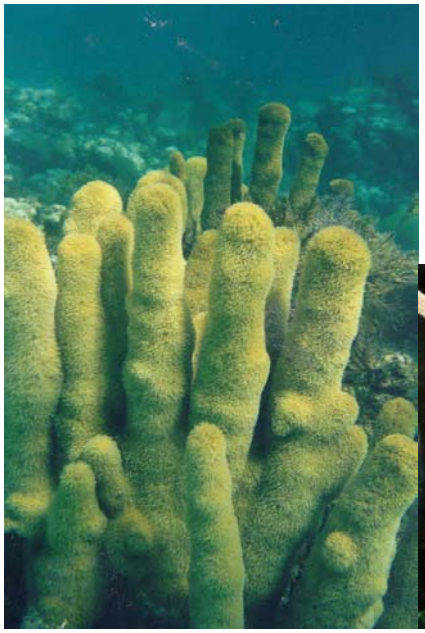


Caye Caulker Forest and Marine Reserve-

Integrated Management Plan 2004-2009

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Prepared For Belize Coastal Zone Management Institute/Authority and
Belize Fisheries Department
By Ellen M McRae, Consultant, CZMA/I

Cover photos © Ellen McRae 2004. Top: L- Pillar Coral (*Dendrogyra cylindricus);* R-Great Egret (*Ardea albus)*
Bottom: L-Beach Morning Glory (*Ipomoea pes-caprae);* R-Baitfishing with castnet

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    - Caye Caulker Watertaxi Association;
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List of Acronyms

AGM……Annual General Meeting
BAS……Belize Audubon Society
BBR……Belize Barrier Reef
BCD……Buoyancy Compensating Device
BCES……Belize Centre For Environmental Studies
BCMR……Bacalar Chico Marine Reserve
BFD……Belize Fisheries Department
BTB……Belize Tourist Board
C……Celsius (degrees)
$CACO_3$ ……Calcium carbonate
CC……Caye Caulker
CCC……Coral Caye Conservation
CCBTIA……Belize Tourism Industry Association, CC branch
CCCAC……Caye Caulker Coastal Advisory Committee
CCFR/MR……Caye Caulker Forest/Marine Reserves
CCTGA……Caye Caulker Tourguide Association
CCVC……Caye Caulker Village Council
CCWTA……Caye Caulker Watertaxi Association
CITES……Convention on Trade of Endangered Species
dbh……Diameter at breast height
DO……Dissolved oxygen
DOE……Department of Environment
CZMA/I……,..Coastal Zone Management Authority/Institute
CZMP……Coastal Zone Management Project
EIA……Environmental Impact Assessment
ENCORE……(Australian coral reef nutrient loading project)
EPA……Environmental Protection Act
EU……European Union
F……Fahrenheit (degrees)
FAMRACC……..……..Forest And Marine Reserve Association of CC
FD……Forest Department (Belize)
FKNMS……Florida Keys National Marine Sanctuary
GEF-SGP……..Global Environment Facility-Small Grants Programme
GIS……Geographic Information System
gpd…..……Gallons per day
GPS……Global positioning system
HCMR……..Hol Chan Marine Reserve
ICM……Integrated Coastal Management
IMP……Integrated Management Plan
in……Inches
ITCF……..International Tropical Conservation Foundation
IUCN…… ……International Union for Conservation of Nature
km……Kilometers
LAC……Limits of Acceptable Change

m……Meters
MBRS……Mesoamerican Barrier Reef System (project)
mg/L……..Milligrams per liter
MOU……Memorandum of Understanding
MPA……Marine protected area
ms……Manuscript
NEAC……National Environmental Appraisal Committee
NFC……Northern Fishermen's Cooperative
NGO……Non-Government Organization
NJS……..Nippon Jogesuido Sekkei
NMS……National Meteorological Service
NPASPO……National Protected Areas System Policy
NTU…….....(Unit of measurement of turbidity)
PA(s)……Protected areas
PACT……Protected Areas Conservation Trust
PCV……..(US) Peace Corps Volunteer
REA……..Rapid environmental assessment
SbF……Siwa-ban Foundation
SC……Specific conductivity
SCUBA……Self-contained underwater breathing apparatus
SI……Statutory instrument
SIT……School for International Training
SPTGA……..San Pedro Tourguide Association
TIDE……Toledo Institute of Development & Environment
TNC……The Nature Conservancy
UW……Under water
VHF……Very high frequency
WCS……..Wildlife Conservation Society
WRISCS……Watershed-Reef Interconnectivity Study

FIVE-YEAR INTEGRATED MANAGEMENT PLAN FOR CAYE CAULKER MARINE AND FOREST RESERVES 2004-2008

1. INTRODUCTION

Coral reefs, along with their support habitats—seagrass, mangroves and caye littoral forests—are fragile, immensely productive systems supporting great biodiversity, comparable in many ways to tropical broadleaf forests. The community of Caye Caulker is dependent upon this system for protection, food, and income. The accelerating pace of development on the island in 1990 raised questions of system longevity and well-being; hence efforts toward protected area enactment by the community. Today, high-density development is encroaching even within swampy areas deemed "least suitable" for development (Caye Caulker Development Guidelines, CZMA/I, 2002), imminently resulting in increased chronic pollution inputs into the environment. Additional system damage has been wrought by the flurry of hurricanes and strong tropical storms1998-2001. Though many areas are recovering nicely, strong management is essential to keep on track.

A skeletal Integrated Management Plan was completed under the Fisheries Department in 1996 for the then proposed protected areas. An updated version was initiated in 2002 by a Peace Corps Volunteer (PCV); completion and, where necessary, updating and revision of this document appears in the following document.

1.1 BACKGROUND INFORMATION

The following sections refer to habitat attributes, the protected areas movement on Caye Caulker and current status, along with a review of the legal framework supporting protected area enactment and operation.

1.1.1 Habitat Suitability—Rationale for Area's Selection

The focus of the **terrestrial portion** is to afford protection to:

- Littoral forest habitat: this is one of the most threatened ecosystems in the country, as well as keystone habitat to a diverse group of permanent and seasonal resident migrant birds, and critical "refueling station" to many more transient migrant bird species (Gibson, 2003; McField et al, 1996; McRae, 1992; McRae, unpub data);
- Critical fringing mangrove habitat, nursery to juveniles of many essential reef species and those of commercial importance. It also provides food, shelter and filtration of water passing through, whether hurricane overwash or heavy rain (Zisman, 1992);
- 170+ species of birds living all or part of their lives on Caye Caulker in mangrove, littoral forest, thicket, strand and near shore seagrass habitat (McRae, unpub. data);

- Threatened species and subspecies, and those of conservation concern, such as the Black Catbird (*Melanoptila glabirostris*); White-crowned Pigeon and others as indicated in literature (Morgenthaler, 2003; IUCN Red Data List, 2002; Jones & Vallely, 2001; Jones et al, 2000; McField et al, 1996).
- Nesting, feeding and resting habitat for CITES I endangered American Crocodile (*Crocodilus acutus);*
- Lagoons and patches of Saltmarsh habitat.

A feasibility study for the **marine portion** described the Caye Caulker barrier reef segment, located within the northern reef province, as an area that contains roughly 40km^2 of high-risk shallow reef and associated habitat (CCC, 1993). With the exception of Ambergris Caye, the reef in this area is a line of ribbon reef; hence this part of the barrier platform is distinguished by a line of mangrove cayes set well inside the continental shelf (CCC, 1993). Receiving protection within this area are:

- 11.1 linear km of barrier reef including three major and a multitude of minor channels. This reef is in a mixed state of recovery from recent hurricanes, and features regenerating populations of two major species of *Acropora* corals, nearly lost due to disease in the region (Aronson & Precht, 2001; REA, 2003), in addition to many other species;
- A number of moderate-sized to large patch reefs behind the barrier (Burkett, 2003, 2002; REA, 2003);
- Moderate biodiversity of associated organisms, many of which are essential attractions for tourism and fisheries (See the species list-Appendix 1);
- Thousands of acres of lagoon habitat, including bare sand, algae and seagrass bottom, immensely productive nursery and feeding ground for a multitude of important species;
- Critical habitat for resident and migrant endangered and threatened species such as West-Indian Manatee (*Trichechus manatus);* Nassau (*Epinephalus striatus)* and Goliath Groupers (*E. itijarra),* sea turtles and others.

Many of those who have utilized the area for a number of years continue to express concern over the general decline in fish activity and coral species. Protected areas constitute a principal methodology of conservation used in Belize to maintain and preserve these environments and resources. The Caye Caulker Forest and Marine Reserves (CCFR/MR), a set of integrated protected areas within the Belize Barrier Reef system, supports a variety of marine and terrestrial habitats and species as noted above. Many of the unique features of CCFR/MR support commercial species as well as attractions for tourists. CCFR/MR therefore protects not only this precious part of the remaining natural habitat of the Northern Shelf Lagoon, but also the livelihoods and industries as well as the very life (during high hurricane surf and surge) on Caye Caulker.

1.1.2 History of Caye Caulker's Protected Areas

Through community-based environmental education presentations by the Siwa-ban Foundation (SbF), Hol Chan Marine Reserve (HCMR), Coastal Zone Management Authority and Institute (CZMA/I), Fisheries Department, Forestry Department, Ministry of Tourism, Belize Audubon Society (BAS), Belize Center for Environmental Studies (BCES), and the Wildlife Conservation Society (WCS), the incentive to create a protected area became clear to the residents of Caye Caulker.

The earliest efforts for both a National Park and Marine Reserve to protect marine and island wildlife and habitats at risk at Caye Caulker began in 1990 with the SbF (McRae,1992). The Siwa-ban Foundation proposed the "Siwa-ban Nature Reserve" in 1990 to incorporate the southern tip of the Caye along with a section of barrier reef encompassing both South Caye Caulker and Caye Chapel channels. Community education efforts commenced with a 3-part series entitled "The Sanctuary in the Community", which demonstrated the benefits to communities from having protected areas in close proximity.

Approximately 108 acres of littoral forest was to be protected along with several miles of adjacent lagoon and reef habitat in a design similar to HCMR. Unfortunately the proposed land to be included was privately owned, thereby requiring a considerable sum for purchase. A series of trips abroad over a three-year period (1990-1992), did not yield these required funds; thus the terrestrial portion of the proposed protected area could not be acquired to form a multi-habitat reserve.

Subsequently (1993) SbF secured a GEF-SGP grant to install reef moorings in combination with an educational programme directed primarily at tourguides held at Caye Caulker in September 1993; this programme continued with extensions until early 1999, primarily with reef mooring maintenance and an additional, smaller educational programme in Sarteneja (July 1994), directed at fishermen with a potential interest in becoming guides (McRae, 1999). It must be noted that this project was designed to turn over reef moorings to an active protected area as of 1995.

The community, including SbF, then (1993) lobbied the former Minister of Tourism and Environment, who later requested the Fisheries Department and Coastal Zone Management Authority and Institute to check into the possibility of establishing a protected area around Caye Caulker. A new area was delineated, targeting the north point of the caye as the core terrestrial section. The reef areas were originally designed using the northernmost and southernmost reef moorings, installed in 1993.

Actions toward designating a multihabitat protected area intensified in the period 1994 to 1996, with the following activities:

- Production of the first integrated Management Document (Belize Fisheries Department (BFD));
- Strengthening and revitalization of the Caye Caulker Tourguide Association (CCTGA);
- Fleshing out of requirements for terrestrial and marine components of the proposed PAs with an eye to procuring funding (SbF with BFD IMP author)
- Establishment of a 1.4-acre mini-reserve demonstration site adjacent to the airstrip, managed by Caye Caulker Belize Tourism Industry Association (CCBTIA) together with Ministry of Energy, Communication, and Technology.

1997 was a busy year for the PA effort. Spring 1997 saw an arrangement made between Conservation Officer of Forest Department, the Caye Caulker Village Council and land donor Mr Harry Dole that arrived at a design for the terrestrial portion of the protected area. Following communication with the Forest Department, it was learnt that the Department was leaning toward enactment as a comparatively weak Forest Reserve rather than the stronger designation of National Park. SbF constructed and circulated a petition during a Tour Guide training session. Following virtually unanimous signing by guides, the petition was subsequently carried throughout the community by CCBTIA. During this time also, SbF produced a document promoting the establishment of the terrestrial section as at least a National Park or a similar category under the Protected Areas Act (1981), based upon recommendations listed in Government-generated publications as those by McField et al, 1996; Miller et al, 1994; and Zisman, 1992. SbF, CCTGA, CCBTIA and others continuously advocated for attention and action to adequately protect the marine and forest environment of Caye Caulker. In Fall 1997 SbF proposed the formation of a sanctuary advisory group based on a Forestry Department model for co-management, including a combination of stakeholders.

Finally, in April of 1998, the two Caye Caulker reserves were declared.
The Caye Caulker Forest and Marine Reserves were officially recognized by the Government of Belize through two Statutory Instruments (S.I.s), described in Section 1.1.4.

1.1.3 Current Status

The current status of Caye Caulker's Marine and Forest Reserves is as legally enacted protected areas. Refer to Appendix 2 for a copy of the Statutory Instruments of 1998, respectively from Ministry of Fisheries and Agriculture and the Ministry of Natural Resources.

1.1.4 Legislative Authority

The Fisheries (Amendment) Act of 1983, Section 7A provides for the establishment of marine reserves. It describes the reasons for declaring such reserves, and includes some general governing rules. The Fisheries

(Amendment) Act of 1988 empowers the Minister to make regulations for the management of marine reserves, such as zoning rules.

The Forest Protection Act of 1922 Allows for the establishment and operation of Forest Reserves. This category of protected area is primarily designed to permit controlled extraction, a some what inappropriate category for the small area at the north of Caye Caulker. Zisman (1992) recommended the status of Wildlife Sanctuary to provide adequate conservation for the area.

The Caye Caulker Marine Reserve was declared under Statutory Instrument (S.I.) No. 35 of 1998, first gazetted on the 25th of April 1998. The Forest Reserve was gazetted on the 4th of April 1998, in Statutory Instruments No. 28 of 1998. Perimeter GPS points appear in the SI.

The Fisheries Regulation 1977, and its various Amendments, also apply within the boundaries of the Zones where fishing is permitted. Section 8(2) states that "no person shall with intent to take fish, use any trap or other device constructed of net or wire in any area within a distance of one hundred yards of the Barrier Reef". Subsection 9A-1(a) provides for special protection to the aquatic flora and fauna, their natural breeding grounds, and habitats. Subsection 9A (a) further states that "no person shall, in a marine reserve, engage in fishing without a license issued by the Fisheries Administrator". Section 26 of this regulation also prohibits anyone from setting nets across channels to restrict the free passage of boats or to wholly prevent the passage of fish.

Zone boundaries will be gazetted along with rules and regulations rapidly following submission of this management document.

The Tourguide SI of 1994 addresses qualifications and conduct of Tourguides while on the job. It supports the Fisheries Act and goes a step further, prohibiting harassment of wildlife and damage to reef corals or other habitat—terrestrial or marine— by guides or tourists while on the job.

The Marine Reserve covers only the marine area, while the Forest Reserve encompasses land ecosystems. Other relevant legislation can be invoked to ensure the protection and sustainable use of the Cayes, such as the:

- Wildlife Protection Act, 1981: Prohibits hunting of all but 6 bird species, only one of which has ever been recorded at Caye Caulker; prohibits hunting or molestation of crocodiles (*Crocodilus acutus)*, marine mammals such as West-Indian Manatee (*Trichechus manatus)* and Bottlenose Dolphin (*Tursiops truncatus)* and other organisms found at CCFR/MR*;*
- Forest (Protection of Mangroves) Regulations 1989: Requirement of permit to cut mangroves; very important in reduction/prohibition of sediment pollution in unprotected portions of the island;

- superseded by this IMP within CCFR boundaries, where cutting/removal of mangroves is prohibited.
- Environmental Protection Act 1992, and the Environmental Impact Assessment (EIA) Regulations 1995: calls for constraints in emissions, effluents and waste materials introduced into waters, affording some protection to marine systems from various forms of pollution. The EIA Regulations require review of all proposed development projects by the National Environmental Appraisal Committee (NEAC), having membership from relevant government departments. Further, projects deemed to be of high impact are required to undergo review by professionals at the developers' expense.

1.1.5 Context

Though a considerable effort was directed during the mid-1990s toward composing a National Protected Areas Systems Plan for Belize, this was never ratified by Government; thus technically no such policy and framework exists. However recently a project has commenced that promises to remedy this situation. The protected areas system represents a wealth of valuable resources, yet, in the face of calls for additional reserves, requires direction in how it should be integrated more effectively with the national economy (Meerman et al, 2004). Thus, this comprehensive System Policy and Plan will be comprised of the following steps:

- Policy formation;
- Protected area system assessment and gap analysis;
- Discernment of management procedures and sustainable use;
- Identification and delivery of economic benefits;
- Strengthening of management and monitoring

This activity falls within the framework of the National Biodiversity Action Plan (cf Jacobs & Castañeda, 1998).

1.2 GENERAL INFORMATION

The following sections include basic information regarding the plan, as well as information regarding the general situation of the land and sea comprising the protected areas. Existing maps, aerial or satellite images and archival video footage are noted.

1.2.1 Purpose and Scope of Plan

The purpose of this Management Plan is to define straightforward and sustainable strategies and subsequent actions intended to upgrade the functioning of the Marine and Forest Reserves to a thriving and sustainable level for a period of five years, with a clear intention of managing the Protected Areas of Caye Caulker in perpetuity. Clearly the Forest and Marine Reserves were conceived to function as a single unit comprising a representative section of coastal zone habitats of the Northern Shelf Lagoon.

A zonation plan has been delineated, with input from stakeholders from Caye Caulker and other locations. This permits a variety of uses while eliminating others that are known throughout Belize and other parts of the tropics to accentuate degradation of reefs and adjacent support habitats.

Programmes in education, research, tourism, fisheries and other related fields are described to provide a gateway into the following five-year period, and many to come, while a financial management plan sets up the ability to perform adequate management actions, including staff, infrastructure and required equipment for the two protected areas.

The scope includes not only thorough updated descriptions and maps of included habitats and known species, but summarizes research and points direction for the future in this area. It includes programmes to promote PA well-being, longevity and sustainable use in the areas of enterprise of local stakeholders as well as those from nearby communities such as fishing, tourism and education. It also contains an evaluation plan, designed to be used in periodic reviews that will aid in assessing the effectiveness of various management actions and programmes.

This Plan is envisioned as a guideline and basis for production of more detailed annual activity plans by PA staff and co-management or advisory bodies. Community individuals and user groups are to be encouraged to participate in the conservation and management decisions and activities where possible. However the background and framework of the Plan is built upon scientific principals and previous work; that is, the basis and underlying principals are designed to support continued survival and well-being of the ecosystems, restricting or curtailing activities known to be destructive to the systems upon which the community of Caye Caulker depends for its ultimate survival.

