the shallow reefs, in some cases as high as 80% (Kramer & Kramer 2000).

McField (2001) surveyed two windward fore reef sites on the Atoll in 1997 and 1999. Coral cover at the Middle Caye site declined over the two-year period from 14.6% to 6.4%, and at the site on the southeast end of the atoll it also declined, from 23.6% to 11.1%. Species diversity also declined at both sites. At the same time, substrate cover increased proportionally, with macroalgae showing a slight, non-significant decline. These changes were attributed to the impacts of the bleaching event and hurricane Mitch in 1998.

Patch Reefs

The majority of the more than 850 patch reefs within the Atoll's lagoon are distributed randomly with the exception of those in the western and northeast portions of the Atoll where they are aligned along NNE-striking trends. They range in size from about 10 m to a few hundred meters (Wallace 1975). They consist of massive corals such as *Montastrea, Diploria, Siderastrea* and *Porites,* with occasional thickets of *Agaricia* and *Acropora cervicornis;* sea fans and brown algae are abundant on dead coral surfaces (McClanahan & Muthiga 1998).

In the 1970s, three distinct coral assemblages were recognized along a north-south transect namely: *Montastrea*, *Acropora* and Algae-*Porites*. This distribution mimicked the zonation on the seaward reef tracts, and was believed to be a response to disturbances such as hurricanes (Wallace & Schafersmann 1977). A list of coral species of the patch reefs provided by Wallace (1975) is shown in Appendix 4.

More recent studies have also focused on the composition of the Atoll's patch reefs, and show that they have undergone a major change in their ecology. They have experienced a 75% reduction in coral cover (with *M. annularis* showing the least loss), a 99% loss in cover of *Acropora* spp., and a 315% increase in algae cover, particularly of the erect brown algae *Lobophora* (McClanahan & Muthiga 1998). The cause for this dramatic change over the past 25 years is complex, and probably due to several inter-related factors, such as reduced herbivory, increased level of nutrients, and disease.

The patch reefs no longer exhibit the zonation described earlier by Wallace and Schafersmann (1977). Furthermore, the phase change in community structure has resulted in the 80% hard coral cover and 20% algae cover reported by Wallace (1975) to be transformed to a 20% coral cover and 80% algae cover (McClanahan & Muthiga 1978).

Lagoon Floor

The lagoon floor, which ranges in depth from 6 to 18 m, is comprised of predominantly fine sand and mud sized carbonate sediment. It supports a sparse flora of *Thalassia* and algae, mainly *Penicillus* with some *Halimeda* (Wallace 1975).

Some deeper areas of the lagoon are almost completely barren of vegetation, though echinoderms and other invertebrates are common.

Terrestrial Ecosystems

The six cayes, all located on the southeast side of atoll, are aligned more or less along a NE – SW axis, with the exception of Southwest II Caye which is aligned almost north-south. The following description of the cayes is taken mainly from Stoddart (1962) and Stoddart *et al.* (1982), updated by recent observations (Figure 17).

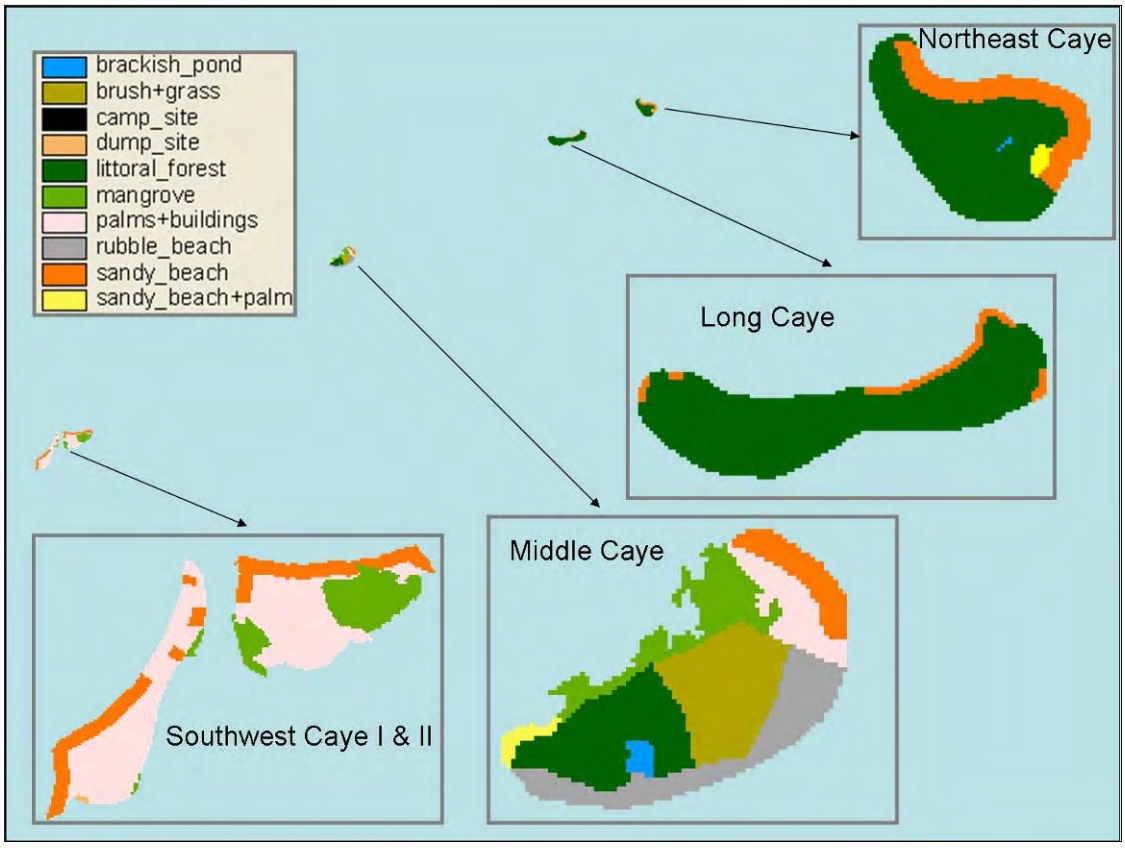
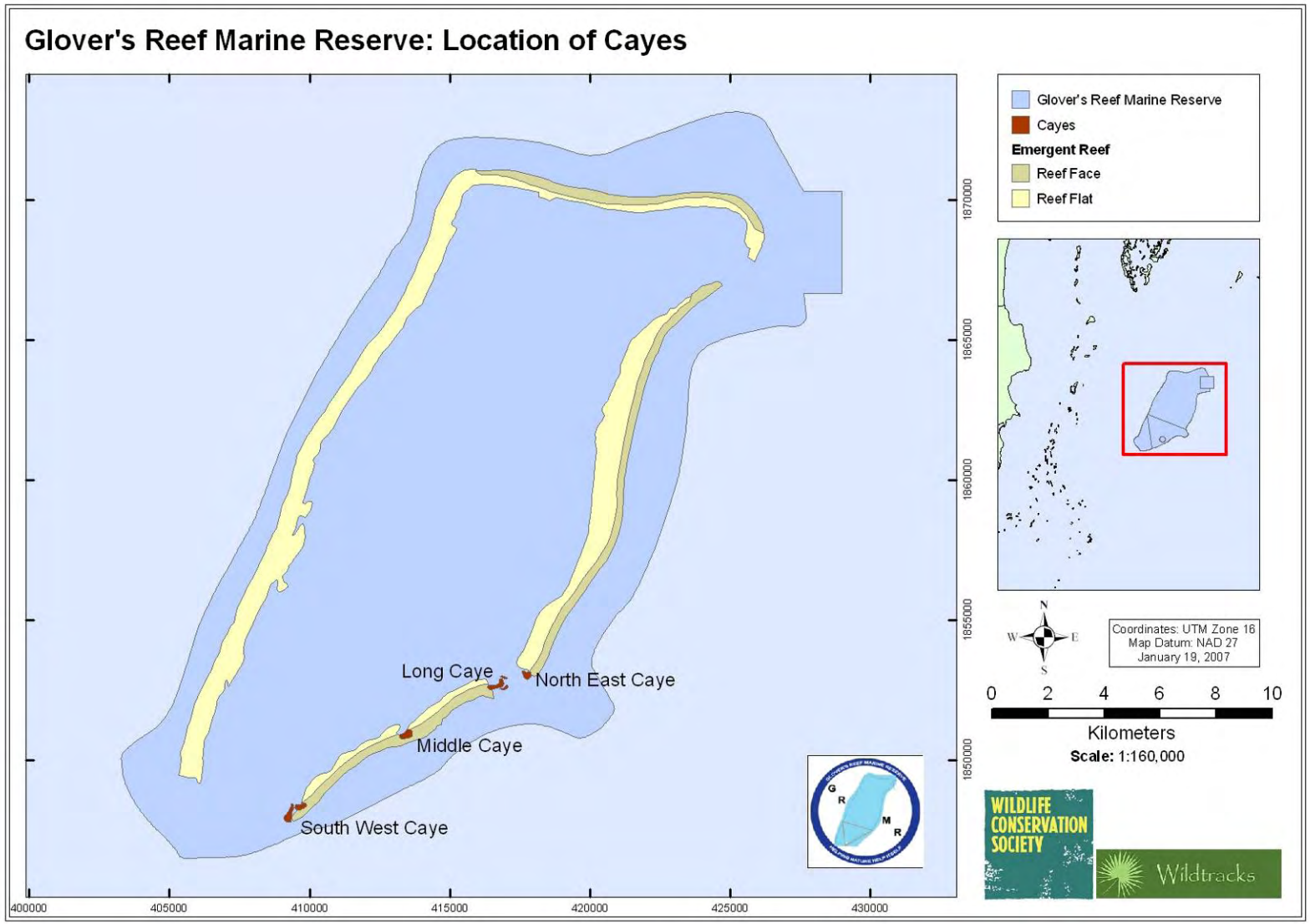


Figure 17: Ecosystems of the Cayes (Living Seascapes, WCS, 2006)



Map 4: Location of Cayes

Northeast Caye

Northeast Caye, the northernmost of the cayes, is located to the north of the eastern channel leading into the atoll. It is semicircular in shape, with an area of approximately 4.5 ha. The windward side has a high rubble/shingle beach.

A total of 40 species of plants were recorded on the island (Stoddart 1962; Linhart 1980; Stoddart *et al.*1982). Presently, a tall broadleaf littoral forest grows on the southeast side of the caye, and is characterized by sea grape *(Coccoloba uvifera*) and gumbo limbo (*Bursera simarubra*), with *Ficus citrifolia, Pouteria campehiana* and *Cordia sebestena*. A patch of black mangrove (*Avicennia germinans*) lies on the western half of the caye (Meerman 1995), whilst a dense, unmanaged coconut grove dominates the centre of the caye (Walker, 2007). A multi-species herbaceous flora to the northwest extends towards a rich beach flora that has established on coral rubble deposited by Hurricane Mitch. A small brackish pond lies in the centre of the caye.

Figure 18: Northeast Caye

The Lomont family owns the island and run a small resort comprised of rustic cabanas over the water (Figure 18), along with a PADI dive shop and kayak rental business.

Long Caye North (Lomont Caye)

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

Long Caye

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

Most of the island is covered with coconut plantation, with 28 other plant species recorded (Stoddart 1962, Linhart 1980, Stoddart et al.1982). In 1994, a survey of the western side of he caye only identified 25 plant species (Meerman, 1995), including chit palms (*Thrinax radiata*), on the southern part of the island, and ziricote (*Cordia sebestena*), on the coral ridge. The black torch (*Erithalis fruticosa*) and the passionflower (*Passiflora suberosa*) were the two most

frequently observed species, forming dense tangles on the southern end of the island. Whilst mangrove was present, it was very limited in its distribution.

Figure 19: Above: Landscaping at Off The Wall
Figure 20: Below: Slickrock accommodation

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

Two companies run tourist businesses from this caye: Slickrock runs a small resort with several cabanas on the northern end and specializes in kayaking, and Off-the-Wall Dive Shop runs a dive operation and small island resort located on the central portion of the caye.

Middle Caye

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

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

Figure 21: Middle Caye (WCS/S. Hoare)

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

A non-exhaustive survey of the flora of Middle Caye (Walker, 2007) demonstrated that, in the absence of the negative impacts associated with invasive coconuts, the native flora and vegetation assemblages are re-establishing very well, with native species assemblages being established over much of the island, greatly increasing the extent and condition of natural vegetation, and enhancing habitat quality for the fauna. A total of 31 species of plant were identified in the survey, not including most of the grasses, and not including at least one more unidentified herbaceous species. Species richness is evidently increasing as a direct result of the reduction of the coconut abundance, and as a result of more environmentally-friendly management. It would appear that overall species richness is rapidly returning to natural levels, though it can be expected that habitat structure will continue to change significantly over coming years as woody shrubs and trees extend the current limits of the littoral forest into some of the areas currently dominated by herbaceous beach flora. Current management (pruning of taller growth, to maintain a vista) of a significant portion of the northern portion of the island has provided a competitive advantage to two semi-woody shrubs: *Ernodea littoralis* and *Erythralis fruticosa* (Figures 22 and 23), the berries of the latter being an extremely attractive food source to the resident white-crowned pigeons, to the migrant birds passing through the Atoll in significant numbers, and to the healthy population of black iguanas. Tall red mangrove provides important habitat on the western side of the caye. Recent vegetation mapping by WCS is highly accurate.

Figures 22; 23; 24:
Top: *Ernodea littoralis*
Middle: *Erithralisfruticosa*
Bottom: WCS Accommodation on Middle Caye

WCS owns the caye and has established a research facility on the cleared northern end of the island. This includes a dormitory for researchers, a laboratory, kitchen, manager's house (Figure 24), staff quarters, showers and composting toilets, workshop, solar panels and back-up diesel generators, air compressor for filling SCUBA tanks, and a dock. WCS has also provided a location in this area for the headquarters of the marine reserve, administered by the Fisheries Dept. This includes accommodation for reserve staff, a kitchen, and an area allocated for a small visitor centre.

Southwest I Caye

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

by coral rubble, reducing the water flow through the area, sedimentation is reducing the depth of the channel.

Figure 25: Southwest I (WCS/S. Hoare)

Southwest Caye I (Figure 25) is the larger and more easterly of the two cayes, with an area of 9 ha. It is comprised of coral rubble on its seaward shore, sand on the leeward shore, and an area of swamp in the interior. The vegetation is mainly coconuts and mangroves, though 40 plant species were recorded in the past by Stoddart (1962), Linhart (1980) and Stoddart *et al.* (1982). The island, however, was heavily impacted by Hurricane Iris in 2001, and some of the vegetation was affected. In addition the coconuts have suffered severely from lethal yellowing. The affected area has been replanted with resistant hybrids. Tourism development of Southwest Caye has been towards the clearance of white sandy beaches and the re-establishment of coconuts - native flora is very much in decline, with paraquat-based herbicide being used to suppress "weed" growth in the Isla Marisol area.

Figure 26: Isla Marisol restaurant / bar facility on Southwest I

The caye is owned by the Usher family which has three small holiday homes located on the northern shore. Other infrastructure includes a building housing a kitchen and dining area and also some platforms for tents located on the eastern end of the caye and operated by Island Expeditions. This company specializes in kayaking trips. Mr. Eddy Usher has also constructed an expanding resort, Isla Marisol, with cabanas, and a bar/restaurant, constructed at the end of a dock (Figure 26), located on the northern shore.

Southwest II Caye

Figure 27: Southwest II Caye (WCS/S. Hoare)

This caye (Figure 27) is the most southerly on Glover's Reef and, unlike the other islands, it is mainly sandy with no swampy areas. It was once entirely covered with coconut woodland, with 40 species of plants recorded by Stoddart (1962), Linhart (1980) and Stoddart et al. (1982). Resort development, however, has reduced the natural vegetation, with clearance for development, leaving bare sand with coconut trees. The southern part of the 6-hectare island, owned by

Port Authority, is the location of the lighthouse, which is operated by the Port Authority (Figure 28).

The remainder of the island is now owned by Mr. Mike Feinstein who has established a hotel, Manta Resort which includes a main house and office, several cabanas, and a large bar and restaurant at the end of a dock. This caye also sustained heavy damage by hurricane Iris, and the resort has recently been rebuilt.

Figure 28: Lighthouse on Southwest II Caye

2.5.2 Flora

A total of 34 naturally occurring native species of plant, representing 22 families, have been reliably identified as currently occurring within the littoral forest and herbaceous beach community of the cayes of Glover's Reef Atoll (Meadows 1998; Walker, 2007; Appendix 3). Whilst earlier surveys recorded up to 40 species, past anthropogenic impacts have had huge impacts upon the flora of the cayes – and the introduced coconut palm continues to have a very major impact. An comprehensive, updated vegetation assessment of the cayes would be beneficial.

There is quite a diverse species assemblage for this ecosystem type, especially in view of the distance of Glover's Reef Atoll from other island and mainland populations. 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 cayes, and in providing habitat for the fauna – including species that are endangered and / or have very limited distributions. National populations of several of the plant species found on the cayes of the Atoll have undergone significant decline in recent years, as coastal beaches are cleared and developed for coconut plantations, tourism and residential use. Those cayes with significant areas of littoral forest and herbaceous beach communities, such as Middle Caye and Northeast Caye, in particular, play a crucial role in the continued survival of these ecosystems.

Figure 29: Above: *Coccoloba uvifera*
Figure 30: Below: Natural herbaceous beach vegetation

2.5.3 Fauna

Mammals

Whilst the cayes themselves have no native mammal fauna, there are reports of small rodents on two of the cayes, presumably transported to the Atoll in materials, from the mainland. These introduced species may be a significant problem in the future if allowed to spread, as has happened on Half Moon Caye, on Lighthouse Reef Atoll.

Spotted, bottlenose and spinner dolphins are seen all year in the deeper waters outside the Atoll, and bottlenosed dolphins also venture into the Atoll lagoon, through the channels, and a recent sighting of a large West Indian Manatee (*Trichechus manatus)* on the outer edge of Glover's Reef Atoll in May, 2007, confirms that this Vulnerable species (IUCN, 2007) does occasionally reach the Atoll (Gibson, pers com., 2007).

Birds

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

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

The species composition of Glover's Reef is very comparable with that of Half Moon Caye, on Lighthouse Reef Atoll (Walker and Walker, 2005), - a comparison of the migratory species on these Atolls with those of migratory species surveys on the remote San Andres Island, offshore of Columbia shows an approximately 87% overlap of migratory species. Of these, the blue-winged, golden-winged, yellow, blackburninan, cerulean, magnolia, prothonatory, worm-eating, Swainson's and hooded warblers are largely believed to fly trans-gulf, relying on making landfall on the Yucatan Peninsula (N. Bayly, pers. com.). If they do wander off course, cayes such as those of Glover's Reef and the more southerly San Andres Island may be very important in allowing them to store up enough fat reserves to survive the next leg of their

migration. An interesting addition to the list of migrants making a stopover on the island is the cedar waxwing, with a flock of approximately 80 individuals observed feeding on the fruit of *Erythralis fruticosa*, an important food source for many of the migratory birds passing through (Figure 31; Walker, 2007). Other migrants that might occur on the caye but have not yet been recorded include the American kestrel, black-necked stilt, common tern, least tern, white-winged dove, mourning dove, common nighthawk, olive-sided, alder and least flycatcher, gray kingbird, and Lincoln's sparrow (L. Jones, pers. com.). See Appendix 3.

Figure 31: Waxwing on Middle Caye

Reptiles of Glover's Reef Atoll

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

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

All three marine turtles - **loggerhead turtle** *(Caretta caretta),* **green turtle** *(Chelonia mydas),* and **hawksbill turtle** (*Eretmochelys imbricata*) - are found in the waters of Glover's Reef Atoll, and nesting on the cayes. The dramatic decline in the number of turtles nesting on the cayes of Glover's Reef follows regional (and indeed global) trends of decreasing marine turtle populations, is reflected in the nesting activity on the cayes of Glover's Reef, where successful hatchings have declined significantly - also to some extent a reflection of the relative ephemeral nature of sandy nesting beaches on such exposed islands, and the beach clearance that is associated with tourism development. Coral rubble washed onto beaches during storm events, and similarly, accumulated washed up garbage, can also impair turtle nesting behaviour or even render nesting beaches inaccessible (Smith, et. al., 1992). No successful turtle nest of any species has been recorded during turtle monitoring activities in 2004, 2005 or 2006, though there are anecdotal reports of eggshells and sighting of a hatchling turtle during this period (Glover's Reef Annual Reports, 2004, 2005 and 2006). Turtle nests have been reported, however, for 2007 (K. Schofield, pers. com.)

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. Nesting is known to have occurred in the past on the north beach of Northeast Caye and on the eastern and western beaches of

Long Caye, where in 1999, 30 nests were recorded, with hatchlings appearing in December (though both Loggerhead and Hawksbill are recorded as nesting in these areas, and there is no record of which species was observed hatching). In 2002, several nests and possible false crawls were observed in late October, (per. com J. Schofield), though again these may equally be Hawksbill. More recently, in June 2007, loggerheads have been reported nesting on Long Caye (J. Gibson, pers. com., from report by K. Schofield)

Green turtles *(Chelonia mydas)* are also classified as endangered (IUCN, 2006), and are primarily a tropical species ranging throughout the Atlantic, Pacific and Indian oceans, though they are known to range into temperate seas at times. It is mostly 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 currently nest in low density on several offshore cayes, including the western beach of Middle Caye (Gibson 1988), and traditionally on Long Caye North, though the erosion of the beach following Hurrcicane Mitch may have removed this caye as a nesting site. It is estimated that an average of 19 females nested in Belize annually from 1979-1982 (Smith et al, 1992) - the species is considerably rarer today than in the past when cayes such as Half Moon Caye at Lighthouse Reef apparently hosted hundreds of nests per year into the early twentieth century.

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 sponges and invertebrates. This species has a protracted nesting season of 6 months or more – peaking in June and July, with the period between nesting seasons generally being 2-4 years (but may be as long as 10 years) (Chacon, D., 2004). 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.

A possible hawksbill nest was recorded on Middle Caye in 1990 (Smith 1990), and recent reports state that all three species, green, loggerhead, and hawksbill turtles, nest on Northeast Caye (B. Cabral, per. com.), though as several large dogs live on the caye, these could deter successful nesting activity. However no turtle nests have been recorded during the last three years during Fisheries Department monitoring activities.

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.

The island leaf-toed gecko (*Phyllodactylus insularis*) and **St. George's island gecko** (*Aristelliger georgeensis*). The island leaf-toed gecko (Figure 32) is Belize's only endemic reptile. Records of its presence on the Bay Islands and from Isla Guanaja of Honduras (Lee, J., 1996, 2000) are apparently erroneous (Wilson, L.D., pers. com.) as those specimens are attributed to *Pyllodactylus palmeus*. Its endemism is the justification for its inclusion on Belize's National List of Critical Species (Meerman, 2005). It has been recorded from Middle Caye and Long Caye (Meerman, 1995, Walker, 2007). Whilst the adults appear to be principally active at night on tree trunks 1-3m above ground, juveniles are commonly observed climbing on the foliage of herbaceous and shrubby plants less than 1m above the ground. Its known range in Belize is extending as further surveys are conducted on more islands - to date in addition to the population on the cayes of Glovers Reef Atoll, this species is also recorded from Half Moon Caye, and more recently from several cayes off the coast of southern Belize (Crawl Caye,

Figure 32: The island leaf-toed gecko (*Phyllodactylus insularis*)

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. It is quite possible that the population of this species has fallen significantly with the loss of the bulk of the coconut trees, and adults now appear to be largely confined to the littoral forest at the southern end of Middle Caye. As the *Thrinax* palm continues to re-establish on the island, habitat conditions for *Phyllodactylus* will improve, and the population may be expected to then recover.

A second gecko species, **St. George's island gecko** (*Aristelliger georgeensis*), was recorded on Middle Caye for the first time (Walker, 2007), and was found to be significantly more abundant than the endemic *Phyllodactylus insularis. Aristelliger georgeensis* (Figure 33) is considered to be a human commensal (Lee, 2000), but it is unclear whether it is a recent colonizer on the island, or whether females and sub-adults had previously been mistaken for *Phyllodactylus insularis.*

Figure 33: St. George's island gecko (*Aristelliger georgeensis*)

The **Brown anole** (*Anolis sagrei*) is abundant on the cayes, and is principally active on the ground and up to 2m elevation on vegetation. This species is widely distributed throughout the western Caribbean. Whilst generally considered a human commensal, it does occur throughout the littoral forest of Northeast and Middle cayes – and indeed on numerous uninhabited coastal islands. It would appear that these ecosystems are the natural habitat for the brown anole, and that its range has extended alongside that of the human population along the coastal plain.

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

Economically Important Species

There are two invertebrate species of commercial importance to the Glover's Reef fishery - the **Caribbean Spiny Lobster** (*Panulirus argus*) and **Queen conch** (*Strombus gigas*) (Figure 34), both of which are fished extensively throughout Belize.

Figure 34: Caribbean Spiny Lobster (*Panulirus argus*)
Photograph: Glover's Atoll Resort

The Caribbean Spiny Lobster fishery is the largest capture fishery in Belize, with production representing over 40% of total capture fisheries production in 2006, and an export value of US$7.37 million (Fisheries Department, 2007) Lobster landings peaked in 1981 at 2,204,622 lbs, but have fallen to 457,680 lbs in 2006 (Fisheries Department, 2007). It is significant to note that the total national lobster production over this period has declined by almost 25%, and there are concerns for the continued sustainability of the lobster fishing industry.

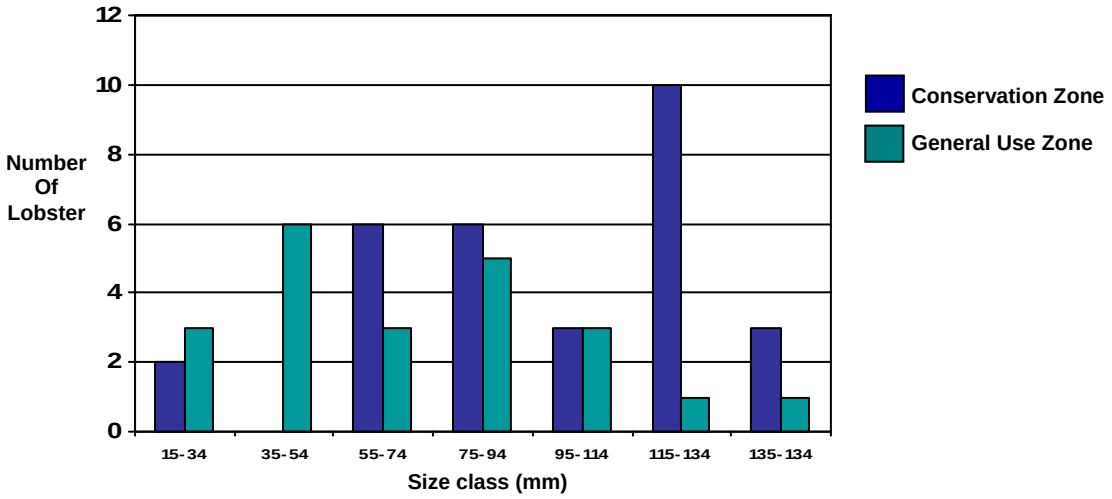


Figure 35: Survey data for lobster (February 2006) (Fisheries Department, 2006)

Results from the 2006 survey of the lobster population using the Field Protocol for Monitoring Coral Reef Fisheries Resources in Belize (2003 edition) show that more lobster (both male and female) were recorded from the Conservation Zone (30 individuals overall, vs. 22) (Figure 35). Of those lobster considered legal (with a minimum carapace length of 3 inches / 76.2mm), the majority were recorded from the Conservation Zone (Glover's Reef Annual Report, 2006). Results such as these show that when effectively implemented, the Conservation Zone does work in protecting the resource, allowing for spill-over to repopulate the General Use Zone.

Whilst there is continued optimism that lobsters are being harvested at a 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, more than 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).

In 2000, Glover's Reef production represented about 8% - 10% of the national annual total catch (Table 15; Gibson, 2003). It would be of interest to investigate current production of Glover's Reef Atoll to see if this is so, or whether the presence of the Conservation Area is having a positive impact on the lobster population available to fishermen, and a greater percentage of the national catch is therefore contributed by Glover's Reef boats.

Table 15: Lobster catches from Glover's Reef Atoll (March 2000 – February 2001)

Month	Diving			Traps			Total (lbs)
	National	Northern	Sub Total (lbs)	National	Northern	Sub Total (lbs)	
March	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-
June	-	2,933.5	2,933.5	0	7,151.0	7,151.0	10,084.5
July	109	703.5	812.5	0	2,486.0	2,486.0	3,298.5
Aug	175	12,155.0	12,330.0	0	1,560.0	1,560.0	13,890.0
Sept	5,321	912.0	6,233.0	0	24.5	24.5	6,257.5
Oct	323	666.5	989.5	0	0	0	989.5
Nov	1,860	1,519.5	3,379.5	0	0	0	3,379.5
Dec	526	951.5	1,477.5	0	0	0	1,477.5
Jan	103	897.5	1,000.5	0	0	0	1,000.5
Feb	718	713.5	1,431.5	0	8	8	1,439.5
TOTAL	**9,135**	**21,452.5**	**30,587.5**	**0**	**11,229.5**	**11,229.5**	**41,817**

Table 15: Lobster catches from Glover's Reef Atoll (March 2000 – February 2001) for Northern and National Cooperatives, according to method (diving / traps). (Fisheries Department)

The Queen Conch fishery is already considered to have collapsed in Belize, and efforts are being made to encourage fishermen to respect the size restrictions and no-take regulations of the protected area, through training and participation in monitoring activities. Conch landings peaked at 1,239,000 lbs in 1972, and have declined since then to 676,67lbs in 2006 (Fisheries Department, 2007). Even as far back as 1996, there was evidence that fishing pressure was too high, with the national population consisting primarily of juveniles.

Figure 36: Queen Conch (*Strombus gigas*)
Photograph: E. Hickerson

The total production of conch for 2000 and 2001 was 513,000 lbs and 579,000 lbs, respectively (Belize Fisheries Dept.), with total annual conch catch from Glover's Reef of 25,553 lbs (Table 16), representing about 4 to 5% of the national annual total catch.

Research on lobster and conch within the Conservation Zone using modeling techniques, has shown that populations increase to a certain level and then become stable when the increase becomes equal to the rate of loss due to natural mortality and outward migration or "spill over" into the fished General Use Zone (Acosta, 1998), demonstrating that the "no take" or Conservation

Table 16: Conch catches from Glover's Reef			
Month	**National**	**Northern***	**Total (lbs)**
March	1,202	343	1,545
April	758	0	758
May	2,266	0	2,266
June	0	433	433
July	-	-	-
Aug	-	-	-
Sept	-	-	-
Oct	8,560	3,269	11,829
Nov	3,264	2,136	5,400
Dec	1,047	186	1,233
Jan	225	560	785
Feb	1,277	27	1,304
TOTAL	**18,599**	**6,954**	**25,553**

Table 16: Conch catches from Glover's Reef Atoll for National (March 2000 to February 2001) and Northern Co-operatives (March 2001 to February 2002)

(*Note that data for Northern is not for the same year as National)

Source: Fisheries Dept & Northern Co-op.

Zone can replenish conch and lobster populations in the General Use Zone, and the extent of this replenishment depends on the configuration of the 'no take' or Conservation Zone - its size, shape and type of boundaries of the zone.

The spiny lobster (*Panulirus argus*), and the Queen conch (*Strombus gigas*) (Figure 36) are the most economically important species of the Glover's Reef Atoll, and form the basis of the traditional fishing industry in Belize. Catches of both species are delivered primarily to Northern and National Co-operatives, the two largest fishing co-operatives in Belize, with active membership of traditional fishermen using the Atoll. Several species of finfish are also commercially important, and include the Nassau grouper (*Epinephelus striatus*), black grouper (*Mycteroperca bonaci*), hogfish (*Lachnolaimus maximus*), mutton snapper (*Lutjanus analis*), and the Queen triggerfish (*Balistes vetula*). The atoll has also traditionally supported a shark fishery
.

Monitoring of commercial species and catch in the Glover's Reef area is being conducted though the Long-term Atoll Monitoring Protocol (LAMP), and through monitoring of fish catch, in collaboration with the traditional fishermen. A full analysis of catch data is presented in Gibson and Hoare, 2006 (2), as a means of ensuring that research results are available to the traditional fishermen.

Fin fish in general comprise a important component of the commercial catch from Glover's Reef, and are taken mainly using spearguns. However, as most of this catch is sold in local markets and directly to hotels rather than through the co-operatives, the data on catch is not complete. Snappers are reported to make up the largest single family of fish that are exported, with whole fish and fish fillet exports totaling 113,500 lbs in 2001, dropping to 52,316 lbs in 2006 (Belize Fisheries Dept. 2002; 2007).

Catch data collected by Wildlife Conservation Society, in collaboration with fishermen using Glover's Reef, highlight barracuda (*Sphyraena barracuda*) and parrotfish (Scaridae) as the most frequently caught finfish species (Figure 37; Gibson and Sergio, 2006).

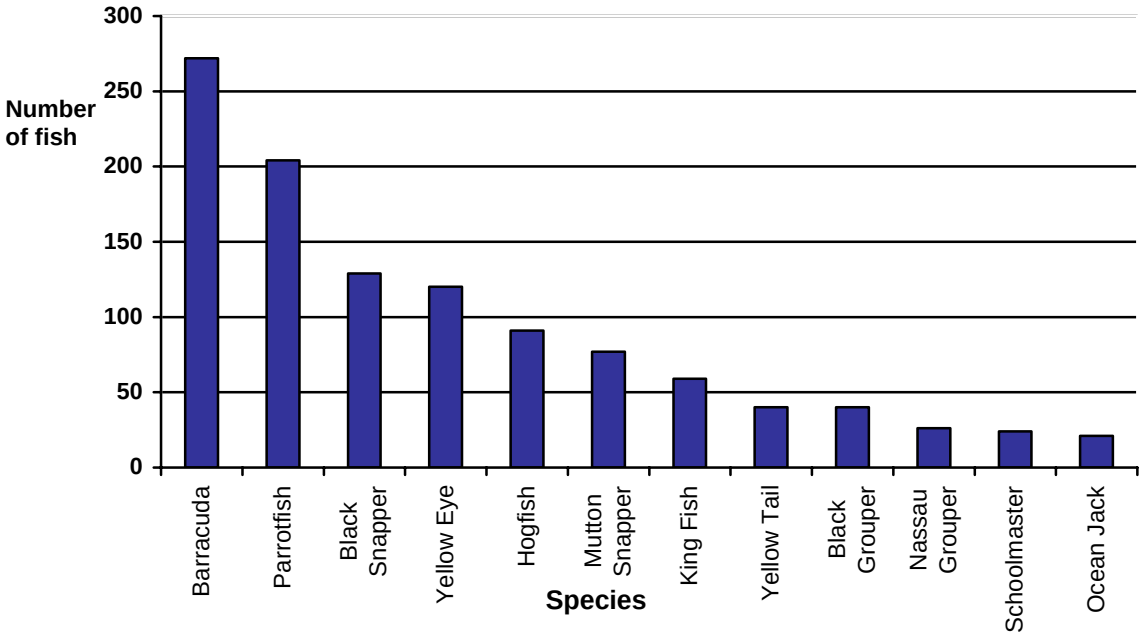


Figure 37: Catch data for finfish (Gibson and Hoare, 2006) NB. Stoplight Parrotfish figures are combined within 'parrotfish'

Table 17: Nassau Grouper numbers at Northeast Point	
Year	**Number of Nassau Grouper**
2001	<2000
2002	4,000 – 6,000
2003	2,400
2004	1,700
2005	2,240
2006	3,000
2007	800

The **Nassau Grouper**, *Epinephelus striatus* (IUCN status: Endangered), is perhaps the most vulnerable of the species known to congregate at the Northeast Point spawning aggregation site on Glover's Reef Atoll. This species is considered one of the top predators, assisting in maintaing the system and buffering against fluctuations caused by other factors such as increasing sea temperatures and pollution. The decline of these top predators results in the system becoming less stable and more unpredictable. The spawning site is being monitored by WCS and Fisheries Department, and has always been considered important for this large species (Heyman and Requena, 2002). The Nassau Gouper has declined nationally by more than 80% since the late 1970s, attributed primarily to fishing pressure, particularly at the spawning aggregation sites, where it is most vulnerable. The Northeast site has been identified as one of only two viable sites remaining for the Nassau Grouper, of nine originally known locations (Paz and Grimshaw, 2001). In 2001, it was estimated to contain over 2000 individuals (Paz & Grimshaw 2001), with over 4,000 to 6,000 individuals counted at peak spawning time in 2002 (Table 17; Heyman and Requena, 2002).

Results from the Northeast site for the 2006 monitoring programme reported over 3,000 individuals (Carballo et. al., 2006). Since then, however, number have shown a sharp decline, with only a maximum of 800 individuals recorded in 2007. Since the 1970s, fishermen from Dangriga traditionally fished the spawning bank, but have reported significant declines in numbers over the last fifteen years, describing congregations of between 20,000 and 30,000 spawning individuals in the 1980's. After the mid 1980's there was a shift in resource utilization to fishermen from Hopkins, using hand lines.

Table 18: Maximum Nassau Grouper counts (2003 – 2006)				
Site	**2006**	**2005**	**2004**	**2003**
North East Point	3,000	2,240	1,700	2,400
Rocky Point	0[1]	200	200	0
Dog Flea Caye, Turneffe	2[2]	-	100[3]	1,500
Sandbore, Lighthouse	1,205[4]	1,800	2,500	1,800
Caye Glory	7[5]	350	1,000	1,000
Gladden Spit	700	360	450	250
Nicholas Caye	48	80	~50	52

[1]Only one dive; [2]Site monitored only in February; [3]Site only monitored in January; [4]Possibly missed peak spawning due to weather; [5]Different dive team used – precise location in question

Table 18: Maximum Nassau Grouper counts for Spawning Aggregation Sites in Belize (Spawning Aggregation Working Group, 2006)

The spawning bank is located within the Seasonal Closure Zone of the marine reserve, which according to regulation 7(3) is closed to fishing during the period of 1st December to the 1st March - the extent of most of the spawning season. However, until recently, fishermen from Hopkins have been allowed to fish the banks for part of each season under special permission from the Minister, and under a quota system. With the decline in numbers of spawning groupers, and the increasing fuel costs, the number of fishermen decreased to only 14 during the 2001 season, and fishing the site is now no longer permitted, with the creation of protective legislation in November 2002 giving much greater protection to spawning aggregation sites, not just at Glover's Reef, but throughout Belize, with the creation of specific 'no-take' Spawning Aggregation Site reserves.

It has been estimated recently that one-third of all known Nassau grouper spawning aggregation sites in the Caribbean region have disappeared, and a recent study estimated that under present management conditions, Nassau Grouper (once the second most commonly caught fish in Belize) will disappear from this country by the year 2013 (Paz and Grimshaw, 2001). 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 (Table 18). In 2002 a closed season was introduced for the Nassau grouper, covering its spawning season in Belize, (1st December – 31st March). However, tag studies have shown that most of the groupers that spawn at the bank remain within the atoll, and that more groupers are caught by spear fishing outside the spawning season than by hand lines during the spawning aggregation (Sala et al. 2001), suggesting that this species needs greater protection generally, not just at the spawning site. There is unfortunately no long term data available from before the population crash to be able to determine trends in the spawning population.

This site is also important as a multi-species spawning aggregation site, with three other species - **Black Grouper** (*Mycteroperca bonaci,* Tiger Grouper (*M. tigris*) and **Yellowfin Grouper** (*M. venenosa;* IUCN: Near Threatened) being recorded using the location for spawning activities over the course of the year (Heyman and Requena, 2002).

The huge **Goliath Grouper,** or Jewfish (*Epinephelus itajara*)**,** another species of the grouper family at risk (IUCN: Critically Endangered), has also been recorded at Glover's Reef Atoll. Like the other groupers, these species are commercially important species, both for fishing and tourism.

Shark fishing is seasonal, utilizing gill nets and long lines. The common species caught include bull, hammerhead, nurse, reef and lemon sharks. Both dried shark fins and salted or frozen shark meat are exported. In 2001, about 9,500 lbs. of shark products were exported (Belize Fisheries Dept. 2002), but it is not known what percentage of this amount was caught at

Glover's Reef. As the use of nets and long lines are not permitted within the boundaries of the marine reserve, it is expected that these types of gear are only used in the deep water beyond the 100 fathom depth line.

The most important sport fishing species is the bonefish (*Albula vulpes*), though the multitude of other colourful reef species are also very important for the marine tourism industry – both for snorkeling and diving activities.

Rare and Endangered Species

Several species of global concern are present in Glover's Reef Marine Reserve, including two 'Critically Endangered' species – the goliath grouper (*Epinephelus itajara*) (one of several grouper species that utilise the spawning aggregation sites of Belize), and the hawksbill turtle (*Eretmochelys imbricata*), which uses the Atoll for both nesting and feeding (Figure 38). Also using the cayes for nesting are the green turtle (*Chelonia mydas*) and the loggerhead (*Caretta caretta*), both listed as 'Endangered' (IUCN, 2006). The third 'Endangered' marine species is the Nassau grouper (*Epinephelus striatus*), a key species of the northeast spawning aggregation site, and one which is showing serious decline.

Figure 38: Species of International Concern of Glover's Reef Marine Reserve

Critically Endangered	
Hawksbill Turtle	*Eretmochelys imbricata*
Goliath Grouper	*Epinephelus itajara*
Endangered:	
Loggerhead Turtle	*Caretta caretta*
Green Turtle	*Chelonia mydas*
Nassau Grouper	*Epinephelus striatus*
Vulnerable	
Queen Triggerfish	*Balistes vetula*
Hogfish	*Lachnolaimus maximus*
Mutton Snapper	*Lutjanus analis*
Cubera Snapper	*Lutjanus cyanopterus*
Rainbow Parrotfish	*Scarus guacamaia*

IUCN Red List (2006)

Five species listed as 'Vulnerable', including the Rainbow Parrotfish (*Scarus guacamaia,* considered to now be locally extinct on Lighthouse Reef Atoll) have been recorded on the Atoll – all these are considered to be commercial species, and are taken by fishermen.

2.5.4 Past and Present Research

Stoddart (1962) described the early research conducted on the Atoll. The earliest known investigation was recorded in the notes of Captain Richard Owen who visited in 1830, and which were compiled by Bird Allen. These notes formed the basis for the information on the Atoll included in Darwin's "Structure and Distribution of Coral Reefs," published in 1842.

Later that century, in 1862, the ornithologist Salvin visited Glover's Reef. The marine fauna was studied in 1925 by the Pawnee Expedition. Schmidt recorded the visit of the Mandel Caribbean Expedition in 1940, which made collections of molluscs and reptiles.

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

Several other studies were carried out during the 1970's: James and Ginsburg (1972) investigated the deeper reefs using the Nekton submersible, a study of the caye flora was carried out in 1973 (Linhart 1980); Schafersman (1972) studied the patch reefs, a sedimentology and ecology study was conducted by Wallace (1974), as was a study of deep water species on the margin of the Atoll (Colin, 1974). An inventory of the marine benthic

plants of the atoll was also completed (Tsuda & Dawes 1974), and a series of icthyological research studies were conducted by Greenfield (1972, 1975 and 1979), Greenfield and Greenfield (1973) and Greenfield and Johnson (1981).

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

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

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

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

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

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

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

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

Table 19: Research studies at Glover's Reef

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

Table 19: Research studies at Glover's Reef / 2		
Name of Researcher	**Research Topic or Species**	**Year**
Acosta & Robertson	Comparative spatial ecology of fished and non-fished lobster species	2002
Carriero-Silva & McClanahan	Role of inorganic nutrients and herbivory in controlling microbioerosion of carbonate substrate	2003
McClanahan, Sala et. al.	Interactions between nutrients and herbivory in controlling algal communities and coral condition	2003
Mumby, Edwards, Arias-Gonzalez et. al.	Importance of mangroves to reef fish communities	2004
McClanahan, Sala & Mumby	Effects of phosphorus and nitrogen enrichment on macroalgae	2004
Godwin and Marsh	Neuroendocrine changes to the bluehead wrasse	2005
Bood	Recovery and resilience of coral assemblages	2005
Clarke	Blenny habitat	2005
Acosta	Modeling of populations of conch, lobster and fish	2005
Mumby, Foster & Henken	Patch dynamics of coral reef macroalgae	2005
Chapman	Shark survey	2005
Steneck & Arnold	Contribution of fish communities to coral reef resilience	2006
Chapman	Shark survey – habitat use and demographic population structure	2006
Thorrold & Gawarkiewicz	Physical oceanography of Glover's (preliminary work to study on the movements of Nassau grouper larvae)	2006
Mumby	Asexual reproduction in *Montastrea annularis*; effects of *Diadema* at Glover's	2005
Acosta	Modeling of populations of conch, lobster and fish	2006
Steneck & Mumby	Linking herbivory to reef resilience	2006
Godwin and Marsh	Neuroendocrine changes to the bluehead wrasse	2006

Table 19: List of research projects carried out through the WCS research station at Middle Caye since 2001 (WCS & Fisheries Dept.)

Several maps of the area have been produced over the years - maps of Glover's Reef atoll are provided by the DOS sheets at a scale of 1:250,000 and also the 1:50,000 series, sheets 58, 59, 61 and 6, available from the Lands Department in Belize or the Ordnance Survey in the U.K. Digital, georeferenced copies are also available. The 1:20,000 chart from the Hydrographic Office of the Royal Navy, sheet 1797 (Monkey River to Colson Point; 1992) provides depth soundings of the area.

Stoddart (1962) provides a map of the Atoll based on aerial photography, and also published maps of the cayes which he surveyed in 1961 (Stoddart 1962) and re-surveyed in 1971 (Stoddart *et al.* 1982).

Aerial photographs are available from several sources such as the Royal Air Force in Cambridge, UK, and Lighthawk.

In 1988, Dr. Franz Meyer of CEDAM developed a map of the Atoll based on a Landsat image, to be followed by the Coastal Zone Management Authority & Institute (CZMAI), which acquired Landsat TM imagery of the coastal offshore region, including Glover's Reef, for the year 1996 from which it derived a 1:50,000 marine habitat map, using the classifications defined by Mumby *et al.* (1998). During mapping activities under different ecoregional planning initiatives, there are now a series of shape files available delineating the protected area, its management

zones, the associated spawning aggregation site, and the marine and terrestrial ecosystems.This is supplemented by more recent data from WCS, which has GIS maps of the Atoll developed from their inventory of the flora and fauna of the patch reefs (Thoney 2000), updated during the Living Seascape intiative. This mapping is on the Wildlife Conservation Society Glover's Reef website.

SeaWifs ocean colour images are available from NASA and have been used for determining temporal and spatial patterns of turbidity in the area of the Atoll after major climatic events such as Hurricane Mitch in 1998 (Andréfouët *et al.* 2002). SERVIR currently has satellite coverage available on sediment runoff and plumes in the Belize / Honduras area from land use change following storm events.

2.6 Cultural and Socio-Economic Values of Management Area

2.6.1 Community and Stakeholder Use

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

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

Traditional Fishing

The Atoll is a traditional fishing area for lobster, conch and finfish, with the greatest activity occurring during the opening of the lobster and conch seasons. Before the seasonal closure zone, and the subsequent closure of the north east grouper spawning site, heavy fishing pressure on the groupers would also occur during peak spawning times.

Table 20: Boat and Crew Sizes Fishing at Glover's Reef

	Fishing Community		
	Dangriga	Hopkins	Sarteneja
No. Sailboats			8
Average crew size			9
No. of skiffs	2	12	
Average crew size	2.5	2.5	
Total estimated no. fishermen	5	30	73
Adapted from Gibson and Hoare, 2006			

Thirty-five boats were recorded as active within the Atoll in 2005, primarily from Sarteneja, Hopkins, Dangriga, Belize City and occasionally Placencia (Table 20), with an estimated total of 108 fishermen (73 sailboat fishermen, and 35 using skiffs) (Gibson and Hoare, 2006).

The two boat types are also indicative of two different fishing sectors. The majority of fishermen who visit the area use wooden sailboats up to 30 feet long, equipped with auxiliary outboard engines and ice boxes, originating primarily from Sarteneja (Figure 39). Each will carry between seven and twelve crew members, who free-dive for conch, lobster and occasionally finfish. These boats sail from Belize City to spend an average of six to twelve days fishing on the Atoll, before returning to the mainland (Sarteneja fisherman, pers. com.) The skiffs, originating from Dangriga and Hopkins are primarily fishing by hand-line, and spending a much shorter time on the Atoll (an average of three to four days). The majority of fishermen are members of either National or Northern Fisherman Co-operatives.

Figure 38: Traditional Sarteneja Sailboat

Of the thirty-five boats recorded at the atoll, five use the Atoll as their main fishing ground (being recorded on the atoll in over six months of the year) (Table 21). Eighteen boats were recorded as present on the atoll during only one month of the year, seven of those being recorded in October, at the opening of the conch season.

Table 21: Main Fishing Stakeholders: Boats using Glover's Reef Atoll as the primary fishing area (> 6 months of the year) (2005)		
Boat	**Number of Months recorded**	**Average Crew size**
Princess	11	7.45
Ubafu	10	10.30
Tormento	9	4.80
La Bonita	8	6.75
Vision	7	11.00

Seasonal use

The fishing activity shows distinct seasonality, with the highest peak (recorded by the presence of the greatest number of fishing boats) being observed in October, at the start of the conch season (Figure 40). A second, smaller peak occurs during June and July, at the start of the lobster season. The lowest activity is seen in March, April and May, whilst lobster season is closed. The majority of sailboats from Sarteneja return to the mainland during these months to repair and do maintenance work on the wooden sailboats.

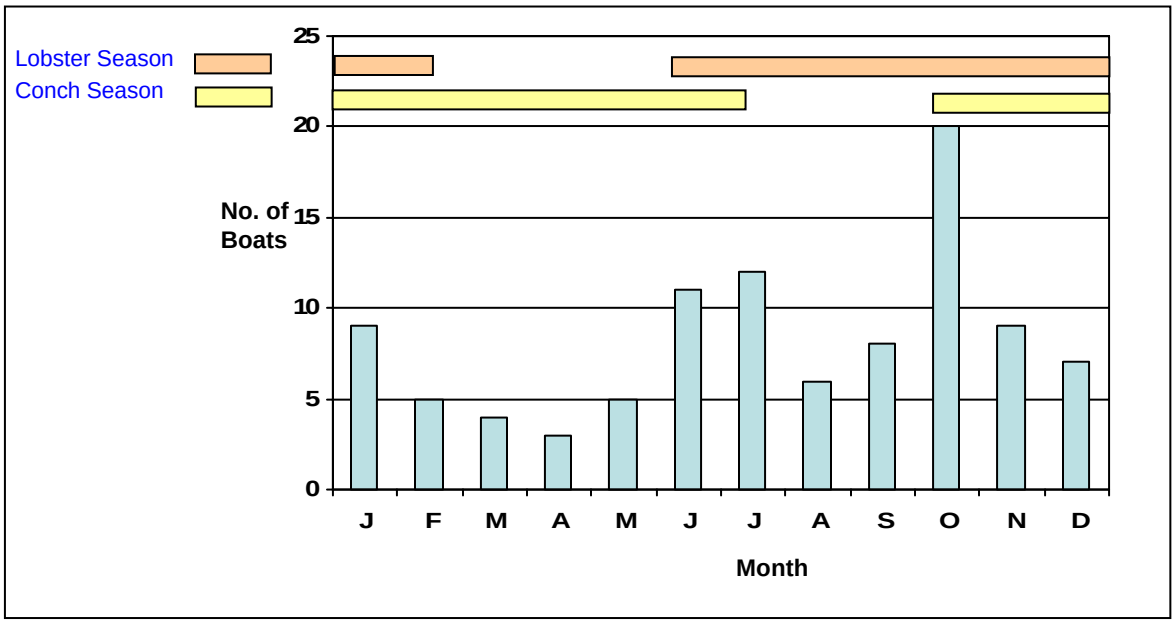


Figure 40: Seasonality of Fishing Boat Activity Recorded at Glover's Reef Atoll (Glover's Reef Marine Reserve Annual Report, 2006)

Research Use

Middle Caye is owned by Wildlife Conservation Society, and provides a base for a number of research projects throughout the year, exploring the marine ecosystems of the Atoll, and advancing knowledge of the biodiversity and physical environment of the area. The facilities can house up to 16 researchers at any one time, along with the station manager and staff. Research activities require permission from the Fisheries Department and WCS before going ahead, allowing filtering of inappropriate research activities. Fisheries Department also conducts research in the area, based from the facilities on Middle Caye. Past research has been summarised in Section 2.5.4.

2.6.2 Archaeological Sites

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

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

The Atoll is noted for its numerous shipwrecks, including the following:

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

2.6.3 Tourism and Recreation Use

Tourism is becoming an increasingly important economic activity on Glover's Reef Atoll, though with accessibility far harder than Lighthouse and Turneffe, much of the tourism is based on live aboards, or based from the five resorts currently operating from the cayes within the Atoll (Table 22). A sixth, Manta Ray Resort, is currently not in operation. Visitors also arrive from other resorts on the mainland and other cayes on a daily basis, such as Hamanasi Adventure and Dive Resort, from the mainland near Hopkins, and from hotels on Tobacco Caye. Sailboats from The Moorings charter yacht business based in Placencia visit the atoll for snorkeling and diving, and other private boats and yachts also visit the reserve, but on a relatively small scale. Dive boats are required to register in order to operate within the reserve.

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

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

Table 22: Resorts located on Glover's Reef Atoll							
Resort	**Location**	**No. of Years Established**	**Activities**	**Maximum Capacity**	**No. of Residential Staff**	**Environmental Stewardship**	
						Sewage System	**Garbage Disposal**
Off the Wall	Long Caye	9 years	Diving (week long package) Snorkeling Fly-fishing Deep sea fishing	10 guests	2 permanent 5/6 on week rotations	Composting toilets and leachfield	Organic – compost on site Inorganic – to Dangriga
Long Caye Resort (Slickrock Adventures Inc.)	Long Caye	11 years	Sea Kayaking Kayak boarding Windsurfing Surfing Snorkling	28 guests (normally 50% occupancy)	7/8/staff on site	Composting toilets	Organic – compost on site (and cleaned by crabs) Inorganic – to Dangriga Burnables burnt
Glovers Reef Atoll	North East Caye		Kayaking Diving Fly fishing	45 – 50 Average 10 - 20		Composting toilets	Inorganic – to Dangriga Burnables burnt
Island Expeditions	South West Caye	12 years in the area	Kayaking Snorkling Fishing	16 guests Average 12 - 16	7 staff	Composting toilet	Inorganic Garbage to Dangriga
Isla Marisol	South West Caye	5 years	Diving Snorkling Fly fishing	22 guests Average 10	8 staff on site	Septic system (1 per cabana), with flush toilets, using well water. Emptied once a year and effuent buried	Inorganic Garbage to Dangriga

generally have dive guides resident on-site. In addition, many of the visitors to the Atoll visit the WCS research station on Middle Caye, where they are given informal presentations on the research being carried out.

Figure 41: Tourism is an important economic activity on Glover's Reef Atoll

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

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

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

2.6.4 Other Economic Use

Whelk Harvesting Whelks have been harvested at Glovers in the past under special license, however a moratorium has been put in place by Fisheries Department, pending further data on abundance and distributions of this species (Fisheries Department, 2005). Research was conducted in 2005 under the Department, showing that the whelks had a limited distribution, being confined to the reef crest, and that there were signs of over-harvesting, with densities being higher within the Conservation Zone, and greater numbers of individuals occurring in the larger size categories.

2.6.5 Research and Education Use

Research Use

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

The WCS research station on Middle Caye, opened to scientists since mid-1997, complements the management activities of Fisheries Department, with many research programmes being carried out on the atoll. There are eight buildings located on the caye, including a boat locker, compressor room, workshop, generator house, ranger station, wet and dry laboratories, kitchen/dining area, dormitory and Station Manager's house. There are four toilets on the island, two near the dormitory and two near the laboratory. The toilets are state of the art Clivus Multrim composting units, enclosed and non-polluting.

There is also a 200 foot dock. The ranger station, dining area, dormitory and residence are all elevated to provide better ventilation. The boat locker is situated on the dock and is used for storage of gear. The compressor room is situated at the base of the dock and houses the air compressor for filling SCUBA tanks. The workshop and generator house contains the battery bank and diesel generators.

The laboratory, a large room with a counter surrounding three sides, has eight bench sites with a set of storage drawers and electrical sockets, with a large work table in the center of the room, and running fresh water. The station has a very limited supply of laboratory equipment, and researchers coming to the station are warned to bring any specialized laboratory or field equipment that they may need. Several aquaria are installed below the main laboratory, furnished with filtered seawater from the atoll lagoon.

Education

The reserve staff has been carrying out an informal education programme targeting visitors to the reserve, including fishermen and tourists. This includes sharing information about the reserve and the importance of the atoll's ecosystems. A reserve brochure was printed several years ago, and has recently been updated WCS has also developed a colour brochure that highlights the reserve's zones and their importance to fisheries management. This publication was designed for use in a school outreach programme.

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

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

3. Conservation Planning

Conservation planning for Glover's Reef Marine Reserve is detailed in the proceedings of the Glover's Reef Seascape Species Selection Workshop (Gibson, Hoare, Strindberg and Agrosa, 2004). The Seascape Species Approach is a wildlife-based strategy for defining and conserving the integrity of wild landscapes. The approach uses a group of surrogate species, called Seascape Species, as conservation targets, with the belief that meeting the needs of this suite will help conserve the composition of the seascape as a whole, the configuration of the seascape (how elements are arranged and connected), and ecological processes occurring at a seascape scale. The approach also helps conservationists to define the extent of the seascape based on the needs of the most demanding species, define ecologically appropriate management units, identify where and when conservation conflicts occur, and structure and prioritise conservation actions accordingly.

The Living Seascape programme fits within the conservation planning criteria required by the National Protected Areas System Plan, identifying a series of conservation targets to represent the biodiversity of the protected area, highlighting threats and concerns, and developing strategies for incorporation into management programmes.

The following project goals were defined during the development of the conservation planning activities:

- To conserve all species and habitats in order to preserve Glover's Reef's diversity & productivity
- To provide an ecological basis for functional seascape boundaries
- To focus conservation actions on key threats, efficiently allocating scarce conservation resources
- To use a wildlife-focused strategies to reconcile wildlife needs and human welfare

3.1 Conservation Targets

3.1.1 Identification of Conservation Targets

The WCS Seascapes Programme (based on the Living Landscapes Programme) focuses on target species, and defining their population and habitat requirements to determine the seascape needs required for long term viability - of both the conservation targets, and of the underlying ecological processes on which they depend.

Seascape Species are defined by their use of large, ecologically diverse areas, the important roles they play in maintaining the structure and function of natural ecosystems, and their susceptibility to human alteration of wild landscapes. As seascape species require large, diverse, minimally impacted areas, it is hypothesized that meeting their needs will provide substantial protection for the species with which they co-occur as well as for the marine ecosystems on which both depend. Additional conservation targets are selected on criteria such as endemism and species rarity.

To define the natural seascape of Glover's Reef atoll for conservation planning purposes, eleven habitat types were recognized:

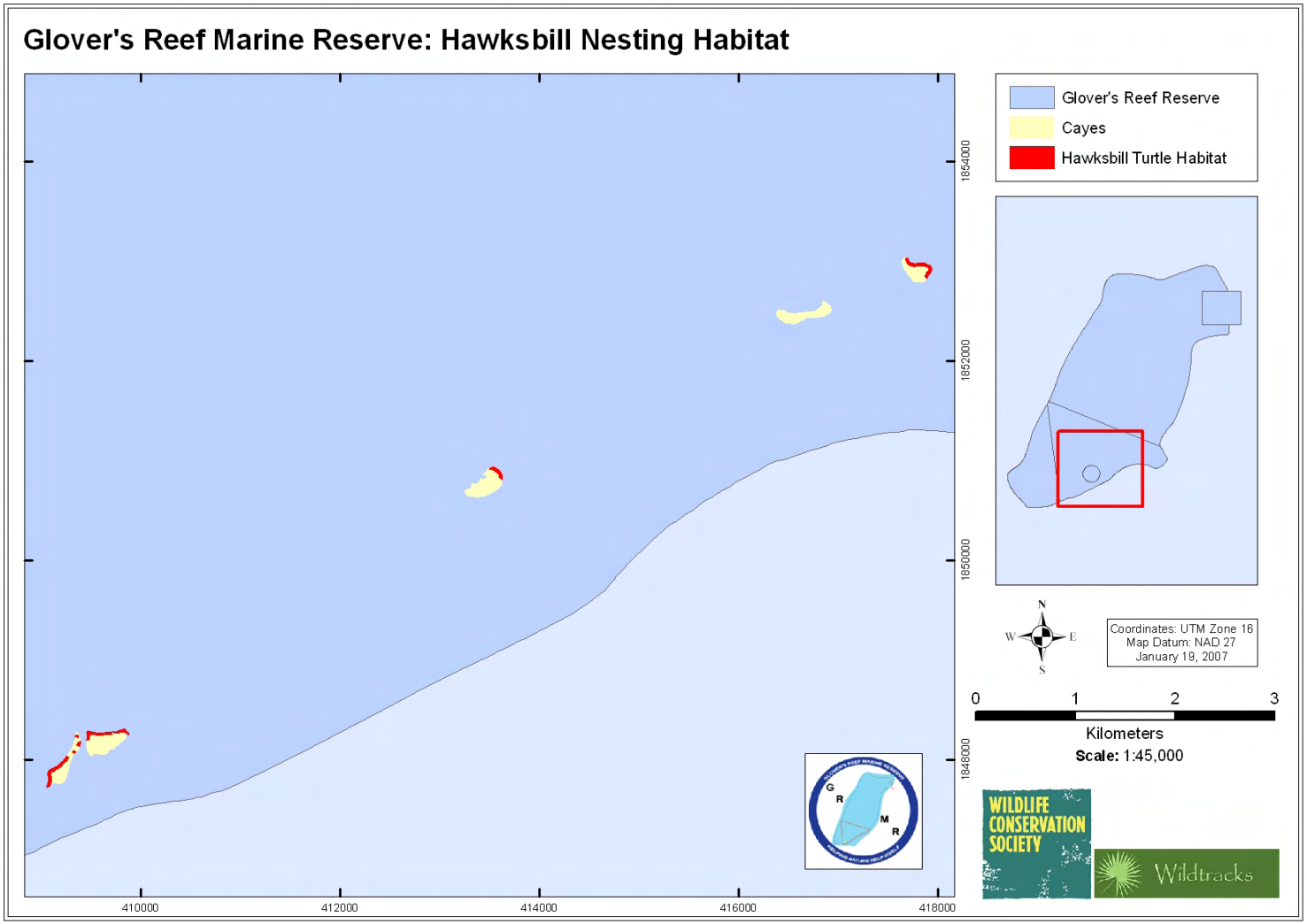
- Sand and sparse seagrass mix
- Dense patch reef
- Diffuse patch reef
- Forereef and dense massive and encroaching corals
- Forereef and sparse massive and encroaching corals
- Low relief spur and groove
- Reef crest
- Shallow lagoon floor and dense seagrass
- Shallow lagoon floor and medium density seagrass
- Shallow lagoon floor and sparse seagrass
- Cayes

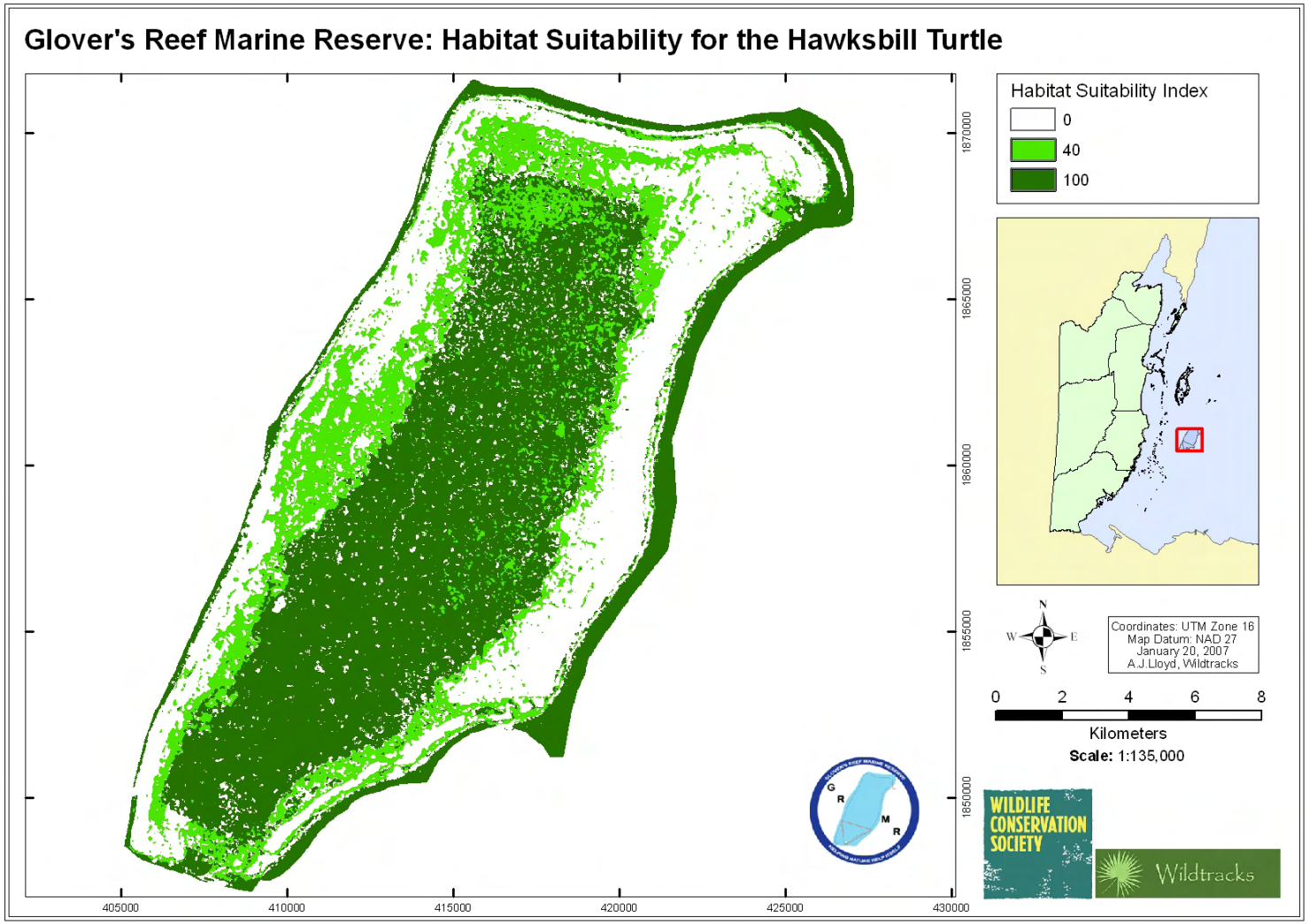
Of the twenty-eight species originally selected as candidates for Glover's Reef (WCS Seascape Species Selection Workshop report, 2004), seven have been chosen as Seascape Species, based on their habitat requirements, their functionality in the food chain and their economic, cultural and/or flagship value (Table 23).