1.2.2 Location

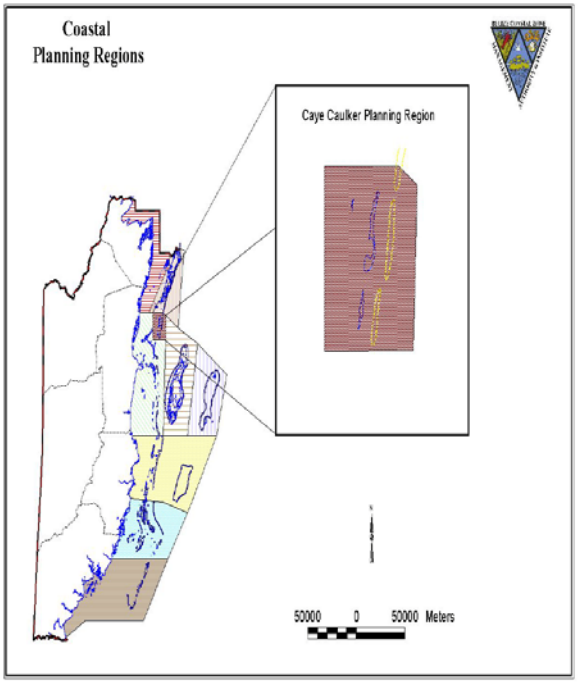
Caye Caulker Marine and Forest Reserves are located at and in the surrounding waters of the island of Caye Caulker, in the Northern Shelf Lagoon off the coast, 21 miles north-northeast (Refer to Map 1). The island lies roughly parallel to the Belize Barrier Reef (BBR). The windward shore is roughly one mile west of the reef crest. The Northern tip of Caye Caulker is roughly 5 miles south of the Southern tip of Ambergris Caye, while Caye Caulker's south point lies about 2 miles from Caye Chapel's Northernmost projection.

The Forest Reserve (CCFR) occupies much of the Northern tip of the island, having an area slightly over 100 acres. Appendix 2 also states the GPS points of the Forest Reserve, along with the SI that brought it into law.

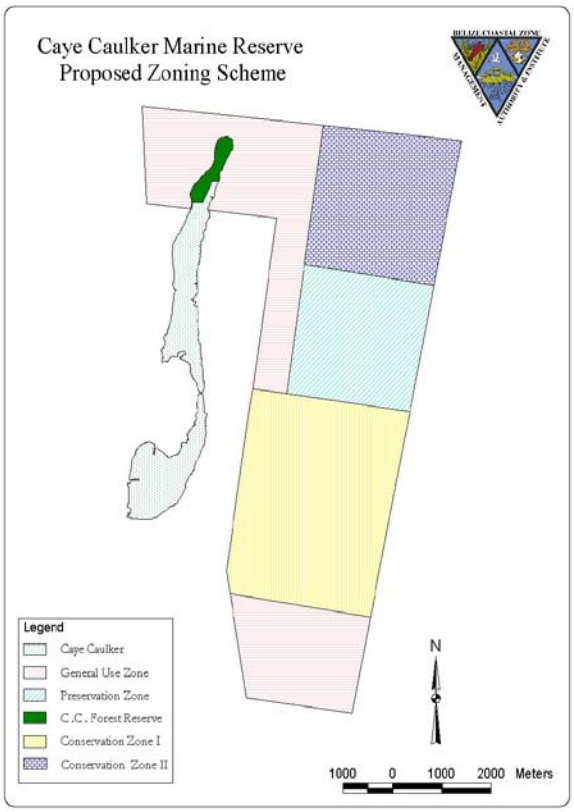
The Marine Reserve forms roughly the figure of a seven some 11.1 km in length, with the top portion crossing the caye's north point and extending into lagoon waters to the west (Refer to Map 2). Area of the marine reserve is 391133460

m^2, or 39,113.346 ha. GPS points of the reserve perimeter appear in Appendix 2 along with CCMR's SI.

Map 1. Location of Caye Caulker



Map. 2. Form of CCFR/MR



1.2.3 Access

Caye Caulker is accessible via both sea and air. Six water taxi departures per day move out from Belize City between 9 a.m. and 5:30 p.m. run by the Caye Caulker Water Taxi Association, while several daily departures arise from the Tourism Village Water Taxi Group. Other independent boats also stop at Caye Caulker along the way to San Pedro. A boat trip takes approximately 45 minutes.

Many flights have the potential to reach Caye Caulker daily, as hourly planes take off from Belize City Municipal and or Belize International Airport each day. A plane trip takes about 15 minutes.

1.2.4 Land Tenure and Seabed Use

The seabed belongs to the Government of Belize; therefore it cannot owned by any individual and is considered public domain. However, much of the lagoon bottom covered by seagrass is considered to be lobster trapping territories of various fishermen from Caye Caulker (King, 1996). Conflicts arise when one fisherman attempts to place traps in territory considered to be for another.

Most of the territories in close proximity to Caye Caulker have been in place for many years. A fisherman that wishes to retire will either give his traps and territory to a son or other close family member, or sell them to an aspiring fisherman or someone with a bordering territory looking to expand their grounds. Reef habitat is usually worked by traditional diving fishermen, either from Caye Caulker or the northern village of Sarteneja, however no territoriality is evidenced.

The land component making up CCFR was part of an inheritance of an American, Harry Dole, from his father. The total inheritance was 206 acres. Mr. Dole opted to donate slightly over 100 acres of littoral forest and mangroves for use as a protected area. This was worked out between Mr. Dole, the Caye Caulker Village Council, and the Conservation Division of the Forestry Department. Currently the land has been remanded to the Government of Belize for the purpose of conservation, and is under enactment as a Forest Reserve since 1998.

1.2.5 Graphic Representation

The following section describes graphic representation of Caye Caulker already in possession of Government or NGOs of Belize.

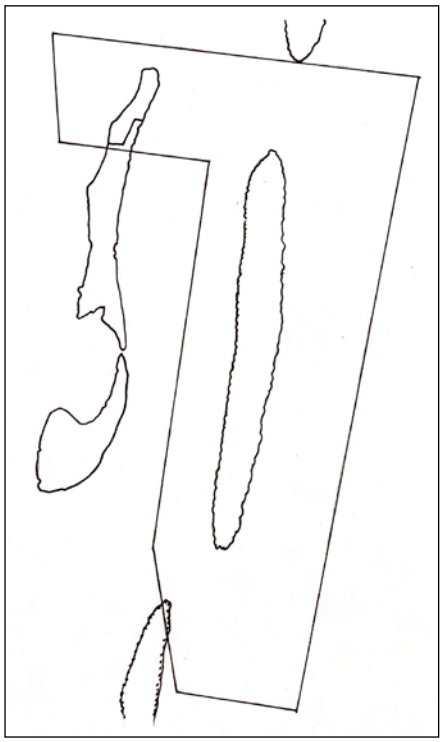
1.2.5.1 Mapping

Two grid maps of the CCPAs have been generated by Belize Coastal Zone Management Institute (Maps 3A, B). The original map for the area (3A) shows lines representing the reef that are an estimation of its position. This situation has been remedied in part by GPS readings collected during the REA. These were taken at various sites along the reef including channel entrances, particularly in southern portions of CCMR, defining the two southern channels and reef ribbons in that region. However some of this area still requires ground truthing, in particular northern barrier reef areas. On Map 3B, GPS points collected during transects and important benchmarks such as the locations of Caye Chapel and South Caye Caulker have been plotted.

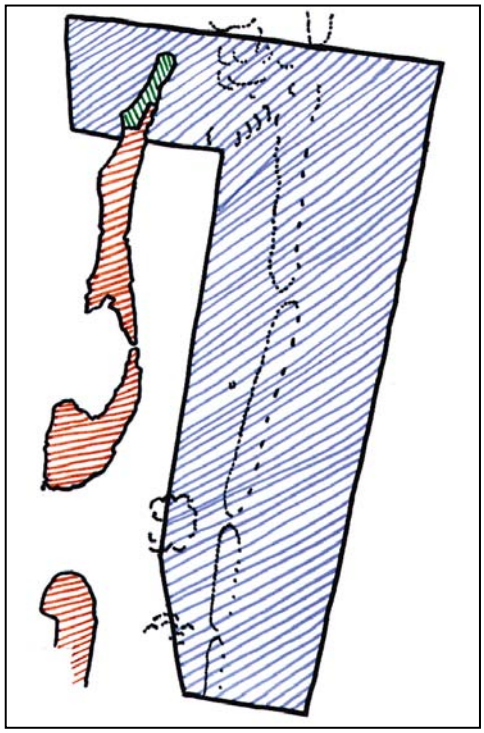
1.2.5.2 Aerial Photographic and Satellite Imagery

Nature Conservancy (TNC) photographs taken in 1995 were digitized to produce a geo-referenced base map of the area of Caye Caulker as well as a GIS vegetation map (CZMA/I, 2000). A total of 11 ground control points were established for this purpose. Sixteen 1:24,000 colour aerial photos were taken by TNC on 15 June 1994, covering the entire protected area. A LandSat TN image, taken in March/April 1993, is available at the Land Information Centre (LIC), showing some detail of terrestrial and marine habitats prior to the passage of the hurricanes of late 20th and early 21st centuries.

Map 3A. Copy of early map of CCFR/MR



Map 3B. Map showing position of reef from GPS points (REA).



1.2.5.3 Other Remote Imagery

The Siwa-ban Foundation possesses archival videography of portions of the protected areas shot from Project Lighthawk flights in March 2000 and 2002. The weather in the latter was suboptimal, as a strong *norther* was on; however, video evidence of sediment transport from both Caye Caulker and Caye Chapel to parts of the Barrier Reef was collected. A subsequent flight was taken in April 2004. These are available for frame-grabbing and subsequent geo-referencing.

2 PHYSICAL ENVIRONMENT

Research in the area of Caye Caulker has been minimal. The following assemblage of information has been collected over the years by a variety of researchers, student groups and Government personnel.

2.1 GEOLOGY, SUBSTRATE AND BATHYMETRY

The proposed geologic history for the BBR platform was summarized by Perkins (1983) and Chamberlain (1995) from research conducted in the 1970s by a number of marine geologists (cf Ginsberg, Wantland & Pusey, and others). At the end of the Cretaceous the Northern portion of the Yucatan Peninsula subsided and tilted to the north. More recent research suggests that this may

have been due at least in part to impact from a major meteor at the northern tip of the Peninsula.

Early reef growth commenced when five roughly parallel, north-northeast-trending fault escarpments were raised, also dating from the close of the Cretaceous, about 67 million years ago. Three of these support coral growth. The first—and least-developed—of these scarps forms the backbone of the BBR system from just south of Cozumel, Q. Roo, Mexico, to about the level of Gales Point, central Belize. Average ridge-top width is 1-5 km (Perkins, 1983). Caye Caulker lies along this first fault escarpment. The seaward ridge top lies in the vicinity of the reef crest, while the leeward edge is more or less under the line of cayes—including Caye Caulker—paralleling the BBR.

Recent seabed sediments are composed of carbonates generated by the reef and other marine sources, including coral and shell fragments, sponge and soft coral spicules and bits of coralline algae such as *Halimeda* (Hanson & von Twistern, 1996; Chamberlain, 1995; Perkins, 1983). Turbidity currents are considered to be the most common depositional form for sediments in the Caribbean; this mechanism is responsible for the flat topography of the Yucatan, Columbian and Southern Venezuelan Basins (Fairbridge et al, 1966-in Hanson & von Twistern, 1996). Average depth in the Northern Shelf Lagoon is 2-4 m (Perkins, 1983).

2.2 HYDROLOGY

Caye Caulker is surrounded by the Northern Shelf Lagoon of the BBR lagoon, an extension of the Caribbean Sea. Surrounding waters are for the most part well-circulated and moderately to modestly clear. High winds serve to raise sediments, especially in close proximity to the caye.

Caye Caulker is a mangrove/sand caye composed of limestone bedrock overlain by calcium carbonate ($CaCO_3$) sand (Stoddart et al, 1982). The island's water table is composed of seawater with a thin lens of freshwater floating on top, periodically replenished by rainfall (NJS, 2001; Table 1). Depth from surface varies from as much as two meters below surface in the highest part of the island during dry season, to standing waters 18-36 inches in depth overlying the lowest land for weeks at a time during rainy season. The water table is contiguous with the sea, and has been observed to raise and lower with the tides (NJS, 2001).

Table 1. Salinity at various water depths, showing depth of the freshwater lens at Caye Caulker (after NJS, 2001).

Water Depth (m)	Chloride concentration (mg/l)
Surface	1600
1m	6500
2m	31,700
3m	35,700

2.3 TIDES AND CURRENTS

Tidal action within the BBR Lagoon is classified as semidiurnal mixed tides, with generally four peaks in any given tidal day as follows: a high high, a high low, a low high and a low low tide (Hanson & von Twistern, 1996; National Meteorological Service, pers. com.). Generally tidal variation is 0.3-0.5 m, raising to 0.8 m during spring tides or associated with storm action. Higher tides result from extreme weather events and will be discussed in Section 2.5.2.

The prevailing water movement entering the Caribbean is the wind-driven Guiana Current, flowing from southeast to northwest; this becomes the Caribbean Current, flowing through the Lesser Antilles with the majority reaching the Yucatan Strait (Hanson & von Twistern, 1996). The current breaks at Rocky Point, northern Belize, to form a small gyre that drives the sea off Belize to flow from north to south (Perkins, 1983). While the prevailing current flow moves from north to south, powerful westerly winds during cold fronts or other storm events may generate temporary strong currents that may carry materials such as sediments as far as the BBR (SbF Archival Video). These currents vary seasonally and, though charted in general, have not been studied in detail (Hanson & von Twistern, 1996).

Tides also affect currents. Narrow cuts such as the Caye Caulker Split funnel can have currents sufficiently fast as to threaten all but those strong swimmers using fins. Channels in the reef will also reflect tidal currents depending upon their dimensions. Hol Chan Channel also shows strong current speeds during peak tides, while the larger channels off Caye Caulker exhibit slower speeds.

2.4 WATER QUALITY

The following sections deal with condition of waters at Caye Caulker itself as well as the surrounding sea. As can be seen, there is little distinction between the two, because the seawater underlying the freshwater lens on the island is contiguous with the surrounding seawater. Water quality data appears courtesy of the CZMA/I water quality programme, while much of the Caye Caulker land-based water data comes from the Nippon Jogesuido Sekkei (NJS) Potable/Wastewater study of 2000-2001.

2.4.1 Seawater

Four stations off Caye Caulker were sampled from 1997-2003 for water quality. Parameters routinely collected included temperature, salinity, dissolved oxygen, turbidity, pH, and specific conductivity (CZMA/I, in prep). Mean ranges are represented in Table 2.

Table 2. Mean range values of 4 water quality stations in the sea around Caye Caulker 1997-2003 (Source: CZMA/I). DO: Dissolved oxygen; SC: Specific conductivity.

Parameter	Mean range values	Extremes
DO	6.54-8.93 mg/l	3.54 (SW Caye Caulker)
Turbidity	2-10 NTU	0-77.1 (highly irregular)
SC	52.19-55.8 µs/cm	
pH	8.33-8.5	7.99-9.16
Temperature	(approximate) 25-30°C	~23-31

During May-December of 2001 data from Caye Caulker's stations was compared with that from two cayes located to the immediate south—Caye Chapel and Long Caye. Mean range calculated from four datasets revealed similar values for Caye Caulker and Caye Chapel in salinity, dissolved oxygen, pH and phosphates. Caye Chapel's highest mean temperature was over 1 degree higher than Caye Caulker's (29.72 vs. 28.62), while average turbidity at Caye Caulker was 9.7-26.4 NTU versus 5.3-10.8. Both cayes showed elevated nitrates, with Caye Caulker running higher (2.2 mg/l) than Caye Chapel (1.5 mg/l) (CZMA/I, 2003).

The data will be useful as a baseline and starting point for essential water quality monitoring within CCMR and its buffer zones.

2.4.2 Groundwater and Surface Waters on the Caye

The groundwater of Caye Caulker is highly saline within 2 m of the surface and subject to seasonal variation as noted previously (Table 1) (NJS, 2001). Additionally, groundwater within the village is largely polluted (Tables 3, 4). Tracing the direction of groundwater flow within the village has yet to be accomplished.

The water table is high—in some cases less than 1m from the surface, with standing water well over the land's surface in some areas—and the overlying sand porous, permitting free passage of water both vertically and horizontally (Miller & Miller, 1997). Recent water quality studies indicate at least organic pollution in Caye Caulker's groundwater (NJS, 2001; Sullivan, 2001) (Table 4). Public Health data supports this (NJS, 2001). Heavy rain has been found to exacerbate nutrient pollution, as may be noted in Table 4 (NJS, 2001). The literature cites instances of expulsion of nutrient- contaminated groundwater via lateral transport through in pulses during times of heavy rain, in at least one instance resulting in degradation of a nearby reef (Weiss & Goddard, 1977).

There are no natural free-flowing water sources on the island. Community water supply is strictly rainwater catchment, with only 18% use of available roofs (NJS, 2001). Where vegetation has been removed, sheet and gully erosion freely move unconsolidated surface soils into surrounding seawater. This may result in influx of sediment to nearshore waters, where currents have the potential to

move it considerable distances. It may even reach the reef (SbF archival videography). During times of high wind, loose bottom sediments raise up and become resuspended in the water column.

In 2000-2001, dredging was conducted in front of Caye Caulker to make an artificial beach. In some areas of the caye this was replacing land lost to erosion over many years. Only in the north is the beach used exclusively for recreation and tourism; further south in the village, it functions principally as a road. The erosion rate has approached 10 m in some locations. This is another potential source of sediment to reef areas.

Table 3. Nutrient levels before and after heavy rainfall (after NJS, 2001).

Sample	NO3 (mg/L)	NO3 (mg/L)	PO4 (mg/L)	PO4 (mg/L)
	Before rain	After rain	Before rain	After rain
Village Well	0.2	0.6	0.01	0.15
Village Dump	12.5	21.6	2.1	16.6

Table 4. Water quality in selected Caye Caulker locations. After NJS, 2001. Col=Coliform bacteria; S=Salinity; PO4=Phosphate; NO3=Nitrate.* Too numerous to count.

Well Location	Depth (m)	BOD (mg/L)	Total Col. (#/100ml)	Fecal Col. (#/100 ml)	pH (Av)	S	PO4	NO3
Hotel- S Windward	0.0	6	5	0	7.58	0.4	2.79	0.7
	0.8	-	-	-	7.33	2.8	-	-
Residence-Leeward	0.0	6	3	3	7.57	2.1	3.6	9.8
	0.6	-	-	-	7.39	5	-	-
Hotel – Leeward	0.0	6	*	3	7.73	2	3.6	0.5
	1.0	-	-	-	7.41	6.3	-	-
	2.0	-	-	-	7.33	32.3	-	-
Residence-Village center	-	18	-	-	-	-	4.93	0.1
Restaurant-C Windward	-	12	*	0	-	-	2.71	2.8
Airstrip	0.0	6	10	0	8.01	0.3	1	18

2.5 CLIMATE AND WEATHER

Caye Caulker is located in northern Belize. This places it within the subtropical climate regime. The following sections deal with climate and weather. All information in this section arises from the National Meteorological Service (NMS), except as indicated.

2.5.1 General Climate Regime

Temperature at Caye Caulker averages 28° C (82 F). Average temperatures range from ~21° C in Jan to 24.8° in June. Average maximum temperature range is ~ 27° C in Jan to 32° C in May.

Cold fronts normally begin in late October and finish by March, with heaviest concentration in November-early December. Dry season normally begins February to March and finishes in May or June. Tropical waves generally commence in May or June, with a peak likelihood of tropical weather formation in the two-month period ranging from 15 September-15 November.

2.5.2 Rainfall

As of Spring 2004 there is no weather station at Caye Caulker. Rainfall is roughly 2000 -2005 mm (75.4-78.9 in/year) (Data for Ambergris Caye-NMS). Months of heaviest rainfall barring hurricanes are November-December (Norther season) and June-July (Tropical weather season).