Table 23: Seascape Species
Nassau Grouper
Conch
Caribbean Reef Shark
Hawksbill Turtle
Osprey
Black-spined Urchin
Star Coral

An understanding and mapping of the biological seascape in which each of these target species exists was developed, and the human landscape, or threats to these species was assessed (WCS, 2005).

Hawksbill Turtle	The Hawksbill turtle (*Eretmochelys imbricata*) is recognized as Critically Endangered (IUCN, 2006), and is fully protected under Belize legislation The atoll is used by both adults and juveniles, which feed on reef sponges and find refuge in coral heads. The sandy beaches, important for nesting during the breeding season (May to November), have been identified on Long Caye and South West Caye. **Habitat preferences:** ▪ Medium sea grass on shallow lagoon floor ▪ Dense patch reef ▪ Forereef with dense massive & encrusting corals ▪ Low relief spur & grove ▪ Deep reef/wall/escarpment Mangroves, dense sea grass on shallow lagoon floor & reef channels are considered marginal habitats **Specific Threats:** ▪ Fishing on the Atoll, particularly netting (illegal at Glover's) ▪ Human impacts encountered during dispersion and migration, away from Glover's Reef Atoll ▪ Development /buildings on nesting areas ▪ Disturbance to nesting turtles by visitors on the cayes (e.g. lights) ▪ Disturbance by dogs on cayes ▪ Disturbance by divers ▪ All threats to the reef ecosystem threats to hawksbills (run-off, anchoring, sewage, dredging, solid waste and oil exploration)


Glover's Reef Marine Reserve: Hawksbill Nesting Habitat
Glover's Reef Reserve
Cayes
Hawksbill Turtle Habitat
1854000
1852000
1850000
1848000
410000
412000
414000
416000
418000
N
W
E
S
Coordinates: UTM Zone 16
Map Datum: NAD 27
January 19, 2007
0
1
2
3
Kilometers
Scale: 1:45,000
WILDLIFE CONSERVATION SOCIETY
Wildtracks


Glover's Reef Marine Reserve: Habitat Suitability for the Hawksbill Turtle
Habitat Suitability Index
0
40
100
1870000
1865000
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Nassau Grouper

The **Nassau Grouper** (*Epinephelus striatus*), is listed as 'Vulnerable' (IUCN, 2006). This species migrates to North East Point to congregate at the spawning aggregation site. The majority of Nassau groupers that spawn here are Atoll resident, though whilst Glover's Reef is estimated to have a carrying capacity of 15,000 spawning adults, most recent estimates suggest that numbers have fallen below 1,000 (Hoare, pers. com.). The 2007 survey recorded a maximum of only an estimated 800 individuals – far lower than previous years.

Habitat preferences:

There is a sharp distinction between juvenile and adult habitats. The juveniles are heavily reliant on:

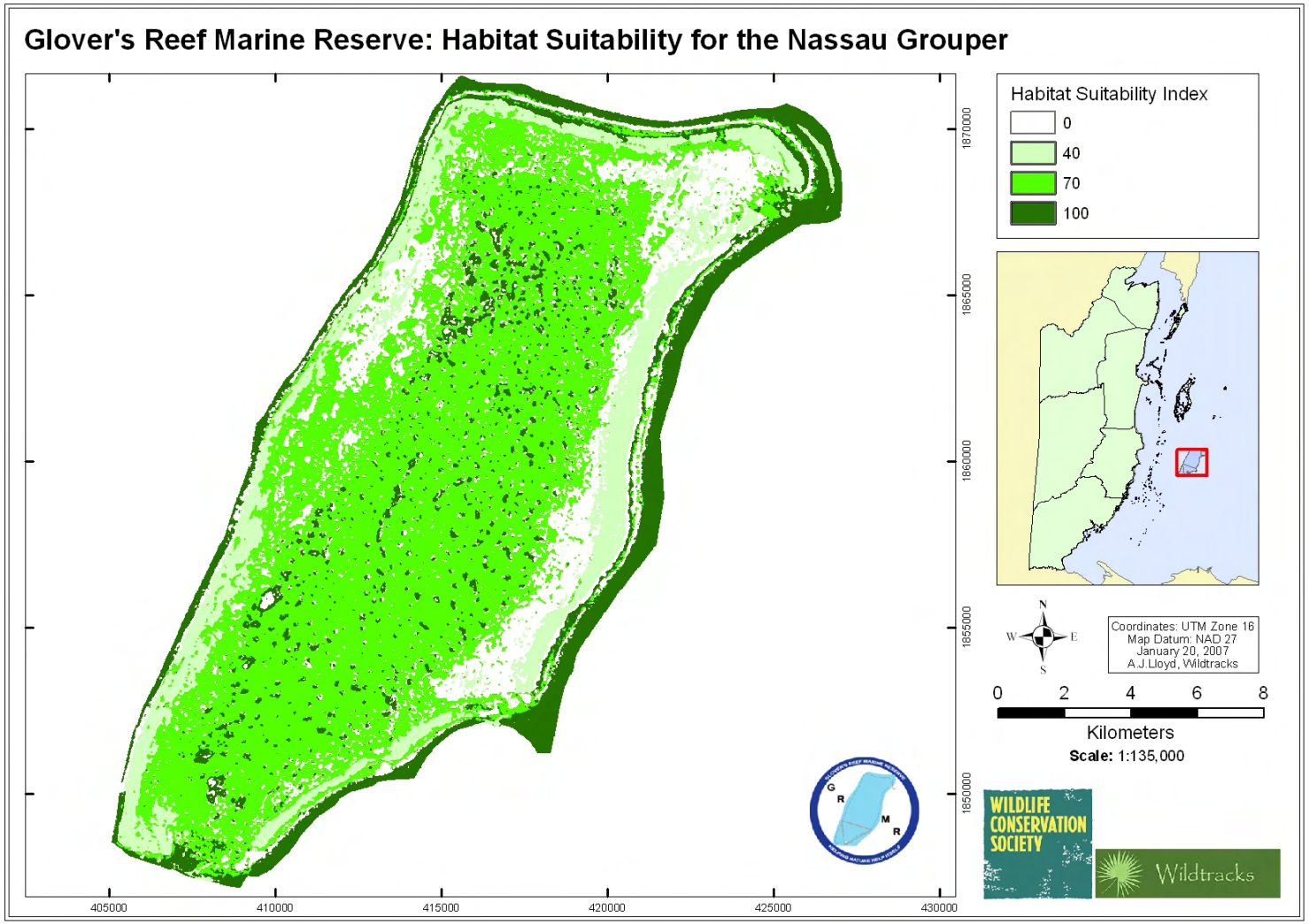
- Shallow sea grass lagoon areas
- Patch reefs
- Mangroves (to a lesser extent)
- Sand & sparse algae (to a lesser extent)

…whilst habitat suitability for the adults focuses on:

- Dense/diffuse patch reefs,
- Forereef with dense massive & encrusting corals,
- Forereef with sparse massive & encrusting corals,
- Low relief spur & grove (females rest here during spawning),
- Deep reef/wall/escarpment
- Reef channels

Specific Threats:

- Fishing at spawning site by hand lines (this species is very vulnerable to over fishing when spawning)
- Spear fishing
- Mangrove clearance
- All threats to the health of the reef and sea grass beds are also indirect threats to the Nassau grouper (including anchoring, global warming, sewage, run-off, dredging, etc.)


Glover's Reef Marine Reserve: Habitat Suitability for the Nassau Grouper
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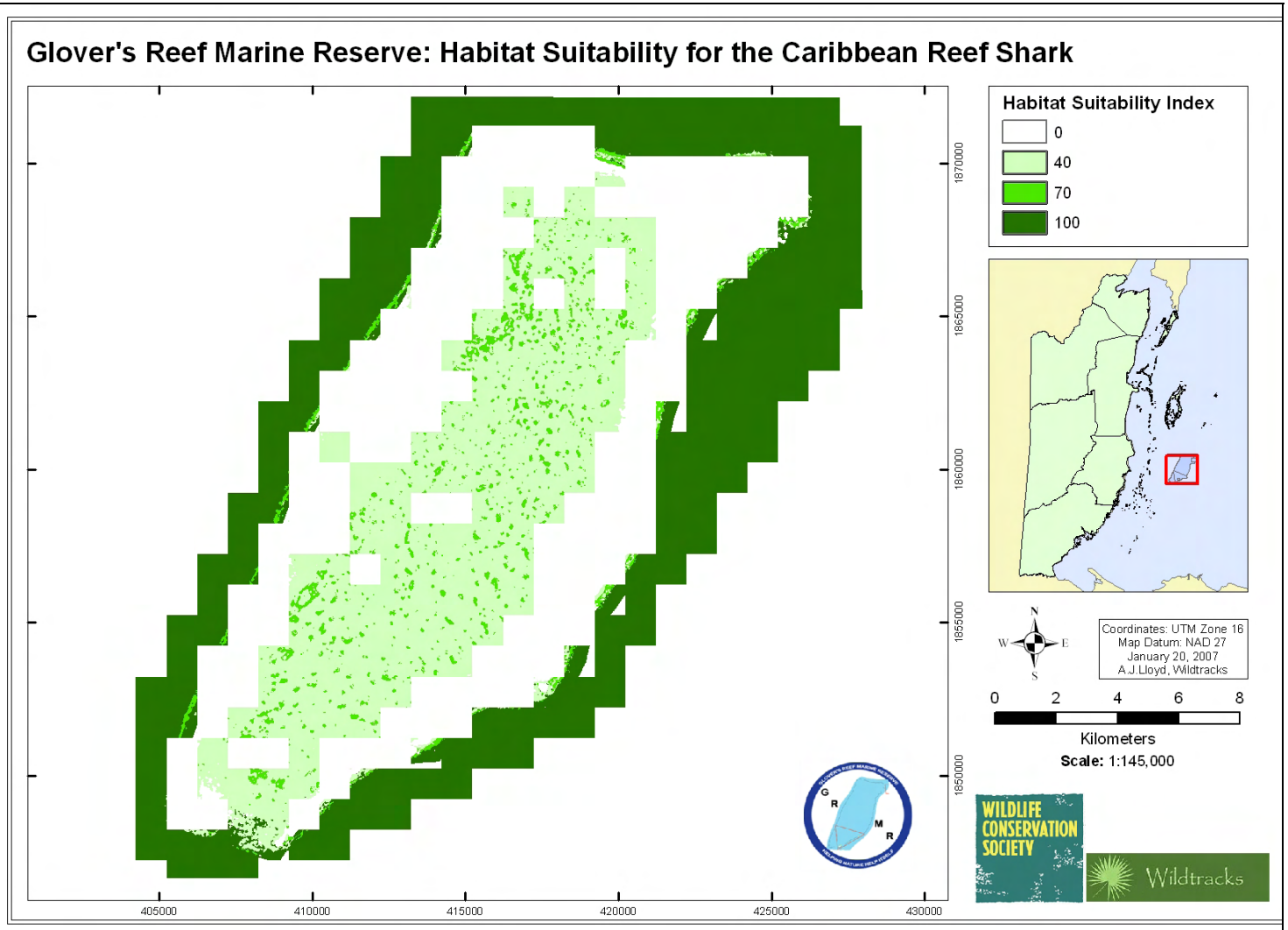
Caribbean Reef Shark	The Caribbean Reef Shark has been identified as a conservation target for a number of reasons - its role as a top predator that spends its entire life in the Atoll area, migrating seasonally (May) to feed on spawning snappers. It utilizes both the outer reef and near shore pelagic zone; with large sub-adults/adults confined to outside Atoll, and juveniles recorded both inside & out. **Preferred Habitats:** ▪ Forereef with dense massive & encrusting corals, ▪ Forereef with sparse massive & encrusting corals, ▪ Low relief spur & grove ▪ Deep reef/wall/escarpment, ▪ Reef channels ▪ Dense patch reef, ▪ Diffuse patch reef, ▪ Reef crest Shallow lagoon sea grass are considered marginal habitats **Specific Threats:** ▪ Long line fishing and nets ▪ All other threats to the health of the Atoll


Glover's Reef Marine Reserve: Habitat Suitability for the Caribbean Reef Shark
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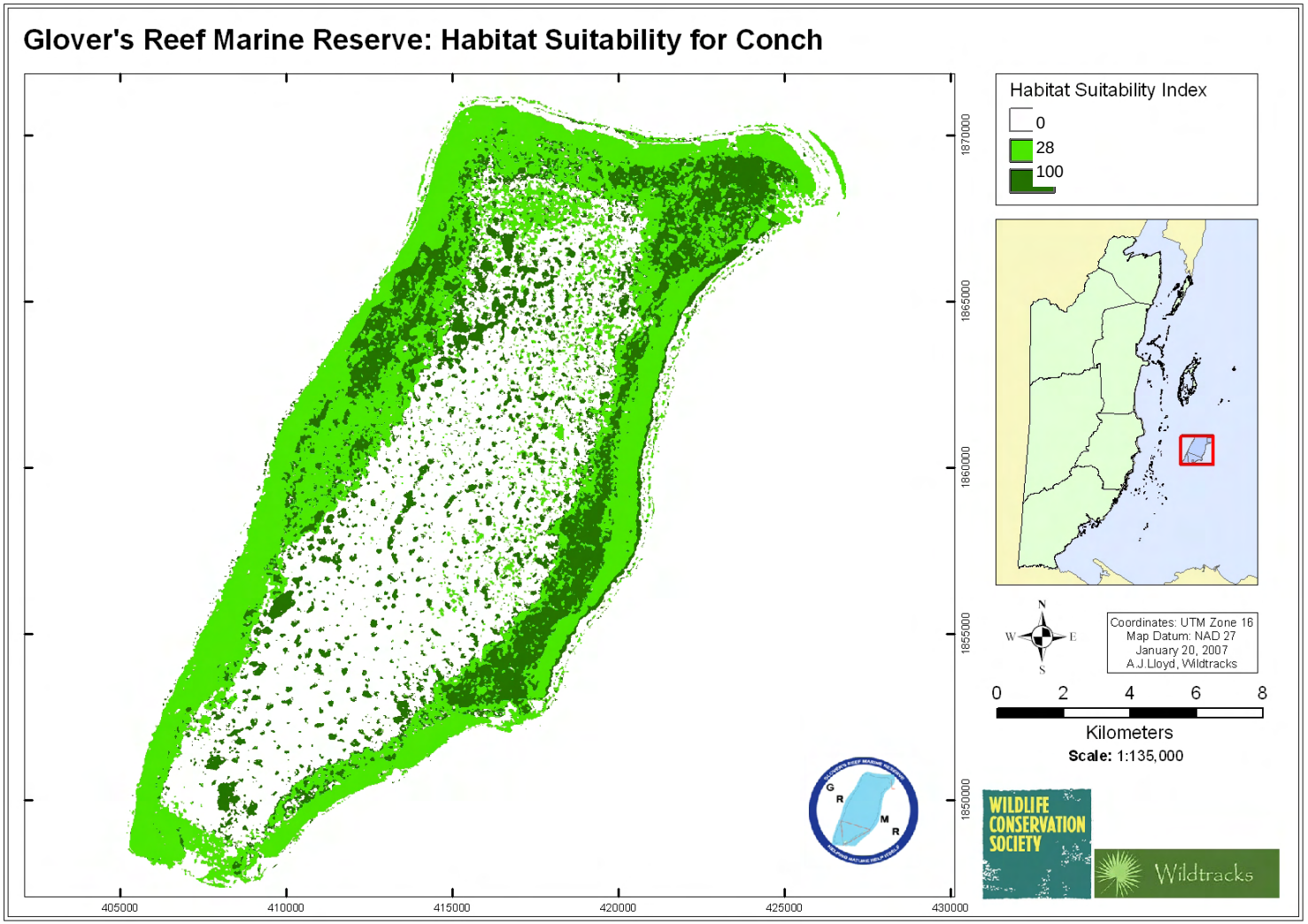
Queen Conch	Queen conch feed in the sea grass areas, breeding in deep sandy areas, with nursery grounds in sandy areas. **Preferred Habitats:** ▪ Sparse/medium/dense seagrass (larvae) ▪ Sea grass on shallow lagoon floor, ▪ Sand & sparse algae, ▪ Reef channels ▪ Diffuse patch reef still good habitat Dense patch reef, mangroves, forereef with dense/sparse massive & encrusting corals, low relief spur & grove deep are considered marginal habitats **Specific Threats:** Fishing during closed season, taking of undersized conch, fishing in no-take zones, and over-fishing generally


Glover's Reef Marine Reserve: Habitat Suitability for Conch
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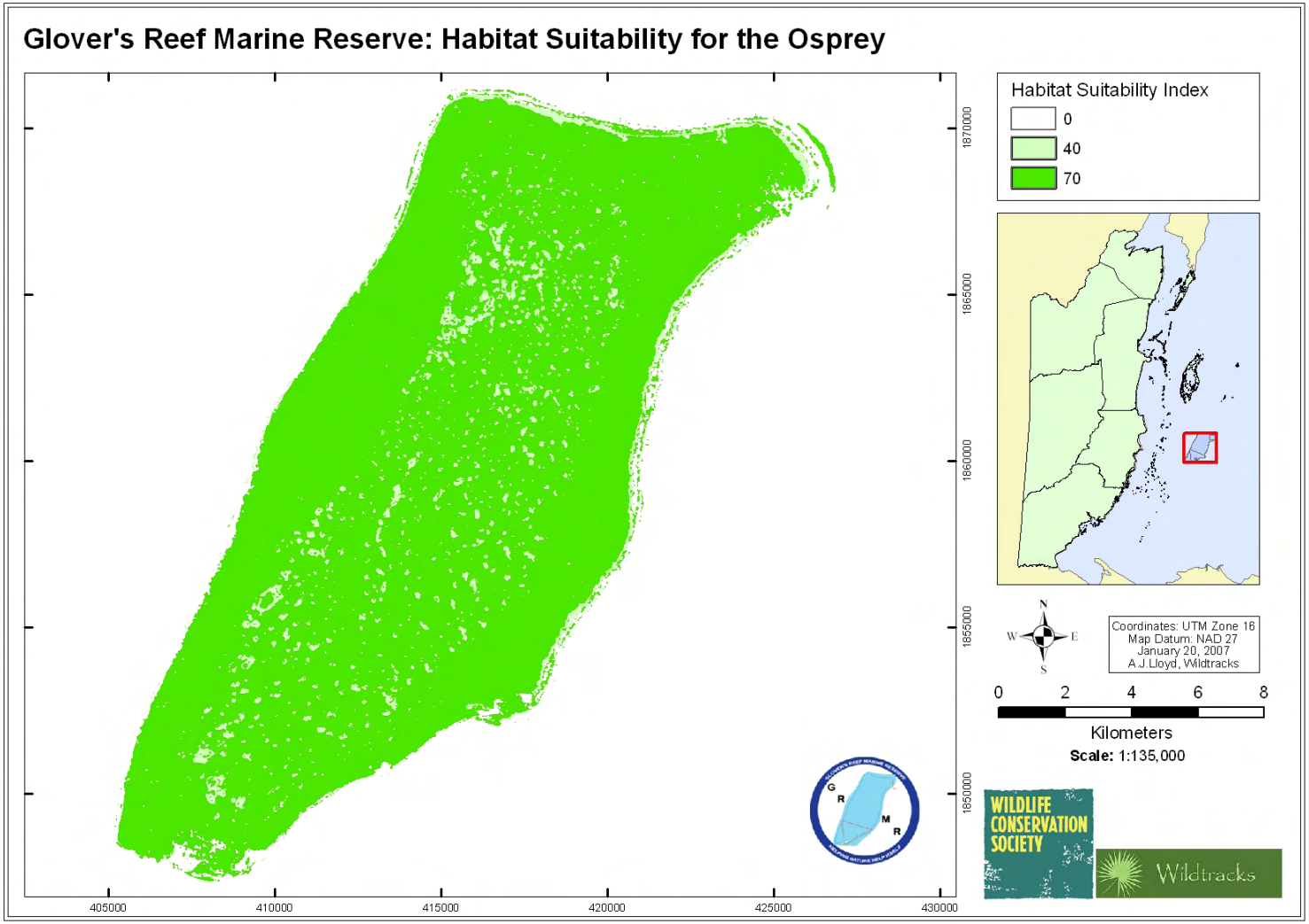
Osprey	The osprey is an important top predator, fishing throughout the atoll's lagoon, and transfering nutrients from the sea to the cayes. **Preferred Habitats** ▪ Littoral forest ▪ Palms ▪ Shallow lagoon floor (good hunting habitat) Mangrove, dense/diffuse patch reef, rubble beach, brackish ponds are considered more marginal **Specific Threats:** ▪ Land development ▪ Lack of nesting sites


Glover's Reef Marine Reserve: Habitat Suitability for the Osprey
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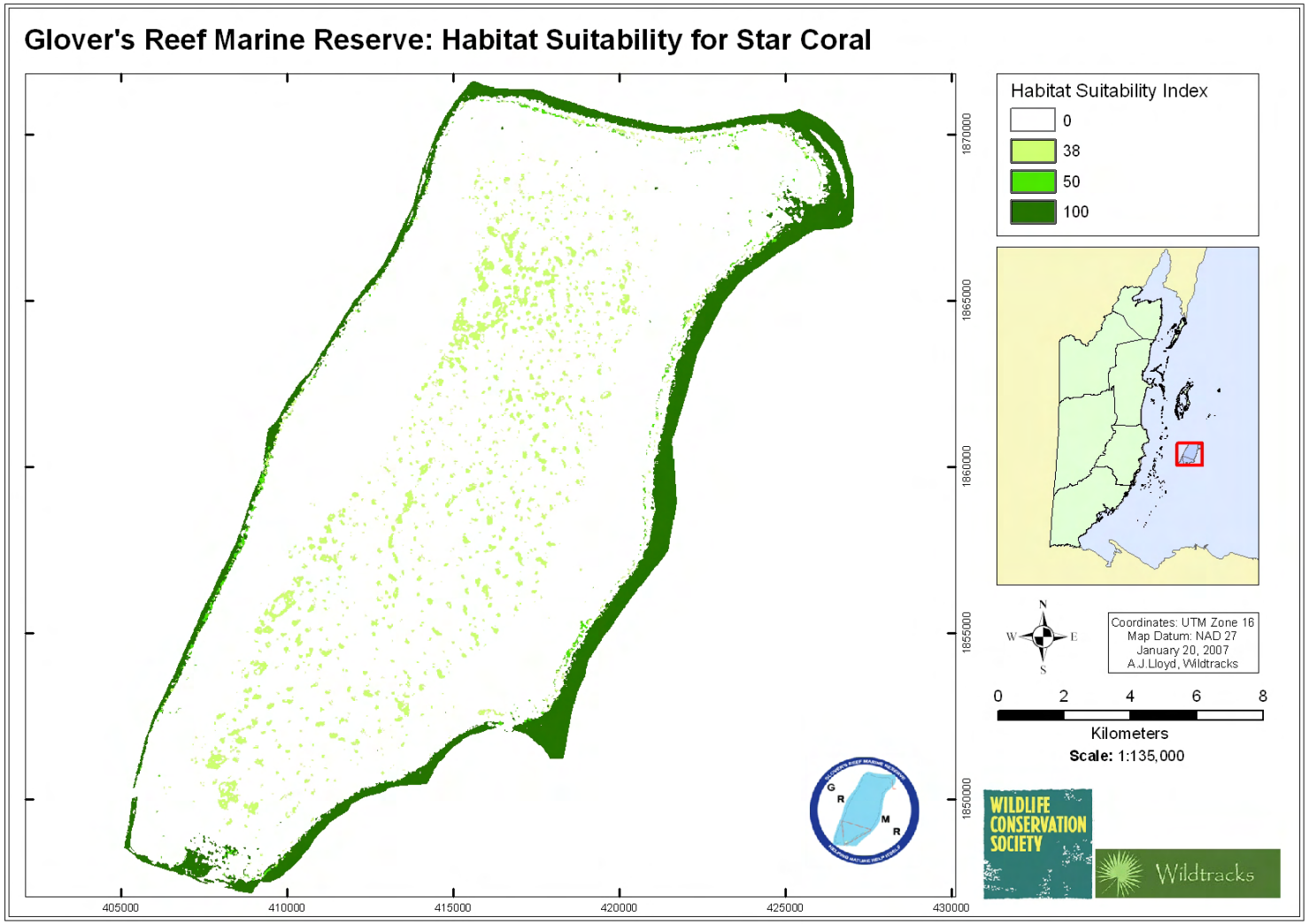
Star Coral	Star Coral has been chosen to represent the health of the coral reef community of Glover's Reef. The coral is critical to the maintenance of local biodiversity, and the reef is highlighted as one of the two key marine ecosystems within the protected area. Coral reefs are one of most diverse ecosystems on the planet, essential to the viability of the majority of fish and marine invertebrates living on the reef, providing basic structure for shelter, foraging, and reproduction. Coral reef is also one of the more important tourism resources Belize has to offer. **Preferred Habitat:** ▪ Dense patch reef, ▪ Forereef with dense massive & encrusting corals, ▪ Low relief spur & grove It is also found in diffuse patch reef, forereef with sparse massive & encrusting corals, deep reef/ wall/escarpment, reef channels, and less commonly found in the reef crest **Specific Threats:** ▪ Coral bleaching ▪ Coral diseases ▪ Anchor damage / diver and snorkeler damage ▪ Run-off, sewage, dredging and oil pollution


Glover's Reef Marine Reserve: Habitat Suitability for Star Coral
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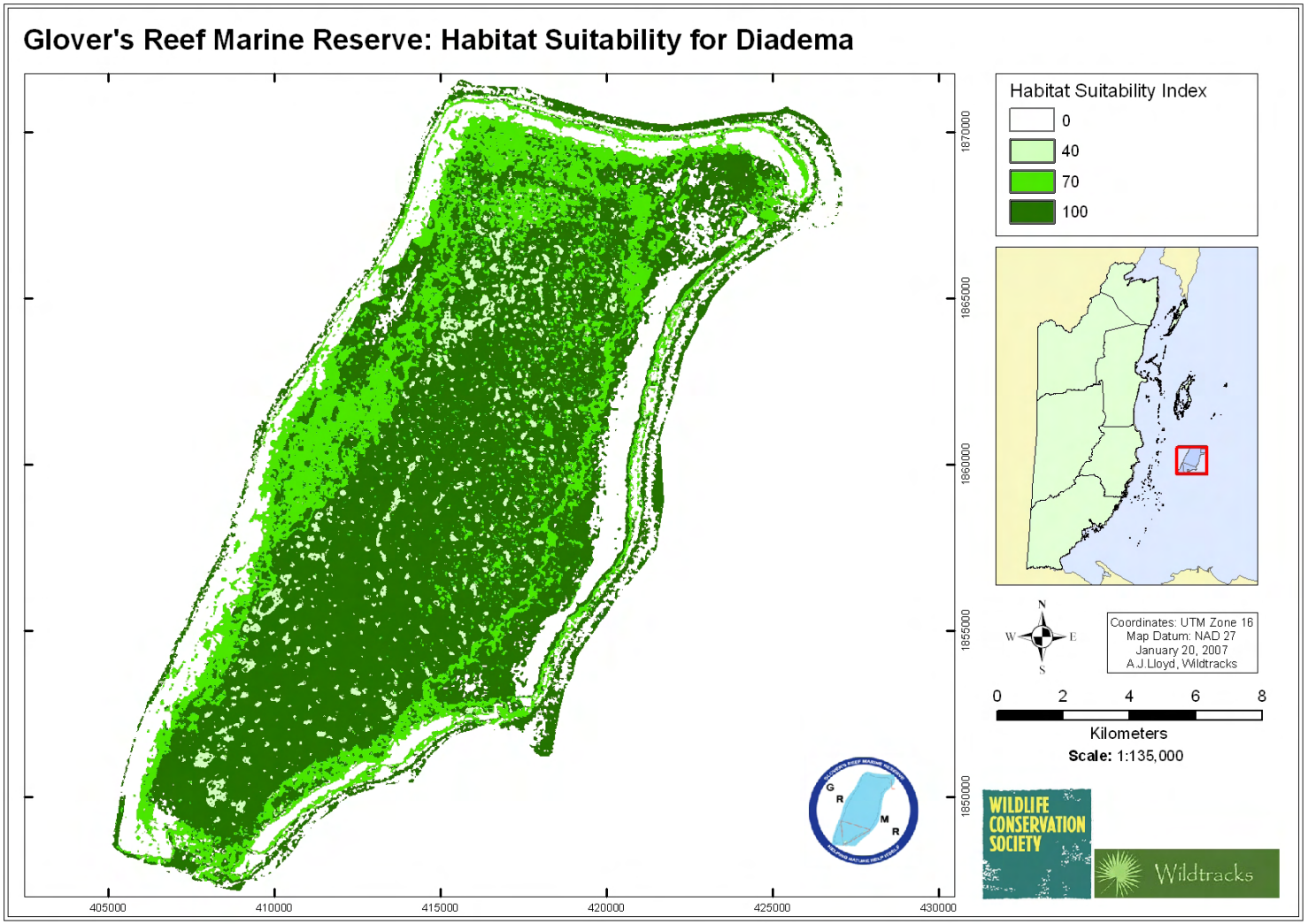
Diadema urchin	The *Diadema* is considered a keystone species for its importance in the maintenance of healthy reefs, in its role as a herbivore. 90% of the population disappeared in a die-off in 1983/84, but it is now making a slow comeback. **Preferred Habitat:** ▪ Sparse sea grass on shallow lagoon floor ▪ Medium sea grass on shallow lagoon floor ▪ Forereef with dense massive & encrusting corals Diffuse patch reef and dense sea grass on shallow lagoon floor are still good habitats, whereas dense patch reef and deep reef/wall/escarpment are marginal habitats **Specific Threats:** ▪ Disease ▪ Dredging


Glover's Reef Marine Reserve: Habitat Suitability for Diadema
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3.2 Threats to Biodiversity

A fully participatory threat analysis was conducted in 2004 for the conservation planning process, with input from a wide range of stakeholders, based on the WCS Living Seascapes programme (WCS Threat Assessment and Mapping Workshop report, 2004). 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 protected area, but also to the Atoll as a whole, as well as oceanic impacts and trans-boundary issues.

- **Fishing**
- **Coral Bleaching / warming sea temperatures**
- **Chemical runoff from land development, agriculture and aquaculture**
- **Direct phyical damage to coral (anchors, divers, snorkelers)**
- **Land development**
- **Introduced species**
- **Solid waste**
- **Liquid waste and sewage**
- **Oil pollution**
- **Dredging**

3.2.1 Overfishing / Illegal Fishing

Overfishing / Illegal FIshing	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
	Damage to coral from fishing activities
	Fishing by boats from Honduras

Glover's Reef Atoll, whilst far from the mainland, is an important resource for a number of the coastal communities – primarily Sarteneja, Hopkins and Dangriga, with an estimated maxium of 170 or more fishermen using the area (using the maximum number of fishermen per boat, Glover's Reef Annual Report, 2006). 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 has resulted in reduced catch per unit effort and a shift in the community and population structures of both fish and invertebrates harvested. Overfishing was identified as occurring throughout the General Use Zone, and illegal fishing activities were recorded from the Conservation Zone and the Seasonal Closure Zone. Lobster fishing out of season was also reported (Figures 42, 43 and 44; GRAC meeting, April, 2007).