2.5.3 Extreme Weather Events

The most extreme weather events affecting Caye Caulker are hurricanes. Almost all historic hurricanes affecting Caye Caulker have formed within mid-September to mid-November. Table 5 lists all hurricanes affecting Belize during the past 50 years, with notation as to which have affected Caye Caulker most profoundly. Hurricane frequency is roughly one every 3.1 years, however they tend to come irregularly.

Surface effects include those from wind (broken branches, defoliation, fallen trees, blowing loose items) and those from storm surge, including beach erosion, undermining and collapse of structures, deposition of debris (NEMO, 2002). Effects to undersea communities include scouring, flaying by sand, as well as smashing and/or overturning coral colonies (CZMA/I, 2000). Figure 1 shows some effects of recent hurricanes, above and below the sea.

Tropical storms are lesser weather events, resulting in scouring, sanding and other minor effects. However they may dump considerable rain both inland and over marine habitat, resulting in flooding as well as runoff to marine areas laden with silt, nutrients, oil and chemical pollution. Refer to Sections 3.1 through 3.2 for a review of impacts to emergent and submerged systems.

Table 5. Hurricanes affecting Caye Caulker within the past 50 years.

Year	Storm	Maximum Wind Speed-Eyewall (kt)	Category	Effect on Caye Caulker
1955	Janet	165	5	Near overwash; minimal wind damage to vegetation
1960	Abby	65	1	Negligible
1961	Anna	70	1	Negligible
	Hattie	140	4	Complete overwash; structural damage to homes; downed trees.
1969	Francelia	85	2	Minimal damage
1974	Carmen	120	3	Minimal damage, some sea rise.
	Fifi	90	2	Some sealevel rise, TS-force wind.
1978	Greta	95	2	Minimal wind effect
1988	Gilbert	175	5	Minimal wind effect; some sea level rise
1998	Mitch	180	5	Minimal wind effect (TS level); full overwash event.
2000	Keith	135	4	Full strength wind effects; full overwash
2001	Iris	140	4	Strong TS winds; some sealevel rise.

Figure 1. Some Effects from Recent Hurricanes Affecting Caye Caulker; Photography © Ellen McRae

a **b**

a) Morning, and b) afternoon, 27 Oct 1998-Mitch approaches Caye Caulker as the Barrier Reef tames wild waves, mitigating impact.

c **d**

c) Beginning of Mitch overwash event, 28 October 1998; d) Effects of Keith overwash, 30 September 2000-gouging of channels by fast-moving water.

e **f**

e) Broken *Montastrea annularis* colony; f) Growing *Acropora palmata* fragment

3 BIOLOGICAL ENVIRONMENT

The following section describes the living systems included under the Caye Caulker Marine and Forest Reserves. A full species list appears in Appendix 1, with flora appearing in the first 4.5 pages.

3.1 EMERGENT SYSTEMS

The North Point appears to be composed of a series of alternating beach ridges with littoral forest and lower mangrove-dominated areas interdigitating (Forest Department Trip Report 12/95). The two habitat types alternate and lie adjacent to one another throughout the area; however they are handled separately in this treatment for purposes of noting specific impacts, concerns, and species. A generalized map was produced by CZMA/I (2002) for purpose of producing development guidelines for the island (Map 4).

The following section describes living elements of the Forest Reserve, including systems normally found above high-water line. These are littoral forest, thicket and strand vegetation as well as emergent mangrove systems.

3.1.1 Littoral Forest

Littoral forests are very limited systems in area, however represent critical habitat for many species of plants and animals (McField et al, 1996; McRae, 1992). Aside from habitat, littoral forests provide important erosion control and filtration functions during hurricane overwash events.

They normally appear in a narrow strip along high beach ridges on cayes and coasts, or in small clumps on patches of high ground (McField et al, 1996). However, Caye Caulker—particularly the southern portion—is unique in having sections of littoral forest and thicket of considerable breadth.

Strand vegetation is the first level of shoreline vegetation on higher beaches. These are very important in stabilizing shorelines from erosion by everyday wave action as well as that from dry season winds.

Successional stages of littoral vegetation are nominally separated as follows (Table 6).

Map 4. Generally accepted development guidelines for Caye Caulker within the CCCAC framework (Source: CZMA/I).

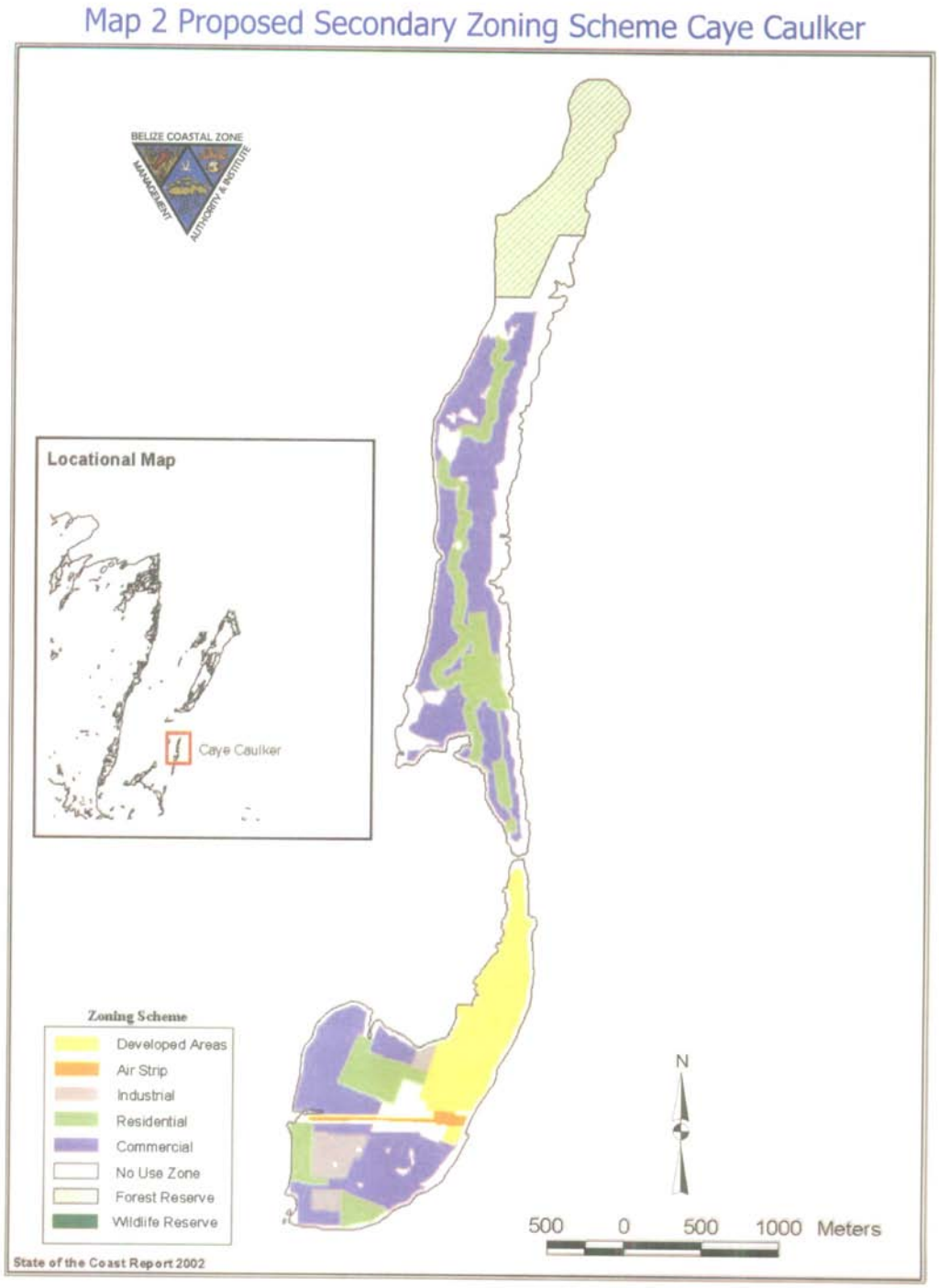


Table 6. Successional stages of littoral vegetation.

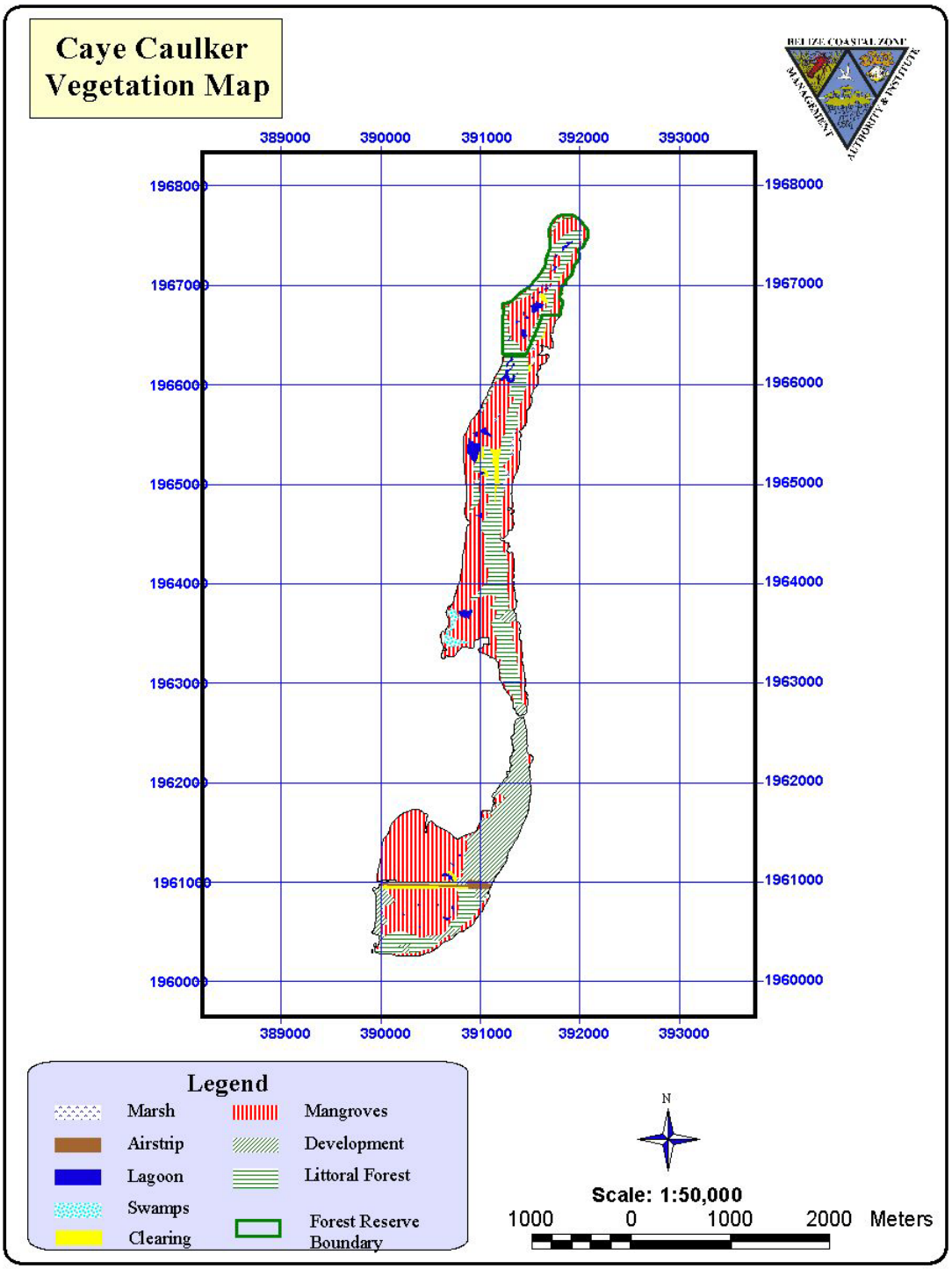
Habitat Type	Vegetation Height	Examples of Vegetation Types
Strand Vegetation	< 1m	Grasses; Herbs
Littoral Thicket	> 1-3m	Shrubs; Young trees
Littoral Forest	>3 m	High shrubs; Low trees

3.1.1.1 Flora

Little written information on the terrestrial flora of Caye Caulker exists. To date, no in-depth survey of vegetation has been done for Caye Caulker, however a few site visits in the past (eg, FD Trip Report 12/95), a habitat survey for the Black Catbird (*Melanoptila glabirostris*) (Miller & Miller, 1993) in addition to the Rapid Environmental Assessment (Appendix 3) associated with this project has produced some information. Morgenthaler (2003) made a brief visit to Caye Caulker during the distribution phase of her Black Catbird research. Map 5 illustrates the most up-to-date habitat distribution for CCFR, while Appendix 1, pages 1-5 lists the known plants of Caye Caulker Forest and Marine Reserves, including plants occurring at other parts of Caye Caulker and other nearby habitat that may yet be discovered within PA boundaries.

Dominant in the CCFR is the Coconut Palm (*Cocos nucifera*), an introduced species thought to have originated in the Indo-Pacific (Kricher, 1999). This species was planted for commercial production at least 75 years ago. Since abandonment of the cocales during the 1950s, the species has proliferated to dominate high land on Caye Caulker's north point (FD Trip Report 12/95). The average height of Coconut Trees is greater than littoral forest vegetation as a whole, thus native vegetation has in many areas been outcompeted for access to sunlight by the tall, high-density palms (FD Trip Report 12/95).

Map 5. Most recent vegetation map of Caye Caulker (Source: CZMA/I, 2001).



In dense diverse littoral forest such as that in southern Caye Caulker, a seasonal succession of fruits and berries are available to birds and other frugivorous

organisms (McField et al, 1996). Mist net surveys were undertaken by Miller & Miller (1993, 1991), comparing avian abundance and biodiversity within PA areas and the forests of southern Caye Caulker. However the dominance by Coconut Palms (*Cocos nucifera)* in CCFR has apparently reduced the availability of food to these species (Miller & Miller, 1993). Larger numbers of frugivorous bird species were noted on the southern island than the north point, presumably due to reduced floral diversity resulting from Coconut overgrowth. Meerman (1993) noted poor floral diversity in comparison with coastal habitat. Refer to Table 7 for a review of important fruit-bearing plants of Caye Caulker.

Table 7. Essential fruit-bearing plants of littoral forest and thicket habitat. Key to Habitat: F=Littoral forest; T=Littoral thicket (sources: Scurlock, 1996; Miller & Miller, 1993, 1990; Fosberg et al, 1982; McRae, unpub. data)

Common Name	Species	Habitat
Xocoi, Black Torch	*Pithecellobium keyense*	F, T
Island Cherries	*Erythalis fruticosa*	T
Beach Creeper	*Ernodia littoralis*	T
Chechem, Black Poisonwood	*Metopium brownii*	F
Cocoplum, Hicaco	*Chrysobalanus icaco*	T
Mul Che	*(?)Bourreria ovata*	F
Seagrape	*Coccoloba uvifera*	F
Island Ziricote	*Cordia sebastena*	F
Chit, Sea Thatch	*Thrinax radiata*	F
Gumbolimbo, Xaca	*Bursera simarouba*	F
Ixcanan, Firecracker	*Hamelia patens*	F, T
Fig	*Ficus* sp	F

In the REA, only Mul-che, Island Ziricote, Island Cherries, and Xocoi were noted in any volume, while single plants were noted of Chit and Beach Creeper. Additionally noted were low-lying early successional plants such as *Euphorbia* and the Caribbean Sedge (*Cyperus ligularis)* in wetter areas.

In addition to the vascular plants of the ecosystem, a narrow range of fungi are present, breaking down dead plant material. The most common of these is the Orange Bracket (*Pycnoporus cinnabarinus)*, commonly noted on downed tree trunks circumtropically (Bryce Kendrick, pers. com.). A flatter grey bracket was also noted in a few locations.

3.1.1.2 Fauna

Faunistic observations at CCFR have been historically limited. Again, animal species are noted in Appendix 1, pp 5 and up, while results from the REA conducted as part of this survey appear in Appendix 3.

Little is known of the terrestrial invertebrate fauna of the northern point of Caye Caulker. The record is limited to site visits by Jan Meerman, associated with the

first REA in April 1993, reviewing respectively Lepidoptera and Odonata (Meerman, 1993). The site visit included both proposed CCFR areas and the uninhabited portion of the southern part of Caye Caulker. The principal dragonfly noted was *Erythrodiplax berenice* (Family Libellulidae), a species known to breed in brackish water and is frequently noted in northern Belize near saltwater lagoons. Another large Anisoptera was noted hunting over littoral forest but could not be collected for identification. All of these were noted in southern Caye Caulker.

All Lepidoptera species were also noted in the southern part of the island. Three species were sighted, while three others extrapolated because their principal food plants are present on Caye Caulker. One of the observed species was migratory while the others were residents based on food plants; refer to Appendix 1 p 11 for species. Additional species that have been noted incidentally on Caye Caulker over the years include many migrants. Particularly high numbers and diversity of butterflies is often noted in late summer-early fall. Examples include Monarch and Queen Butterflies (*Danaus plexippus* and *D. gilippus*, respectively), Julia *(Dryas iulia), s*ulphurs (*Phoebis* spp) and swallowtails (*Papilio* spp).

Several moth species have also been noted but remain unidentified due to lack of literature source. One bagworm pupa is occasionally noted from tree limbs in littoral forest. Other unidentified insect groups also exist on the island but no work has been done on them. A variety of ants, termites, roaches, beetles, flies, leafhoppers, true bugs and others have been noted. Also present are colonies of Nasuti termites.

Other invertebrates known from the south end of the island include spiders such as *Gasteracanthus aculeatus* (“Spinning Burr”) and other less well-known species such as the Pale Jumping Spider and the Mangrove Orb Weaver, a large species that may spin its colonial webs in littoral forests or mangroves. The land crabs, also noted at times in littoral forests, will be described in the Mangrove section; however the Ghost Crab (*Ocypode quadrata*) prefers high sandy beaches (Kaplan, 1988). Centipedes have also been noted, though no research has targeted them.

The only amphibians to reach the island have undoubtedly done so in lumber and other bulk supplies. Occasional treefrogs and once even a toad made it to the island, but did not establish populations.

The 1993 REA also surveyed reptiles at Caye Caulker. Several lizards were noted in CCFR territory, predominantly in coconut woodland. Littoral forest-occurring species are noted in Appendix 1, p. 22. Notable examples include the Spiny-tailed Iguana (*Ctenosaura similis),* anoles (*Anolis* spp), Geckos (Gekkonidae) and a whiptail (*Cnemidophorus* sp).

Also of note is the Asian House Gecko, widely distributed through settled areas of Belize and only noted on Caye Caulker since Hurricane Keith (McRae, unpub). The only snake recently noted on Caye Caulker is the Boa Constrictor (*Boa constrictor*), however the Blacktail Indigo (*Drymarchon corais*) is a historic resident last sighted during the 1980s.

Last year, observations by PA staff identified a female Saltwater Crocodile (*Crocodilus acutus)* nesting in the high coral sand of the north point of Caye Caulker. A smaller individual of unknown gender was noted by a Malaspina University group in the hole created by partial uprooting of a coconut tree during Hurricane Keith, and more recently a dead individual was collected in CCFR areas near a clutch of obviously nonfunctional eggs. Currently crocodiles are frequently noted in CCFR. The 1993 REA noted several also at the southern part of the island (Meerman, 1993).

While mainland or coastal littoral forest shares many bird species with adjacent habitats, caye forests are limited to certain species known to favour islands in addition to migrant species. Littoral forest of all types has long been known to be of disproportionate importance to resident and migrant bird species. Studies such as Meadows (1994) for the Bacalar Chico area and Lopez-Ornat & Lynch (1990) for the Si'an Ka'an area indicate a bird biomass of 2-4 times greater in littoral forest than other adjacent habitats.

A total of 173 bird species in 36 families has been confirmed on Caye Caulker in all, including accidental species brought in by Hurricane Keith (McRae, unpub data). Most of this work has taken place in the southern portion of the caye. Of these, 17 species in 12 families were observed in CCFR in both littoral forest and mangroves, or over the sea in CCMR territory during a brief visit in the REA of Fall 03, while 7 others, 3 in two additional families were noted opportunistically during the course of the survey. Two additional terns have been noted opportunistically while at sea in the past, yielding an overall species count of 26, in 14 families. The habitat at the north point has been seldom visited and shows only a few hours of opportunistic viewing in dense habitat

Common permanent resident species found in Caye Caulker's littoral forests include the Black Catbird, the Yucatan Vireo (*Vireo magister)*, Cabot's Bananaquit (*Coereba flavidus caboti)*, Hooded Oriole (*Icterus* cuculatus*),* and Mangrove Warbler (a locally-nesting subspecies of Yellow Warbler (*Dendroica petechia erithacoides)* among many others (McRae, unpub data).
Common seasonal resident and transient migrants found in the littoral forest include a multitude of warbler species (*Vermivora* spp, *Dendroica* spp, *Seiurus* spp, *Wilsonia* spp, and others); an array of flycatchers (*Empidonax* spp, *Contopus virens, Myiarchus* spp, and others) and swallows (*Tachycineta* spp, *Hirundo* spp, the Northern Rough-winged Swallow -*Stelgidopteryx serripennis*- and the Purple Martin -*Progne subis);* in addition to the Summer and Scarlet Tanagers (*Piranga rubra* and *P. olivacea*), Rose-breasted Grosbeak *(Pheucticus*

ludovicianus), thrushes (Turdidae) and many other species. Many species have been noted only once or twice on Caye Caulker; undoubtedly the list will expand as more time is put into observations in CCFR territory. The large majority of migrant species are obligate or facultative insectivores, some also partaking of the fruit generated in littoral forest and thicket habitats.

The most common terrestrial bird species noted in CCFR during the REA conducted October 2003 were a variety of warblers, many of which remained unobserved but could be heard chipping from the vegetation. The most commonly observed warbler was the resident Mangrove Warbler, occurring in both mangrove and littoral forest habitat. Refer to Appendix 1, pp 22-28, for a complete bird species list; those marked A or A* were noted within CCMR/FR areas.

No native mammal species inhabit the north point of Caye Caulker with the exception of bats. Although unidentified to species as yet, insectivorous bats are occasionally noted swinging back and forth in lit areas, while fruit bats have been observed consuming papayas and other fruit in the village.

Other mammals noted in the Southern half of Caye Caulker include such introduced species as the Tree or Roof Rat (*Rattus rattus)*, Feral House Cat (*Felis catus),* and the Yucatan Squirrel (*Sciurus yucatanicus*) (ref. Emmons, 1990). The first probably arrived along with the first humans, the second originally brought to control the first, and the third—and most recent—arrived during the 1980s when caged wildlife-as-pets escaped captivity.

At this time it is unknown if any of these exotic mammal species have reached the remote north point of Caye Caulker. The recently-opened road stops well short of the PA boundary; however development of the Harry Dole land immediately to the east of CCFR will facilitate their movement as the northern side of the island undergoes increasing colonization, if strong prohibition against cats, especially within that development are not enforced.

3.1.1.3 Commercially Harvested Species

Historically leaves of Caye Caulker's native palm, Chit or Sea Thatch, were harvested for roofing. However any thatch used these days on the island—for atmospheric tourism practice—comes from the mainland. Coconuts from CCFR areas continue to be harvested sporadically, taking a downturn since Category 4 Hurricane Keith in Sep-Oct 2000. At this point several pickers, including individuals from Sarteneja-based fishing boats, are randomly visiting CCFR areas to take coconuts. Several husk piles were noted during the REA (Appendix 3). Additionally the Caretaker of the Reserve collects coconuts for personal use in the vicinity of the Reserve Headquarters.

Historically many bird species were used for protein supplement, in addition to the Spiny-tailed Iguana, or Wishwilly (*Ctenosaura similis)* and Giant Crab

(*Cardisoma guanhumi)*. American Saltwater Crocodiles (*Crocodilus acutus)* were hunted for skins or as pests. However predation today is limited to occasional children with slingshots, little to none of which is eaten. Occasionally, large crocodiles near inhabited areas are shot for fear of interfering with children. Occasionally, immigrants to the Caye shoot or trap White-crowned Pigeons (*Columba leucocephalus)* or White-winged Doves (*Zenaida asiatica*) for food supplement. This is an area that requires further attention, especially with the recent influx of inhabitants from other parts of the country or Central America.

No terrestrial animal species is currently hunted commercially at Caye Caulker.

3.1.1.4 Rare, Threatened and Endangered Species

As described below, littoral forest and thicket habitat represent a threatened ecosystem due to its small extent, rarity and high demand as development property. In the current economic climate this fact alone renders the flora and fauna of the systems at least vulnerable. According to McField et al (1996), as of 1995 less than 2000 ha of caye littoral forest remained in Belize. Since that time incremental loss has resulted in further littoral forest removal. As to individual species, the weak level of study on this habitat type leaves the status of most species occurring in littoral forest habitats rather poorly known. However, several known cases appear below.

- **American (Saltwater) Crocodile –** Use high ground on islands for nesting (Platt, pers. com.).
- **White-crowned Pigeon--** Nest in mangroves and feed in littoral forest.
- **Black Catbird, Yucatan Vireo, Caribbean Elaenia—**Use littoral forest for food, nesting and shelter.
- **Cabot's Bananaquit –** Habits as above; not distinguished on Caye Caulker as a distinctive subspecies until the late 1990s (Jones et al, 2000). Only known in Belize from Caye Caulker and Ambergris Caye.

Appendix 4A shows avian species known to nest at Caye Caulker that spend considerable time within littoral forests that are considered to be at some form of risk in Belize (Miller & Miller, 1997). Some have also been shown to be in decline (cf Sauer et al, 2002; Jones & Vallely, 2001; McField et al, 1996; Rappole, 1992; Hill & Hagan, 1991). Others are not yet at threat in Belize however their small area of occupation lays them potentially at risk (cf Miller & Miller, 1997; Reed, 1992).

Appendix 4B shows several migrant bird species known primarily in the coastal zone, some of which are in decline in a long-term Breeding Bird Survey in North America (Sauer et al, 2002). Records in a 17-year dataset also indicate that Caye Caulker also hosts at least 20 other land bird species that have been shown to be in decline at a rate of over 1%/year during the past 20-37 years (Sauer et al, 2002; McRae, unpub data). At least some of this decline is

attributed to degradation in stopover or wintering habitat (cf Askins, 1995; Moore & Simons, 1992).

3.1.1.5 Threats to Systems

The major threat to littoral forest systems in Belize is destruction for development, as they are the highest and driest coastal and island land and do not require fill (McField et al, 1996; McRae, 1992). However this cannot occur in CCFR without dereservation—a potential threat to every protected area in Belize due to the design of the Forestry Law (SI, 1922) and National Parks System Act (1981).

The current Cayes Development Policy (CZMA/I, 2000) mentions the uncertain future of littoral forest and thicket habitat, however to date (Winter 2004) no law exists on government registry to protect these ecosystems (Forest Department, pers. com).

Zisman (1992a) recommended that Caye Caulker's littoral forest-mangrove protected area be enacted at least at Wildlife Sanctuary level "for maximum protection". Forest reserves have until recently been the only category of protected area that has been dereserved to date; however recently portions of two National Parks (Gra Gra Lagoon, Payne's Creek) have been dereserved for large-scale development (Barrier Reef Committee, BACONGO, pers. com.). This trend has the potential to jeopardize funding for protected areas in Belize, as donor agencies prefer that the Protected Area, to which their money is donated, not be converted to commercial use by private individuals or corporations rather than ecotourism and visitation by the general public.

The land for CCFR was donated by a private citizen for the purpose of conservation; this area requires a strong defense against the current tide of accelerated, even runaway, development pattern underway at Caye Caulker at this time. Housing subdivisions sponsored by foreign individuals as well as government entities are occurring in areas designated by CZMA/I (2000) as "least suitable" for development in violation of provisional guidelines, including overriding a ban on development in marsh and swamp areas.

On Caye Caulker, the following elements have resulted in littoral forest loss:

- The bulldozing on the north side of a 40-foot wide road approximately 1210m north-south and about 45m east-west up the middle portion of the island to facilitate village expansion;
- The handing out of 117 new lots on the northern portion of the island along with the 2003 election, many of which are being cleared;
- The complete clearing of littoral forest lot by lot for building on parts of both northern and southern portions of the island.

The exact area of this removal is difficult to calculate, as developers remove varying increments of littoral forest as a continuous process. Most lot owners, however, eradicate the habitat altogether, leaving a few isolated trees or shrubs if anything. Area of recent and potential littoral forest removal is estimated at a minimum of 5% per year since 1995. The newest Government-sponsored development on the north point includes lots, all quite small (12-18 X 24 m) and occupying less space than previous lots on the maps (CCVC, survey maps). Caye Caulker averaged the smallest lot sizes for Final approvals in 2000 (CZMA/I, 2000).

Development actions—especially high-density or large-scale—in these areas such as dredging and filling, habitat destruction, canal-building and loss of shoreline vegetation involves a number of impacts. These may include the introduction of a variety of pollutants to adjacent marine ecosystems:

- High sediment levels associated with dredging and deforestation entering adjacent lobster grounds (Blease, pers. com.)--as well as drifting to reefs within CCMR under specific weather conditions (cf SbF videography records);
- Bacterial effluent reaching nearshore waters as well as reef corals by the same mechanism noted above, drifting along with the currents, or adsorbed to sediment particles (cf Patterson et al, 2002);
- High nutrient levels in surrounding water from increased sewerage in the area, increasing turbidity and other effects;
- Dumping of litter, garbage and/or debris deposited within CCFR perimeter, or upcurrent to CCMR, resulting in drift pollution within MPA waters.

Other current and potential threats to elements within the system include:

- Poaching, especially by construction workers (American Crocodiles, White-crowned Pigeons, other species);
- Feral housecats from adjacent inhabited areas—responsible for considerable island extinctions worldwide (cf Veitch, 1985);
- The spread of Tree Rats (*Rattus rattus)* from inhabited areas, if they have not already arrived (Atkinson, 1985).

3.1.2 Mangroves

Mangroves as an ecosystem in general cover about 3.4% of the land surface of Belize (McField et al, 1996). Historically they covered all the low ground on Caye Caulker, including a belt of varying widths surrounding the coast. They actually provide cover both immediately above and below the waterline.

Mangroves hold loose saturated soils in times of extreme weather events. Emergent mangroves provide habitat for countless living things, while their shed leaves decompose in surrounding seawater and help fuel marine systems with their contained nutrients (Zisman, 1992a, b).

3.1.2.1 Flora

The literature variously records four mangrove species, or three mangroves and one associate—the Buttonwood (*Conocarpus erectus*), alternatively termed the Grey Mangrove. The three remaining species include the Red Mangrove (*Rhizophora mangle*), White Mangrove (*Laguncularia racemosa*), and Black Mangrove *(Avicennia germinans).* These form the major structure for mangrove ecosystems ranging from partially submerged fringes around cayes (Red Mangroves) to moderately high, mainly dry grounds (Buttonwoods, some White Mangrove). Even evapouration grounds, with occasional indundation by seawater, are normally occupied by the very salt-tolerant Black Mangrove, along with Saltmarsh vegetation such as Saltwort (*Batis maritima)* and Southern Glasswort (*Salicornia perennis)*.

Other flora may include low-lying succulent shrubs or vines, or tough grasses growing amidst mangrove roots. In a few areas Red Mangroves may have epiphytes such as Cowhorn (*Schomburgia* sp) or Dama de Noche (*Brassavola nodosa)* Orchids, or straplike *Tillandsia* bromeliads. In higher areas a variety of littoral forest species including Coconut Palms may noted. Table 8 names some representative plants other than littoral forest species that may be found in mangrove areas.

Table 8. Non-saltmarsh plants found among mangrove roots.

Common Name	Species	Habitat
Seashore Dropseed	*Sporobolis virginicus*	Shoreline amongst mangroves or on open strand.
Seaside Purslane	*Sesuvium portulacastrum*	" " "
Portulaca	*Portulaca oleacea*	" " "
Seaside Daisy	*Borrichia arborescens*	" " "
Seaside Ageratum	*Ageratum litorale*	" " "

The primary substrate for subtidal flora includes both living and hurricane-killed roots of Red Mangroves along with adjacent mud and sand. Plants occurring among submerged mangrove roots include a variety of algae; however this portion of the REA could not be undertaken due to weather. A few were noted by peering down into dead Red Mangrove roots alongshore the Headquarters. These are: *Halimeda* sp (Dense clumps packed on dead roots); *Caulerpa racemosa* (A few mats on roots)*; C. sertularioides* (A few plants detected in mud nearer dry land).

3.1.2.2 Fauna

Much terrestrial fauna is shared between mangrove and littoral forest. Many animals pass freely from one habitat into the next, and back again.
However some species are limited to emergent mangrove habitat. One of these is the Mangrove Periwinkle (*Littorina angulifera).*

Dragonflies (Odonata) as a group require both aquatic and terrestrial habitat. Their early stages (nymphs) spend 1 to 2 years as predators in long-term puddles, ponds or lagoons while winged adults attack mosquitoes and other smaller insects on the wing.

As previously noted (Section 3.1.1.2), the dragonfly *Erythrodiplax berenice* is commonly breeding in brackish puddles, where larvae are predators on mosquito larvae and other arthropods (Meerman, 1993).

Land crabs form an important part of the terrestrial fauna of Caye Caulker. The burrows of several species may be found in mangrove habitat, particularly colonies of small Fiddler Crabs (*Uca* spp) living in perennially moist soils. Most noticeable in mangrove and littoral forests are the largest true landcrabs in Belize—the Giant or Blue Land Crab (*Cardisoma guanhumi)* or littoral forest habitat. Their burrows may extend a meter or more through sandy soil to reach the water below (Kaplan, 1988). The supply of these creatures is continually replenished by maturing planktonic larvae, deposited into the sea by berried females. This activity occurs predominantly in months of September and October near the full moon, resulting in increased movements of crabs at these times.

Other common species include Ghost Crabs (*Ocypode quadrata)* –rare in CCFR due to lack of sandy beach habitat; Marsh Crabs (*Sesarma* spp); Black Land Crabs (*Gecarcinus lateralis*) and the Land Hermitcrab or Soldier (*Coenobita clypeatus)*. Living on mangrove trunks themselves are Sally Lightfoot crabs (*Grapsus grapsus*).

Reptiles such as Spiny-tailed Iguanas (*Ctenosaura similis)*, the Brown Anole (*Anolis saigre*) and the Boa (*Boa constrictor)* hunt their prey in either habitat. While reptiles require dry soil in which to lay their eggs, feeding may take place in either mangrove or adjacent littoral forest.

Crocodiles particularly spend much time in swampy areas, requiring high dry land for basking and nesting. On Caye Caulker, adults feed primarily on the Blue Landcrab (*Cardisoma guanhumi*), while juveniles consume insects and other small food items (Platt, pers. comm.).

Several species of birds nest in mangroves, however no heron rookeries are known from CCFR. The principal at-risk species known to nest in Caye Caulker's mangrove communities is the White-crowned Pigeon (*Columba leucocephalus).* Though not documented for Caye Caulker, there is a possibility that Rufous-necked Woodrails (*Aramides axillaris)* and the Yucatan subspecies of Clapper Rails (*Rallus longirostris pallidus)* may nest on the island (Miller & Miller risk assessment numbers 4 and 11, respectively). The principal reason these are considered at risk is that they are shy, retiring and poorly understood while having habitat requirements that are being compromised with increasing

frequency, especially on Caye Caulker (Miller & Miller, 1997; McField et al, 1996; McRae, 1992). Current status in Belize is unknown due to their secretive habits (Miller & Miller, 1997), but they are rare in Mexico. Clapper Rails appear to be at least moderately common in the southern portion of Caye Caulker (McRae, unpub data).
Many species of smaller migrant insectivorous birds, however, spend much time amongst mangroves. Shorebirds such as plovers (*Charadrius* spp) and sandpipers (*Calidris* spp, several larger species) prod the soft muds of mangrove zones in addition to wracklines and exposed nearshore seagrass beds at low tide in search of invertebrates. Many warblers and flycatchers also spend considerable time gleaning or hawking insects from amongst mangrove branches.

Of a minimum of 90 species known to spend at least part of their time in mangroves on the island, 56 are migrants (McRae, unpub data). Of these, 24 are transient (appear for less than one month on the island—many for less than a week), while others are present for much longer periods. A few are present in summer while the majority reside on the island between September and March or appear briefly in spring, fall or both as a stopover during migration. See Appendix 1 for a complete species list of birds known to have occurred at least once at Caye Caulker and surrounding regions; those marked “A” are known from CCFR.

In CCFR mangrove habitats, including the northern rim of the northernmost central lagoon, the most commonly noted mangrove bird species during the REA were Brown Pelicans (*Pelecanus occidentalis)*, associated with the outer fringe. A Belted Kingfisher (*Ceryle alcyon)*—a winter resident—was also noted in this habitat. Three heron species were noted in the lagoon—Great Egret (*Ardea alba)*, Little Blue Heron (*Egretta caerulea*) and Green Heron (*Butorides virescens)*. Also noted was a variety of landbirds and a Roseate Spoonbill (*Ajaia ajaja)* overflight.

Fauna of submerged mangrove roots is diverse, ranging from sessile creatures such as sponges, tunicates, and anemones, through benthic organisms living in association with the roots and extra substrate provided by attached lifeforms; to those actively swimming forms such as fish which merely take shelter amidst the structure. A list of 86 distinct fish species living in mangroves at southern Ambergris Caye was compiled by Carter (1990, in Zisman, 1992). Southern Ambergris lies about 5 miles (7 km) north of the CCFR, therefore the fish fauna is likely similar. Historically a number of species have been noted amongst mangroves at other parts of Caye Caulker. These include a wide range of fish and invertebrate species, noted in Appendix 1, with habitat designated “M”.

3.1.2.3 Commercially Harvested Species

White Mangrove poles are occasionally cut by fishermen in search of balisa (marker poles for lobster traps), however not in commercial quantities.

Otherwise, the commercially harvested fauna of emergent mangrove areas is the same as that for littoral forest. For example, though White-crowned Pigeons consume the fruits and berries of littoral forests, they nest in mangroves. This species was not resident during the time of the REA.

Several organisms that spend at least their early life history in the mangrove root community are harvested commercially. These include, but are not limited to:

- **Spiny Lobster** (*Panulirus argus)*- Postlarvae settle amongst mangrove roots in solitary fashion, usually moving into seagrass beds and reefs as they mature. Thus the mangrove root community is essential for lobster production.
- **Grey Snapper** (*Lutjanus griseus)*-Sizes range from juveniles to large adults.
- **Barracuda** (*Sphyraena barracuda)*-as above; very small juveniles (7-16 cm) are noted amongst the roots.

However, little fishing actually takes place within the habitat, but occurs in adjacent habitats including seagrass and reefs.