Whilst the majority of extractors 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 the majority of fishermen and tour guides reporting reduced numbers of lobster and conch and commercial species (Consultations, 2007). LAMP surveys in 2006 showed that whilst there were similar numbers of conch recorded in both the Conservation and General Use Zones, there were significant differences in the ratio of adults to juveniles within these two zones. Over 90% of individuals recorded within the General Use Zone were juveniles, as compared with 58% in the Conservation Zone, an indication of severe fishing pressure on the resources. This is representative of the national pattern, with depressed

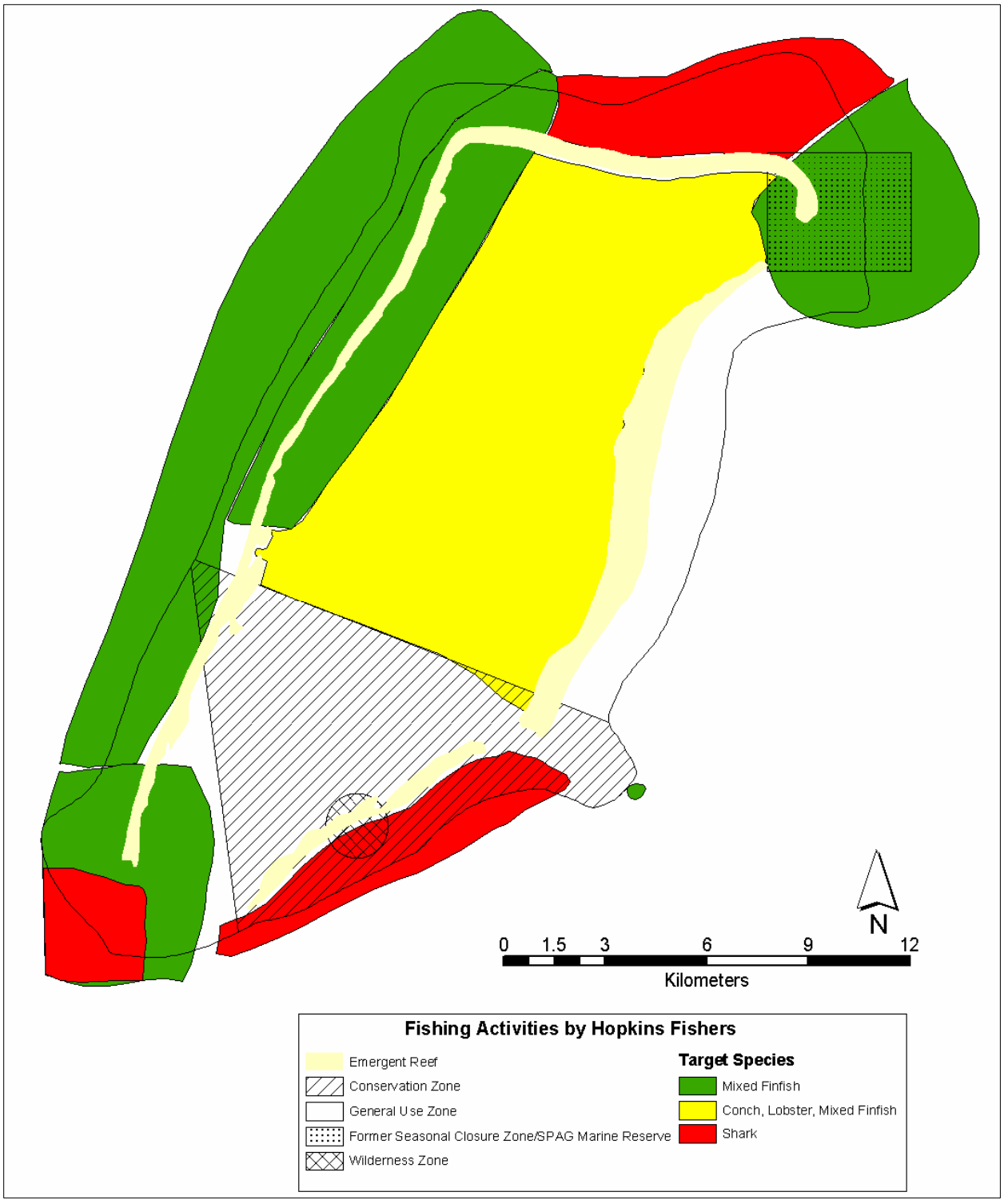


Figure 42: Fishing activities by Hopkins fishers
WCS – Living Seascapes Programme – Glover's Reef Threats Assessment and Mapping Workshop 2004

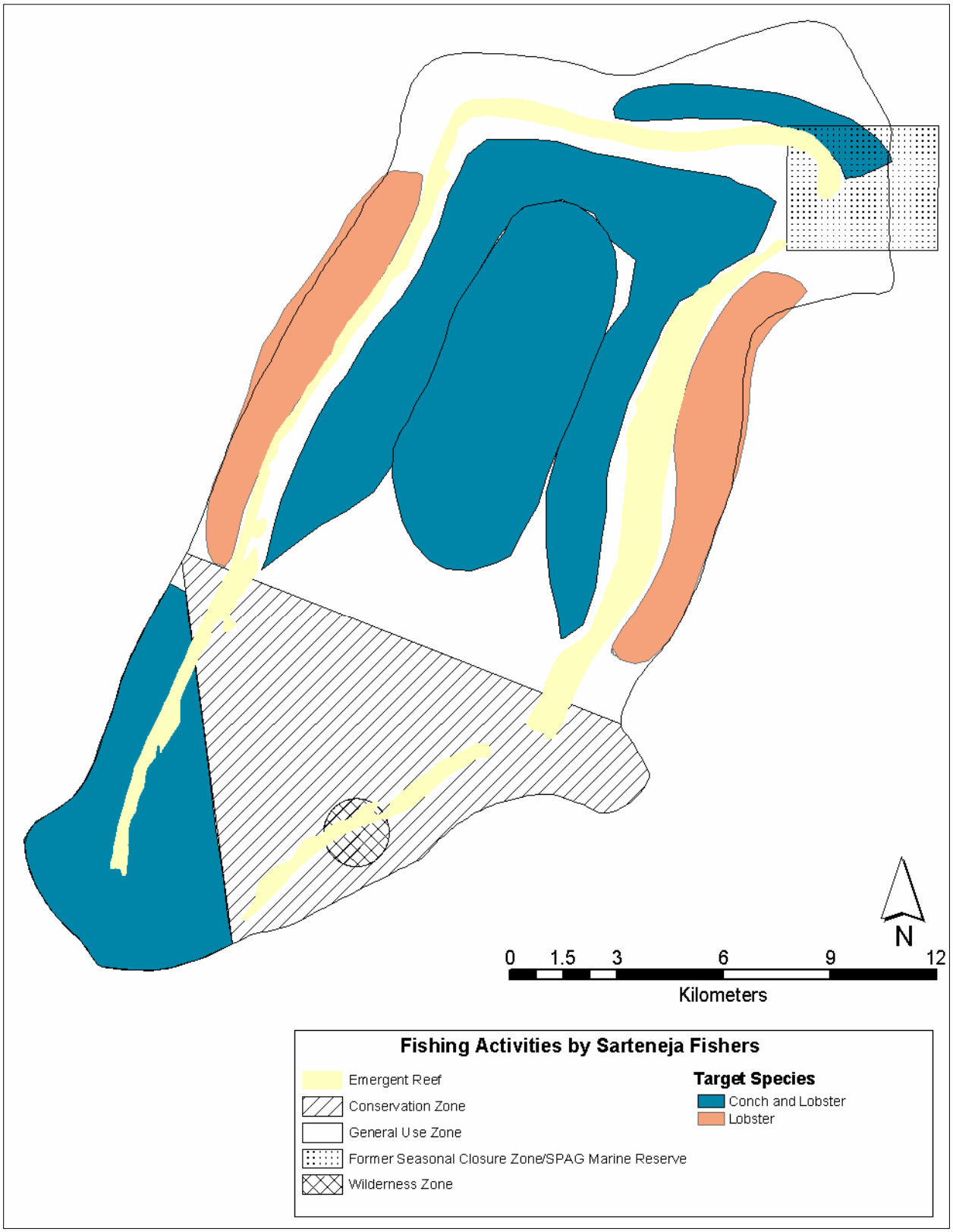


Figure 43: Fishing activities by Sarteneja fishers
WCS – Living Seascapes Programme – Glover's Reef Threats Assessment and Mapping Workshop 2004

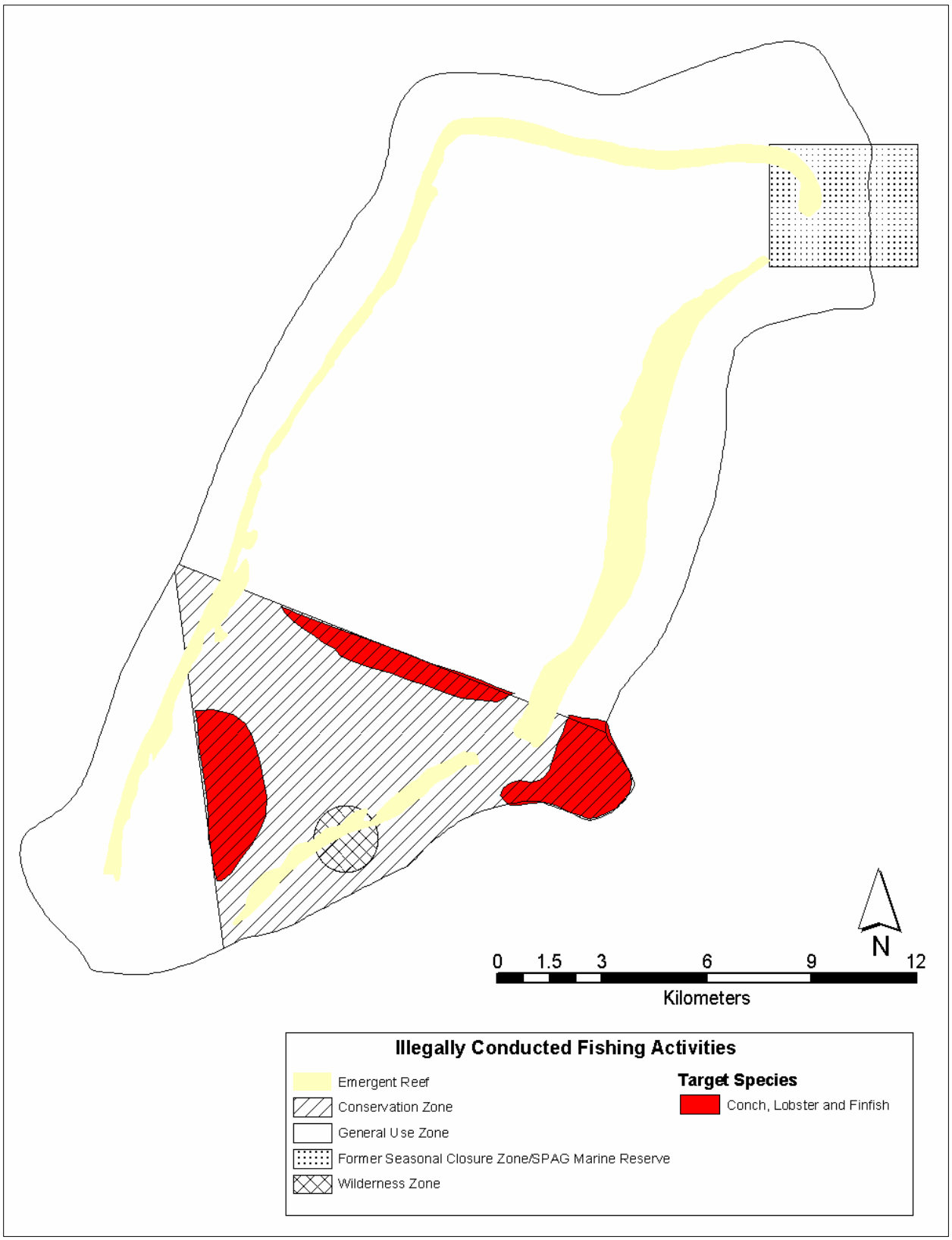


Figure 44: Areas of Illegal Fishing Activities
WCS – Living Seascapes Programme – Glover's Reef Threats Assessment and Mapping Workshop 2004

numbers of commercial marine species generally, and a drastic decline in numbers of conch in particular, throughout Belize (Gillet, 2003). The higher percentage of adults in the Conservation Zone suggests that enforcement activities in the Glover's Reef Marine Reserve are relatively effective.

Studies in Lighthouse Reef Atoll, a similar system with similar pressures, indicated that the composition of the fish community is skewed, with a low abundance of large, predatory fish (Graham et. al., 2004). This pattern was also reported during consultations with fishermen and tour guides for Glover's Reef, though there is general concensus that community structure is better in the Conservation Zone than the General Use Zone. 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,

Fishermen target different sectors of Glover's Reef during different times of the year and for different species (Figures 45, 46 and 47). The northeastern channel is a Nassau Grouper spawning site and has been fished in the past by hand-line from December to March, coinciding with the spawning event. In addition to targeting Nassau grouper, the fishermen also target Yellowtail, Black and Deep-water Grouper, several species of Jack, and Mutton Snapper. A snapper spawning site inside the Conservation Zone and just east of Northeast Caye is impacted by illegal fishing (mostly at night) from April to June, a time that also coincides with spawning events.

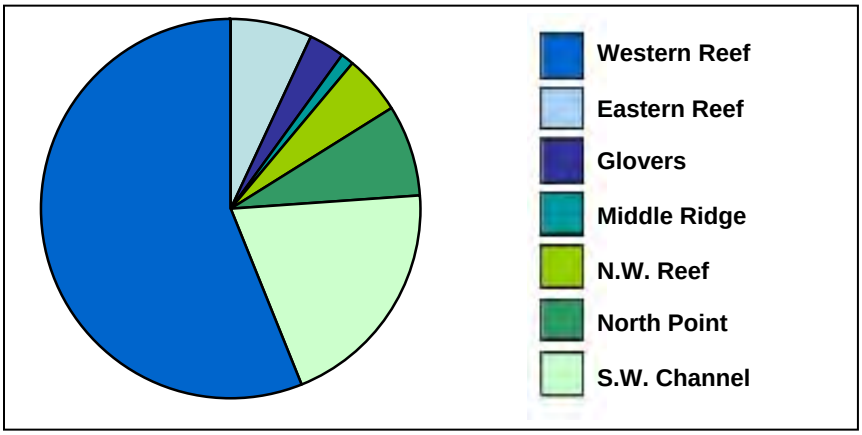


Figure 45: Percentage of conch caught at each location on Glover's Reef, 2004

Gibson and Hoare, August 2006

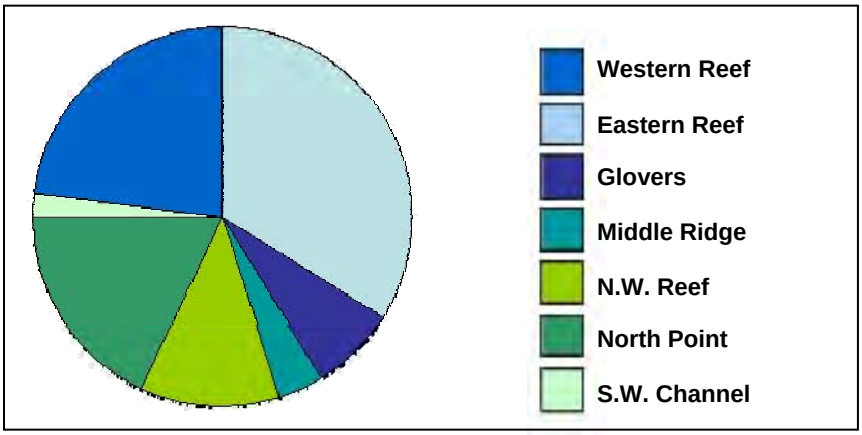


Figure 46: Percentage of lobster caught at each location on Glover's Reef, 2004

Gibson and Hoare, August 2006

Both the inside and outside of the western side of the atoll, is fished year-round, and several species are targeted (barracuda, parrotfish, blackfin snapper and yellow eye being the most fished species) (Figure 48). The area surrounding the southwestern channel has highest fishing

pressure in March and April, whilst the central lagoon of the atoll is primarily fished for conch and lobster from June to February by divers on sailboats, and who will also opportunistically spear reef fish. Sharks are sporadically fished in the northern and southeastern sectors throughout February and March. All fishing occurs in 160 ft of water or less and all conch and lobster, in particular, are fished at 80 ft or less.

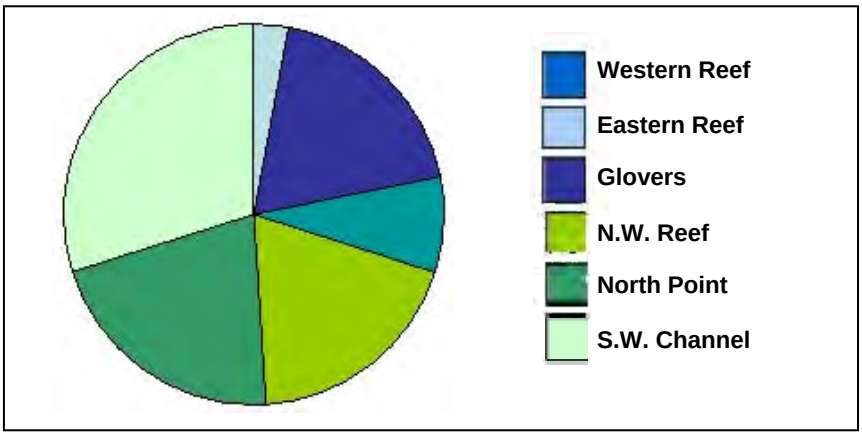


Figure 47: Percentage of fish caught at each location on Glover's Reef, 2004

Gibson and Hoare, August 2006

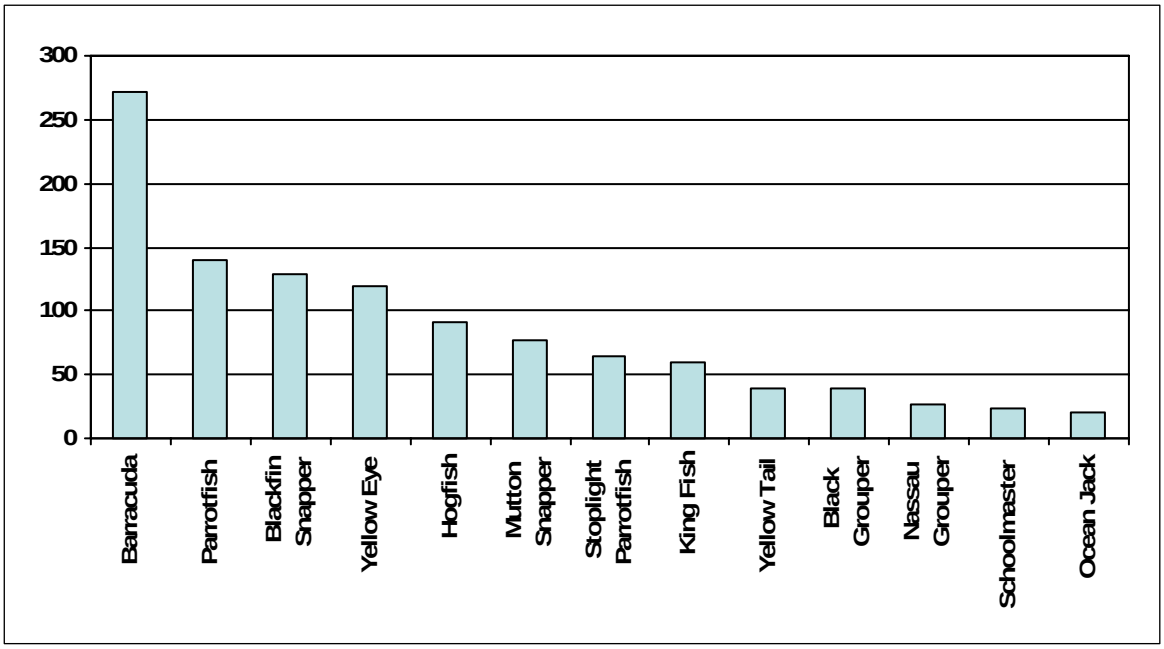


Figure 48: Number of most frequently sampled species from capture records for Glover's Reef, 2004
Gibson and Hoare, August 2006

3.2.2 Coral Bleaching/Warming sea temperatures

High water temperature and high solar insolation (UV) are the two factors that cause corals to eject their symbiont zooxanthellae algae. The group at the threats assessment workshop realized that coral bleaching would occur throughout the atoll; thus, they decided to focus on areas that would be more resilient and resistant to a bleaching event. Given prevailing currents and wind patterns the eastern (windward) side of Glover's experiences more wave action and water column mixing, and as a result is less prone to temperature-associated bleaching events compared to the patch reefs within the atoll, particularly those located at a distance from the two windward channels and the reefs located along the western (leeward) edge of the atoll. Particulates generated within the atoll tend to move westward and effectively shade the leeward coral from UV making these reefs less susceptible to high insolation bleaching. The group argued that though the windward reefs may be more likely to be affected by coral bleaching they are also more likely to be rapidly recolonized (assuming adequate coral reproductive capacity) and thus can be considered relatively resilient. The leeward reefs, in contrast, may not experience as much coral bleaching (more resistant) but may take longer to recover if they were damaged.

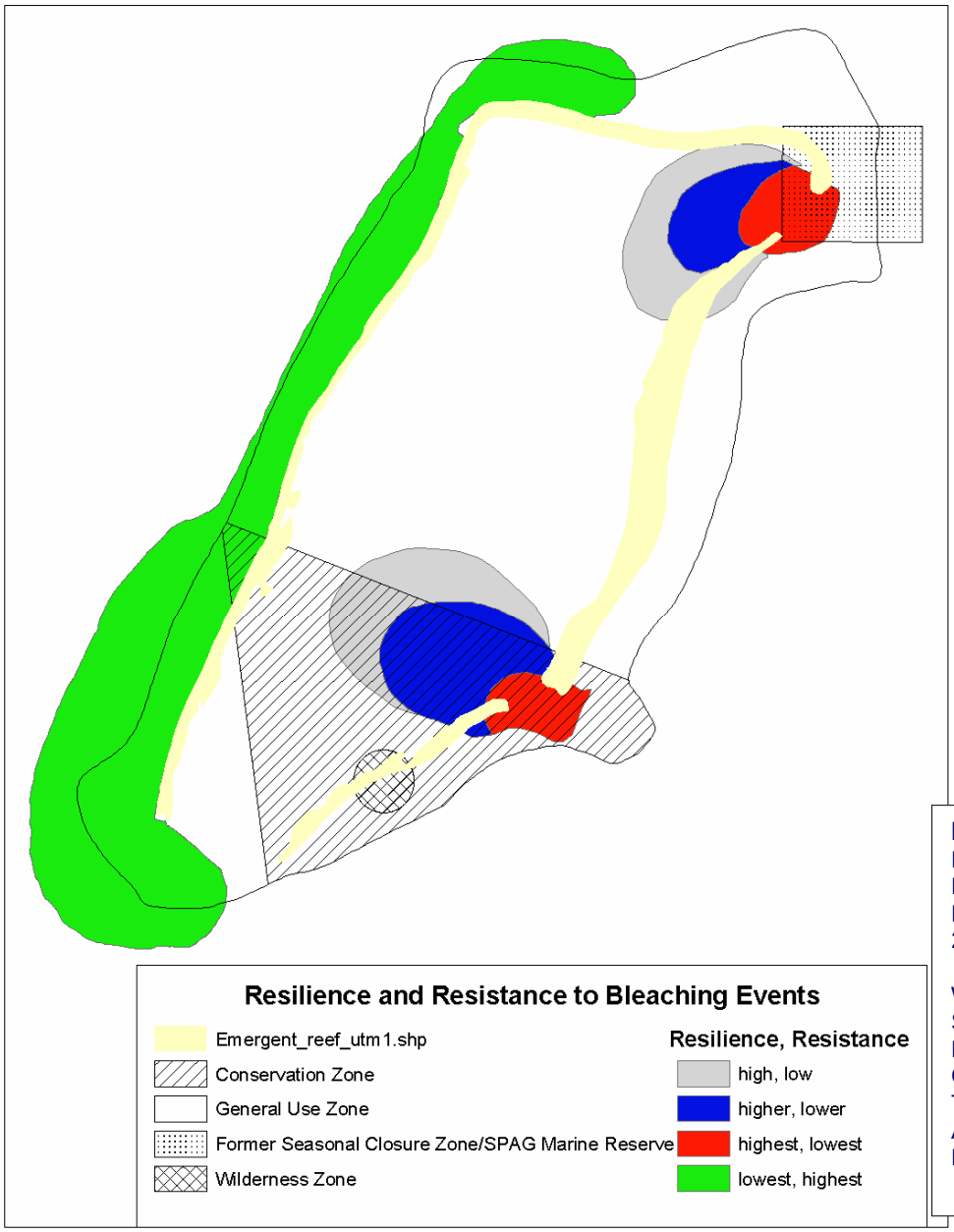


Figure 49: Resilience and Resistance to Bleaching Events, 2004

WCS – Living Seascapes Programme – Glover's Reef Threats Assessment and Mapping Workshop 2004

3.2.3 Chemical runoff from land development, agriculture and aquaculture

Runoff from mainland development is manifested in the form of sediment-laden river plumes rich in nutrients (effluents) that potentially can extend to Glover's Reef, cause algal blooms and coral death. Definitive research to characterize the effects of pesticides and nitrate and phosphate nutrients from agriculture and aquaculture has yet to be undertaken in Glover's Reef. That said, there is growing concern, given prevailing water currents, that the vast banana and pineapple plantations in Honduras are introducing pesticide and nitrification pollutants in the Glover's Reef system. Similar concerns exist for banana and citrus plantations and shrimp farms in the Stann Creek area (due west of Glover's).

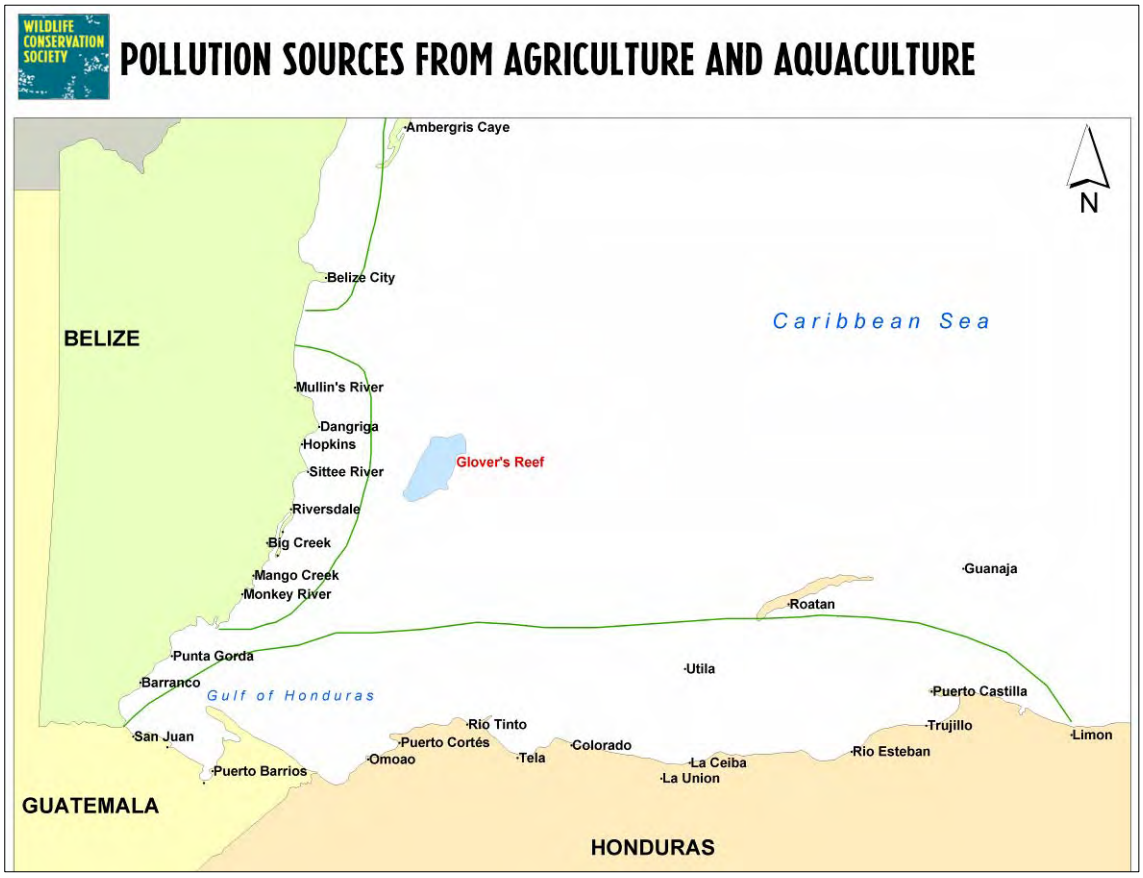


Figure 50: Potential Impact Area from Sedimentation and Runoff
WCS – Living Seascapes Programme – Glover's Reef Threats Assessment and Mapping Workshop 2004

3.2.4 Direct Physical Damage to Coral

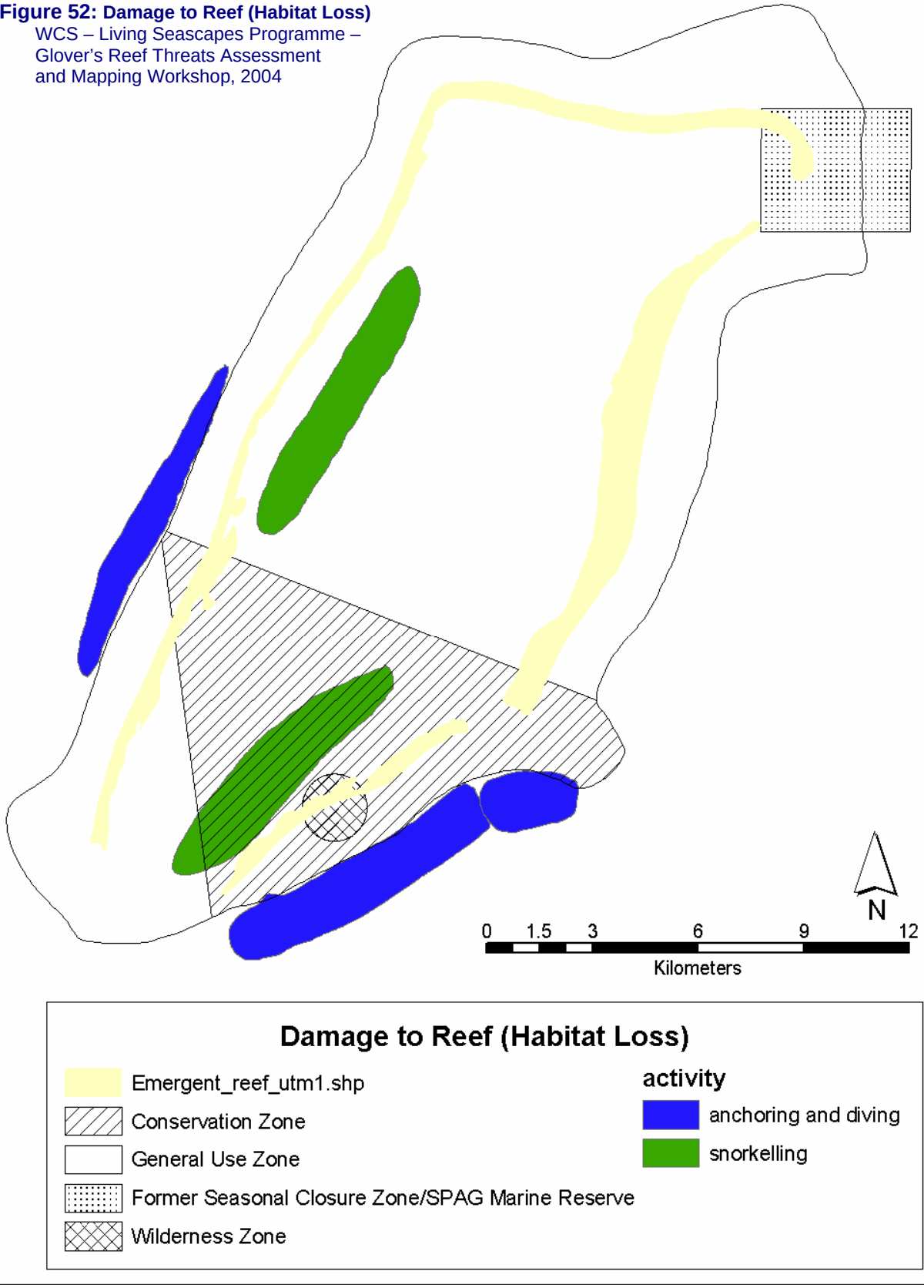
Figure 51: Anchoring using a chain on coral

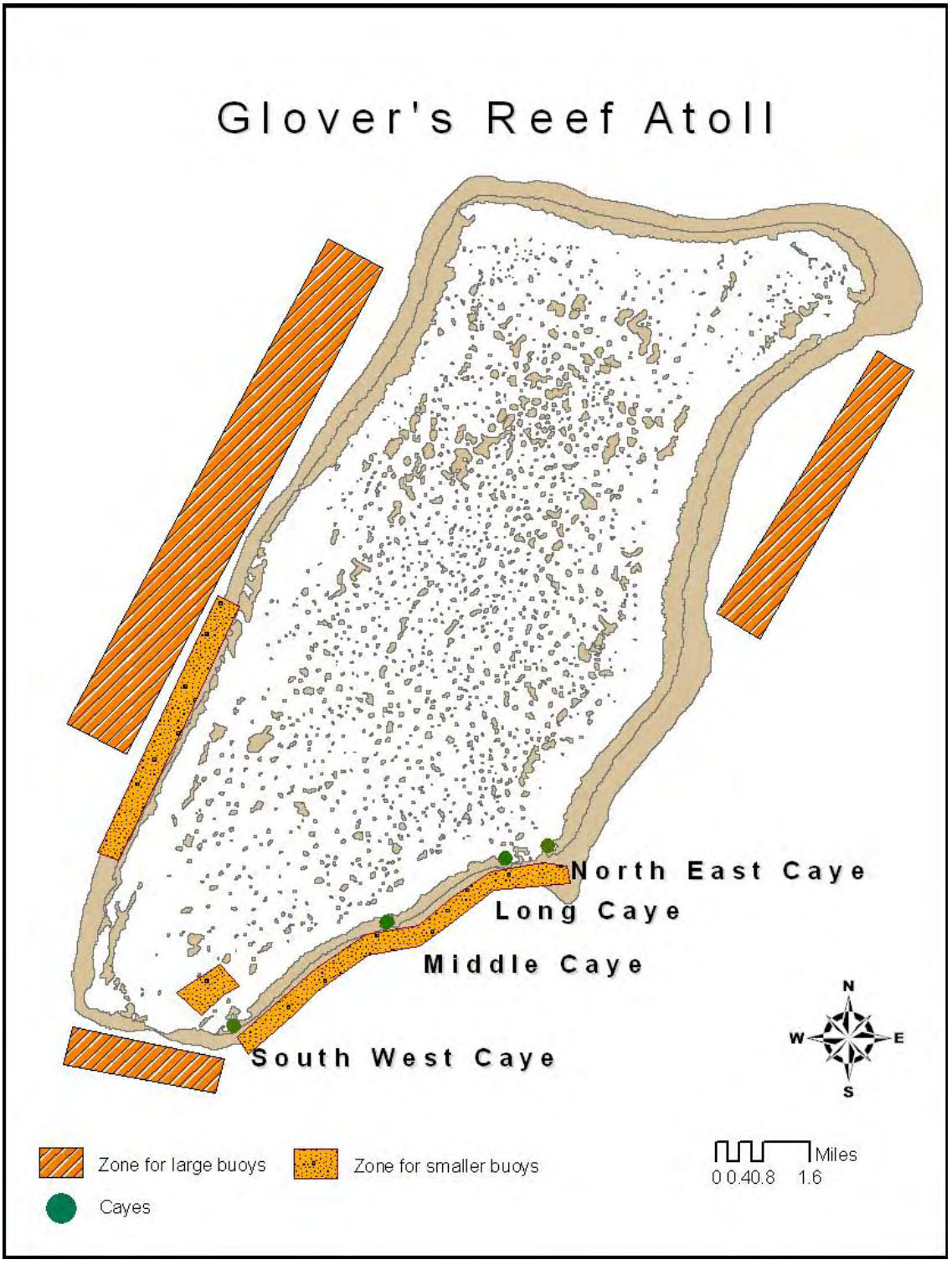
WCS/S. Hoare

This type of damage is generally caused by boats and anchors, divers or snorkelers. Boats that visit Glover's Reef Atoll 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 Sarteneja sail boats, and fishing skiffs from Dangriga and Hopkins).