3.1.2.4 Rare, Threatened and Endangered Species

See Section 3.1.1.5 for mutually shared species between littoral forests and emergent mangrove systems. Other species appearing principally in emergent mangrove systems include migrant (Appendix 4C), as well as resident birds such as the reclusive Rufous-necked Woodrail (*Aramides axillaris)*—one of a group of species known to suffer loss of habitat and/or a variety of pollution effects. Some of these include loss of habitat, eggshell thinning, immunosuppression and hormonal interference due to bioaccumulation of chlorinated hydrocarbons and other biocides, oil and other fuel spills, and dumping or deposit of other toxic substances (McField et al, 1996; Ross) (Appendix 4D, E).

Other bird species encountered primarily in mangrove and on some occasions in adjacent littoral forest or thicket habitat have been judged to be at risk, either in Belize or regionally. Some of these species may be observed among wrack in roots or among strand vegetation such as shoreline grasses, succulents and vines, while others are noted off the ground among leaves.

According to the Breeding Bird Survey of North America, the Clapper Rail in that area is declining at 1.3%/year survey-wide (Sauer et al, 2002). The Yucatan subspecies has not seen directed research. However, the rate of development along the Caribbean coast in Quintana Roo, Mexico and the Cayes and coastal zone of Belize is undoubtedly resulting in habitat loss.

Rare and endangered species in submerged mangrove systems include primarily the American Crocodile. Crocodiles spend much of their time in close proximity to mangroves. Figure 2 shows an American Crocodile. At this time no other endangered species are known to utilize submerged mangrove habitat.

Figure. 2. American Crocodile, CCFR (Photo © E.McRae).

3.1.2.5 Threats to System

The principal threat to mangroves, like littoral forests, is removal for development (McField, 1996; Zisman, 1992). The 1989 Mangroves Protection Act offers protection to mangroves excluding the Buttonwood; however these laws are routinely disregarded at Caye Caulker, as in other locations; low fines undoubtedly exacerbate this problem.

Notwithstanding the work done in the mid-1990s, no formal policy toward protected areas exists. However, at this point in time a task force has been assembled with an eye to setting a comprehensive protected area policy. One of the areas to be addressed is the issue of dereservation (NPASPO lit, 2004). See Section 1.1.5 for more about the National Protected Areas Policy and System project.

Aside from this perennial threat, sea borne pollution such as fuel spills (McField et al, 1996; Dodge et al, 1995; Jackson et al, 1989); sewerage and other organic pollution runoff from nearby and upcurrent development such as housing, resorts and agriculture (CZMP, 1998; McField et al, 1996; Dodge et al, 1995; Sorensen & West, 1992). Some effects of these to mangroves and the animal life inhabiting them include a variety of lethal and sublethal effects brought about by contact with these substances (cf Dodge et al, 1996; Klumpp & Von Westernhagen, 1995; Jackson et al, 1989; Ohlendorf et al, 1989). Other threats include poaching; introduction of exotic species and trashing from adjacent development pose lesser but significant threats (McField et al, 1996). Threats to mangrove communities may also arise from biocide use in adjacent development. Insecticides such as Malathion may drift into nearby mangrove communities including lagoons or nearshore habitat, causing fish kills, loss of low-level invertebrate forage animals and other loss to the communities. Gramoxone may run off into mangroves, resulting in kills.

3.2 SUBMERGED SYSTEMS

The following is a survey of submerged ecosystems protected by CCFR, including lagoon bottom habitats such as bare sand, algae, seagrass as well as mixtures of these; and a variety of coral reef habitats.

3.2.1 Seagrass and Other Lagoon Systems

Lagoon ecosystems are protected by the living breakwater of the Barrier Reef. Thus they flourish in generally low-energy conditions. They range in complexity from bare sand or mud, through a succession of mixed algae, to mixed small seagrass (*Halodule wrighti, Syringodium filiforme),* on to Turtlegrass (*Thalassia testudinum).* Seagrass may be sparse (> 30% coverage); moderate (30-70% coverage); or dense (> 70% coverage) (Mumby, 1997). All classifications and all three species are found in CCMR (App. 3-REA).

The most productive of these habitats is moderate to dense seagrass (McField et al, 1996; Zieman et al, 1979, Kikuchi & Perez, 1977). Energy is exported by drifting detached blades onshore, often bitten by parrotfishes (Scaridae) then completely detached by wave action; by foraging on the grasses or associated fauna by reef-based organisms such as parrotfishes and *Diadema antillarum* urchins (herbivores); grunts (Haemulidae) and snappers (Lutjanidae) (carnivores); or by dissolution of detached blades in the sea (Zieman et al, 1979; Ogden & Zieman, 1977).

Seagrasses form a dense rhizomal mat that holds bottom sediments, reducing erosion in times of strong current (McField et al, 1996; Zieman, 1982; Kikuchi & Peres, 1977). Their leaves accumulate sediments, helping to filter the water before it reaches fragile reef corals (McField et al, 1996).

3.2.1.1 Flora

Principal lagoon flora includes a variety of algae and the seagrasses. Known seagrass species from the Caye Caulker area include the broad-bladed Turtlegrass (*Thalassia testudinum)*; the narrow, cylindrical Manateegrass (*Syringodium filiforme)*; and the fine, flat Shoalgrass (*Halodule wrighti)*.

A number of algal species are also found in lagoon habitats. The most common known algae include a variety of Chlorophyta, including *Halimeda* spp; *Penecillus capitatus; Udotea flabellum* and a variety of *Caulerpa* spp (REA, 2003-Appendix 3). Patches of bare ground between seagrass areas may have fine filamentous algae overgrowing its surface in places.

3.2.1.2 Fauna

A wide variety of organisms are known to spend all or part of their lives in lagoon habitats (McField et al, 1996; Heck & Orth, 1980; Weinstein & Heck, 1979).

Appearing empty at first glance, bare substrate features a considerable full- or part-time infauna, such as Lugworms (*Arenicola cristata*); a variety of mollusks,

for example West-Indian Fighting Conchs (*Strombus pugilis),* West-Indian Chank (*Xanus angulatus*) and Milk Conch (*Strombus costatus)*; and an occasional fish such as Slippery Dick (Labridae: *Halichoeres bivittatus)* (REA, 2003). Just after dark the Luminescent Threadworm or "Glowworm" may be sighted nearshore in surface waters over seagrass, participating in reproductive activity (Gaston & Hall, 2000).

Seagrass habitat hosts a broad range of macroscopic species of nearly every phylum, ranging from sponges such as the Chicken Liver (*Chondrilla nucula)* through cnidarians, a variety of worms, mollusks, crustaceans, echinoderms and chordates, such as fish, sea turtles and marine mammals. The species list in Appendix 1 notes species found in Caye Caulker seagrass habitat, flagged by the designations L5 through L9, and 3 species—one of which was unique to the habitat—located in bare substrate or algae, recognizable by the designations L1-L4. See Table 9 for fauna noted during the REA associated with this project.

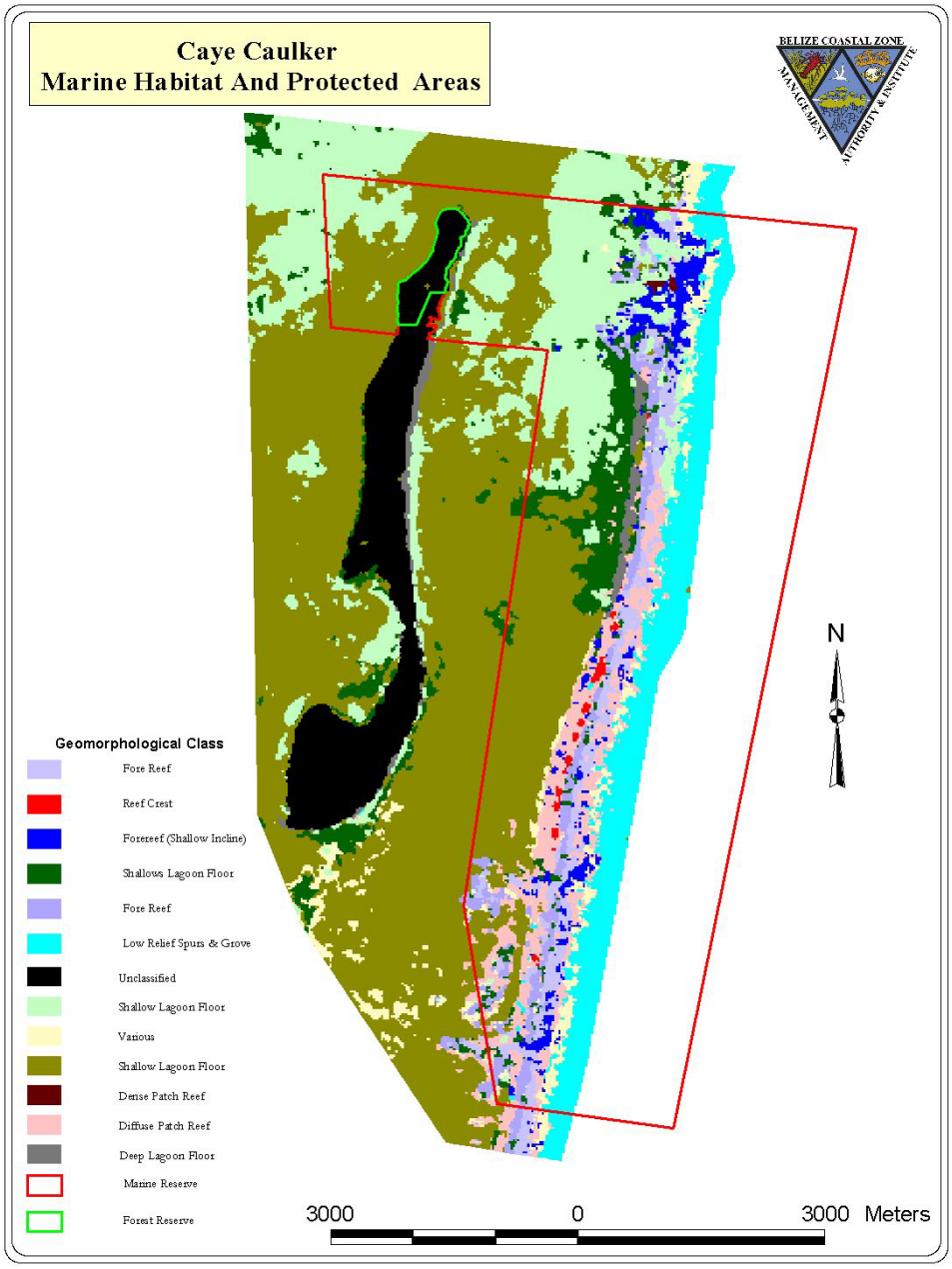
Table 9. Most common invertebrate fauna in lagoon and seagrass habitat noted during the REA (2003).

Species	Common name	Habitat type
Manicina aureolata	Rose Coral	Seagrass; Seagrass/algae
Arenicola cristata	Lugworm	Seagrass; Seagrass/algae; Bare sand
Leodia sexiesperforata	6-Hole Sand Dollar	Seagrass; Seagrass/algae
Xanus angulatus	West-Indian Chank	Seagrass; Seagrass/algae; Bare sand
Oreaster reticulate	Cushion Seastar	Seagrass/algae
Strombus gigas	Queen Conch	Seagrass; Seagrass/algae
Spheciospongia vesparium	Loggerhead Sponge	Seagrass; Seagrass/algae
Petrochirus diogenes	Conch Hermit Crab	Seagrass; Seagrass/algae

A total of 8 fish species were noted living within CCMR in lagoon/seagrass habitats during the REA, including 2 species appearing as adult and 6 as juvenile. Map 6 shows a composite of survey locations and previously known bottom topography.

Features such as coral colonies, patches of octocorals, sponges and even lobster traps occur as relief in seagrass beds, serving as extra habitat and therefore resulting in increased aggregation points for organisms in search of safe places to hide; abundance of associated macrofauna increases in

Map 6. Submerged systems habitat map (Sources: CZMA/I, REA)



association with proximity to coral habitat (Weinstein & Heck, 1979; Ogden & Zieman, 1977).

3.2.1.3 Commercially Harvested Species

Seagrass in particular is critical habitat for a number of commercially important species. The Spiny Lobster in particular is obligately dependent upon seagrass habitat for 2.5-4 years of its life (Zieman, 1982). The most productive fishery for this species is using traps; 8 fishermen from Caye Caulker run traps in seagrass beds located from directly offshore to several miles distant (Ditzler, student

project 2003). Diving fishermen work barrier and patch reef areas using a hook stick to extract lobsters from beneath coral heads. The species brings in an estimated $ in foreign exchange to the nation annually (Carcamo, pers. com.). Production for Northern Fishermen's Cooperative—founded in Caye Caulker and the co-op of choice for its fishermen—in 2002 was 229,361 pounds, valued at over $19.75 per pound—this was down 13.28% from the previous year (NFC, 2002).

The Queen Conch (*Strombus gigas)* is another species taken predominantly from seagrass beds and secondarily from the reef. This fishery has fallen far from its peak production in the mid-1970s, but still brought in 354,898 pounds to Northern Fishermen (NFC, 2002).

Seagrass is also critical habitat for juveniles of a wide variety of fish species which are fished commercially in reef habitat. Groups known to be represented in seagrass from other studies include members of the grunt (Pomadasyidae), Snapper (Lutjanidae), and Parrotfish (Scaridae), all utilized by commercial fishermen in Belize (Weinstein & Heck, 1979).

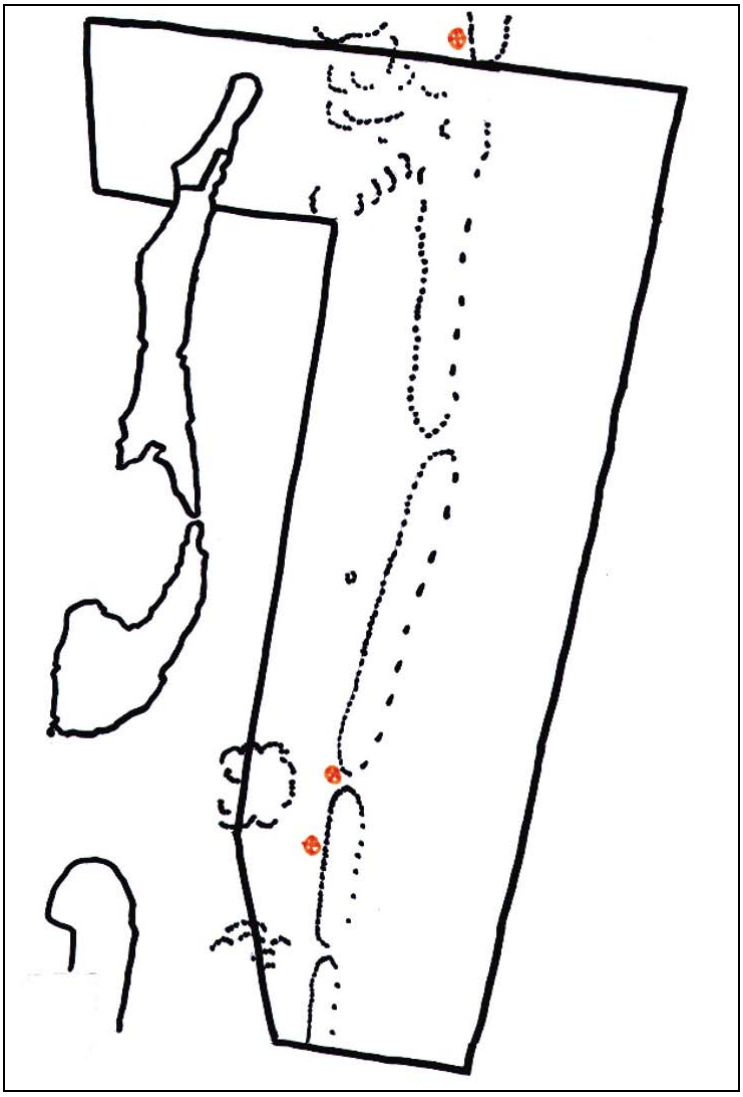
Data from an 11-year sampling effort in the Northern Shelf Lagoon indicates over 95 species, collected ancillary to a commercial trapping operation in waters a few miles south of CCMR (McRae, unpub. data). Most sought after of these are Yellowtail (*Ocyuris chrysuris*), Lane (*Lutjanus synagris*), and especially Mutton Snappers (*L. analis*). Research indicates the latter spends most of its life over seagrass and algae/rubble habitats (Bortone, 1986).

3.2.1.4 Rare, Threatened and Endangered Species

Several CITES Appendix 1 endangered species inhabit CCMR seagrass areas. Hawksbill (*Eretmochelys imbricata)*, Green (*Chelonia mydas)*, and Loggerhead Turtles (*Caretta caretta)* have all been noted in waters around Caye Caulker. These appear in Appendix 4F. Recent fisheries laws impart complete protection to all of Belize's sea turtles (Fisheries SI, 2000). The Antillean subspecies of the West-Indian Manatee (*Trichechus manatus)* has been noted in many locations within CCMR areas. The following map summarises locations where Manatees have been repeatedly noted over the past 15 years (Map 7).

Some other declining species are not as yet protected by law, aside from basic season and size limitation. Since 1994 the Queen Conch (*Strombus gigas)* has been afforded protection under CITES, Appendix II. However, to date no extra management has been afforded the species (Azueta, pers. com.). The Queen Conch is still available in commercial quantities in Belize; however, other parts of the Caribbean show drastically reduced populations (Azueta, pers. com). Recently surveys were in progress in several areas within the BBR Lagoon and Atolls to ascertain *S. gigas* populations (Alegria, Majil, pers. com.). Research is currently being analyzed and written (Azueta et al, in prep).

Map 7. Approximate locations of repeated West-Indian Manatee sightings within CCMR.



3.2.1.5 Threats to system

The principal threats to seagrass ecosystems include pollution from a variety of sources, including the following: sedimentation from excessive and inappropriate dredging, canal building and land clearance; agrochemicals (potentially arising from the golf course at Caye Chapel in addition to a variety of recent threats from Caye Caulker itself); oil/fuel spills; excessive nutrient input into the system; and leachate and rubbish from solid waste (Sibley, 2001; Dodge et al, 1996; LaPointe, 1992; McField et al, 1996; Klumpp & Von Westernhagen, 1995). Waste management has been deemed a serious problem at Caye Caulker, as solid waste is dumped directly into or next to a pond adjacent to the airstrip, and septics discharge nutrient-rich, potentially bacteria-contaminated material into the groundwater (CZMP, 1998). The latter study warns of the potential of a “no-win

situation" for residents, the caye and reef resources if these problems are not addressed soon.

Dredging brings the double-edged sword of outright destruction, added to downcurrent drift of sediment overflow (Johannes & Hatcher, 1986). The latter increases turbidity and particulate content of surrounding water, resulting in reduced productivity (McField et al, 1996) and compromised fishing grounds (Blease, Novelo, Badillo, pers. com); in addition to resuspension of pollutants in sediments already previously deposited (Duarte, 1997; Terrados et al, 1998). Results, such as Caye Caulker's beach, are often short-lived in moderate to high energy areas.

The most recent data for Caye Chapel's golf course is five years old (Pesticides Control Board, pers. com.). 1999 records indicate that 14 biocides were on the shelves; these are indicated in Table 10. According to Pesticides Control Board, no site visit has been made since 1999.

A list of 25 biocides, three of them chlorinated, was detected in water catchments from 9 golf courses in Florida (Swancar, 1996). In absence of knowledge of the biocides in use at Caye Chapel, this serves to illustrate common chemicals in use on golf courses in general, to illustrate additional chemicals that may be in use at this time (Appendix 5). Additionally, biocides in occasional use at Caye Caulker include the insecticide Malathion and the herbicide Gramoxone.

Additional chemicals are in potential use at the golf course, including potassium permanganate, used to make pondwater appear blue. A recent anecdotal report of water from the golf course's ponds being pumped directly into the sea should be investigated along with today's biocide complement. Site visits by the Pesticide Control Board and DOE should be resumed as soon as possible.

Some biocides are known to mimic hormones of organisms, interfering with reproductive cycles; others have resulted in immunosuppression, resulting in increased incidence of disease in birds and marine mammals, respectively (eg, Sibley, 2001; Ross, 1996); fish eggs exposed to pollutants in Australia showed chromosomal aberrations and deformities (Klumpp & von Westernhagen, 1995). Similarly, organisms such as manatees, dolphins and large fish at the top of marine food webs in the northern BBR lagoon may suffer effects of chemical runoff from the golf course at Caye Chapel, in addition to potential runoff of breakdown products of Malathion, occasionally dispersed by fogger at Caye Caulker (cf Pimentel & Leviton, 1986). A thorough investigation of the compounds in use as to their residence time in the ecosystem, breakdown products, potential for bioaccumulation, immunosuppression and other effects should be undertaken. This study should also include breakdown products.

Table 10. Pesticides at noted at Caye Chapel in 1999 (PCB files).

Biocide Class	Name	Impact on aquatic life (cf Extoxnet)
Fungicides -	Benomyl	H to VH tox to fish; Adsorbs to soil; Highly persistent Absorbed by plants; -
	Mancozeb	Cancer, birth defects (exp. animals); Md-H toxic-fish, inv
	Bravo	Oganochlorine; Md. persistent; H tox fish, inv; Md bioacc
Insecticide –	Malathion	Md toxic-birds; Md-VH tox-fish; VH tox, inv; Md-L bioacc Md bind to soils; Soluble in water; Degrade faster in SW
	Carbaryl	Md-VH tox ; Transport by runoff on soil; Can bioaccm
	Diazinon	1988-USEPA cancelled reg. of use on golf cs due to bird die-offs; H tox-fish, esp. SW; 6 mos half-life
	Pyrethrins	Extrm tox –aquatic life, esp in high T;
	Chlorpyrifos	Md-VH tox-birds; VH tox estuarine, marine orgs; Persistent in sediment; Aquatic, gen. agric. Use pose serious hazard to wildlife, bees; Strong adsorp. to soils May accumulate in certain crops
	Phoxim	Unk.
	Sulfuramid	Unk.
	Bifenthrin	VH tox-fish, aquatix; May bioaccum. in birds; Poss. mutagen, teratogen, carcinogen
Herbicide -	Glyphosate	(Roundup) Reprod. changes; Md tox, birds, aquatic inverts; Lo tox-fish; No sea data;
	MSMA	(Monosodium methanearsonate)-Tightly bound to soils
	2,4-D	Chlorinated compound; Different formulae=diff effects: @ high dose, mutagen, poss, carcinogen, reprod., birth defects; Md-VH tox-fish; Md tox, inv; Halflife in water-1 to several weeks, decomposed by microbes

For comparison, a study of pesticides in sediments of Sarasota Bay, Florida, revealed the highest residues in a shallow, tidally influenced creek draining residential, commercial and recreational (golf course) areas (Sherblom et al, 1995). Most of the sites showing contamination were inshore.

A major oil spill drifting over shallow nearshore seagrass beds and other shallow marine habitat was found to cause mortality and decreased resistance to disease in shallow marine habitats including mangroves, seagrass and coral reefs on the Caribbean coast of Panama (Jackson et al, 1989). Fuel barges bound for Caye Caulker and San Pedro routinely pass through or near the northwestern lagoon areas of CCMR, exposing the similar shallow marine habitats to potential fuel spills.

Excessive nutrients may result in increased epiphyte cover over seagrass blades (McField et al, 1996). This effect is primarily local at Caye Caulker, as nearshore areas off the village tend to have higher epiphyte load than even short distances further offshore, while seagrasses even one mile off polluted Haulover Creek at North Drowned Caye did not reveal elevated epiphyte levels (McRae, 2003a). Nutrients may also result in increase of plankton in the water column, causing greater turbidity (cf McField et al, 1996; LaPointe, 1992).

3.2.2 Coral Reef Systems

Coral reef systems constitute an essential portion of CCMR. They are the focal point for a growing tourism industry, and are routinely visited by tourist trips originating from Caye Caulker and San Pedro, 12 miles north of Caye Caulker.

Caye Caulker reef systems are extensive, with the Barrier forming an 11.1- km-long wall slightly over a mile offshore the island with three major breaks—North and South Caye Caulker and Caye Chapel Channels. Significant patch reefs are associated with all channels within the protected area (Caye Chapel and South Caye Caulker Channels). Lesser patch reefs are found sporadically throughout lagoons, with significant known patches shown in Map 8.

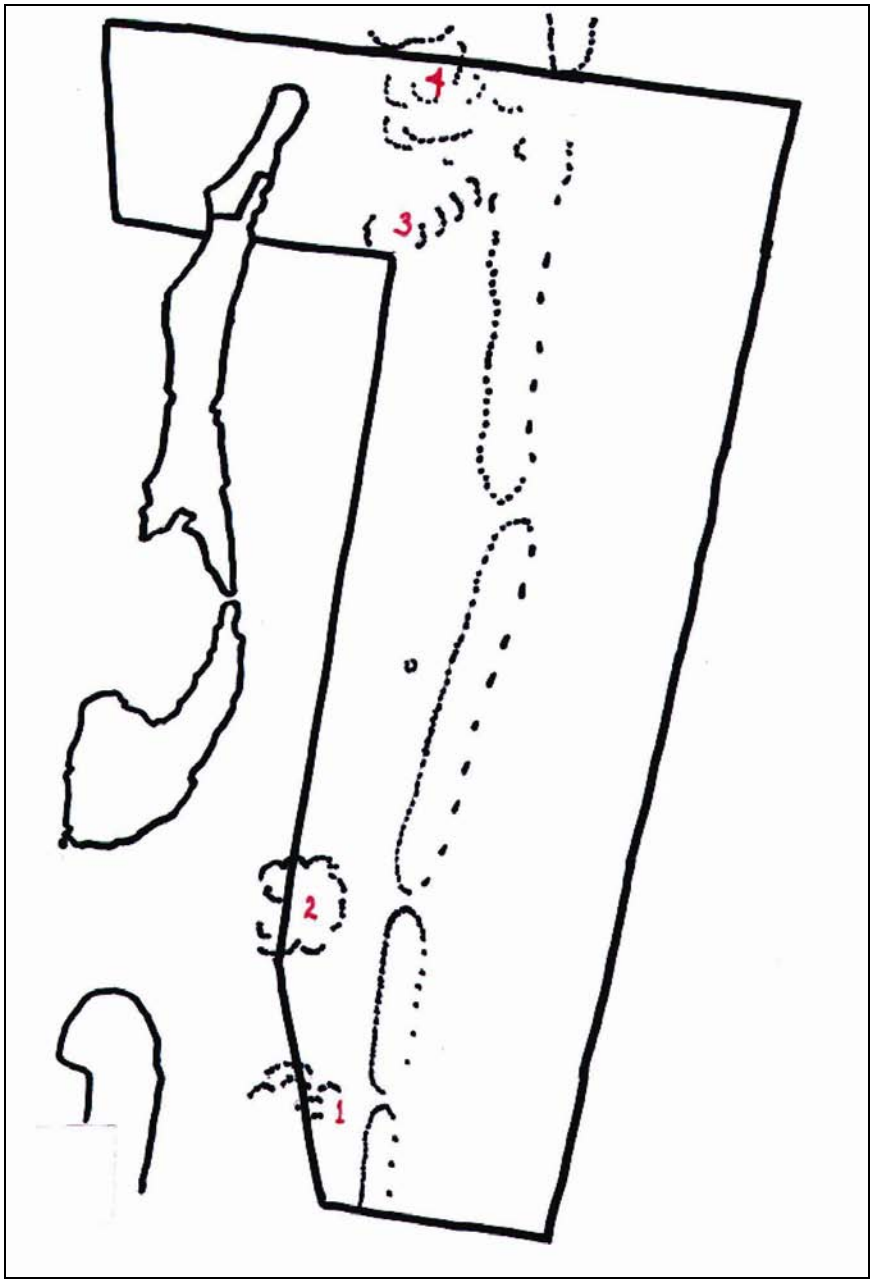
Caye Caulker's reefs have been damaged in recent years (1998-2001) by coral bleaching and a series of hurricanes and strong tropical storms (CZMA/I, 2000). However, in most areas a varying degree of regeneration has been noted (Burkett et al, 2002). Low-level bleaching was noted last year along many southern area reefs within CCMR (REA, Oct-Dec 2003).

In years past *Acropora* corals were dominant throughout the Caribbean (Aronson & Precht, 2001), however these have experienced nearly total loss (Burkett et al, 2002; Aronson & Precht, 2001). Caye Caulker's patch reefs are currently dominated by *Montastraea annularis,* which has also experienced impacts as shown in Section 3.2.3.4. However, related *M. faveolata* appears to have experienced lesser damage and disease levels.

At this point most areas of CCMR are exhibiting at least early stages of recovery (REA, Oct-Dec 2003). Remarkably much regenerating *A. palmata, A. cervicornis,* and *A. prolifera* is evident in many parts of the barrier. Some of the Staghorn Corals in some areas are already showing signs of White Band, however many more are not (ibid.). Most regenerating Elkhorn corals also to date appear clear of this serious plague.

An ongoing study by University of Wisconsin (Superior) on Caye Caulker's patch reefs revealed 31 species of Scleractinian corals with an average species richness of 12.2 species per site in Caye Caulker's patch reefs (Burkett et al, 2002). On average, density of coral was 584 colonies/25 m^2, with coral cover averaging 14.64%. Dominant species by coverage were *Montastraea annularis, Porites asteroides*, and *Montastraea faveolata* (88.4%), while *M. annularis, P. asteroides, Porites* porites*, Agaricia agaricites,* and *Acropora cervicornis* were dominant by density (90.1%). The U Wisconsin study found that, of all coral species, *M. annularis* was by far the most important species, with 97.6% of density and coverage.

Map. 8. Major patch reefs present in CCMR. Sources: Burkett et al, 2002; REA, 2003). 1. Caye Chapel Coral Gardens; 2. Caye Caulker Coral Gardens ; 3. Leslie Rocks; 4. North Caye Caulker Channel « Coral Gardens"



The study also demonstrates 23 species of Octocorals, with *Briareum asbestinum* dominant (Burkett et al, 2oo2). Two common species of Hydrocorals—*Millepora alcicornis* and *M. complanata*—were also noted. The stated goal of CCRI (The Caye Caulker Research Initiative) is to conduct long-term research to better understand community succession and recovery of coral

reefs following both anthropogenic and natural disturbances (Burkett, et al, 2002). Failing long-term exposure to pollutants (Section 3.2.3.4) or further hurricane damage, the patch reefs have good chances of recovery in coming years (Burkett et al, 2002). Minimal change was recorded except increases in octocoral coverage between 2002 and 2003; with plentiful recruits yet some evidence of mortality of slightly larger colonies, Caye Caulker's patch reefs remain in an early stage of succession—more data is necessary to discern trends (Burkett et al, 2003).

3.2.2.1 Flora

The principal flora in reef habitats is planktonic and benthic algae. The U. Wisconsin (Superior) study noted 28 species of macroalgae, most common of which were *Dictyota* spp, *Porolithon pachydermum, Laurencia obtusa, Galaxaura* sp, *Amphiroa rigida* and *Halimeda* spp (Burkett et al, 2002). Most commonly-noted macroalgae noted during the Oct-Dec 2003 REA in reef habitat appear in Table 11, distributed by habitat. Percent cover of algae overall in patch reefs was noted at 72% and attributed to damage from the recent hurricanes (Burkett et al, 2002).

The most essential microalgae is *Zooxanthella (=Symbiodinium)* spp, zooxanthellae within living reef corals (cf Kaplan, 1982). Phytoplankton remains unstudied in Caye Caulker waters.

Table 11. Most common algae species noted on various reef habitats in Caye Caulker reef areas, REA Oct-Dec 03.

Species	Group	Habitat
Halimeda opuntia	Calcareous green	Backreef; patch
Porolithon pachydermum	Calcareous red	Backreef; patch; crest
Turbinaria turbinata	Brown	Reef flat
Dictyota spp	Brown	All reef types
Halimeda discoidea	Calcareous Green	Backreef; patch
Dictyota bartrayresi	Brown	Reef crest; backreef
Amphiroa spp	Calcareous red	All reef types
Ventricaria ventricosa	Green	Backreef
Sargassum polyceratium	Brown	Reef crest
Neomeris annulata	Green	Reef crest

3.2.2.2 Fauna

Coral reef ecosystems rival tropical broadleaf forests as one of the most biodiverse ecosystems on Earth (Longhurst & Pauly, 1987). Species occupy every conceivable niche, including benthic, infaunal or pelagic and represent every major animal phylum. Non-coral invertebrate, coral and vertebrate species appear in the species list (Appendix 1); breakdown from the REA in CCMR waters is shown in Tables 12, 13 and 14. Nineteen sponge species were noted by Burkett et al (2002). The same study noted that invertebrates other than hard

and soft corals, sponges, and hydrozoan corals comprised less than 1 % of total bottom cover.

Table 12. Most frequently-encountered non-coral reef invertebrates noted during the REA (Oct-Dec 2003).

Phylum	No. Species	Most Commonly Encountered Species
Porifera	6	*Calyspongia* spp.
Cnidaria	3	*Palythoa caribaea*
Annelida	3	*Spirobranchia gigantean*
Mollusca	7	*Strombus gigas; Xanus angulatus*
Arthropoda	7	*Panulirus argus*
Echinodermata	8	*Diadema antillarum; Echinometra viridis; E. lucunter;*

A total of at least 24 hexacoral, 10 octocoral, 2 zoanthid and 2 hydrozoan coral species were noted during the REA. Sheet corals (*Agaricia* spp) noted during forereef visits were not identified to species. The most common of the group are regenerating or remnant Seafans (*Gorgonia ventolina);* young Branching and Crenulated Fire Coral (*Millepora alcicornis, M. complanata)*; Columnar Boulder Coral (*Montastraea annularis)* in various states of repair; and a surprising number of new young *Acropora palmata (*Elkhorn Coral) young colonies. Also encouraging was the number of small colonies of *A. cervicornis* and *Porites asteroides.*

Table 13. Most frequently noted living Hexacoral and Octocoral species during the REA (2003).

Species	Habitat	Group
Gorgonia ventolina	Backreef; patch	Octocorallia
Millepora alcicornis	Backreef; patch; crest	Hydrozoa
Montastraea annularis	Backreef; patch; forereef	Hexacorallia
Acropora palmata	Backreef; crest; patch	Hexacorallia
Millepora complanata	Crest; backreef	Hydrozoa
Porites asteroides	Backreef; patch; crest	Hexacorallia

The most frequently-encountered vertebrate species are the fish. Ninety-four (94) species in 32 families were noted during the REA (2003) in patch and barrier reef habitats. The most common fish species were Striped Parrotfish in patch reefs (n=115); Sergeant Majors in the backreef area (n=333) and on the outer crest (n=151); and Creole Wrasse in the forereef (n=335). The most well-represented families were Serranidae (15 species); Pomacentridae and Labridae with 9 species each; and Haemulidae with 8 species (REA, 2003).

The U Wisconsin study plans to survey reef fish and herbivory in addition to further coral studies in its second phase (Burkett et al, 2002).

In addition to fish, several marine reptiles and mammals are known from the area. These include Hawksbill (*Eretmochelys imbricata),* Loggerhead (*Caretta*

caretta) and Green (*Chelonia mydas*) Sea Turtles; the Bottlenose Dolphin (*Tursiops truncatus)* and West-Indian Manatee (*Trichechus manatus).* Other sea turtle species may pass through occasionally.

3.2.2.3 Commercially Harvested Species

In keeping with their immense biodiversity, coral reef systems harbour many commercially important species. Enforcement on spearfishing has recently (July 2003) commenced at CCMR; however several important species have been fished down considerably over the years. Spiny Lobster is also caught in reef habitat by diving fishermen; total lobster catch from both traps and divers for Northern Fishermen's Cooperative is marketed abroad. See Section 4.2.2.2 for a discussion of mixed species diving fisheries, a portion of which is also caught in reef habitat. In CCMR reef fish are speared by commercial fishermen, and trolled or drop-fished by sportfishing guides, who may also be fishermen and consequently sell all or a portion of their catch to local restaurants or the Co-op.

Table 14. Most frequently-encountered reef fish noted during the REA (Oct 2003). No. in.=Number of individuals noted.

Species	Common name	Reef type noted	No. in.
Thalassoma bifasciatum	Bluehead Wrasse	Common everywhere	≥ 940
Abedefduf saxatilis	Sergeant Major	All, esp. backreef & crest	≥ 692
Scarus croicensis	Striped Parrotfish	Principally backreef, patch reefs	≥ 609
Clepticus parrai	Creole Wrasse	Principally forereef	≥ 381
Acanthurus coeruleus	Blue Tang	Common everywhere (An additional 340 mixed Blue Tangs-Doctorfish were reported)	≥ 320
Haemulon flavolineatum	French Grunt	Mostly backreef and forereef	196
Stegastes planifrons	3-Spot Damselfish	Mostly back and patch reefs	179
Microspathodon chysurus	Yellowtail Damselfish	Most backreef	173
Caranx ruber	Barjack	All habitats, but most on forereef	≥ 171
Stegastes fuscus	Dusky Damselfish	Most backreef	≥ 170

Some fish species have been noted to decline over time in the area of Caye Caulker. A study is recommended to be undertaken on the status of reef fish on Caye Caulker reefs. Some of this is proposed to be done by University of Wisconsin (Superior) however this study is targeting patch reefs. Some commercially caught fish species known to have declined over the past 12 years include the Goliath Grouper (*Epinephalus itijarra)*, formerly known as Jewfish*;*

Nassau Grouper (*E. striatus);* and a variety of snapper (Lutjanidae) and Grunts (Haemulidae) (BFD, pers. com; McRae, unpub. data).

3.2.2.4 Rare, Threatened and Endangered Species

Most marine species undergo dispersion while in the larval state by sea currents as part of the plankton; therefore, wide distribution reduces likelihood of extinction (Kaplan, 1982).

Though some species have wide dispersion, they have undergone heavy extraction pressure throughout their range; of these, the Nassau Grouper (*Epinephalus striatus)* has been decimated over the years due to a long-term fishery on a spawning population (Carter et al, 1994b). Another Serranid, the Jewfish or Goliath Grouper (*E. itijarra*), is not currently under protection; however its size at adulthood is so large (1.8 m, 600-800 lbs), that young individuals of 35 to 120 lbs are taken opportunistically by spearfishers because they are so large relative to other species. Thus, few if any very large adults remain, inhibiting the species' reproductive potential.

Occasionally West-Indian Manatees and a variety of sea turtles are encountered at coral reefs. The Hawksbill Turtle has been more frequently noted on the reef at CCMR by the author than any other species. Refer to Section 3.2.1.4 for more about these species.

3.2.2.5 Threats to system

Over the world's tropics many common threats to reef corals have emerged in the literature. Threats are one of two types—those arising from natural situations—and those resulting from human activity (anthropogenic threats). Natural hazards to hit CCMR reefs are summarized in Table 15.