Both categories have similar impacts from mechanical damage from anchors, though the area of impact of anchor damage from fishing boats rarely overlaps with that of the tour boats (Figure 51). Lack of mooring buoys in the heavily used dive sites is a major concern, as is the lack of sufficient mooring buoys, especially where there is use by larger live-aboard dive boats such as the Nekton. Creation of new mooring buoys and enforcement of their use would both reduce damage to reefs from anchors and anchor chains and if sited strategically may encourage divers to visit other sectors of the reef and reduce pressure on the most heavily visited areas.

Figure 52: Damage to Reef (Habitat Loss)
WCS – Living Seascapes Programme – Glover's Reef Threats Assessment and Mapping Workshop, 2004





Map showing areas identified as high risk locations requiring dive boat mooring buoys to prevent further damage to reef structures by anchors.

3.2.5 Land development/habitat loss

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 (Island leaf-toed gecko)

Habitat loss through land development for tourism. This includes the removal of mangroves and littoral forests. In addition, shoreline structures such as piers, marinas, and seawalls can lead to loss and/or alteration of habitats. Red mangrove, littoral forest and herbaceous beach communities play a critical role in stabilizing island structure, reducing coastal erosion, beach loss and sedimentation. Among 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 Island leaf-toed gecko, a species with extremely disjointed distributions, and for numerous migratory bird species. Clearance on the cayes of the Atoll 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 caye-based tourism and residential developments can be made significantly more financially viable through the maintenance of this ecosystem.

3.2.6 Introduced Species

The introduction of species from bilge waters of cargo vessels using East Glovers route is a potential threat. The introduction of exotic plant species on the cayes is another potential threat to the terrestrial habitats.

Introduced coconuts have already replaced the natural vegetation on significant portions of some of the cayes of Glover's Reef. As an invasive species, it is able to gradually out-compete natural vegetation through direct competition for light, nutrients and water, as well as smothering the regenerating herbaceous and shrub layers with heavy leaf debris. Natural vegetation has a far more extensive root system than do coconut groves, and is therefore far more effective in stabilizing the sandy soils of islands against the impacts of tropical storms and hurricanes – invasive coconuts therefore increase the likely impacts from such storms. In the late 1990s, most coconut trees on the cayes succumbed to lethal yellow disease, but are currently being replaced with the resistant Maypan hybrid.

Rats have been recorded on South-west Caye, and mice on Long Caye, threatening the native species there. Abundant literature documents the very negative impacts of introduced rats on island communities. In the absence of natural predators on the cayes, rats can become 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.

3.2.7 Pollution

Pollution	Contamination of waters near cayes and throughout Atoll due to inappropriate sewage and grey water treatment on cayes, leading to eutrophication
	Inappropriate waste disposal
	Contamination of waters with runoff containing herbicides, insecticides or detergents from both the atoll and the mainland
	Contamination from international shipping
	Garbage from the mainland

Solid Waste: Solid waste originating from the cayes and mainland is another concern. Some types of garbage have been shown to be very detrimental to marine wildlife, such as plastics to sea turtles. There is also concern over the increasing levels of solid waste originating from international shipping, particularly with the increase in cruise shipping and freight shipping destined for, and departing from, Belize.

Liquid Waste & Sewage: A more insidious impact is the leaching of nutrients and chemicals into the ground water or fresh water lens of the cayes, which then percolate through the sandy soil into the sea. Groundwater is an important source of freshwater on the cayes, and is also important for supplying the mangrove areas and coral reefs with fresh water. If the groundwater becomes polluted, these ecosystems are affected. The leakage of sewage from island resorts can cause algal blooms, visible as a ring around the cayes or patches of increased algal growth near the highest impacted areas, due to nutrient enrichment. This impact, however, is relatively low due to the current small scale of operations and low level of visitation, as well as the use of closed sewage systems on a couple of the islands.

At present, although there is little sign of the impacts of water contamination by excessive nutrients, and the majority of developments on the cayes appear to include adequate sewage treatment, results of recent nutrient testing (Gibson and Hoare, 2005) when compared with previous results (Tomasko and LaPointe 1991), suggest that nutrient runoff from the cayes should be carefully monitored. Whilst development activities are generally low key, and there is an appreciation among most caye owners / lease holders of the fragility of the environment and the need to ensure minimal impact, there is currently little guidance given in areas such as wood preservatives, herbicides and pesticides, and contamination of waters by biocides and detergents is likely to become an increasing problem as more tourism accommodation is developed on the 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.

Oil Pollution: The offshore area of Belize has been divided into oil blocks that are given out on concession to various oil exploration companies, though the Glover's Reef block (Block 11) has not yet been allocated. Several years ago, exploration was carried out between the barrier reef and Glover's Reef. The impact of oil spills and drilling muds is a potential threat if there is any future active exploration. Additionally, any oil spills from passing ships due to accidental spillage or bilge clearing is a concern.

3.2.8 Dredging

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

Dredging and mining of sand used in construction and landfill continues to be a common practice along the mainland coast and cayes along the barrier reef. To date, no dredging activities have occurred on Glover's Reef, but dredging remains a potential threat. If inappropriately managed, dredging activities within the Atoll will impact areas of conservation importance. Dredging activities are usually associated with development on the cayes, and can result in removal of seagrass besds, siltation on the reef, water quality degradation and smothering of benthic flora and fauna by excessive sedimentation.

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.

3.2.9 Threats from adjacent Shipping Lanes

Whilst not incorporated into the Seascapes planning, threats from adjacent shipping lanes cannot be ignored. The shipping lane between Belize and Honduras passes close to Glover's Reef Atoll, 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. Any vessel traveling in the adjacent shipping lane, whether cruise ship or not, is a potential threat, though it is recognized that 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 Lighthouse Reef Atoll raised the profile of the threat, as has the unreliability of the lighthouses on the north and south ends of the Atoll.

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.

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

Blackwater

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

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

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

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.

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 of the Atoll. It is recommended that an emergency plan be developed and put in place, with the input of DoE, in case a major incident should occur.

3.3 Strategies to Reduce Threats

A series of strategies have been developed to address concerns, threats and stresses raised during the WCS Seascape planning process, and presented in the Glover's Reef Atoll Conceptual Model (Figure 53). Conceptual models have also been developed for each of the Seascape Species.

3.4 Monitoring of Success of Conservation Strategies

A monitoring programme is currently being developed to measure the success of conservation strategies, as an integrated component of the Seascape planning process.

Living Landscapes Program

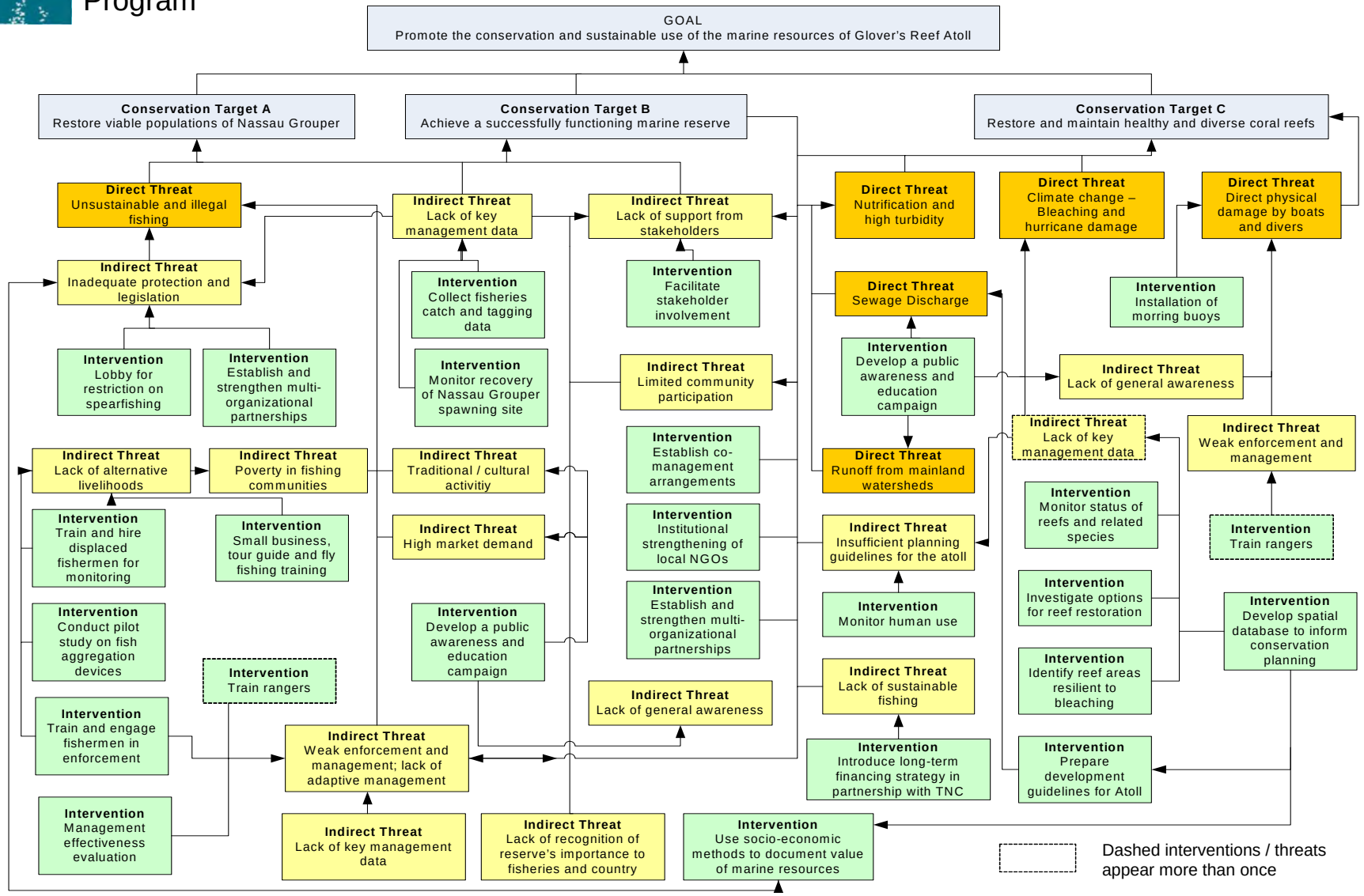


Figure 53: Glover's Reef General Conceptual Model
WCS – Living Seascapes Programme

4. Management Planning

4.1 Management and Organizational Background

Glover's Reef Marine Reserve, established in 1993 under the Ministry of Agriculture and Fisheries, is managed by Fisheries Department. The Fisheries Department has the mandate to sustainably manage and develop Belize's fishing sector, under the Fisheries Ordinance, Chapter 133, of 1948, and subsequent amendments and subsidiary legislation, revised in the Fisheries Ordinance, 2000, and complimented by the Fisheries Regulations of 2004.

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

Under this mandate, the Fisheries Department is able to establish and manage the marine reserves in Belize (including Glover's Reef), under the Protected Area Management (Marine Reserve) programme of the Ecosystems Management Unit. The Wildlife Conservation Society provides assistance to the Fisheries Department through collaborative research and monitoring activities, and a location on Middle Caye for the Fisheries Base to operate from in the management of the Glover's Reef Marine Reserve.

The Ecosystems Management Unit is one of four units under the Fisheries Administrator (the others being the Aquaculture and Inland Fisheries Unit, the Capture Fisheres Unit, and Administration), and includes the Protected Area Management programme, which is specifically in charge of the management of the Marine Reserves, under the Marine Protected Areas Coordinator.

At Glover's Reef, on-site management is under the Reserve Manager, who is supported by two rangers and a marine biologist. It is recognized, however, that at least one additional Ranger is required to help ensure that the objectives of the marine reserve are adequately met. These personnel are responsible for the on-site, day-to-day management of the reserve, and the implementation of its management plan. The Reserve Manager is responsible for achieving the on-site management objectives of the plan through the most efficient use of funds, staff and equipment, and supported by centralized activities such as environmental education and outreach. He is required to submit annual operational or work plans, monthly progress reports, and comprehensive annual reports to the Marine Protected Areas Coordinator. Each staff position is described by a general terms of reference (Appendix 2).

4.2 Review Previous Management

The first management plan was prepared for Glover's Reef in 1988, but was not revised until 2003. The 2003 management plan, whilst not formally adopted by the Fisheries Department, has been informally adopted in practice, as a guide for management of the protected area (Gibson and Hoare, 2006), and incorporates regulations that are laid down by law and are fully enforceable. The 2003 management plan is itself currently being revised to comply with the updated National Protected Area System Plan framework.

An assessment of management effectiveness was conducted in 2006, focusing on Biophysical, Socioeconomic and Governance indicators (Gibson and Hoare). Results suggested that enforcement against the main perceived threat of illegal fishing would benefit from further strengthening, both on-site through increased presence (both in terms of number of patrols and number of staff), and through increasing awareness of the benefits of the Conservation Zone in stakeholder fishing communities (particularly Sarteneja, where there is less support (50%) for the fact that a 'no-take' zone is important for sustaining fisheries).

A review of the management programmes themselves (Appendix 1) suggests that of the 93 action points identified within the 2003 management plan, 28% have been implemented successfully, 50% have resulted in an improvement in the situation (partial implementation) and 22% showed no change (Tables 24 and 25). No area, however, showed a decrease in status.

Table 24: Summary of Success of Activities Identified from the 2003 Management Plan

	Succeeded	Improved	No Change	Worse
Total No. Action Points (of 93)	26	47	20	0
% of total	28%	50%	22%	0%
% +ve change	78%			
% -ve change or no change			22%	

Table 25: Programme Rating Table for 2003 Management Plan

Programme	Total no. Action Points	Succeeded	Improved	No Change	Worse
Surveillance and Enforcement Programme	**10**	**4**	**3**	**3**	**0**
Research and Monitoring Programme	**25**	**11**	**10**	**4**	**0**
Interpretation and Education Programme	**23**	**1**	**13**	**9**	**0**
Recreation and Tourism Programme	**12**	**0**	**8**	**4**	**0**
Administration and Maintenance Programme	**23**	**10**	**13**	**0**	**0**
Total no. Objectives / Actions	**93**	**26**	**47**	**20**	**0**
% of total		**28%**	**50%**	**22%**	**0%**

The weakest area is the Interpretation and Education Programme, with the majority of identified action points rating as 'No Change', showing no successful implementation of recommended actions under the 2003 management plan. Conversely, the Research and Monitoring Programme is considered to be very strong, particularly with the research input from Wildlife Conservation Society, highlighting the benefits of such a collaborative relationship.

The Surveillance and Enforcement Programme has been strengthened over the three years since the 2003 management plan was unofficially adopted for guiding management, though still has weak areas, such as radio communications, and the implementation of special licensing of traditional fishermen for Glover's Reef General Use Zone.

The Infrastructure Development and Maintenance Programme and the Administration Programme are both operating relatively effectively, with all action points rating 'Improved' or 'succeeded', though there is still room for improvement in both programmes.

4.3 Management Goals

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

Objectives

- to preserve the outstanding beauty, uniqueness and naturalness of the atoll
- to regulate use of the area to ensure the sustainability of its resources, resilience of its ecosystems, and maintenance of ecological processes
- to provide protected habitats for commercially important species in order to enhance recruitment and replenishment, thus achieving sustainable yields, and to demonstrate these benefits to fishermen
- to protect critical habitats for endangered species
- to manage the area based on sound scientific information, and based on adaptive management principles

Goal II: To increase awareness and understanding of the natural resource of Glover's Reef through education and research

Objectives

- to encourage use of the atoll for applied scientific research by the national and international scientific community, and to feed the results of research into the marine reserve's management-decision process
- to foster use of the atoll as a study center by both local and international students
- to foster awareness of the importance of the marine environment, and the marine reserve specifically, through educational and interpretive programmes to encourage use of the reserve as a training center in marine resources and MPA management, and for demonstrating the benefits of MPAs

Goal III: To provide a resource for recreation and tourism

Objectives

- to provide undisturbed areas for tourism and recreation in a controlled and well-informed manner
- to enhance the social and economic benefits of the area by promoting uses compatible with conservation and sustainable development principles

4.4 Management Strategies

4.4.1 Management Constraints and Limitations

Several constraints and problems exist that can adversely affect the management of the Glover's Reef Marine Reserve. In an assessment of management effectiveness conducted in 2000, the reserve was ranked as only "moderately satisfactory" (McField 2000), which identified a number of weaknesses in the areas of administration, related to staffing, accounting, filing and record keeping, and internal communication. In this study, the Glover's Reef Marine Reserve also scored poorly in a number of its management programmes, with very little implementation in areas such as environmental education and community outreach. Many of the weaknesses identified in the 2000 assessment have been addressed since that time, though there are still areas that can benefit from further strengthening.

- **Enforcement**

  Illegal fishing remains a continuing problem – there is particular concern for incursions into the Conservation Zone and the north-east spawning aggregation site. The lack of sufficient reserve staff for a continuous on-site presence, the budget limitations for fuel, the remoteness of the spawning aggregation site, and the inability to conduct night patrols, particularly in the spawning aggregation seasons, severly constrain the reserve wardens, and these limitations are fully exploited by illegal fishermen. The current regulation allowing residents to fish within the Conservation Zone is causing some friction, and decreasing respect for the protected area from the traditional fishermen (this is being addressed through the standardized marine reserve regulations currently being developed).

  Patrolling is limited by budget, and whilst training is ongoing, the high staff turnover results in qualifications and skills being lost. Difficult logistics, weak understanding of the Fisheries regulations and protocols for the collection of evidence, and delays in court appearances hinder convictions. Reserve staff are also frustrated by the past leniency seen towards non-compliant fishermen, though this is currently being addressed by the development of more stringent prosecution procedures

  Recommended Management Actions:
  - Increased staff numbers
  - Increased fuel allowance for patrol activities
  - Prioritized patrolling of spawning aggregation site during peak spawning season, with overnight presence
  - Continued collaboration with Belize Coastguard to supplement patrols during peak fishing times
  - Continued increased communication with fishermen on Glover's Reef Atoll
  - Staff training in enforcement and handling of evidence
  - Improved communications system
  - Improved accessibility and transport (a second boat in operation)

- **Personnel Management**

  The high rate of staff turnover at all levels is a serious constraint to the achievement of management objectives, resulting in a lack of long term continuity in the implementation of management policies. This is considered to be partly as a result of the remoteness of the Glover's Reef Atoll, the associated logistical problems, and the isolated work conditions,. 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 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 almost daily antagonism from the fishermen. Improvement of communications between the fishing community, and their ongoing participation in monitoring activities is assisting in relieving some of these pressures and increasing staff motivation, with improved, cooperative relations between staff and fishermen.

For effective management, there should be at least two officers present in the reserve at all times. However, this is hard to achieve in reality with the current staffing levels, and in general, although the full complement of staff has been appointed (a manager, a biologist, and two rangers) there are extended periods when no staff member is present in the reserve, numbers being affected by officers needing to participate in meetings and training sessions, being on sick leave, or taking vacation time. As this sustained presence appears difficult to maintain under the present system, it is considered necessary to hire a third ranger for effective management.

The staffing limitations are further exacerbated by the presence of only one boat, which is used for both patrol activities, and for ferrying staff and supplies to and from the mainland, and at times needs to be pulled up for maintenance and repairs. The need for a second boat has been recognized, and a smaller boat has recently been provided, to be permanently based on site. However this still lacks an outboard, and will still be contsrained by limited fuel allocations.

The situation has improved since the 2000 management effectiveness assessment – reserve staff generally agree that Glover's Reef Marine Reserve has some of the best facilities when compared with other marine reserves, with continuity in research and monitoring activities, presentation and availability of results through the Annual Reports, and improved staff continuity in both the Reserve manager and the biologist positions.

Recommended Management Actions:

- Greater support for staff on-site
- Increased number of staff on-site at any one time
- Continued increased communication with traditional fishermen on Glover's Reef Atoll

- **Co-ordination and Cooperation with State and Commercial Neighbours, and Private Sector**

Whilst already ongoing, continued strengthening of increased communication with adjacent caye owners, is considered particularly important, especially in view of the potential threat from development activities on the cayes. The cooperative relationship currently established between the Marine Reserve and developers / caye owners should be maintained and built upon, providing the foundation for future collaborations.

Greater contact and coordination is required with the Port Authority, to ensure that the lighthouse is maintained in good working order, to minimize the potential for impacts from boat groundings on the reef, particularly with the increase in cruise ship traffic in the area.

Recommended Management Actions:

- Continue increased liaison and cooperation with landowners and developers on the cayes
- Increase liaison with Port Authority

- **Stakeholder Involvement in Management Decisions**

The Glover's Reef Advisory Committee (GRAC) is currently functional, with representatives from all major stakeholders. Active participation of stakeholders on the committee has improved significantly since the 2003 draft management plan, and this motivation needs to be maintained.

The traditional fishermen are increasingly involved in management activities (such as monitoring of commercial marine species), and have had significant input into this management plan, both in the 2003 draft and through subsequent discussions and consultations for this revised plan.

However, 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.

There is a need for greater engagement of the tourism industry in the management of Glover's Reef Marine Reserve, though there is good representation from the Caye resorts on the GRAC. Sport fishing, kayaking and dive guides in particular, to ensure good practices during tour activities.

Recommended Management Actions:

- Ensure visible results from recommendations arising from community consultations, and feedback on areas of concern
- Increase stakeholder participation in management decisions, management and monitoring activities

- **Outreach and Environmental Education**

Perhaps the single largest weakness that remains as inadequately implemented since the 2000 management effectiveness assessment and the 2003 draft management plan is Outreach and Environmental Education activities to stakeholder communites. Whilst there has been joint hosting of a number of student groups by Fisheries Dept. and WCS, there is no distinct programme or structure to these events. Environmental Education is centralized by Fisheries Department, and is currently being addressed through submission of a proposal to PACT (Majil, pers. com. 2007).

- **Funding**

Glover's Reef Marine Reserve, whilst generating sufficient funds from tourism to run the protected area, is not considered sustainable, as entrance fees go into a centralized Government treasury fund rather than returning directly into management. The protected area is currently funded through Government funding, which covers basic running costs (fuel and salaries). Research and monitoring activities benefit from collaborative efforts (WCS) or targeted funding (MBRS) for specific activities. There is also some input from caye owners, who are assisting with provision of an extra staff member and equipment, to fill in identified gaps in effective enforcement (GRAC meeting, January 2007).

To be effective, however, the protected area needs to seek funds over and above the basic running costs, for implementing activities such as environmental education.

4.4.2 Management Zones

Glover's Reef Marine Reserve has been divided into four zones to allow for the management of resource for sustainability, to ensure the multiple uses of the marine protected area to continue (Map 5). These range from the least regulated to the most restrictive:

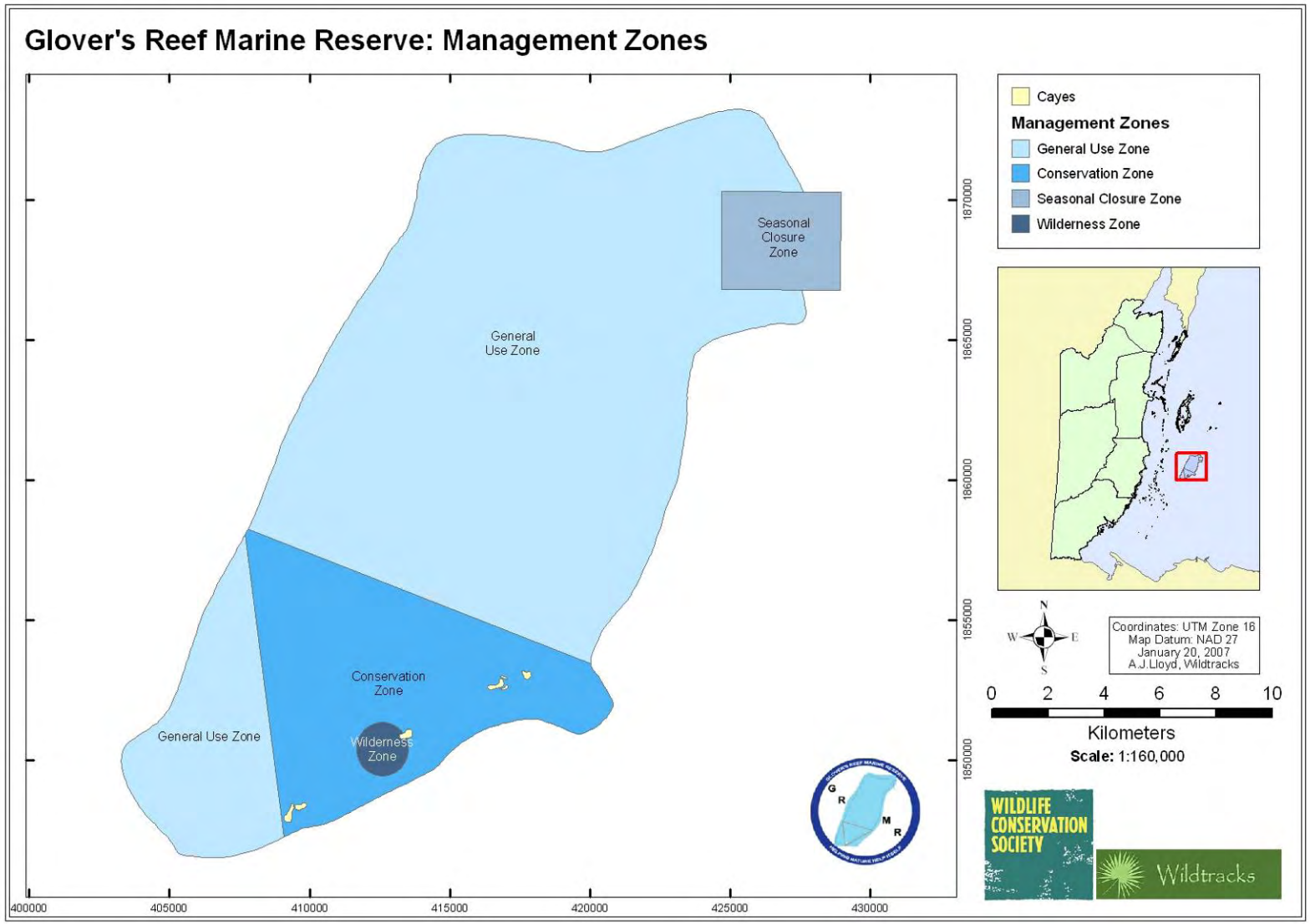
- General Use Zone
- Seasonal Closure Zone
- Conservation Zone
- Wilderness Zone

A fifth zone has recently been created to offer greater protection to the north-east spawning aggregation site (Map 6).