Anthropogenic threats may be direct, resulting in immediate damage or destruction; or indirect, resulting in some other effect which causes reef degradation. Direct anthropogenic threats include trampling by uncontrolled visitation; boat groundings; breakage by commercial divers going after fish, lobsters or salvage operations (McField et al, pers. com.; various, pers. com.). Indirect threats include sedimentation (Gibson & Carter, 2003; McField et al, 1996, Cortes & Risk, 1985); nutrient loading (Burkett, 2003; LaPointe, 1992; McField et al, 1996; CZMP, 1998; Goreau, jr, 1991); chemical/oil pollution (Dodge et al, 1995); biocide residues (Glynn et al, 19) and solid waste (McField et al, 1996). Overfishing must also be counted in this area (Roberts, 1998). Overall reviews of regional reef impacts have also been produced (eg, Kramer et al, 2000, in CZMA/I, 2001; McField et al, 1996). These impacts and their effects are summarized in Table 16 (page 43-44); an early review of actual and potential impacts was presented for Caye Caulker (McRae, 1992).

Even more susceptible to toxic chemicals are the gelatinous animals that form the basis for the marine systems of Belize—the reef corals. These simple

animals—95% water—take in everything borne by the water around them. Thus, they have no ability to reject or screen out waterborne pollutants. Research has demonstrated conclusively that at least one coral disease—White Pox—directly results from polluted waters—in this case, from bacteria in human sewerage (Patterson et al, 2002). Research has also shown that some Florida reef corals display biocide residues within their tissues (FKNMS symposium presentation, 1992). While not necessarily related, Florida Keys reefs have shown a high rate of disease (as much as 28% of all stations, and 55% of backreef stations) (Santavy et al, 2001). The southern portion of CCMR extends to offshore northern Caye Chapel, exposing corals in patch reef and barrier backreef areas to some elements of biocide pollution. Some chemicals adsorb to soil particles and may be carried far in sediment by currents (McField et al, 1996). Dredging in the area not only raises sediment, but resuspends contaminants embedded within sediments (cf McField, 1996). This can drift considerable distance downcurrent from its source (cf Cortes & Risk, 1985).

A less well-known effect of excessive nutrient load is reduced survival of coral recruits, demonstrated in one coral species during the ENCORE project in Australia (Ward & Harrison, 1996). This effect may arise from even very minute quantities of nutrients in the water column, particularly nitrates and phosphates in combination (Hoegh-Guldberg et al, 1996; Ward & Harrison, 1996).

Table 15. Recent natural impacts to *Montastraea*-dominated patch and backreef habitats in Belize—Caye Caulker effects noted; it must be remembered that some of these may due indirectly to human impacts such as global climate change and pollution (after Burkett, 2002 and others as noted).

Time Frame	Impact and Explanation in Belize and Caye Caulker
Since 1983-4	Massive die-off of algae-grazing *Diadema antillarum* urchins, resulting in increased algae overgrowth of coral throughout the Caribbean—encroaching turf algae evident at Caye Caulker for over 15 years (cf Lessios, 1988). Some recovery in recent years
1990s	Die-off of *Acropora* corals due to a variety of disease, such as White Band and White Pox, the latter recently linked to a human enteric bacterial; much die-off at Caye Caulker prior to Hurricanes Mitch and Keith (Patterson et al, 2002; Aronson & Precht, 2001; McField,2001). Some patchy recovery since hurricane, especially along Barrier (REA, 2003).
1998-9	Massive worldwide bleaching event 1998 (McField, 2001; Porter, 2001) causing increased coral mortality; a lesser amount has been noted on some Caye Caulker reefs during the REA (2003).
1998, 2000, 2001	Hurricanes resulting in widespread breakage, overturning, sedimentation and flaying of delicate tissues by suspended sand grains in turbulent water (CZMA/I, 2000; McField, 2001). Recovery in some areas (REA, 2003)

Table 16. Anthropogenic threats to reef corals in the area of CCMR; citations appear in text.

Impact	Result	Source
Direct Damage		
Boat Groundings	Coral breakage	Careless boat handling
Anchors Thrown Into Coral	Coral Breakage;	Careless anchor placement
Uncontrolled Visitor Damage (tourism, commercial fishermen)	Trampling; Breakage; Collection of Souvenirs; Spearfishing; raising sand/sediment from bottom onto coral.	Lack of tourguide control over visitor behaviour; lack of knowledge and/or concern on part of reef users.
Indirect Damage		
Excess nutrient input	Cloudy Water (sublethal stress); Algae turf overgrowth of coral and seagrass (if enough, death results); reduced survival of recently settled colonies.	Sewerage effluent; contaminated groundwater (septic overflow); fertilizers; decomposing food waste; food processing, excessive/Inappropriate coastal & caye development.
Excess sediment	Cloudy water; introduction of disease; suffocation of coral.	Dredging within 2 miles of reef corals; Inadequate/ inappropriate dredge/fill; mangrove deforestation; Poorly-designed roads; excessive/inappropriate coastal & caye development.
Overfishing	Algal overgrowth of healthy living coral; breakage from fishermen; loss of reproductive potential of large individuals; reduction of biodiversity.	Removal of algae-grazing species such as large parrotfishes; upsetting the natural balance by removal of the largest predators
Introduction of chemicals, including oil and fuel, into marine environment	Suppression of natural immunity to disease; hormonal interference; death by poisoning.	Fuel spills; industrial effluent; excessive pesticide use; use of persistent pesticides; hypersaline brine from desalination plants.
Solid waste, including leachate (seepage of waste materials into ground or seawater)	Entry of toxic chemicals into sea or groundwater (see above); drifting trash in sea, including entanglement with reef corals; ingestion of waste by marine life, including turtles, often resulting in death.	Improper waste disposal (ie, dump sites into groundwater or permeable soil, permitting leaching; throwing trash into the sea).
Elevated sea temperatures, UV	Coral bleaching, elevated disease levels	Global climate change brought about by excessive pollutants in the atmosphere.

4 SOCIOECONOMIC FRAMEWORK AND EXISTING USES

The socioeconomic scenario at Caye Caulker has undergone change over the years as tourism has provided a viable alternative to fisheries. Many persons work both fields as seasons arise. The current socioeconomic situation at Caye Caulker will be presented in this section.

4.1 THE COMMUNITY OF CAYE CAULKER

In this section, community history and ethnic makeup of Caye Caulker will be presented.

4.1.1 Overview of Settlement and History

Caye Caulker is a mixture of traditional Belizean fishing village with footloose and fancy-free tourism. With 1,228 permanent and part time residents (BTB 1999) and approximately 50,000 overnight tourists/visitors each year (NJS, 2001), the Caye is a busy place. Caye Caulker, approximately 980 acres, remains the second most populated Belizean Caye (Mc Rae 1990). Caye Caulker is made up of two portions—northern (relatively undeveloped) and southern (village side), originally opened by hurricane action (1942, 1961), then later enlarged by village council dredging (Various, pers. com.).

On early British maps, the Caye Caulker's name is spelled "Cay Corker" and is historically known for its plentiful supply of exposed aquifers (CCBTIA, 1999). One theory as to how the name originated was from the story that this island was a favorite stop for sailors to replenish and cork water bottles. Another popular story is that it was a place where people hauled up their boats to for repairs, including caulking, at *la ensenada* on the leeward side of the island. However, "Caye Caulker" is more likely to be an anglicized pronunciation of the Spanish name for Caye Caulker, Cayo Hicaco, meaning "the island of coco plum"—a littoral forest fruiting shrub—in Spanish.

Caye Caulker's settlement, originally named Pueblo Asuncion, began when refugees from the Caste Wars arrived around the 1850s. The island was formally purchased in 1870 by Luciano Reyes. For decades, the seven dominant families and other Belizean families survived on coconut plantations (cocales), commercial lobster fishing, traditional harvest of conch and fish, and shipbuilding. The founding of Northern Fishermen's Cooperative Society, Ltd., (NFC) in 1960 by 32 men and women is the greatest highlight of the fishing history on Caye Caulker, exemplifying the importance of the industry.

Tourism became an alternative income source in the late 1960s by backpackers visiting the Caye while traveling Belize and Yucatan Peninsula. Guests to the Caye often shared boats with anglers when visiting the reef and local families provided meals. Today fishermen and tour guides typically hold both licenses as each season opens and closes, and many of the most experienced guides are also members of NFC.

Tourism continues to become a mainstay of the local economy and supports a significant portion of Caye Caulker's population (NJS, 2001).

Residents of Caye Caulker, a growing community, recognize the strain on their local resources by fishing and tourism development. Through the example of Hol Chan Marine Reserve established in 1987, the village has focused on the idea of conservation and sustainable development benefits of a similar marine reserve with conjoined forest reserve.

4.1.2 Current Ethnicity and Community Makeup

Currently Caye Caulker is like a microcosm of all of Belize; elements of nearly every ethnicity live in the community, drawn by the lure of economic opportunity in tourism and fisheries. In addition to the original Mestizo villagers, other ethnic groups include Creoles, Garinagu, Hindu ("Coolie") and three elements of Maya (Yucatec, Mopan and Kekchi).

More recent immigrants are represented by Chinese, Salvadoraneans, Guatemalans, Hondurans, North Americans and Europeans. Many of these individuals have elected to become Belizean nationals.

4.2 OCCUPATION AND LIVELIHOOD; CURRENT USE

The following enumerates the principal means of people on Caye Caulker to earn a living. Other uses and activities are also outlined.

4.2.1 Tourism

The tourism industry is the second-largest foreign exchange earner in Belize after Agriculture, and its growth makes it soon likely to become first (BTB, pers. com.). Caye Caulker people work in many elements of tourism; following are the major ones. Hurricane Keith's devastation of the lobster industry resulted in a number of fishermen to turn from fisheries—once the leading income generating industry on the island—to tourism for income.

A significant number of members of the Caye Caulker Tourguide Association run lobster traps or conduct other extractive commercial fishing activity in addition to running tourist trips. Both activities require a license to pursue. There are at least 110 licensed tourguides living at Caye Caulker (CCTGA records).

Guides from San Pedro, Ambergris Caye, also use CCMR during tours. An estimated 60 San Pedrano guides currently utilize the MPA areas for snorkeling, diving or sportfishing activities (SPTGA, pers. com.). Daytrips to Caye Caulker for snorkeling, with a break for lunch and short walk around the island, are popular.

Growing in importance is the cruise ship industry in Belize. Projected cruise ship arrivals for 2004 as of 26 Sep 2003 include 415 calls with a combined capacity for 1,010,922 passengers; 80% capacity was used for more reliable actual

projected visitation, yielding total of 808,738 (BTB, unpub. data). This brings far more cruise ship passengers to Belize than have ever arrived before (2003 arrivals projected at 671,990—BTB, pers. com.).

Currently use of CCMR for cruise ship daytrips is sporadic. However, increased arrivals mean increased demand for suitable sites for snorkeling trips. This increases the likelihood of higher demands on Caye Caulker's marine environment. Many of the boat captains and guides of these passengers are from Caye Caulker, further increasing the likelihood of cruise ship visitation. Already watertaxi owners are planning trips into CCMR (CCWTA, pers. com.). Given the large capacity of vessels transporting this tourism bracket, there is high potential for overuse of areas with impacts such as the coral destruction at Goff's Caye.

Meetings were held with a number of guides and fishermen from Caye Caulker, San Pedro as well as Sarteneja fishermen (Appendix 6). Unanimous opinion within Caye Caulker community meetings demands strict control of cruise visitation, with some individuals looking to proscribe it altogether. Clearly this is an area requiring considerable attention.

4.2.1.1 SCUBA

There are four working SCUBA shops at Caye Caulker. SCUBA diving is a popular activity, with all shops very busy in the high season (Christmas through Easter) and increasing numbers of divers arriving during "off" season. An unknown quantity of diving activity also originates from San Pedro.

Use of CCMR areas most typically includes boatloads of two to eight divers, visiting a variety of sites off Caye Caulker. Most of these are within spur and groove areas, between 35-40 and 90+ feet deep in the forereef, while some takes place in the Mackerel Hole (approximate position shown in Map 9).

Community meetings revealed that SCUBA professionals would like reef moorings in some forereef spots, in addition to designated areas for instruction drills (Appendix 6).

4.2.1.2 Snorkeling

This is the largest tourism element at Caye Caulker. Most guides, including at times the SCUBA shops, run some type of snorkeling trip at least occasionally. Currently there are 10 snorkel shops on the island, along with numerous independents. Additionally, the Caye Caulker Tourguide Association is on the verge of obtaining a Tour Operator license, which will enable it to market tours from its members while collecting a commission, while the Caye Caulker Water Taxi Association is thoroughly involved in cruise ship tourism, principally snorkeling tours in this area. However, there is a problem with some guides in their conduct while on tour, while other individuals including some foreigners persist in guiding without a license, usually indicating no training at all. Some

legally licensed guides harvest small and/or off-season conchs or lobsters to feed guests, while others are inattentive to their guests, permitting coral contact, raising of sediment and other negative impacts.

Caye Caulker was the site awarded for having the most guides taking the first tour guide training in 1997 (CCTGA, pers. com.). Thus it bears the burden of the most guides with weak marine training, as that was the initial programme's greatest problem. Some tour guide training with enhanced marine emphasis occurred at Caye Caulker from spring 1999 to spring 2001, coordinated by a partnership between the Siwa-ban Foundation and the CCTGA, under the auspices of the BTB. The second generation programme was written in 2000 and finally went into effect in 2002. This has far more in-depth marine treatment than even the enhanced programme of 1999-2001. The resulting situation is that Caye Caulker has a high number of guides with weak marine training if long experience. An advanced marine tourguide training programme has been also written by a consultant and handed over to BTB by the grantee organization, BTIA (cf McRae, 2003b). Even so, most Caye Caulker guides are sensitive to environmental concerns. Most guides are in favour of strict controls in the area of wildlife contacts, including Shark/ Ray attraction (cf Knopf, 2003).

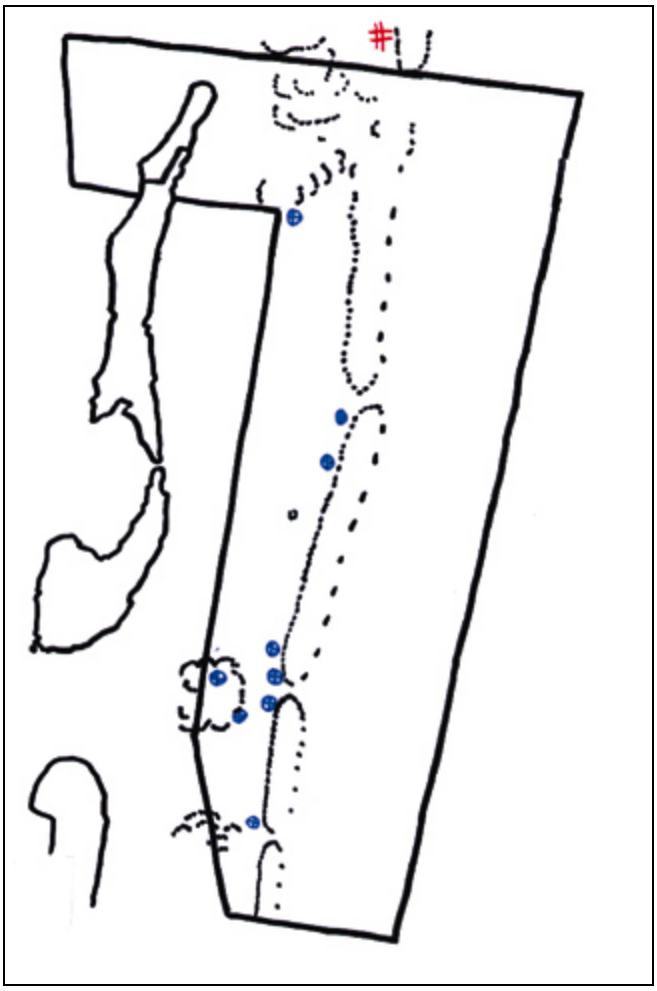
Snorkeling is also the favored pastime of San Pedrano visitors and at this time is the sole CCMR-related activity of cruise ship visitors. The large boats and high density of passengers render the latter source of tourism a "double-edged sword", carrying the blessing of increased revenue with the danger of excessive and poorly controlled visitation if strict management is not defined and rigorously implemented. The situation of Goff's Caye is sufficiently well-known to warrant efforts to avoid duplication at Caye Caulker however guides and captains working with cruise ship companies are motivated financially over the short term to please tourists who may prefer high density. This element will bear strong supervision by enforcement personnel, with legal framework to back it up. Favored sites including some of those originally marked by the previous system of reef moorings installed in 1993 appear in Map 9.

4.2.1.3 Sportfishing

Sportfishing is a growing attraction at Caye Caulker. In recent years only 4 guides had specialized in fishing, predominantly fly fishing for bonefish (*Albula vulpes)*. No bonefish flats are found within CCMR's perimeter, so up to now limited sportfishing originating at Caye Caulker has occurred within the MPA. Some sportfishermen troll for Barracuda (*Sphyraena barracuda)*, Kingfish (*Scomberomorus cavalla),* and other fast-moving species along the outer margins of CCMR. However, new fishing guides have recently been licensed, with intention to carry a variety of fishing styles including bonefishing, deep-sea fishing, drop fishing and trolling, in addition to snorkeling. These extractive fishing styles must be taken into account in zonation design as well as education programmes; this is reflected in meetings in all locations (Appendix 6).

In addition to those from Caye Caulker, San Pedrano guides also use the area. These guides are principally using the northern stretches of reef north of North Caye Caulker Channel for trolling. Therefore there appears to be little conflict from this user group, except by catch limitation.

Map 9. Favoured snorkel sites within CCMR (*). The (#) marks a section of reef normally used by snorkel and sportfish tours that was included in the original plan (Parham, 1996) but which was apparently omitted when the boundary was surveyed.



4.2.1.4 Natural History

Natural history tours include birding and crocodile-watching trips on Caye Caulker. They also include educational walks into littoral forest and mangrove habitat on primarily the southern portion of the island at this time. This is a tourism type that is open to expansion, as the island has a relatively high crocodile population in addition to many bird species not readily observable in other destinations (McRae, 1992; McRae, unpub. data). The CCFR is not currently being used for these purposes although it has an adequate supply of

crocodiles as well a variety of birds. Birding is a hobby that has increased drastically in recent years (155% in the decade 1985-1995) and contributes considerably to the economic integrity of natural areas worldwide (American Bird Conservancy, 1997). It is already enjoying popularity in many parts of Belize; these contribute heavily to economies of nearby communities (Kerlinger et al, 1997). BTB is planning an advanced course in birding (Palacio, pers. comm.).

However, the current lack of infrastructure in the territory, exacerbated by the long-standing debris from overwash of hurricanes in 1998 and 2000, reduces likelihood of strong use of this excellent resource at this time.

Appropriate use of the area demands placement of a system of platform trails and hides in strategic places within the Forest Reserve to enhance the tourism experience at Caye Caulker, as well as increase support for the Forest Reserve.

4.2.2 Commercial Fishing

The following section deals with the commercial fisheries that have traditionally brought Caye Caulker into prosperity and today remain an integral part of village life. From 1996-2001 the estimated combined export value of marine fisheries (lobster, conch, sea-caught pink shrimp and finfish) ranged from $12.3 to $24.2 million Belize ($6.15-$12.1 million USD) (CZMA/I, 2003).