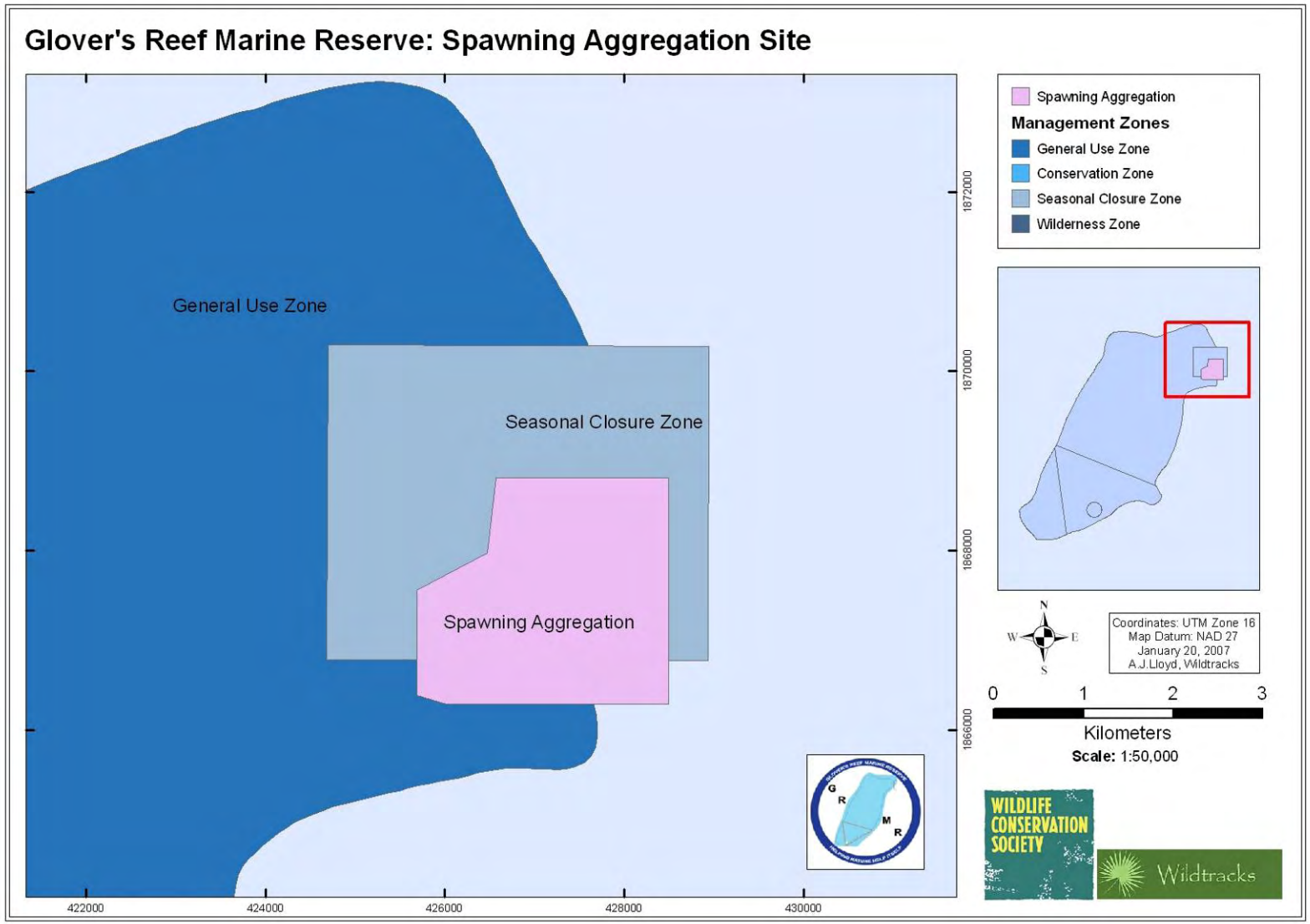
Boundaries

The Glover's Reef Marine Reserve encompasses the entire atoll, extending out to the 100-fathom depth contour, with a total area of 35,067 ha. To date, only the northern and western boundaries of the Conservation Zone have been demarcated by marker buoys (Figure 54).

Figure 54: Marker buoy on northern boundary of the Conservation Zone



Map 5: Glover's Reef Marine Reserve: Management Zones



Map 6: Glover's Reef Marine Reserve: North-east Spawning Aggregation Site

4.4.3 Zones and Regulations

General Rules of the Reserve

Several rules apply to all areas within the reserve, and are documented in Part IV of the reserve regulations (Appendix 1). These regulations refer mainly to applications and conditions of licenses, duty to report accidents and damage to property, fees, permitted activities, the application of all other Fisheries regulations, and penalties.

The regulations for each Zone are also detailed in the legislation (Appendix 1), summarized below:

General Use Zone

The General Use Zone is the largest of the four zones, with an area of 26,170 ha, (74.6% of the marine reserve), and is divided between two areas - the majority of the northern part of the atoll, and a smaller portion in the south (Figure 55).

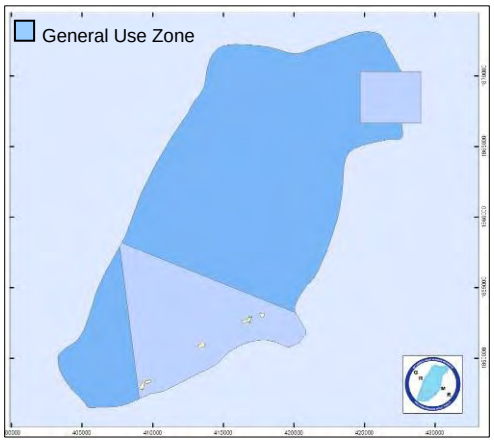


Figure 55: General Use Zone

Fishing is permitted in the General Use Zone - however, it is recognised that with the limited natural resources available, priority should be given to fishermen who have traditionally used the area (Gibson, 2003), and a special license system is to be implemented to limit the number of fishermen extracting the natural resources (Majil, 2007). There are gear restrictions within the General Use Zone, including a ban on the use of fish traps (the term 'fish' being used to include all forms of commercial marine animal), nets, long lines and spear fishing (though spear fishing is soon to be prevented under the new revisions to the regulations.

Objectives

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

Use and Entry

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

Conservation Zone

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

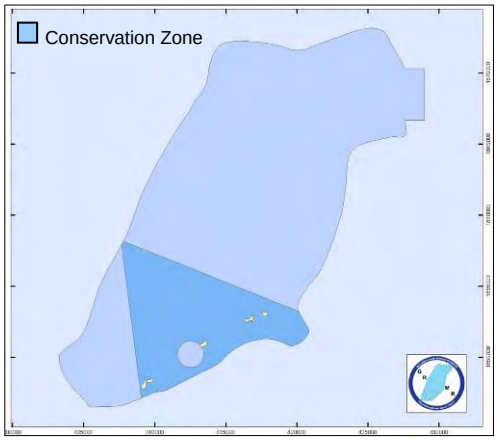


Figure 56: Conservation Zone

Objectives

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

Use and Entry

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

Seasonal Closure Zone

This zone encompasses the Nassau grouper spawning bank located on the northeast corner of the atoll (Figure 57). It covers an area of 1,550 ha, including the channel in the reef and extending out to the deep water of the fore reef and drop off. This zone overlaps with the more recent Spawning Aggregation Site.

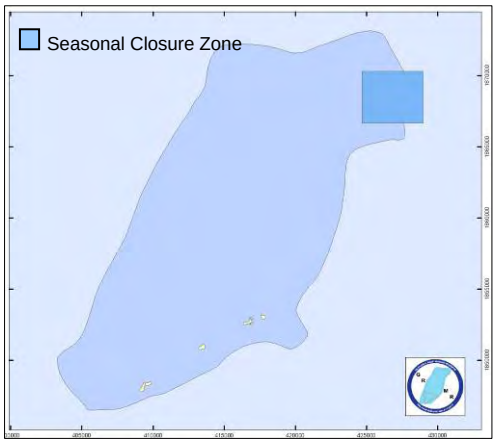


Figure 57: Seasonal Closure Zone

Objectives

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

Use and Entry

- The zone is closed to fishing from the 1st December to the 1st March. With the recent passing of the spawning site protective legislation (SI 161 / 2003), an area more closely linked to this spawning aggregation site has been closed to all fishing year round, and overlaps with the Seasonal Cleasure Zone.

Wilderness Zone

This zone, equivalent to a "Preservation Zone", is the smallest of the zones, encompassing an area of only 270 ha. It is located within the Conservation Zone, just south of Middle Caye, lying along the southeastern reef tract (Figure 47).

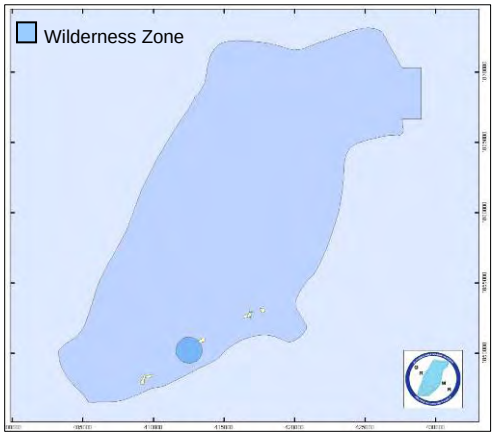


Figure 58: Wilderness Zone

Objectives

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

Use and Entry

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

Spawning Aggregation Site

This zone is permanently closed to fishing to protect the spawning aggregation site. It overlaps the Seasonal Closure Zone, but is more specifically linked to the area covered by the Spawning Aggregation Site (Figure 59)

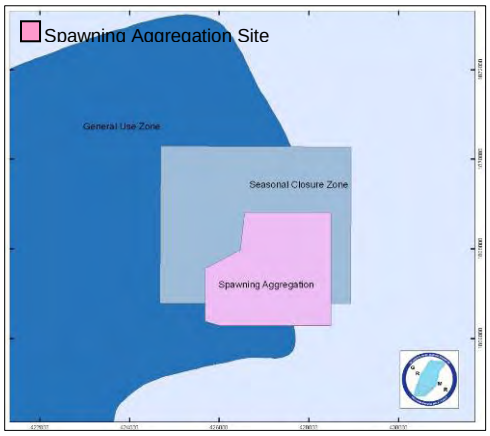


Figure 59: Spawning Aggregation Site

Objectives

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

Use and Entry

- The Zone is permanently closed to fishing.

4.4.4. Limits of Acceptable Change

At present there are no carrying capacities set for activities within Glover's Reef Marine Reserve – whether commercial fishing or tourism related. It has been recognised that this will need to be addressed as use of the Atoll increases. Assessment of carrying capacity is therefore one of the medium term actions planned for Glover's Reef.

4.5 Management Programmes and Objectives

Management programmes are a means of grouping management objectives within related areas – for example, grouping objectives related to natural resource management, or to public use. The strength of the combined programmes is greater than the sum of the individual programmes, as each supports the others over space and time, with areas of overlap that strengthen the overall management of the protected area.

Six Management Programmes are identified under the National Protected Areas Policy and System Plan framework:

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

As this revision of the 2003 management plan is to enable it to follow the NPAPSPS management planning framework (NPAPSP, 2005), the six categories outlined above have been used, and the current management programmes reallocated between them.

Also feeding into the adaptive management process are the strategies defined during the seascape planning process led by the Wildlife Conservation Society, which seeks to assist Fisheries Department in ensuring the long-term conservation of Glover's Reef Marine Reserve. The WCS Belize Marine Program implemented the Seascape Species Approach (SSA), funded under GCPII/USAID. This programme is a framework for strategic conservation planning at the Glover's Reef Atoll, as part of the WCS' Living Seascape Project. One of the outputs of this planning is the identification of intervention strategies that might be applied to mitigate the threats identified during the planning process – strategies that have now been incorporated into the management programmes, and into the measures of success programme for effective management.

4.5.1 Natural Resource Management Programme

The Natural Resource Management Programme deals with direct management of the marine environment, surveillance and enforcement. This includes activities such as delineating boundaries, and enforcing no-fishing regulations.

Surveillance and enforcement of reserve regulations are perhaps the highest priority for effective management of Glover's Reef, and come under the responsibility of the Reserve Manager and rangers.

The rules of the various zones need to be strictly enforced at all times in combination with education and public awareness activities, to ensure that all visitors to the protected area are familiar with the restrictions.

> Approximately 95% of all fishing vessels had crew members that either did not posses a valid fisher folk license or their license was expired. In addition about 85% of the fishers had undersize conch in very small quantities.
>
> **(Glover's Reef Annual Report, Fisheries Department, 2005)**

Natural Resource Management Programme, 2007 - 2012		
Provide the framework for effective surveillance and enforcement		
	Boundaries	Clearly demarcate the boundaries and management zones on paper and, where relevant, on the water
	Staff	Ensure protected area staff numbers are sufficient for effective management of the Marine Reserve (1 Reserve Manager, 1 Marine Biologist, 4 Rangers (on rotation))
	Training	Rangers are trained in standard procedures and guidelines for enforcement activities, as per the new Enforcement Plan (currently under development , 2007)
	Patrols	Patrols scheduled and implemented on a regular basis in Conservation and Wilderness Zone (daily if possible)
		Regular patrols scheduled and implemented in General Use Zone (at least weekly)
		Patrols scheduled and implemented in Seasonal Closure Zone during closed season (December through March), over the full moon spawning periods
		Nocturnal patrols scheduled and implemented in north east spawning aggregation site during peak spawning activity at full moon (NB. Conflict with Fisheries Dept. regulations re. boat use at night)
	Enforcement	Enforcement of traditional fishing only in General Use Zone
		Enforcement of equipment restrictions within General Use Zone (no long lines, traps, nets or spear guns)
	Reporting	Log books are maintained of number of patrols, zones patrolled, number of boats checked, infractions noted, warnings given, and arrests made
	Equipment	Patrols are fully equipped and rangers fully trained for surveillance and enforcement activities (including a permanent boat stationed at Glover's Reef, and reliable radios installed on boats)
	Liaison and Collaboration	Strengthen communication and cooperation for surveillance and enforcement with other stakeholders of Glover's Reef Atoll – fishermen, residents, and tour guides
		Continue collaboration with Belize Coastguard for surveillance and enforcement
	Awareness	Continue raising awareness in all stakeholders of the benefits of Glover's Reef

General Recommendations

- Patrols should be carried out according to approved standard procedures under the new Enforcement Plan currently being developed as a Fisheries Department policy.

- Patrols should be conducted at irregular intervals so as not to develop a pattern recognizable by illegal users of the resources

- Boats should be equipped with radios in order to maintain good communications with the Reserve Headquarters. Reliable radio contact should also be maintained with the Fisheries Department in cases where advice and back–up assistance are required.

Natural Resource Management Programme, 2007 - 2012	
Preserving the Integrity of Glover's Reef Atoll	
Lighthouses	Collaborate with other stakeholders to ensure lighthouses work, to prevent potential groundings of ships in adjacent shipping lane
Impacts from Honduras / Guatemala	Investigate impact of illegal fishing by Honduaran / Guatemalan fishermen, and develop intervention strategies
Development Plan	Produce and disseminate Development Plan for Atoll, to integrate the Development Guidelines being produced for caye residents (see Public Use). This should address major concerns such as the issue of sewage and solid waste disposal.
	The Plan should assist in the formulating of recommendations of environmental assessments and EIAs for future developments proposed for the atoll.
Oil / Chemicals	Develop a strategy for mitigating impacts of potential oil or chemical spills
	Ensure safe storage of oils and chemicals on the cayes during storm events
	Increase awareness among fishermen on proper disposal of oil / lube containers, and effects of pollution on the marine environment
	Include guidelines for fogging of pesticides and use of herbicides on the Atoll cayes in the Best Practices Guidelines and Plan, and investigate the merits of using the least harmful types available, or alternatives.
Oil / Mining Exploration	Develop a proactive strategy for potential mining / oil exploration

Natural Resource Management Programme, 2007 - 2012	
Management of fisheries resources	
Awareness	Ensure all fishermen are aware of regulations and rationale for the Marine Reserve, and distribute brochures, handouts and other educational material related to regulations
Traditional Fishermen	Enforcement of 'traditional fishing only' in General Use Zone - this is reserved for traditional fishermen, through addition of a special stamp to their national fishing license
	Develop a register of traditional fishermen, and maintain log of boat presence on the Atoll per month
	Train and engage fishermen in management activities
	Ensure constant open lines of communication with traditional fishermen using the Atoll
Resident Subsistence Fishermen	Ensure all resident subsistence fishermen are registered
	Ensure all resident subsistence fishermen are informed and aware ahead of time of shift to closure of Conservation Zone for subsistence fishing, and understand the reasons behind the change in regulations

Natural Resource Management Programme, 2007 - 2012		
Management of recreational resources		
	Regulations	Ensure regstration of all recreational boats
		Ensure all regular users of recreational resources (tour guides, tour operators, resorts etc.) are aware of regulations and rationale for the Marine Reserve
		Inform all visitors of rules and regulations when visiting the Marine Reserve through distribution of brochures, handouts and other educational material
		Enforcement of mooring regulations at dive sites
		Enforcement of fee payment
		Ensure regular contact is maintained with residents of the Atoll and with tour guides to encourage particiapation and collaboration
	Carrying Capacity	Use results of research and monitoring on tourism impacts to develop carrying capacity for tourism activities
	Development Guidelines	Develop and disseminate 'Best Practices' guidelines for tourism activities on the cayes to advise residents on ways to avoid impacts on the marine environment
		Develop and disseminate 'Best Practices' guidelines for traditional fishermen
		Increase awareness among caye owners of the biodiversity value and importance of littoral forest, and encourage protection
		Continue to increase awareness among caye owners of the biodiversity value and importance of mangrove, and encourage protection

4.5.2 Research and Monitoring Programme

Research and monitoring are essential activities to ensure informed, effective management, and to assess the effectiveness of the Marine Reserve in achieving its objectives. The Reserve Biologist is the officer primarily responsible for this programme. At Glover's Reef, Fisheries Department works closely with Wildlife Conservation Society in the areas of research and monitoring, with much of the WCS research being focused on providing information for identified gaps and filling research and monitoring priorities.

The Wildlife Conservation Society research station is located on Middle Caye within the marine reserve, and provides a mechanism for conducting much of the management-related research required. As such, it serves as a valuable resource to the reserve management team. Research proposals are reviewed by the Fisheries Department, and if approved, a research license is granted on an annual basis. Plans are underway to establish a research review committee to carry out this function, thus expanding the knowledge base feeding into the decision-making process. Recommendations have also been made to include the Reserve Manager and Biologist on this committee (as *ex officio* members), when projects proposed for the Glover's Reef Marine Reserve are being reviewed.

Research Activities 2007 - 2012	
Priority Research Activities	
Priority Research	Encourage priority research activities in the Glover's Reef area
Collaboration with WCS	Continue collaborative relationship with WCS and the WCS research station
	Ensure participation of Glover's Reef Marine Reserve Biologist in WCS research activities
Tourism Impacts	Investigate the impacts of sport fishing on the Atoll, with particular focus on reef flats bone fishing with associated trampling impacts and use of cast nets for bait collection
	Investigate the impacts of kayaking, wind surfing and sailing on ecosystems of Glover's Reef Atoll
	Investigate the impacts of snorkling and diving on ecosystems of Glover's Reef Atoll
Adaptive Management	Integrate research results into management planning process

The WCS research station is carrying out several high priority, ongoing research projects, which are expected to continue over the next few years. These include:

- Establishing and monitoring the status of Nassau grouper population on the atoll and its spawning aggregation site
- Investigate the effectiveness of conservation zone in conserving the populations of spiny lobster and queen conch
- Investigate the effect of algal dominance of patch reefs on ecology of the reefs
- Investigate the dynamics of coral recruitment, grazing, and nutrient enrichment on coral populations
- Determination of the Atoll's connectivity to the rest of the Mesoamerican Barrier Reef system as a 'source and sink' of larvae
- Assessment of reef recovery after 1998 bleaching event and hurricane Mitch
- Assessment of shark populations.

Other research areas highlighted as research priorities include the following:

- Develop a comprehensive species list of fish, corals and other invertebrates for the protected area
- Continue investigations into the status (size, age, abundance, distribution, recruitment, etc.) of lobster, conch and main commercial species of finfish populations on the atoll, to determine the sustainable level of harvest.
- A socio-economic study of the economic value of the Atoll to the economy of the country in terms of fisheries and tourism, and also in terms of the less easily measurable factors such as recreation and storm protection (possible with WRI).
- Continue investigations into the status of the fore reef near Northeast Caye as an aggregation site for snappers, etc.
- Continue updating ecosystem mapping of the atoll

The recent Living Seascapes planning initiative developed a number of research priorities, incorporated into the Research Programme.

Research Activities 2007 - 2012		
Research Highlighted by WCS Living Seascapes Planning		
	Priority Research Highlighted under Living Seascapes Planning	Collect and analyse fisheries catch and tagging data
		Investigate options for reef restoration
		Identify reef areas resilient to bleaching

Monitoring

Several long term monitoring programmes have recently been initiated on the atoll under the WCS Long-term Atoll Monitoring Program (LAMP) and the Mesoamerican Barrier Reef System Synoptic Monitoring Program, though there are still gaps in coverage of some of the basic parameters that are being adequately tracked. Additional species specific national monitoring programmes are also being established for conch, for establishing a quota under the CITES convention, and for lobster (Majil, 2007).

Every opportunity is being used to involve the local communities/stakeholders in monitoring activities, for example in the collection of fisheries catch data, data collection at spawning sites, and in recording turtle nesting, primarily through WCS activities.

Monitoring Activities 2007 - 2012		
Established Monitoring Programmes		
	LAMP	Continue LAMP in collaboration with WCS
	MBRS	Continue monitoring of finfish and coral in collaboration with WCS
		Continue monitoring of spawning aggregation sites (Nassau Grouper site in the north east, Middle Caye and Southwest Caye sites) in collaboration with WCS
	Coral Bleaching	Monitor any incidence of coral bleaching
	Fish Catch	Continue the monitoring of fish catch in collaboration with WCS, and with the participation of traditional fishermen
	Metereological Data	The weather station at Glover's reef should be maintained or replaced, and staff trained in its operation, to ensure that temperature, rainfall, wind speed and direction, relative humidity, and barometric pressure are measured on a continuous basis

Both Kramer & Kramer (2000) and McField (2001) have carried out coral reef monitoring at georeferenced locations on the atoll, producing valuable data sets on percentage coral cover, coral diversity, percentage of coral disease for these sites, (AGRRA technique by Kramer & Kramer and video transect method by McField) in order to determine changes or coral reef recovery over time. This is being continued through the AGRRA-based monitoring programme.

The collection of catch data for lobster, conch and finfish, essential for determining the effectiveness of the reserve in relation to fisheries production, should be considered a high priority, and be continued in collaboration with WCS. The involvement of fishermen in the data collection process should continue to be prioritized, providing regular feedback to the fishermen on its progress.

Long-term Atoll Monitoring Program (LAMP)

This is a physical and biological monitoring program for commercial species, recently introduced by Acosta (2001), detailed in CARICOMP Methods Manual Levels 1 and 2 (March 2001 Edition) and in Acosta (2001).

- The CARICOMP component measures productivity of corals, sea urchins, sea grasses and mangroves, and follows the CARICOMP methodology. Parameters measured include:
    - meteorological (temperature, precipitation),
    - oceanographic (temperature, salinity, turbidity)
    - biotic productivity.

- The data is comparable to those collected in 22 countries in the region, and all data are housed at the CARICOMP Data Management Centre at UWI in Jamaica.

- Additional parameters measured include plankton sampling and fisheries surveys inside and outside the Conservation Zone of the reserve. The plankton sampling is carried out in the two main cuts in the reef, near Southwest Cayes and Long Caye. Fisheries surveys include lobster, conch and five commercial finfish species.

- Reserve staff members have been trained in the techniques for carrying out the LAMP, working closely with research scientists. Initial monitoring results are documented by the Reserve Biologist in the annual reports.

Monitoring Activities 2007 - 2012		
Recommended Monitoring Programmes		
	Turtles	Collaborate with WCS to finalise and implement monitoring of turtle nesting on the cayes
		Implement turtle monitoring use of the waters of the Atoll
	Water Quality	Monitor nutrient levels on a regular basis
		Monitor run-off from northern Honduras during extreme storm events using remote sensing information (NOAA website / SERVIR, ICRAN-MAR)
		Monitor any incidence of coral bleaching
	Birds	Establish annual monitoring of migratory birds to show the importance of the cayes of the Atoll to autumn and spring migratory routes
		Monitor nesting success of osprey
		Record any nesting activity by brown noddys on Southwest Caye
	Terrestrial Reptiles	Record the presence and location of crocodiles on the Atoll
		Develop accurate information on the distribution of the two gecko species on the cayes – *Phyllodactylus insularis* and *Aristelliger georgeensis*
	Database	Maintain the database of GIS data, research and monitoring information in order to enhance the level of coordination between researchers, help identify gaps in information, and to provide a platform from which the results can be communicated to a wider audience
	Integration of Results	Monitoring results should continue to be presented in the annual reports, and integrated into the adaptive management cycle

4.5.3 Community Participation Programme

Glover's Reef Marine Reserve has a number of mechanisms for ensuring community participation in reserve activities. There is stakeholder representation on the Glover's Reef Advisory Committee (GRAC), which makes recommendations towards the management of the protected area. There has also been an increased focus on engaging traditional fishermen through participation in monitoring activities.

The Glover's Reef Advisory Committee (GRAC) was appointed for the Glover's Reef Marine Reserve several years ago, and was strengthened through the signing of a Stakeholder Agreement, on the 30th March 2000. The Committee has gone through a number of changes, and currently is comprised of the following members:

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

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

- Ensure regular revision and review of the management plan
- Comment on and recommend legislation and regulations
- Maintain an overview of management issues and, where necessary, provide advice on applications for permits relating to the site, and subdivisions and development on private land adjacent to the site
- Report on matters impacting the site and liaise with government enforcement agencies
- Assist with enforcement activities
- Assist in the development of sustainable financing mechanisms for the site
- Advise on and, where appropriate, assist with administrative matters, publicity, education and interpretive programmes, and decisions relating to research to be carried out in the site.

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

Community Participation Activities 2007 - 2012	
Glover's Reef Advisory Commitee	Continue the participation of GRAC in the management of Glover's Reef Marine Reserve, and ensure recommendations feed into the adaptive management process
	Ensure GRAC members are kept informed of reserve activities and management decisions
Stakeholder Communities	Ensure traditional fishermen are kept informed of reserve activities and management decisions affecting them
	Further develop socio-economic benefit strategies for stakeholder communities
Residents	Ensure resort owners / managers and other residents are kept informed of reserve activities and management decisions affecting them
Tour Guides	Ensure tour guides operating on the Glover's Reef Atoll are kept informed of reserve activities and management decisions affecting them
Participation in monitoring	Continue involving fishermen in monitoring of commercial species
	Develop mechanisms for tour guides to participate in monitoring activities of , for example, turtles and coral bleaching
	Engage caye residents in the monitoring of turtles and turtle nesting
Participation in Surveillance and Enforcement	Continue developing collaboration with residents for participation in surveillance and enforcement activities
	Successfully engage fishermen in surveillance and enforcement activities, with provision of training and equipment

Socio-Economic Benefit Strategies for Stakeholder Communities

Sustainable financing should also extend to areas surrounding the reserve, including those communities most impacted, by identifying alternative or additional sources of income, or new market opportunities (Morris 2002). The marine reserve staff should therefore work closely with the ongoing programmes of several NGOs (e.g. Green Reef, WWF, TNC) and the COMPACT project which are focusing on providing training and alternative activities for fishermen.

Furthermore, a portion of the revenue generated from entrance fees, donor contributions etc. should be invested in activities benefiting local communities. The Advisory Committee should be instrumental in identifying such activities, and liaising with the communities involved.

4.5.4 Public Use Programme

The Public Use Programme encompasses two primary activity areas: Visitor Management, and Interpretation and Education.

Public Use Activities 2007 - 2012	
Visitor Management	
General Management	Maintain accurate visitor records (Local and International), as well as records of visitor activities, and any enforcement action needed in respect to tourism visitiation
	Maintain accurate records of sport fishing fees paid, and catch according to species, size, type of fishing, etc. in order to monitor this activity. Issue licenses according to the regulations and keep records of these, as well as of visitation
Awareness	Ensure tour guides and tour operations using Glover's Reef are aware of management zones, and rules and regulations
	Increase good practices awareness among dive groups through development and dissemination of information
	Increase awareness of visitors on live-aboard boats of good practices, management zones and rules and regulations
	Ensure all researchers with WCS (or independent) are aware of the rules and regulations of the Marine Reserve, and research regulations under the Fisheries Department
	Ensure visitors in independent sailboats visiting Glover's Reef are aware of management zones and rules and regulations, and mooring regulations
	Ensure all Reserve staff are aware of the rules and regulations of the protected area
	Develop and produce laminated poster for distribution to resorts with map of Glover's Reef Marine Reserve highlighting zones, regulations, major dive / snorkeling sites, and dive best practices
Carrying Capacity	Develop carrying capacities and Limits of Acceptable Change (or similar) for primary dive and snorkel sites
	Develop a Tourism Plan for integration into the Development Plan (Natural Resource Management Programme), based on the outputs of research, the carrying capacity assessment, and Limits of Acceptable change planning
	Produce and disseminate best practices guidelines for the caye-based tourism operations and other residents. Meadows (1998) provides some simple guidelines to enhance the bird populations on the cayes such as implementing a policy of no cats and dogs, minimizing the clearing of vegetation, restricting fogging against insects to only the inhabited areas, and allowing the native vegetation to re-colonize most of the areas formerly occupied by coconuts many of which have now died from lethal yellowing.
Surveillance and Enforcement	Enforcement of mooring buoy regulations, fee payment and other regulations relevant to tourism activities
	Enforce 'no take' regulations for tourists and tourism operations in the Conservation and Wilderness Zones
	Ensure primary snorkel areas are defined by tour guides with markers when in use, to avoid boat injury to visitors
	Ensure enforcement of all identified and marked 'no wake' zones
	Ensure dive boats fly ' divers down' flag when divers are in the water
	Ensure that dive boats follow the recommended dive:guide ratio
Signs	Ensure there is a large, clear sign with a map of the Marine Reserve, positioned on the dock / at the end of the dock at Middle Cay, including zones and regulations
	Ensure there are 'no wake' signs in areas of safety concern – eg. dive sites and primary snorkeling areas

All reserve personnel are responsible for the implementation of interpretation and education activities, under the leadership of the Reserve Manager. Other than a few educational materials and a very rudimentary Visitor Center, located in the Fisheries building, this has been one of the hardest programme areas to implement, and the programme requires significant strengthening. Three main components have been identified for development: a visitor center, educational and interpretive material, and an outreach programme. Although these activities will require significant time and effort, and the ability of the reserve personnel to carry them out is limited, the approach recommended is that each year a few of them should be targeted within the annual operational plans, beginning with those of highest priority. Funding for this programme is being sought under a PACT funding proposal (Majil, pers. com., 2007)

Public Use Programme Activities 2007 - 2012	
Increasing Awareness of Glover's Reef Marine Reserve	
Visitor's Centre / Information Centre	Re-establish Visitors Centre / Information Centre on Middle Caye
	Equip Visitors Centre / Information Centre with interpretive information designed to raise awareness of the environmental and socio-economic benefits and services of the Marine Reserve
	Ensure relevant information on rules and regulations is available for dissemination to fishermen, tourists and other visitors
	Include information on traditional fishing, stakeholder communities, research activities
	Include information targeted specifically at fishermen, using it as a platform to inform fishermen about the ongoing research being carried out, for example on the Nassau grouper, surveys on conch and lobster, and catch data
	Change some of the displays on a regular basis to ensure there are still items of interest to attract regular visitors
	Seek funds for interpretive display creation
	Include a small gift shop area in the Visitor's Centre / Information Centre, as an income generating project
Educational Material	Ensure continued production and distribution of brochures on Glover's Reef MR
	Translate brochure into Spanish for distribution to Spanish speaking fishermen and visitors
	Develop PowerPoint presentation on Glover's Reef, for use in educational talks to visitors, in schools etc.
	Produce laminated fieldguides to common corals, fish, caye plants, etc.
	Develop a library of key publications and videos at the Visitors's Centre as a resource for Reserve staff, visitors, students and outreach programme. Copies of all published work on Glover's Reef should be available in this library.
	Collaborate with national and international initiatives to increase awareness of spawning aggregation sites and grouper
Interpretive Trail	Collaborate with WCS in maintaining the interpretive trail established on Middle Caye, and upgrading signage
	Provide additional interpretive information on the caye, its plant life and animals, as a self-guided leaflet
Website	Produce Glover's Reef Marine Reserve webpages for incorporation into Fisheries Department website
	Ensure all awareness documents relevent to Glover's Reef are available for download from the website (brochures, leaflets, regulations, posters etc.)
	Develop digital library of all published work on Glover's Reef, and make available for download on line
Advisory Committee	Ensure Advisory Committee input into the development of education and interpretive information

Public Use Programme Activities 2007 - 2012		
Outreach		
	Schools in Stakeholder Communities	Presentations targeting primary and secondary schools in stakeholder communities on Glover's Reef Marine Reserve and its environmental and socio economic benefits
		Liaise and collaborate with local NGOs for joint educational outreach to schools in stakeholder communities
		Develop handouts (colouring books, posters etc.) for dissemination during school presentations
		Design and implement a day trip for high school biology students from stakeholder communities, targeting Year 2 or 3, aimed at engaging their interest in the marine environment
		Collaborate with other marine reserve in joint education activities
	Fishermen	Fishermen visiting the Atoll should be encouraged to visit the Visitor's Centre / Information Centre, and presented with a boat sticker showing support for the marine reserve as they leave
		Presentations on research and monitoring results, and reserve activities should be given to traditional fishermen and in stakeholder communities at least twice a year
		Presentations on work at Glover's Reef should be given during the Northern and National Co-operative AGMs at least once every two years
		Reserve staff should work closley with fishermen during training exercises for monitoring activities and workshops to ensure accurate transfer of information on rationale behind research and monitoring activities
	General Public	Ensure there is awareness of Glover's Reef and the environmental services and benefits it provides to the general public through use of media opportunities and posters (focusing particularly on biodiveristy protection, fisheries production and tourism)
		Displays and exhibits should be placed at public shows such as the Agriculture & Trade Show, Earth Day, etc.
	Keeping Stakeholders Informed	An annual summary flier of reserve activities and achievements should be distributed to residents, tour guides, tour operators and fishermen

Funding for this programme is being sought under a PACT funding proposal (Majil, pers. com., 2007)

Safety Issues

- The risk to snorkelers from passing boats has become a safety issue and needs to be addressed as a high priority. Safety marker buoys are required to demarcate the popular snorkeling areas near the various cayes, and boats need to be informed of the need to avoid these areas. Alternatively, a "no-wake zone" could be declared up to 150 ft. from the shoreline around all the cayes. This measure should be noted in the reserve brochure, and the areas should be depicted on the accompanying map.

- Similarly, dive boats should fly the "divers down flag" when their divers are in the water, as required by the reserve regulations. In an effort to avoid damage to corals, additional mooring buoys should be installed. Locations should be decided on by consulting with the dive and kayaking industry operators who use these sites.

4.5.5 Infrastructure Management Programme

The Infrastructure Management Programme covers activities such as the future infrastructure, and equipment, and maintenance of present infrastructure (buildings, jettys etc.). In general, the infrastructure for the reserve headquarters is in good condition, having been upgraded and repaired in 2002. Staff members consider that the upstairs living quarters are adequate, though there is a request for locks for the doors for security. It is recognized that a fourth room is required to accommodate a fourth staff member. A Visitors Centre exists adjacent to the staff accommodation, though this is currently not in use.

Downstairs, the small kitchen and dining area are in need of upgrading with the increased use from visiting Coastguard and Fisheries Dept. groups collaborating in surveillance and enforcement activities. A storeroom provides storage for the monitoring equipment. WCS provides the Marine Reserve staff with access to dining facilities, showers, and composting toilets (Table 26).

The dock and storeroom are in good repair, though there is concern at the proximity of the fuel storage, which is directly under the Fisheries Dept. accommodation, and a request to investigate the possibility of locating the storage area closer to the dock, and further from the accommodation.

Whilst the office has a desk, it is in need of upgrading to include office furniture for more effective management of paperwork and administration tasks.

An outboard engine is needed for the second smaller boat, to ensure that one boat remains permanently on the Atoll.

Table 26: Glover's Reef Marine Reserve Equipment (2006)

Item	Quantity	Condition
Boat		
25' fiberglass skiff	1	Fair
40 hp two stroke Yamaha engine	2	Good
6 gallon container	2	Good
60 gallon container (blue)	2	Good
12 volt battery	1	Good
Monitoring		
Fins	3	Good
Mask (blue and black)	3	Good
BCD (black)	2	1 Good other poor
Regulator	2	1 Good other poor
30 meter measuring tape	2	1 Good other poor
Facilities		
Kitchen Equipment		Generally good
Beds	3	Good
Mattress	3	Poor
Television	1	Good
Office desk	1	Good

The radio system also needs to be up-graded as contact is not always maintained with Belize City. However, the reserve staff has access, within certain guidelines, to the WCS telephone. WCS also provides the reserve headquarters with running water and electricity from solar panels and generators, and internet access. The reserve also has its own small back-up generator.

Infrastructure Management Programme Activities 2007 - 2012		
Infrastructure and Maintenance		
	General Infrastructure and Maintenance	Ensure adequate infrastructure for effective management
		Ensure all infrastructure is maintained in good condition
		Schedule maintenance checks - routine checks of the roof and gutters, painting of the building, replacement of rotten wood, etc.

Infrastructure Management Programme Activities 2007 – 2012 (cont.)	
Infrastructure and Maintenance	
Infrastructure Requirements	Upgrade kitchen and dining area for increased use
	Investigate feasibility of moving fuel storage further from accommodation
	Upgrade the current office facilities
	Wire up Fisheries building for increased electricity (currently 3 hours per night)
	Resolve Visitor Centre / Information Centre situation – complete development of Visitors Centre, or develop Information Centre in new location
Equipment	Purchase and maintain a butane freezer for evidence
	Acquire outboard motor for second, smaller boat
	Ensure radio equipment is acquired and installed in both base and boats
	Diving equipment is required for Reserve staff – currently staff borrow WCS equipment
	Schedule maintenance of outboards, the generator, dive equipment, mooring and marker buoys, and other equipment, and record servicing in log book

4.5.6 Administrative Programme

The administration of the Marine Reserve is the responsibility of the Fisheries Department, under the Ministry of Agriculture and Fisheries. Glover's Reef Marine Reserve is managed under the Ecosystems Management Unit of the Department, and the Reserve Manager reports directly to the Unit's Marine Protected Area Coordinator. Staff recruitment, employment, training and management are covered under the Administrative Programme.

Administration Programme Activities 2007 - 2012	
General Administration	Ensure adequate infrastructure for effective management
	Ensure all infrastructure is maintained in good condition
	Schedule maintenance checks - routine checks of the roof and gutters, painting of the building, replacement of rotten wood, etc.
	Collection and recording of entrance fees
Staff	Develop an employee handbook, covering topics such as job duties, employee policies, transport policy, gender issues and a staff appraisal process
	Ensure staff are provided with uniforms
	Annual evaluation of staff performance
	Ensure the Reserve Manager is trained in marine resource management
	Ensure staff have sufficient admiinistrative training for effective general management, fundamental accounting, budget and proposal preparation
	Ensure staff have sufficient surveillance and enforcement training to be effective
	Ensure staff are trained in operation and maintenance of reserve equipment (boat handling, outboard engine repair etc.)
	Ensure staff have sufficient training in monitoring protocols for effective monitoring
	Ensure staff are trained in conflict resolution, consensus building and communications skills
	Ensure staff are trained in CPR, First Aid and use of the oxygen kit
	Annual review of staff capacity and training requirements
Health and Safety	Ensure an effective Hurricane Plan is in place, and staff trained in implementation
Administration Procedures	Reserve Manager to develop Annual Report, for submission to MPA coordinator
	Reserve Manager to submit budget request each December for the following financial year
	Reserve Manager to develop Annual Operational Plan
	Reserve Manager to report to GRAC

4.5.7 Management Policies

The Belize Fisheries Department has a number of policies in place or being developed, guiding management:

Enforcement Policy

The Fisheries Department is currently developing an Enforcement Plan, as an offical Fisheries Department policy, following a review of current enforcement limitations (I. Majil, 2007). This will guide reserve staff through standardized procedures for approaching and apprehending people in contravention of the protected area regulations. This should be incorporated into the Management Plan as an appendix once completed.

Hurricane Preparedness

A Hurricane Preparedness Plan is in place (Fisheries Dept., 2002) to ensure protection of life and property during hurricane events, particularly with the distance of Glover's Reef Marine Reserve to the mainland. The main elements of the Plan include the following:

- During the ***preliminary alert phase***, the reserve building, equipment and files are to be secured and the reserve staff evacuated from their base on Middle Caye, bringing the reserve boat to Belize City.
- The boat is to be secured at the Belize Defense Force Compound in Belize City.
- In the event that Belize City is the area to be affected by the storm, the reserve boat is to be taken to Dangriga, in coordination with the South Water Caye reserve boat. The boats are to be secured inland.
- Once the ***All Clear*** is issued, all staff members are expected to report to work within four hours, provided it is during daylight hours and road conditions permit.

The current Hurricane Plan will be revised in the near future, and reserve staff will be apprised of any relevant changes. A sub-plan also needs to be prepared specifically for the reserve that provides clear details of the how the building and equipment will be secured (e.g. what priority items will be taken to the mainland) and what emergency supplies such as extra fuel, wood and nails, First Aid kit, etc. will be kept on hand. In addition, a specific location for the boat needs to be identified in the event that it is taken to Dangriga.

4.6 Evaluation and Review

Monitoring and evaluation are integral components of any management system and annual evaluations of reserve management are recommended. In the revision of this management plan, the action areas are more specific, simplifying the process of monitoring success of implementation, and providing a mechanism for continual tracking of management activities, through annual review by the reserve manager, the MPA coordinator, and the Advisory Committee.

Checklist for an Effective Marine Reserve

Be clear about objectives
Seek local support
Build partnerships
Plan for financial sustainability
Don't prohibit more than necessary
Build for the unforeseen
Put in place structures for conflict resolution
Establish self-enforcement as much as possible

Adapted from Kelleher, 1999

Management evaluation is also achieved by an assessment of management effectiveness. An initial management effectiveness evaluation was conducted in 2000 (McField 2000), and repeated in 2006 (Gibson and Hoare, 2006). Whilst not directly comparable, as they focus on slightly different thematic areas, both processes reveal areas of weakness, and allow incorporation of adaptive management measures into the overall management of the protected area.

The 2000 evaluation results showed that the management of Glover's Reef Marine Reserve was 'moderately satisfactory' (68.2%), reflecting that resource integrity is not guaranteed and the objectives of the reserve may be only partially accomplished. The main weaknesses were identified in the areas of Administration, Planning and Management Programmes (McField, 2000). The majority of the priority actions under this assessment have been implemented.

The more recent assessment (Gibson and Hoare, 2006) highlights management effectiveness in terms of protection of natural resources, and suggests that the zoning of the marine reserve is working as an effective resource management tool, with population densities of conch and lobster being higher within the Conservation Zone than outside. Illegal fishing activities, however, are still impacting the protected area, and staffing limitations (the number of staff on site and availablility of fuel and boats) are highlighted as the main obstacles to fully effective management

4.7 Timeline

Adapted from Glover's Reef Work Plan for 2007 (January – June)

Activity	Jan	Feb	Mar	Apr	May	June
Administration						
a. Advisory Committee Meeting						
b. Conduct Staff Meeting						
Surveillance and Enforcement						
a. Patrols						
b. Install missing marker buoys						
Research and Monitoring						
a. Lobster collectors						
b. Lobster Monitoring						
c. Turtle Monitoring						
d. Daily Measurements						
e. Weekly Measurements						
f. Spawning Aggregation						
g. Coral Monitoring						
Tourism and Visitors						
a. Collect park fees						
b. Keep records of tourist visitation						
c. Keep records of researchers who visit the atoll						
d. Keep records of Belizeans who visit the atoll						

4.8 Financing

The Manager is responsible for preparing the annual budget for the reserve and submitting it to the Fisheries Administrator for approval and onward submission to the Ministry. The budget is required to be submitted in December each year, in time to form part of the government's consolidated budget, which is generally announced in February or March.

GEF/UNDP support has provided the Marine Reserve with past funding, finishing in December 2003. Funds for basic operational costs, such as salaries and fuel, are provided by the Government of Belize. Non-operational costs, however, have to be sought by the Fisheries Department, which is currently developing a proposal for PACT to cover many of the associated costs of Reserve Management.

Financial Sustainability Plan

Most marine protected areas need to develop a diverse portfolio of funding sources in order to achieve sustainable financing to cover their expenses. In Belize, these sources have traditionally included direct subventions from government, entrance fees, some sales, and grants from national and international donors. With a decreasing government budget, this conventional source of financial support can no longer be depended on to significantly assist marine reserves. Other innovative sources and mechanisms for revenue generation will become increasingly essential.

To provide justification for the financing of the marine reserve, an economic or cost/benefit analysis of the protected area should be prioritized, and has been highlighted as required research for the reserve. This would determine the direct and indirect values of the reserve and compare these to the costs of management, including the opportunity costs (e.g. foregone fish catches from areas closed to fishing) (Morris 2002). Demonstrating that the value of the reserve can be clearly shown to outweigh the management costs is a powerful argument to justify the expenditures made in protecting the reserve area, and also in providing benefits for local people who have borne some opportunity costs by the establishment of the reserve. This requirement for a Business Plan has also been recognised, with allocation of WCS funds being made towards this in mid-2007.

Entrance Fees

According to the reserve regulations, several fees and licenses apply to resource use within the reserve, but only the Water Recreational Activity fee (equivalent to an Entrance fee) of BZ$5/day or BZ$20/week for tourists (children under the age of 12 are exempt), and a $500/annum research fee are in effect (Table 27). Collection of the entrance fees has not been systematic in terms of record keeping and regularity of implementation.

The charge for 'Other water recreational activities' is well below the total amount recommended by a willingness-to-pay study conducted in 2001 by Programme for Belize. The fee collection system has been established since 2003, and is based on a manual ticket sale system by Reserve staff, with additional ticket sales through special agreement with tourism stakeholders on the mainland – Hamanasi, for example, keeps records of guests taken to Glover's Reef, and pays its entrance fees once a month, based on these records. Entrance fees used to be deposited in the Marine Protected Area Trust Fund, for use in funding the costs of managing the protected area. This has recently been regularized to follow general Government procedures, funds now going to a Ministry of Finance approved Fisheries Management Account, to be available for allotment at the end of each year.

Table 27: Charges for licenses and tickets		
Licenses / Tickets	**Legislated Fees**	**Current Implemented Fees**
Commercial fishing license	$50/annum	$25/annum*
Sport fishing (catch & release only)	$20/month (Belizeans) $50/month (non-Belizeans)	$50/month (non-Belizeans) Not charging Belizeans
Research	$500/annum	$500 per research application
Dive boat registration	$100/annum	Not implemented
Other water recreational activities	$5/day or $20/week	$10/day or $30/week**

*The $25 is the national fishing license. No aditional costs are levied on traditional fishermen using the Atoll, though they should have their licenses stamped as covering Glover's Reef

**Glover's Reef Marine Reserve has been chosen as one of four marine protected areas to be included in a Fee Pilot Scheme for Belize MPAs. Under this pilot study, the fee rate will be BZ$10/day and BZ$30/week.

Sales and Marketing

With the increasing number of visitors visiting Middle Caye, it would be advantageous to sell promotional and educational items such as T-shirts, booklets, postcards, etc., in an Information Centre or Visitor Centre

Donor Contributions

A major source of funding is grants from both national and international agencies. For example, PACT (the Protected Area Conservation Trust) has been a contributor to the reserve in the past and is currently being approached for funding for the Marine Protected Area programme (Majil, 2007).

Accessing international donor funds is becoming more and more competitive and the marine reserve will need to demonstrate effective management to be able to successfully compete. However, the recent shift of focus onto the Belize Barrier Reef, especially in its role as a World Heritage Site, has released new funding streams accessible especially for special programmes, such as increasing awareness and capacity building. Proposals to international donors (e.g. WWF, Summit Foundation, and Oak Foundation) need to be prepared and submitted preferably with sufficient time Advantage should be taken of other funding opportunities offered (e.g. through NOAA, UNEP, US National Fisheries and Wildlife Foundation (NFWF), IUCN, COMPACT etc.). Collaboration with other marine reserves and NGOs through joint proposals should also be considered. Small donations, too, are equally important - in 2005, for example, $300.00 was donated by Isla Marisol Resort to purchase binoculars for enforcement activities, and over $500.00 in ropes were donated by the Usher family, for the installation of new mooring buoys to complement the donation of the buoys themselves by NFWF. Equipment was also donated for the Visitors Centre the windows, furniture, TV etc.

Other possibilities include developing partnerships with the private sector, primarily with the tourism businesses. Hotels or tour operators operating within the Atoll depend on the health of the resources within the marine reserve for their livelihood, and often use the marine reserve, and its status as a World Heritage Site, in their marketing and promotion.

Cost sharing mechanisms

In an effort to reduce costs and yet achieve good management, the Manager should explore possibilities of sharing certain management responsibilities with stakeholder groups through special co-management agreements (Morris 2002). For example, the maintenance of mooring buoys could be made the responsibility of the dive or tour operators in the reserve. Cost-sharing may also be in terms of fines for damages following bad practices. Recently, for example, damage to a mooring buoy through mooring of an over-sized live-aboard has resulted in a call for damages to be paid and the mooring point to be replaced by the live-aboard (GRAC, 2007). Collaboration with caye and resort owners in monitoring activities, such as monitoring of sea turtle nesting activity, would also assist in sharing the financial burdon, as would the involvement of fishermen in enforcement and catch data collection. This type of sharing of responsibility also fosters a greater sense of ownership by the users of the reserve.

Glover's Reef Marine Reserve has already developed this type of mechanism through its partnership with WCS, with much of the necessary research in the reserve being carried out by this international organization. In addition, WCS provides the reserve with some essential facilities and services. Resort owners have also contributed towards the salary of an extra ranger (from February, 2007), to overcome staffing shortages.

This type of sharing could also be expanded to include sharing of specialized equipment and expertise of reserve staff within the national MPA network.

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APPENDIX 1

Measuring Success of Implementation of 2003 Management Plan

Measures of Succes Matrix, 2007

Measures of Success of Implementation of the 2003 Management Plan for Glover's Reef Marine Reserve					
	Measures of Success of Implementation				Comments
Objectives/Actions	Succeed	Improved	No Change	Worse	
Surveillance and Enforcement Programme					
Regular patrols should be scheduled and implemented, preferably on a daily basis.					Annual reports for 2004, 2005 and 2006 show that the number of patrols has increased, though it is still recognized that patrolling of the Seasonal Closure Zone, Spawning Aggregation Site and General Use Zone is below that required for effective enforcement. LAMP data suggests that enforcement of Conservation Zone regulations is more effective, with increased densities of commercial species inside the 'no-take' areas, but there are still concerns about illegal fishing. Major limitations include the large size of the area to be covered, and staff, gasoline and boat availability. Problem of Fisheries Dept. policy of no patrolling at night. Patrols are being supplemented at peak fishing seasons by Coastguard activities.
Patrols should be carried out according to an approved standard procedure					There is recognition of the fact that current enforcement procedures are not documented, and a lot (too much) is unclear, and left to the discretion of the Fisheries Officer. This is being addressed by the creation of standardised regulations, and a more structured enforcement plan, to be adopted as a Fisheries Policy (Majil, pers. com.), which will give much greater guidance on the steps to be carried out, supplemented by training, both in enforcement and in Fisheries legislation. Also standardising the use of GPS and photographic evidence to maximise possibility of convictions.
Boats should be equipped with radios					The radio system is not considered currently reliable, though the presence of telephone communications at the WCS facility does alleviate some of the communication problems previously encountered. The new boat is to have a radio system installed, and it is hoped that this is to be further strengthened through funds from PACT (proposal in prep.)
A boat should be based at the Reserve at all times					A second, smaller boat has been purchased for permanent presence at the Marine Reserve for patrolling. However it currently lacks an outboard motor. It is hoped that this is to be supplemented by pool of boats available at Fisheries Dept. for marine reserves, as substitutes when boats have to be taken out for maintenance, through funds from PACT (proposal in prep.)
The Conservation Zone should have additional marker buoys on its boundaries					Marker buoys are now considered sufficient for adequate recognition of the protected area boundaries (though a few may need to be realigned to more accurately reflect the boundaries of the protected area.
The registration of recreational boats and resident subsistence fishermen should be regularized, according to the regulations					Recreational boats are registered. The standardised Marine Reserve regulations will no longer permit subsistemce fishing within the Conservation Zone.

Measures of Success of Implementation of the 2003 Management Plan for Glover's Reef Marine Reserve					
	Measures of Success of Implementation				Comments
Objectives/Actions	Succeed	Improved	No Change	Worse	
Surveillance and Enforcement Programme					
All fishermen currently using the Atoll should be specially licensed, to ensure that fishing within the General Use Zone is reserved for traditional users					Whilst this is not considered to have been implemented, there are plans in place for providing traditional users with an additional stamp to their national fishing licence, to recognize their rights to continue fishing at Glover's Reef
Regular contact should be maintained with the residents of the Atoll and tour guides operating within the reserve, to help encourage their participation in surveillance					There is regular contact between residents and Fisheries staff, strengthened through the GRAC structure, with participation in surveillance activities. Response to reports of illegal activities, however, has at times been frustrated by fuel, staff and equipment limitations, and by regulations preventing night patrols. Increased collaboration with residents, however, is closing the gaps (eg. through funding of an interim additional staff member, and of providing a boat for night surveillance at the north east SPAG)
Logbooks should be kept recording all patrols, number of boats checked, infractions noted, ect.					Each Fisheries Officer maintains a personal logbook, and a general incident log is maintained at the Fisheries base on Middle Caye. These are summarised in standardised quarterly and annual reports, which include the relevant information (NB. The 2006 Annual Report lacks the standard patrol table, which prevents an accurate assessment of patrol effectiveness. It is recommended that the report be revised to include this information)
Reserve regulations should be amended to restrict spear fishing throughout the reserve					All types of spear fishing are currently allowed, including use of spearguns, and Hawaiian slings . Recommendations are being made to ban all spear fishing in all Marine Protected Areas, but there may be limited support for the recommendation to become incorporated into the regulations
Research and Monitoring Programme					
High Priority Research Projects					
Status of Nassau Grouper and the associated spawning aggregation site					The Nassau Grouper and the associated north-east spawning aggregation site have been the focus of research work by both Fisheries and E. Sala, with increased understanding of how this species utliizes the Atoll at different life stages summarized in the Living Seascapes target assessments
Effectiveness of Conservation Zone in conserving populations of spiny lobster and queen conch					A number of studies have investigated the effectiveness of the Conservation Zone in conserving commercial species. Gibson and Hoare analysed LAMP data from 2004 / 2005 to show that lobster densities, for example, are five times higher in the Conservation Zone than the General Use Zone. Acosta and Robinson (2002) also focused on this issue.

Measures of Success of Implementation of the 1997 Management Plan for Glover's Reef Marine Reserve (cont.)					
	Measures of Success of Implementation				Comments
Objectives	Succeed	Improved	No Change	Worse	
Effect of algal dominance of patch reefs on ecology of the reefs					Work by Mclanahan et. al. (2003) investigates the role of nutrients and herbivory in controlling macro algal communities and coral condition, whilst Mclanahan et. al (2004) looks at the effects of phosphorus and nitrogen enrichment on macro algal growth.
Dynamic of coral recruitment, grazing, and nutrient enrichment on coral populations					Work by Mclanahan et. al. (2003) investigates the role of nutrients and herbivory in controlling macro algal communities and coral condition. Steneck (2002) investigated the environmental factors affecting coral recruitment
Determination of the Atoll's connectivity to the rest of the Mesoamerican Barrier Reef system as a source and sink of larvae					Purcell (2000).
Assessment of reef recovery after 1998 bleaching event and Hurricane Mitch					Kramer and Kramer (2000), Mumby (2001) and McField (2001) have both investigated bleaching and the impact of hurricanes
Assessment of shark populations					Pikitch 2002; Pikitch et al 2005
Other priority research					
Investigation of the status of lobster, conch and main commercial species of finfish populations to determine sustainable level of harvest					There is much greater understanding of the commercial species, with research on lobster and conch in particular (Acosta, 2002, Acosta et. al. 2002). Results of analysis of LAMP data suggest that the current size categories for conch may not sufficiently cover the requirements for sustainable fishing (Gibson and Hoare, 2006). Ihde (2001) investigated the impacts of fishing intensity on five species of finfish
A socio-economic study of the economic value of the Atoll					A study of the economic value of the Atoll to its immediate stakeholders and to Belize as a whole has not yet been done, however WCS will be partnering with WRI in 2008 to conduct an evaluation for Glover's
Status of the fore reef near northeast caye as an aggregation site for snappers etc.					S. Hoare is currently spot checking this site in an effort to verify that it is a spawning area (2007).
Greater detail habitat mapping of the Atoll					Detailed ecosystem mapping by WCS of the Atoll under the Living Seascape conservation planning initiative
Preparation of Development Guidelines for the Atoll					WCS currently in the process of developing Best Practices for residents of the Atoll, to guide future development for minimizing impacts
Monitoring					
CPACC Monitoring					Supersceeded by MBRS synoptic monitoring programme, which is currently in place
Monitoring of Coral Bleaching					Monitoring of coral bleaching is included within the MBRS synoptic monitoring programme
Monitoring of Nassau Grouper Spawning aggregation					The Nassau Grouper site is being monitored, in collaboration with WCS (however the future viability of this site is in question)

Measures of Success of Implementation of the 1997 Management Plan for Glover's Reef Marine Reserve (cont.)					
	Measures of Success of Implementation				Comments
Objectives	Succeed	Improved	No Change	Worse	
Monitoring of Middle Caye and other spawning aggregation sites					The other spawning aggregation sites are monitored, but not with the same regularity as the north east site
Collection of Catch Data for lobster, conch and finfish					Catch data collection by WCS is ongoing
Monitoring of impacts of subsistence fishing and sport fishing					No monitoring – subsistence fishing will no longer be allowed in the Conservation Zone under the standardised marine reserve regulations
Implementation of the LAMP monitoring protocol					LAMP monitoring protocol is being implemented in collaboration with WCS.Fisheries staff are trained in the techniques for carrying out survey work. Not all suggested parameters are currently covered comprehensively (eg. metereological data),
Turtles					Whilst there is awareness of the need to monitor turtles and turtle nesting, there is also the awareness that the current efforts are not sufficient for understanding the status turtle species, and their use of the Atoll. This is being addressed through the WCS, which is developing a protocol for turtle monitoring, with training for protected area staff.
Acquisition of standard data sheets					Glover's Reef Marine Reserve using standardised data collection sheets
Migratory Birds					No standardised monitoring protocol for migratory birds in place
Crocodiles					No standardised monitoring protocol forcrocodiles in place (it is also believed that the one crocodile reported on Glover's Reef may have been shot recently)
Coconuts – incidence of lethal yellowing					This was monitored and documented during the main die-off period. No standardised continued monitoring of the remaining coconuts
Development of a GIS database to enhance level of coordination between researchers					Data more readily available on http://programs.wcs.org/gloversreef
Interpretation and Education Programme					
Development of a small Visitor's Centre					A room in the Fisheries building has been designated as a Visitor's Centre but is not currently being utilized, primarily through problems of accessibility and size. Fisheries Deot. Are considering adapting a room downstairs to act as an Information Centre, for the dissemination of brochures and leaflets, to be funded through the PACT grant (in prep.)
Development of murals and displays for the Visitor's Centre					The Visitor's Centre does have a mural, but is not currently open to visitors. It lacks other displays, and isn't fulfilling its purpose of providing a platform to target increasing the awareness of fishermen
Small gift shop					Fisheries Dept. is considering including a small gift shop within the Information Centre

Measures of Success of Implementation of the 1997 Management Plan for Glover's Reef Marine Reserve (cont.)					
	Measures of Success of Implementation				Comments
Objectives	Succeed	Improved	No Change	Worse	
A colour brochure of the reserve to be produced and distributed					A colour brochure of the reserve has been produced and distributed
Fisheries Dept website					A Fisheries Dept. website is currently being developed, and will include information on Glover's Reef Marine Reserve
Development of other educational material – posters, pamphlets etc.					Some educational material is available as a by-product of other intitiaives (eg. on conch, lobster, spawning aggregation sites, WHS posters). The PACT grant proposal includes a strong educational component for educational literature etc.
Laminated maps and guidelines for the tourism sector					There are currently no maps or guidelines available for distribution to tour guides or resorts
A library of key publications and videos available at Glover's Reef					WCS and Fisheries Dept. both have copies of research reports, videos and other materials, but there is no central repository that allows easy access to external sources for key publications
Signs to designate 'no-wake' zones in swimming areas, and to mark the Baking Swash and Southern Channel. A sign to show zones of Glover's Reef					'No wake' zones and channel markers not yet impemented. There are signs for the most frequently used snorkel entry points. No sign showing map of Glover's Reef with zones and zone regulations
An interpretive trail on Middle Caye, with signs pointing out areas and plants of interest					A well maintained trail has been developed on Middle Caye, with signs identifying many of the plants. There was no interpretive material, however, to provide the interpretation
Advisory Committee review of material developed for the Interpretation and Education Programme					There is little material currently for the GRAC to comment on
Presentations to primary and secondary schools, particularly in Dangriga and Hopkins, describing the role of the marine reserve					There are a number of initiatives that are raising awareness of the role of marine reserves within fishing communities, including centralised education initiatives. No visits are reported to have been made by reserve staff to schools during in 2004, 2005, or 2006, and the 2006 workplan lacks an interpretation and education component.
School comptetition for designing logo					Logo has been developed -though not through a school competition
Field trips by high school classes from Dangriga					The logistics and costs of arranging school visits to Glover's Reef have been a major limiting factor. Fisheries Dept. also feel limited by the need to rely on WCS facilities and hospitatility if running such an activity. At least 3 school groups have been hosted jointly by WCS and Fisheries over the past couple of years – one from Belmopan and 2 from Dangriga
Tour operators and hotels using the Atoll are informed of the regulations, benefits and services					Whilst not really considered a component on its own within the current workplans, the representation of the tourism sector on the GRAC has established a much better understanding and working relationship between resorts and operations based at Glover's Reef. Mainland tourism initiatives may be less well informed and engaged

Measures of Success of Implementation of the 1997 Management Plan for Glover's Reef Marine Reserve (cont.)					
	Measures of Success of Implementation				Comments
Objectives	Succeed	Improved	No Change	Worse	
Tour operators and tour guides should be well informed about the Visitor's Centre once it becomes operational					The Visitor's Centre is not currently operational
Glover's Reef should feature on the Fisheries Department website and on the Belize Tourism Board website					The Fisheries Dept. website is currently under development. Glover's Reef Marine Reserve does have a page on the Belize Tourism Board website (www.travelbelize.org)
Fishermen visiting the Atoll should be given a tour of the Visitor's Centre					The Visitor's Centre is not currently operational
Presentations on work being carried out in the Reserve should be given to Fishermen					Fishermen are receiving a greater number of presentations, both during the two main co-operative AGMs, and in the individual communities, primarily through WCS activities
Reserve personnel should be involved in workshops for training fishermen in monitoring techniques for the spawning aggregations					Fishermen are being encouraged to take part in monitoring activities
All opportunities should be used to publicize the reserve, explaining its benefits for biodiversity protection, for fisheries production and for the tourism industry					Whilst there is some publicity on Glover's Reef, there could be increasing participation by Fisheries staff in protected area initiatives under the NPAPSP, which would increase awareness in the general protected area community
Monthly or quarterly press releases to update public on activities and accomplishments					Not being implemented
Displays and exhibits should be placed at national shows					Fisheries Dept. and WCS provide exhibits from time to time at national events
Recreation and Tourism					
A Development Plan should be developed to ensure development is compatible with the objectives of the marine reserve					A Development Plan was produced by Coastal Zone, but has not been effectively implemented. Best Practices guidelines are currently being developed
Assessments should continue for infrastructure such as piers, resorts, seawalls etc. following existing draft policies					Infrastructure assessments have not been carried out, probably due to remoteness of area and the related high costs to travel there.
Implementation of basic actions for protecting the integrity of the cayes – minimizing clearance of natural vegetation, fogging with insecticide only in inhabited areas etc.					As the cayes are not within the Marine Reserve, these need to be more in the way of recommendations. Should be incorporated into the Best Practices guidelines
Caye owners should be encouraged to leave any small remaining areas of littoral forest intact					The majority of caye owners are aware of the value of littoral forest for migratory birds (though not necessarily of its status as an ecosystem of concern in Belize).
Caye owners should be encouraged to protect any remaining areas of mangrove					The majority of caye owners are aware of the value of mangrove as a nursery area for fish and lobster, and as a refuge for many other species, and will leave the majority of mangrove on their cayes if it doesn't interfere with their tourism areas

Measures of Success of Implementation of the 1997 Management Plan for Glover's Reef Marine Reserve (cont.)					
	Measures of Success of Implementation				Comments
Objectives	Succeed	Improved	No Change	Worse	
Fogging with pesticides – caye owners should be encouraged to use less harmful pesticides such as Suspend SC					Fogging with pesticides appears to happen on all cayes (and Gramoxone on one of the cayes for weed supression). It should be noted that the Suspend SC recommended has warnings of high toxicity to fish.
A record of the number of visitors to the Atoll should be maintained					The majority of visitors to the Atoll are accurately recorded in the Fisheries Dept. Annual Report. However, the 2006 report does not include figures from Hamanasi, and staff are not always on site to collect figures and fees from some of the kayak groups. There is less information on the cross section of visitors.
Safety for snorkelers, either through use of marker buoys to mark popular diving sites, or by declaring a 'no-wake' zone up to 150ft from the shoreline around all cayes					There are still safety concerns for snorkelers, including researchers at study sites
Safety for divers – dive boats should use the 'divers down' flag, as required by reserve regulations					The majority of divers do ensure they fly flags, but some, including researchers, do not. There is no noticeable enforcement of this regulation, or mention of patrols ensuring that flags are being flown at dive locations
Tourism impact monitoring for diving and snorkling					It is recognized that there is a need to monitor tourism impacts and set carrying capacities, but this has not yet been started
Tourism impact monitoring for other tourism services – fly fishing, kayaking, sailing, windsurfing, camping etc.) to determine carrying capacities					It is recognized that there is a need to monitor tourism impacts and set carrying capacities, but this has not yet been started. Of particular note are impacts associated with fly fishing, with cast nets and trampling occuring in the reef flats
Licenses should be issued for sport fishing according to the regulations, and records kept of these, as well as of catch, according to species, size, type…in order to monitor this activity					Licenses are issued, but little information is collected
Administration and Maintenance					
One additional ranger is required for the effective management of the reserve					The need for an additional ranger is recognized, and an interim measure is currently in place, through funding for an additional ranger by caye residents. It is anticipated that his salary will then be continued by Fisheries Department in the new financia year (2007/2008)
The Reserve Manager is required to submit quarterly and annual reports to the MPA Coordinator					Quarterly and Annual reports are submitted
There should be a specific terms of reference for each staff position					There is a TOR for each staff position
There should be rules of conduct for the staff, similar to those developed by BAS					There are currently no specific rules of conduct in place for the MPA staff, but they do fall under those relevant to all Government employees

Measures of Success of Implementation of the 1997 Management Plan for Glover's Reef Marine Reserve (cont.)					
	Measures of Success of Implementation				Comments
Objectives	Succeed	Improved	No Change	Worse	
Reserve staff should be provided with uniforms					Reserve staff are provided with uniforms
A clear and regular system of appraisals of performance, with associated incentives linked to achievements, should be developed, to help foster wider acknowledgment of good performance and boost staff morale					Reserve staff fall under the GoB employee system of appraisals, though this may not be linked to incentives scheme
The Reserve Manager should develop the Annual Operational Plan, with the assistance of other reserve staff, and in consultation with the Fisheries Department and GRAC					A general plan outline is usually prepared and shared with the GRAC, but the plan needs to be more detailed and the practice more systematic.
Glover's Reef should have a fully functional Advisory Committee (GRAC)					Glover's Reef has a fully functional Advisory Committee, meeting regularly with good participation
The GRAC should meet once a quarter					The GRAC meets quarterly
Fisheries Department acts on the recommendations of the GRAC					The Fisheries Department does act on the recommendations of the GRAC, but realises that implementation of some of the recommended actions may be much slower than expected by GRAC members. There needs to be greater understanding by GRAC members of the Government/Fisheries Department framework the MPA has to operate within
Staff should continue to participate in training programmes					Training opportunities weretaken in 2004 and 2006, but there was little training in 2005. The high staff turnover does cause some problems in maintaining trained staff, and staff participation in training courses also results in staff limitations for other activities within the protected area during the timeframe of the training course
Staff members should be trained in conflict resolution, consensus building, and communications skills					A new training package is being developed by Fisheries Department to provide staff with the training they need for enforcement activities
Maintain staff infrastructure in good condition					The station was completely renovated in 2002, and only needs minor maintenance – a better equipped office, an extra, lockable room downstairs, and an upgraded second kitchen for coastguards and other visiting Fisheries patrols
Ensure that there is the required infrastructure					Staff suggest that a new gasoline store room is required, located further from the Fisheries building for safety. Better electricity supply (currently 3 hours per night)
WCS provide staff with dining facilities, showers and toilets					WCS provide staff with dining facilities, showers and toilets, and internet service
Staff have the basic equipment necessary for implementing the management plan effectively					The Marine Reserve currently has two boats, but only one outboard engine. A freezer is required for storing evidence. Full dive gear is needed, as currently dive equipment is borrowed from WCS. Radio system needs to be upgraded

Measures of Success of Implementation of the 1997 Management Plan for Glover's Reef Marine Reserve (cont.)					
	Measures of Success of Implementation				Comments
Objectives	Succeed	Improved	No Change	Worse	
Routine maintenance for equipment and infrastructure					Routine maintenance is carried out where not limited by finance
Hurricane preparedness plan					Fisheries Dept. have a hurricane preparedness plan in place
The budget is prepared and presented to Fisheries Department in December					The budget is prepared and presented to Fisheries Department in December
Development of a Business Plan / Financial Sustainability Plan					WCS is currently developing a preliminary plan.
Developing cost sharing mechanisms with stakeholder groups					Stakeholders are contributing towards the new ranger, and have provided a boat as a mobile station at the SPAG site during the SPAG season, to assist with enforcement. There is currently no formal agreements in place for cost sharing collaboration.
Provision of Alternative Livelihoods opportunities to stakeholder communities					WCS has targeted the main stakeholder communities for alternative livelihood projects, with a focus on Glover's Reef fishermen
Evaluation of management effectiveness					Management effectiveness has been assessed twice – most recently in 2006. The methods used were not identical, though, so comparison between the two assessments is not easy.

Summary of Success of Activities Identified from the 2003 Management Plan				
	Succeeded	Improved	No Change	Worse
Total No. Action Points (of 93)	26	47	20	0
% of total	28%	50%	22%	0%
% +ve change	78%			
% -ve change or no change			22%	

Programme Rating Table for 2003 Management Plan					
Programme	**Total no. Action Points**	**Succeeded**	**Improved**	**No Change**	**Worse**
Surveillance and Enforcement Programme	10	4	3	3	0
Research and Monitoring Programme	25	11	10	4	0
Interpretation and Education Programme	23	1	13	9	0
Recreation and Tourism Programme	12	0	8	4	0
Administration and Maintenance Programme	23	10	13	0	0
Total no. Objectives / Actions	93	26	47	20	0
% of total		28%	50%	22%	0%

APPENDIX 2

List of Plant Species – Middle Caye, Glover's Reef
(Meadows 1998; Walker, 2007)

Plant Species of Glover's Reef Atoll		
Family	**Species**	**Common name**
Marine Species		
Hydrocheritaceea	*Thassalia testudinum*	Turtle grass
Terrestrial Species		
Amaryllidaceae	*Hymenocallis littoralis*	Spider lily
Arecaceae	*Cocos nucifera*	Coconut **
	Thrinax radiata	Chit, Salt-water Palmetto
Asteraceae	*Ageratum littorale*	
	Borrichia arborescens	
	Sphagneticola trilobata	Creeping daisy
Boraginaceae	*Cordia sebestena*	Red-flowering zericote
	Tournefortia gnapheloides	
Burseraceae	*Bursera simaruba*	Gumbo limbo
Combretaceae	*Conocarpus erecta*	Buttonwood
	Laguncularia racemosa	White Mangrove
	Terminalia catappa	Almond
Convolvulaceae	*Ipomoea pes-caprae*	Beach morning glory
Cyperaceae	*Cyperus ligularis*	
Euphorbiaceae	*Chamaesyce blodgettii*	Chicken weed
	Chamaesyce mesembrianthemifolia	Chicken weed
Fabaceae		
Mimosoideae	*Pithecellobium keyense*	Xo-coy, red fowl
Papilionoideae	*Canavalia rosea*	Seaside bean
	Sophora tomentosa	
Graminae	*Andropogon glomeratus*	Brromstraw rush
Lauraceae	*Cassytha filifirmis*	Jaundice tie-tie
Moraceae	*Ficus citrifolia*	Fig
Nyctaginaceae	*Neea psychotrioides*	Salat
Passifloraceae	*Passiflora suberosa*	Passionflower

Plant Species of Glover's Reef Atoll		
Polygonaceae	*Coccoloba uvifera*	Sea-grape
Rhizophoraceae	*Rhizophora mangle*	Red Mangrove
Rubiaceae	*Erithalis fruticosa*	Black torch, botoncillo
	Ernodea littoralis	Wild cherry
Sapotaceae	*Pouteria campechiana*	Mamey cerilla, sapotilla
	Sideroxylon americanum	Mol-che
Solanaceae	*Solanum donianum*	Solanum
Surianaceae	*Suriana maritima*	Bay cedar
Verbenaceae	*Stachytarpheta jamaicensis*	Stachytarpheta
	Avicennia germinans	Black Mangrove

APPENDIX 3

List of Bird Species – Glover's Reef

Middle Caye, October 1998 (Meadows 1998)
North East Caye, April 2007 (Balderamos, 2007)

Bird Species of Glover's Reef Atoll

Species		Status	Habitats	Endemism
Red-footed Booby	*Sula sula*	vP	LF, OC	
Brown Pelican	*Pelecanus occidentalis*	cV	LF, BE, OC	
Magnificent Frigatebird	*Fregata magnificens*	vP	LF, BE, OC	
Double-crested Cormorant	*Phalacrocorax auritus*	cP	BE	
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	
Osprey	*Pandion haliaetus*	fP	LF, BE, OC	
Merlin	*Falco columbarius*	uT	LF, BE	
Peregrine Falcon	*Falco peregrinus*	fT	LF, BE, OC	
Sora	*Porzana carolina*	oT	LF	
Black-bellied Plover	*Pluvialis squatarola*	uW	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
f = fairly common
u = uncommon
o = occasional
l = local
X = one or two records only

P = permanent resident
S = seasonal resident
V = visitor
T = transient (migrant)
W = winter resident
F = former resident

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)

YE Yucatan Endemic

Table 22: Bird Species of Glover's Reef Atoll / 2

Species		Status	Habitats	Endemism
Laughing Gull	*Larus atricilla*	cW	OC	
Royal Tern	*Sterna maxima*	cV	OC	
White-crowned Pigeon	*Columba leucocephala*	fS	LF	
Yellow-billed Cuckoo	*Coccyzus americanus*	fT	LF	
Chimney Swift	*Chaetura pelagica*	uT	O	
Rufous-tailed Hummingbird	*Amazilia tzacatl*	cP	LF	
Ruby-throated Hummingbird	*Archilochus colubris*	uT	LF	
Belted Kingfisher	*Ceryle alcyon*	fW	BE	
Yellow-bellied Sapsucker	*Sphyrapicus varius*	oT	LF	
Eastern Wood-Pewee	*Contopus virens*	vT	LF	
Yellow-bellied Flycatcher	*Empidonax flaviventris*	cT	LF	
Great-crested Flycatcher	*Myiarchus crinitus*	cT	LF	
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	
Black-whiskered Vireo	*Vireo altiloquus*	x	LF	
Yucatan Vireo	*Vireo magister*	cP	LF	**YE**
Purple Martin	*Progne subis*	cT	O	
Bank Swallow	*Riparia riparia*	uT	O	
Tree Swallow	*Tachycineta bicolor*	cW	LF	
Barn Swallow	*Hirundo rustica*	cT	O	
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	
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	
Northern Parula	*Parula americana*	cW	LF	
Yellow Warbler	*Dendroica petechia*	cW	LF	
Chestnut-sided Warbler	*Dendroica pensylvanica*	cT	LF	

Status

Legend

v = very common
c = common
f = fairly common
u = uncommon
o = occasional
l = local
X = one or two records only

P = permanent resident
S = seasonal resident
V = visitor
T = transient (migrant)
W = winter resident
F = former resident

Regional Endemics

Legend

YE Yucatan Endemic

Habitat Preferences within HMCNP

Legend (Adapted from Jones and Vallely, 2001)

LF Littoral forest
BE Beaches
OC Ocean
O Overhead

Table 22: Bird Species of Glover's Reef Atoll / 4				
Species		**Status**	**Habitats**	**Endemism**
Magnolia Warbler	*Dendroica magnolia*	cT	LF	
Cape May Warbler	*Dendroica tigrina*	uT	LF	
Black-throated Blue Warbler	*Dendroica caerulescens*	uT	LF	
Black-throated Green Warbler	*Dendroica virens*	cW	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	
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	
Kentucky Warbler	*Oporornis formosus*	uT	LF	
Common Yellowthroat	*Geothlypis trichas*	cW	LF	
Hooded Warbler	*Wilsonia citrine*	cW	LF	
Yellow-breasted Chat	*Icteria virens*	cT	LF	
Summer Tanager	*Piranga rubra*	cW	LF	
Scarlet Tanager	*Piranga olivacea*	cT	LF	
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	cT	LF	
Blue Grosbeak	*Passerina caerulea*	cT	LF	
Indigo Bunting	*Passerina cyanea*	vT	LF	
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	

Status

Legend

v = very common
c = common
f = fairly common
u = uncommon
o = occasional
l = local
X = one or two records only

P = permanent resident
S = seasonal resident
V = visitor
T = transient (migrant)
W = winter resident
F = former resident

Habitat Preferences within HMCNP

Legend (Adapted from Jones and Vallely, 2001)

LF Littoral forest
BE Beaches
OC Ocean
O Overhead

Regional Endemics

Legend

YE Yucatan Endemic

APPENDIX 4

Fish Species of Glover's Reef
NB. This list is considered a first draft

Fish Species of Glover's Reef Marine Reserve			
Family	**Species**	**Common name**	**IUCN**
Acanthuridae	*Acanthurus bahianus*	Ocean surgeonfish	
	Acanthurus chirurgicus	Doctorfish	
	Acanthurus coeruleus	Blue tang	
Aulostomidae	*Aulostomus maculatus*	Trumpetfish	
Balistidae	*Aluterus scriptus*	Scrawled filefish	
	Balistes vetula	Queen triggerfish	VU
	Balistes capriscus		
	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 chrysargyreum		
	Haemulon flavolineatum	French grunt	
	Haemulon plumieri	White grunt	
	Haemulon sciurus	Bluestriped grunt	

Table 19: Fish Species of Glover's Reef Marine Reserve			
Family	**Species**	**Common name**	**IUCN**
Holocentridae	*Holocentrus adscensionis*	Squirrelfish	
	Holocentrus marianus	Longjaw squirrelfish	
	Holocentrus rufus	Longspine squirrelfish	
	Myripristis jacobus	Blackbar soldierfish	
Kyphosidae	*Kyphosus sectatrix*	Chub	
Labridae	*Bodianus rufus*	Spanish hogfish	
	Clepticus parrae	Creole wrasse	
	Halichoeres bivittatus	Slippery dick	
	Halichoeres garnoti	Yellowhead wrasse	
	Halichoeres maculipinna	Clown wrasse	
	Halichoeres pictus		
	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 dorsopun		
	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 aurofrenaturm		
	Scarus coelestinus	Midnight parrotfish	

Table 19: Fish Species of Glover's Reef Marine Reserve			
Family	**Species**	**Common name**	**IUCN**
Scaridae	*Scarus coeruleus*	Blue parrotfish	
	Scarus croicensis	Striped parrotfish	
	Scarus iserti		
	Scarus taeniopterus	Princess parrotfish	
	Scarus vetula	Queen parrotfish	
	Sparisoma atomarium	Greenblotch parrotfish	
	Sparisoma aurofrenatum	Redband parrotfish	
	Sparisoma chrysopterum	Redtail parrotfish	
	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	

APPENDIX 5

Common Coral Species of the Patch Reefs of Glover's Reef
(Wallace 1975)

Common Coral Species of the Patch Reefs of Glover's Reef (Wallace, 1975)	
Species	
Acropora cervicornis	Staghorn coral
Acropora palmata	Elkhorn coral
Acropora prolifera	
Agarcia crassa	
Agaricia purpuria	
Cladocora arbuscula	
Colpophyllia natans	Boulder brain coral
Dendrogyra cylindrus	Pillar coral
Dichocoenia stokesi	Elliptical star coral
Diploria clivosa	Knobby brain coral
Diploria labyrinthiformis	Grooved brain coral
Diploria strigosa	Symmetrical brain coral
Eusmilia fastigiata	Smooth flower coral
Favia fragum	Golf ball coral
Isophyllastrea rigida	Rough star coral
Madracis decactis	Ten-ray star coral
Manicini areolata	Rose coral
Manicini mayori	
Meandrina brasiliensis	
Meandrina meandrites	Maze coral
Millepora alcicornis	Branching fire coral
Millepora complanata	Blade fire coral
Monterasraea annularis	Lobed star coral
Montastraea cavernosa	Great star coral
Mussa angulosa	Spiny flower coral
Mycetophyllia lamarckiana	Ridged cactus coral
Porites astreoides	Mustard hil coral
Porites clavaria (?)	
Porites divaricata	Thin finger coral
Porites furcata	Branched finger coral
Porites porites	Club tip finger coral
Siderastrea radians	Lesser star coral
Siderastrea siderea	Massive star coral
Stephanocoenia michelinii	Blushing star coral
Total Number Species	**34**

APPENDIX 6

Habitat Types

(Mumby and Harborne 1999):

Mangrove: The areas around Middle Caye and Southwest Cayes that are occupied with *Rhizophora mangle* extending to the lagoon areas and not limited to the island's terrestrial areas. Black mangrove (*Avicennia germinans*) is also found on the western part of Northeast Caye.

Shallow lagoon floor - sparse seagrass: The lagoon floor where the angle of slope does not exceed 45° and depth <12 m. This benthic class is dominated by seagrass from the genera *Halodule*, *Halophila* and *Syringodium* and low densities of the genus *Thalassia*. Standing crop (dry weight) is 1-10 g.m-2 and seagrass cover is < 30%. Corals are usually absent. Algae from the genera *Batophora*, *Laurencia*, *Halimeda*, *Penicillus*, *Avrainvillea*, *Udotea* and *Cymopolia* are likely to be present. The substratum is dominated by sand or mud.

Shallow lagoon floor - medium density seagrass: The lagoon floor where the angle of slope does not exceed 45º and depth <12 m. This benthic class is dominated by seagrass from the genera *Syringodium* and *Thalassia*. Standing crop biomass is 11-80 g.m-2 and cover is 30-70%. Some corals may be present, particularly *Manicina areolata*, *Siderastrea radians* and *Porites* spp. Some gorgonians from the genera *Pseudopterogorgia* and *Pterogorgia* may be present. Algae from the genera *Laurencia*, *Halimeda*, *Penicillus*, *Avrainvillea*, *Udotea* and *Cymopolia* are likely to be present. The substratum is dominated by sand - mud.

Shallow lagoon floor - dense seagrass: The lagoon floor where the angle of slope does not exceed 45º and depth <12 m. This benthic class is dominated by seagrass from the genera *Syringodium* and *Thalassia*. Standing crop biomass is > 80 g.m-2 in most areas but can exceed 300 g.m-2 near mangrove systems (e.g. at Turneffe Atoll). Seagrass cover is > 70%. Algae from the genera *Halimeda*, *Penicillus*, *Avrainvillea*, *Udotea* and *Cymopolia* are likely to be present. The substratum is dominated by sand or mud.

Sand & Sparse Algae: Sand is defined as coarse sediment (diameter˜1 mm). This benthic class is dominated by sand (over 90% cover). There is usually some sparse algae, particularly green algae (calcified or not calcified), and red or brown branching algae.

Diffuse Patch Reef: Coral formations in the lagoon which are surrounded by either seagrass, sand or algae. Although patch reefs are usually formed by hard corals, the term still applies to areas where coral has died and is now colonised by other organisms (e.g. macroalgal dominated patch reefs at Glovers Atoll). *Area of dispersed coral colonies where <30% of benthos is covered by coral colonies. The remainder of the substratum is usually sand, seagrass or macroalgae.*

Dense Patch Reef: Coral formations in the lagoon which are surrounded by either seagrass, sand or algae. Although patch reefs are usually formed by hard corals, the term still applies to areas where coral has died and is now colonised by other organisms (e.g. macroalgal dominated patch reefs at Glovers Atoll). *Area of aggregated coral colonies (living or dead) where colonies cover >70% of benthos. The remaining substratum within the patch (i.e. the substratum between groups of colonies) may include sand, seagrass or macroalgae. The patch is often surrounded by a halo of sand.*

Forereef - dense massive and encrusting corals: Forereef is any area of the reef with an incline of between 0 and 45 degrees. Forereef is found seaward of the reef crest along the length of the barrier reef and the fringing reef. *Massive and encrusting corals* consists of a diverse community of species. The commonest coral species include *Montastraea annularis*, *M. cavernosa*, *Siderastrea siderea*, *Dichocoenia stokesii*, *Agaracia agaricites*, *Porites* spp., *Diploria* spp., and *Millepora alcicornis*. Fleshy brown algae, red/brown branching algae and green calcified algae are abundant. Soft corals are also common, particularly *Pseudoplexura* spp and *Pseudopterogorgia* spp. The substratum is dominated by bedrock and sand. **Hard coral cover >5%.**

Forereef - sparse massive and encrusting corals: Forereef is any area of the reef with an incline of between 0 and 45 degrees. Forereef is found seaward of the reef crest along the length of the barrier reef and the fringing reef. *Massive and encrusting corals* consist of a diverse community of species. The commonest coral species include *Montastraea annularis*, *M. cavernosa*, *Siderastrea siderea*, *Dichocoenia stokesii*, *Agaracia agaricites*, *Porites* spp., *Diploria* spp., and *Millepora alcicornis*. Fleshy brown algae, red/brown branching algae and green calcified algae are abundant. Soft corals are also common, particularly *Pseudoplexura* spp and *Pseudopterogorgia* spp. The substratum is dominated by bedrock and sand. **Hard coral cover 1-5%**.

Low relief spur and groove: Spurs are usually formed by accreting hard corals and calcified green algae whereas the grooves usually contain sand or bare bedrock. Low relief spur and groove: height of spurs < 5 m. Most commonly located immediately seaward of the reef crest at an orientation of 90˚ (i.e. at right angles to the reef crest). Wave energy can be high. For a more detailed description see Aronson and Precht (1995).

Deep reef /wall/escarpment: Escarpment is defined as any area of the benthos whose angle of slope exceeds 45°. While it is often associated with the drop-off wall of the barrier reef and atolls, its use is not confined to such areas (e.g. it applies to the sides of rhomboid reefs in the lagoon). Escarpment is found throughout the length of the barrier reef, around the atolls, and around rhomboid reefs. Steep escarpments are also found throughout the lagoon. Escarpments are difficult to represent on maps because their principal orientation is in the vertical plane (rather than the horizontal plane mapped using remote sensing).

Reef Crest: Reef crest is the shallowest and often emergent part of the reef and separates the forereef from the backreef and lagoon. Breaks in the reef where the crest is absent are known as “cuts”. The reef crest absorbs much wave energy and is an important coastal defence.

Reef Channels: The Reef Channels occur at three different locations, all on the windward side of the atoll, where the lagoon waters are connected to the open ocean. These channels are the North East Channel (about 1400 yards wide), the Southwest Channel (the largest at about 1 mile wide) and the Channel between Long Caye and Northeast Caye (the smallest entrance at about ¼ mile wide).

Rubble Beach: The Rubble beach area is the located mostly on the windward side of the islands where coral rubble forms dense beaches of rocks from dead broken corals. On some cayes these coral shingle ramparts or ridges are very high (5 ft.).

APPENDIX 7

Living Seascape Species - Habitat Use

Hawksbill Turtle (*Eretmochelys imbricata)*

No.	Habitat Name	Habitat Quality	Required? (yes/no)
1	Mangrove	Marginal	No
2	Shallow lagoon floor - sparse seagrass	Not used	No
3	Shallow lagoon floor - medium density seagrass	Excellent	Yes
4	Shallow lagoon floor - dense seagrass	Marginal	No
5	Sand & Sparse Algae	Not used	No
6	Diffuse Patch Reef	Not used	No
7	Dense Patch Reef	Excellent	Yes
8	Forereef - dense massive and encrusting corals	Excellent	Yes
9	Forereef - sparse massive and encrusting corals	Not used	No
10	Low relief spur and groove	Excellent	Yes
11	Deep reef/wall/escarpment	Excellent	Yes
12	Reef Crest	Not used	No
13	Reef Channels	Marginal	No
14	Rubble Beach	Not used	No
15	Sandy Beach	Excellent	Yes
16	Caye Littoral Forest	Not used	No
17	Brackish ponds	Not used	No
18	Palms	Not used	No

Nassau Grouper (*Epinephelus striatus)*

No.	Habitat Name	Habitat Quality	Required? (yes/no)
1	Mangrove	Marginal	No
2	Shallow lagoon floor - sparse seagrass	Good	Yes
3	Shallow lagoon floor - medium density seagrass	Good	Yes
4	Shallow lagoon floor - dense seagrass	Good	Yes
5	Sand & Sparse Algae	Marginal	No
6	Diffuse Patch Reef	Excellent	Yes
7	Dense Patch Reef	Excellent	Yes
8	Forereef - dense massive and encrusting corals	Excellent	Yes
9	Forereef - sparse massive and encrusting corals	Excellent	Yes
10	Low relief spur and groove	Excellent	Yes
11	Deep reef/wall/escarpment	Excellent	Yes
12	Reef Crest	Not used	No
13	Reef Channels	Excellent	Yes
14	Rubble Beach	Not used	No
15	Sandy Beach	Not used	No
16	Caye Littoral Forest	Not used	No
17	Brackish ponds	Not used	No
18	Palms	Not used	No

Osprey (*Pandion haliaetus*)

No.	Habitat Name	Habitat Quality	Required? (yes/no)
1	Mangrove	Marginal	N
2	Shallow lagoon floor - sparse seagrass	Good	Yes
3	Shallow lagoon floor - medium density seagrass	Good	Yes
4	Shallow lagoon floor - dense seagrass	Good	Yes
5	Sand & Sparse Algae	Good?	Yes
6	Diffuse Patch Reef	Marginal?	Yes
7	Dense Patch Reef	Marginal?	Yes
8	Forereef - dense massive and encrusting corals	Not used	No
9	Forereef - sparse massive and encrusting corals	Not used	No
10	Low relief spur and groove	Not used	No
11	Deep reef/wall/escarpment	Not used	No
12	Reef Crest	Not used	No
13	Reef Channels	Not used	No
14	Rubble Beach	Marginal	No
15	Sandy Beach	Not used	No
16	Caye Littoral Forest	Excellent	Yes[1]
17	Brackish ponds	Marginal	No
18	Palms	Excellent	Yes

[1] Nesting

Star Coral (*Montastrea spp.)*

No.	Habitat Name	Habitat Quality	Required? (yes/no)
1	Mangrove	Not used	No
2	Shallow lagoon floor - sparse seagrass	Not used	No
3	Shallow lagoon floor - medium density seagrass	Not used	No
4	Shallow lagoon floor - dense seagrass	Not used	No
5	Sand & Sparse Algae	Not used	No
6	Diffuse Patch Reef	Good	Yes
7	Dense Patch Reef	Excellent	Yes
8	Forereef - dense massive and encrusting corals	Excellent	Yes
9	Forereef - sparse massive and encrusting corals	Good	Yes
10	Low relief spur and groove	Excellent	Yes
11	Deep reef/wall/escarpment	Good	Yes
12	Reef Crest	Marginal	Yes
13	Reef Channels	Good	Yes
14	Rubble Beach	Not used	No
15	Sandy Beach	Not used	No
16	Caye Littoral Forest	Not used	No
17	Brackish ponds	Not used	No
18	Palms	Not used	No

Black-spined urchin (*Diadema antillarum*)

No.	Habitat Name	Habitat Quality	Required? (yes/no)
1	Mangrove		No
2	Shallow lagoon floor - sparse seagrass	Excellent	Yes
3	Shallow lagoon floor - medium density seagrass	Excellent	Yes
4	Shallow lagoon floor - dense seagrass	Moderate	Yes
5	Sand & Sparse Algae		No
6	Diffuse Patch Reef	Moderate	Yes
7	Dense Patch Reef	Marginal	Yes
8	Forereef - dense massive and encrusting corals	Excellent[1]	Yes
9	Forereef - sparse massive and encrusting corals		No
10	Low relief spur and groove		No
11	Deep reef/wall/escarpment	Marginal	Yes
12	Reef Crest		No
13	Reef Channels		No
14	Rubble Beach		No
15	Sandy Beach		No
16	Caye Littoral Forest		No
17	Brackish ponds		No
18	Palms		No

[1] On eastern side only

Conch (*Strombus gigas*)

No.	Habitat Name	Habitat Quality	Required? (yes/no)
1	Mangrove	Good	Yes
2	Shallow lagoon floor - sparse seagrass	Excellent	Yes
3	Shallow lagoon floor - medium density seagrass	Excellent	Yes
4	Shallow lagoon floor - dense seagrass	Excellent	Yes
5	Sand & Sparse Algae	Marginal	Yes
6	Diffuse Patch Reef	Good	Yes
7	Dense Patch Reef	Marginal/Good	Yes
8	Forereef - dense massive and encrusting corals	Excellent[1]	Yes
9	Forereef - sparse massive and encrusting corals	Excellent	Yes
10	Low relief spur and groove	Excellent	Yes
11	Deep reef/wall/escarpment		
12	Reef Crest	?	?
13	Reef Channels	Excellent	Yes
14	Rubble Beach	Excellent	Yes
15	Sandy Beach	Excellent	Yes
16	Caye Littoral Forest	Excellent	Yes
17	Brackish ponds	Excellent	Yes
18	Palms	Excellent	Yes

[1] Spawning

Caribbean Reef Shark (*Carcharhinus perezi (springeri)*)

No.	Habitat Name	Habitat Quality	Required? (yes/no)
1	Mangrove	?	?
2	Shallow lagoon floor - sparse seagrass	Marginal	?
3	Shallow lagoon floor - medium density seagrass	Marginal	?
4	Shallow lagoon floor - dense seagrass	Marginal	?
5	Sand & Sparse Algae		
6	Diffuse Patch Reef	Good	Yes
7	Dense Patch Reef	Good	Yes
8	Forereef - dense massive and encrusting corals	Excellent	Yes
9	Forereef - sparse massive and encrusting corals	Excellent	Yes
10	Low relief spur and groove	Excellent	Yes
11	Deep reef/wall/escarpment	Excellent	Yes
12	Reef Crest	Good	Yes
13	Reef Channels	Excellent	Yes
14	Rubble Beach	Not used	No
15	Sandy Beach	Not used	No
16	Caye Littoral Forest	Not used	No
17	Brackish ponds	Not used	No
18	Palms	Not used	No

APPENDIX 8

Terms of Reference for Reserve Staff

RESERVE RANGER

Duties and Responsibilities:

The Ranger will be responsible to and supervised by the Marine Reserve Manager. The Ranger will be expected to conduct him/herself in a polite and courteous manner when dealing with the public. The Ranger's foremost responsibility is one of Reserve surveillance and education of the public in Reserve regulations. Direct enforcement by exercise of authority should only be used where other methods have failed and only with the approval of the Reserve Manager.

The main duties are:

1. Liaison with users and visitors to marine reserve;

2. Surveillance and enforcement of Marine Reserve regulations;

3. Maintenance of Reserve facilities and equipment;

4. Assistance in research projects;

5. Routine Marine Reserve habitat and species assessment and monitoring;

6. Assistance with development of interpretive and educational material;

7. Assistance with day-to-day running of the research facility where required.

RESERVE BIOLOGIST

Duties and Responsibilities:

The Reserve Biologist will work under the supervision of the Reserve Manager.

Specific duties will include:

1. Collect ecological and socioeconomic data and data analysis;

2. Assist with the preparation *of* management plans, work plans and budgets;

3. Implement environmental monitoring programme;

4. Assist with the preparation *of* annual reserve reports;

5. Liaise with fishermen, tourism industry personnel, village councils and proper;

6.Assist with development of public awareness programmes for relevant community groups;

7. Assist with development and running of reserve facilities;

8. Develop individual annual work plan and submit quarterly progress reports.

RESERVE MANAGER

Duties and Responsibilities:

The Reserve Manager will work under the supervision of the Marine Protected Areas Coordinator who is the representative for the Fisheries Administrator (Fisheries Department, Ministry of Agriculture, Fisheries and Cooperatives),

Specific duties will include: ~

1. Supervision of reserve biologists, reserve rangers and allocation of duties including preparation and implementation of six-monthly work plans for all Reserve staff,

2. Implementation and supervision of field operations including environmental monitoring, basic research, enforcement of protected areas legislation and maintenance of equipment;

3. Implementation and regular review of the management plan for the respective n protected area;

4. Design and participation in educational programmes, preparation of educational material and organization of Visitor's Center;

5. Collection of license fees, handling of all monies and management of accounts of Reserve, and preparation of six-monthly budgets as part of the work plans;

6. Procurement of necessary equipment along with supervision of the construction maintenance of Reserve facilities;

7. Liaison with other government departments, the relevant Marine Protected Areas Advisory Committee, Non-Governmental Organizations and the general public.

APPENDIX 9

Composition and Procedural Matters for Glover's Reef Marine Reserve Advisory Committees

Composition

A Committee should consist of one or more representative(s) of the following organizations or interest groups:

1) Local Town or Village Council/Planning Committees
2) Relevant fishermen's co-operatives
3) BTIA Chapter/Tourist Guide Association/local tourism operators
4) CZMAI
5) Fisheries Department.
6) Forest Department.
7) Protected Area Manager
8) Funding Agencies
9) Relevant NGOs
10) Academic/Educational institutions involved
11) Other enforcement agencies as necessary

(NB. The composition of the committee has been amended, 2007)

Procedural Matters

The Committee should consist of about 10-12 members. Members should be free to send an alternative representative to meetings in their place but should provide authorization in any voting matters. A Chairperson and Secretary (perhaps the manager of the protected area) should be chosen. The name of the Committee, length of term of office for members, details of re-election, size of quorum, frequency of meetings and other procedural matters should be determined by the Committee, in consultation with the responsible management authority.

APPENDIX 10

Legislation