4.2.2.1 Spiny Lobster Trap Fishery

This is the fishery that brought Caye Caulker into prominence in the field of cooperative enterprises. Northern Fishermen's Cooperative, Ltd, (NFC) was founded on Caye Caulker in 1960 primarily by lobster trap fishermen.
Today, 8 fishermen run traps—palmetto strips arranged in trapezoidal form over a hardwood (usually Santamaria (*Calophyllum brasiliense*) frame—at least partially located within CCMR territory. The number of traps located within MPA waters is unknown, although territories have been roughly mapped by Ditzler (2003). Most trap fishermen have operated in these waters for 15 to 45 years; some inherited the waters from their own fathers or uncles (Ditzler, 2003).

Some of the above fishermen are experimenting with shades in their areas. Additionally, an unknown number of other fishermen—some from San Pedro—place shades (zinc rectangles nailed over a wooden frame, designed to take advantage of the natural aggregating tendencies of Spiny Lobsters and their diurnal habit of hiding) on seagrass bottoms within or adjacent to lobster trap territories. An unknown number of shades have been placed within CCMR waters, some in close proximity to the reef (Sabal, pers. comm.). Shades are accessed by diving; lobsters are caught with a hook-stick. Some local fishermen have been running shades in proximal backreef areas, especially in northern areas (Guzman, pers. com.); this will require attention by MPA personnel. A rough map of fishermen's territories appears in Ditzler (2003); however these require proper mapping using GPS.

4.2.2.2 Diving Fishery-Mixed Species

Since the advent of snorkeling equipment in the 1960s, Caye Caulker's reefs have been fished by a variety of hands-on, direct methods. Conchs are picked by hand from the sea bottom in reef and seagrass areas, a low-impact activity. However, spearfishing and hook-stick removal of lobsters requires direct contact with coral, often resulting in hard grabbing, chipping or even breaking coral to reach concealed lobsters or cavity-dwelling fish. These activities are high-impact, resulting in ongoing direct localized damage to reef corals.

A few diving fishermen operate from Caye Caulker. Most of these only occasionally work the reef in CCMR areas, preferring to work patch reefs to the leeward as well as Mitchell Rocks and various Coral Gardens. However at times they work the southern areas of the MPA, or shallow forereef areas. Most of these fishermen are originally from other parts of Belize.

Sarteneja, a fishing/farming village of about 1500 population located in the Corozal District, is the principal origin of diving fishermen working reef areas in front of Caye. About five boats, each containing from 5-10 fishermen, routinely work the Caye Caulker area (Garcia, pers. com.). These fishermen work reefs in front of the island, often diving in shallow to moderate depth forereef areas for larger fish. However, any given fisherman may stop in Caye Caulker waters to supplement his catch.

Frequent targets are larger groupers (Serranidae), snappers (Lutjanidae), large grunts such as margates (Haemulidae), jacks (Carangidae), Barracudas, Hogfish (*Lachnolaimus maximus),* and Queen Triggerfish (*Balistes vetula).* Of particular interest to spearfishers in addition to large members of the above species, are the largest parrotfishes (Scaridae) such as Midnight (*Scarus coelestinus)* and Rainbow Parrotfish (*S. guacamaia),* stocky fish yielding a large amount of high-quality fillet. However, these fish (along with small herbivores such as Acanthurids, moderate-sized parrotfish species such as Stoplight (*Sparisoma viride),* Yellowtail (*S. rubripinne),* Redband (*S. aurofrenatum)* and Queen Parrotfishes (*Scarus vetula)* as well as the Caribbean Long-spined Urchin (*Diadema antillarum)* are very important in keeping algal growth under control on coral reefs (Reinthal & Macintyre, 1995; Lessios, 1988). These species are present in most areas of Caye Caulker reefs visited during the REA.

Many large showy target species of the spear fishery are also of great interest as prime reef attractions for tourism. Thus spearfishing—capable of stripping a reef of large individuals of many species—is in direct conflict with tourism in this way. Additionally, Queen Conch are heavily impacted by divers, from whom there is no chance of escape. However, in some areas of CCMR there are good numbers of this species, including juveniles. In view of the overfished condition of this species regionally, routine conch surveys are planned in all marine reserves including caye Caulker. Additionally fish surveys inside and outside managed areas will assist in determining recovery in different zones.

4.2.2.3 Hook and Line Fishery

Several tourguides remove reef fish while on a drop fishing or trolling trip, then sell much of the catch to the Cooperative or restaurants at the end of the tour. Most tourists have no use for large amount of catch. Some guides may cook up a few fish for the tourists on the beach, but the remainder is frequently left with the guide for disposition as s/he chooses. Catch for drop-fishing in coral areas is principally snappers and larger grunts, while troll-caught fish are mainly Barracudas and an occasional mackerel. Outside the reef trolling may yield Kingfish (*Scomberomorus cavalla)* or Wahoo (*Acanthocybium solandri)* and large jacks (Carangidae)*,* while dedicated sportsmen pursue large gamefish such as Marlins (*Makaira* spp), Sailfish (*Istiophorus platypterus*) and Dolphinfish (*Coryphaena hippurus).*

Diving fishermen may troll as they move from one place to another, or take an occasional trip into the Blue, catching Barracudas, mackerels (*Scomberomorus* spp), jacks, and occasional Cobia (*Rachycentron canadum)*. An annual blue water fish tournament is run by the Caye Caulker Tourguide association; catch from this is often sold to NFC or local restaurants. However hook and line fishing for pure commercial purposes is infrequently pursued by Caye Caulker fishermen, although some Hicacenos and San Pedranos indicated interest in this during meetings.

During community meetings many guides from both San Pedro and Caye Caulker indicated that the northernmost portion of reef in CCMR is a traditional area where trolling is done, both for sport and, seasonally, for commercial purposes (cf Appendix 6). In addition to this, trolling along the outside of the BBR dropoff is a popular fishing method. This is indicated in sufficient cases to warrant attention in the zonation exercise.

4.2.2.4 Bait Fishery

This fishery is carried out in shallow nearshore seagrass, often near mangroves. Gear used is a castnet. Targetted species are principally the Redear Herring (*Harengula humeralis*) and, in smaller quantities, the Scaled Sardine (*H. jaguana).* These species are principally used as bait for catching larger species, either from the docks in the village or by groups in boats. As sportfishing and thus need for bait grows in importance, potential exists for overfishing; thus a management plan for baitfish management will be required.

4.2.3 Environmental Monitoring and Research

To a small extent at this time, monitoring and research, including training sessions, influence Caye Caulker villagers in the following manner:

- They bring income to village guides or fishermen that are hired to work with them;
- They contribute knowledge of habitats, species and field techniques to persons working with them;

- They bring secondary income to the village in the form of maintenance such as hotel, food and other purchases they make.
- They focus attention on whichever habitat is receiving the research.

This is in addition to the valuable data they should be leaving with management entities. Research and monitoring, from UB or abroad, is an arena with considerable opportunities for expansion.

The following section reviews scientific research and monitoring in the area of Caye Caulker.

4.2.3.1 Scientific Research

Little formal research has been conducted to date at Caye Caulker. The most recent is the current ongoing reef initiative conducted for the past two years by University of Wisconsin (Superior), preliminary results of which are described in Section 3.2.3 (Burkett et al, 2002). A timeline of known work appears in Table 17.

The sole formal work having occurred at CCFR was the original REA, conducted in April 1993. Components of this study are noted in Sections 3.1. and 3.2. (Meerman,1993; Miller & Miller, 1993). A brief REA has also been conducted in reference to this IMP update (McRae, 2003c).

Table 17. Formal research in the area of Caye Caulker.

Date	Researcher	Topic
2001-ongoing	U. Wisconsin (Superior)	Baseline information on patch reefs of Caye Caulker: coral cover, condition, species composition, algal cover & species, sponges, octocorals to date.
1999	WRISCS	Mapping of seafloor between Caye Chapel and southern San Pedro (single action: actual project focus on three southern estuaries)
1993	Bruce & Carolyn Miller	Investigation of the birds at the site of CCFR (REA)
	Jan Meerman	Survey Caye Caulker: Insects and reptiles (REA).
Early 1990s	Smithsonian	Investigation of submerged cave fauna
Early 1970s	David Greenfield	Identification of smaller fishes such as gobies and blennies of Belize.

4.2.3.2 Monitoring

Monitoring has not been rigorously pursued by the previous staff in CCMR/FR. However the current staff is making up for lost time in this area. This important area warrants an extensive baseline dataset on which to base a monitoring programme that is relevant to the goals and objectives of the Protected Areas.

To date the University of Wisconsin (Superior) has implemented preliminary studies on some patch reefs within CCMR, and plans to continue such activities,

increasing through time should funding and in-kind assistance from the Fisheries Department and PA staff prove adequate. Additionally a baseline REA has been conducted in connection with this project; refer to Appendix 3 for highlights.

4.2.3.3 Undergraduate Research Projects

A variety of undergraduate biological, environmental and social research projects has been undertaken at Caye Caulker by various students from international student programmes based in Belize. Organizations such as School for International Training (SIT) continue to function in Belize. Table 18 outlines some of these efforts. The two ongoing SIT projects (Fall 03) are associated with activities pertinent to this document. They include Mapping of Lobster Fishing Territories within CCMR territory and Analysis of Behaviour and Recommendations for Management of Shark/Ray Alley-Caye Caulker.

Table 18. Undergraduate research projects conducted at Caye Caulker under supervision of the Siwa-ban Foundation.

Date	Topic
Fall 2003	Lobster fishing and the Caye Caulker Marine Reserve
	Animal encounters: An assessment of tourguide practices at Shark/Ray Alley-Caye Caulker
Fall 2001	Comparison of reef management in 3 reserves.
Spring2001	Study of heavy metals in Caye Caulker groundwater
	The future of development on Caye Caulker
Fall 1999	Caye Chapel: impacts and lessons of development
	Coral recovery at Caye Caulker after Hurricane Mitch
Fall 1995	Investigation of coral bleaching east of Caye Caulker
Fall 1993	Bird population relationships with various habitats on Caye Caulker

4.2.4 Education

The Caye Caulker Forest and Marine Reserve Staff have participated in the community towards environmental education and awareness of the reserves through presentations to the school, community, presence at community meetings, and consultations with stakeholders.

Materials developed currently include three independent slide show presentations and reference material for reef awareness. The Caye Caulker Primary School's Environmental Club receives Belize environmental activities and presentations twice a week. Trips with students to the reef have been completed with the assistance of FAMRACC's representatives and Fisheries Department's staff. It is essential that educational activities be intensified at all levels. SbF's PCV has created an informational brochure about CCFR/MR in addition to a detailed workup for the Environment Club at CCRC School, while PCVs from San Pedro have made presentations at the school as well. CCMR Biologist Maxine Monsanto and SbF Managing Director/FAMRACC Secretary Ellen McRae have also worked on the Environment Club in addition to giving school presentations. Adult presentations should be initiated; Advanced Marine

Tourguide Training, in addition to a special CCFR/MR seminar, is planned for this year.

Students from the University of Belize have made trips to the Caye Caulker Reserves for visits with staff and the conservation site as part of their Natural Resources education.

Educational groups from abroad are visiting Caye Caulker with increasing frequency. The habitats of CCFR/MR lend themselves to short, on-site projects in marine biology, fisheries and tourism. This is an activity that has potential for revenue generation for the reserves.

4.2.5 Forestry and Agriculture

The overgrown cocal covering most of the CCFR, along with similar plantations on southern Caye Caulker as well as many other islands, once was a source of copra (Carrasco, pers. com.). However, in the 1950s copra was replaced by synthetic materials and the market dropped for coconuts (Carrasco, pers. com.). Since that time coconuts have been harvested for coconut oil production on a local scale. At the time of enactment, a few persons continued to harvest coconuts in CCFR territory for sale or personal use in coconut oil production; however lethal yellowing disease and Hurricane Keith (30 Sep-2 Oct, 2000) have negatively impacted the number of available coconuts. Another factor is the extreme crowding of trees, likely resulting in reduced production. These days primarily Sarteneja fishermen stop on the north point to harvest coconuts (CCMR staff, pers com).

Additionally a minimal amount of White Mangrove (*Laguncularia racemosa)* is sporadically cut for balisa (marking for lobster trap locations). However this is not in commercial quantities, and usually occurs without a Mangrove Permit from the Chief Forest Officer. Forestry and agriculture as such are not practiced at Caye Caulker.

5 CONSTRAINTS, OBSTACLES AND MANAGEMENT DIFFICULTIES, CURRENT AND POTENTIAL

In the following sections existing difficulties and potential problems for CCMR/FR will be discussed. These will be handled in a numbered format. The first section deals with overall difficulties, while the two following deal with the Forest and the Marine Reserves, respectively.

5.1 OVERALL

Problems affecting both protected areas are mainly those in the arenas of infrastructure deficiency, finance, staffing, co-management and publicity, some of which are closely related. These are causing continuous difficulties in effective management. They will be dealt with individually below.

5.1.1 Infrastructure Deficiency

A number of infrastructure deficiencies have arisen, in part at least stemming from some of the other situations noted in Sections 5.1.2, 5.1.3 and 5.1.4.

Perimeter demarcation is a major problem, translating into an inability of the Protected Areas to collect fees. This results in a "Catch 22" in which nothing could be done for lack of funds, yet funds could not be accessed due to lack of infrastructure; see following section. Interim anchors for perimeter markers have been donated by the SbF and various dive and snorkel shops in the community; however, the preferred method of installation is unavailable. In addition, reef moorings were installed in 1993 by the SbF, but were ruined by hurricanes; these are of great assistance in controlling impact of reef visitation. Required for CCFR to function is a platform trail system and entry point, as the site is virtually impassable in areas; ultimately the site has little opportunity for fee collection until this infrastructure materialises.

CCMR depends upon its boat for patrols, research and surveys, and access to the village for food, medical assistance and transport to the mainland. Without use of the boat, MPA objectives cannot be met. However its engines—at least 5 years old—are not always reliable. Fuel is virtually impossible to secure. Meanwhile, illegal fishing and guiding, in addition to inadequately managed or excessive visitation, is routinely observed in reef areas. This scenario is inimical to the well-being and effectiveness of the protected areas.

There is also a weakness within the solar power system; the staff lack a clear concept of optimal use of the system. Communication is hindered by a lack of handheld units. Other relatively simple lacks, brought about by lack of finance, likely due to the following constraint.

5.1.2 Financing

CCMR/FR has good potential for sustainability, primarily based upon fees collected from visitation. The REA conducted this fall has shown that in many areas reefs are recovering from hurricane and bleaching impacts, and constitute good attractions for visitors, while habitat diversity within the Forest Reserve includes a surprising variety of ecosystems.

However to date no such fees have been implemented prior to termination of the CZMA/I-implemented project, largely due to the lack of infrastructure. Thus, movement toward independent collection of fees has been delayed considerably. Similarly FAMRACC—the co-management organization having MOUs with Government resource management agencies—had proven unable to procure funding through grants to assist in the CCFR/MR's advancement (see following section) between 2000 and mid-2003. Government through the Fisheries Department has allocated funds for basic operations for the 2004-5 fiscal year.

Currently through the Ministry of Agriculture and Fisheries, the MPA/ICM Working Group is planning to implement an across-the- board 20$ (=10 US) fee for use of all MPAs within the network. For CCFR/MR, this fee will include visitation to both Protected Areas. The mechanics of this is still in planning stages and implementation has been delayed to November 2004. Within this scheme must be covered visits to two MPAs in one day, and packages for multiple visits. This will be important at CCFR/MR as many groups opt to visit both it and HCMR.

Support grants are in process for acquisition of funding for a variety of essential equipment and materials to improve the general function of the Protected Areas in the areas of research and patrols, and to augment their attractiveness to controlled tourism via sound infrastructure and interpretation. More are planned for medium- and long-range activities vital to attain the goals and objectives of the Protected Areas.

5.1.3 Staffing

Since inception CCMR/FR—like most MPAs in Belize—has been plagued with some staff continuity problems. Initially CCMR/FR was given sufficient funding only for one person to occupy both Manager and Biologist positions. These duties included day-to-day management oversight, fundraising/grantwriting, biological research, co-management coordinator and educational outreach, all while supervising enforcement. This workload may have been at least partially responsible for the lack of progress of the areas from inception through mid-2003.

A new Manager joined the staff in July 03, and as of mid-November of that year, a new Biologist also came on stream. A new ranger has recently been hired (Feb 04), and a second (May 04). Thus a new competent staff is present at this time. It is hereby recommended that when a replacement ranger is needed in the future, s/he be hired from Caye Caulker. Such an individual will know the area and be accomplished in the skills of boat handling and maintenance, as well as being more motivated than someone from outside the area.

Due to the length of CCMR, two more rangers are recommended to augment patrols and monitoring, as widely separated attractions make it difficult to adequately supervise the area. Additionally, once activities commence in the Forest Reserve, at least one Ranger—perhaps assisted by the Caretaker—will be required. Current staffing needs include also an education officer, some of which duties have been carried out by both the Manager and the Biologist.

The Budget includes a section on staff, including a timeline designed to be funded by a combination of fees, activities described in the Sustainability section by FAMRACC and PA staff, and grants. However, if a large grant could be obtained utilizing the budget as a model, the existing timeline could be accelerated to acquire staff and other budget elements sooner.

5.1.4 Co-management Situation

In February of 1999, a broad umbrella group having representatives from any interested organization on the Caye was formed to co-manage Caye Caulker's PAs. After a full year of effective working on startup mechanisms such as Articles and Memorandum of Association and completion of a draft of a viable MOU for co-management with both Forestry and Fisheries, internal conflict surfaced, driving away many core members whose knowledge and areas of expertise would have benefited the PAs.

In June 2003 interested parties from some of the original component community groups within FAMRACC—principally the CCTGA—decided to attempt a revival of the organization. New officers were elected and several meetings have since been held. It has still proven difficult to keep the quorum; however the most recent meeting made it. Current plans include an invitation of ministers involved in the National Protected Areas System Plan along with the Area Representative to a meeting to bring them closer to the Reserves. Within this context a site visit is planned.

The Presidency of FAMRACC is currently held by Mr Robert Blease, President of Caye Caulker Tourguide Association, a group deeply concerned about CCMR/FR. As previously stated, many of these guides are also members of Northern Fishermen or are independent fishermen. Guides are the numerically dominant user group of CCMR and, over time, CCFR. Other groups retaining interest are the Parks Committee (Ms Dora Badillo-First Vice-President); Police Citizens Committee (Mr Marcial Alamina III-Second Vice-President); The Siwa-ban Foundation (Ms Ellen McRae-Secretary); Caye Caulker RC School (Ms Liliana Marin-Treasurer). FAMRACC will be rebuilt around the interested membership. Failing interest by member organisations, FAMRACC may be streamlined with those that retain interest.

5.1.5 Community Awareness

The community as a whole is largely unaware of the extent, activities or ongoing work associated with CCMR/FR. However this is beginning to change through enforcement work by staff (restaurant checks, occasional patrols); obvious efforts toward perimeter installation; as well as through meetings and interviews from this project. Reasons for poor community awareness may be variously attributed to:

- Absence of PA presence such as office, museum or education center, within the community (however since Fall 2003 the CCTGA office is sharing space with CCPAs Manager Victor Alegria and his staff);
- Absences caused by long education programmes or research programmes in other MPAs on the part of the staff;
- Lack of community and/or stakeholder education programmes by PA staff or Co-management group at this time due to time constraints;

- Lack of motivation by townspeople to attend meetings; while the majority support the Protected Areas, most are apparently satisfied to permit others to manage it;
- Lack of boundary infrastructure (until late May 2004);
- Loss of reef moorings (installed prior to enactment) due to hurricane.

5.2 FOREST RESERVE

The following section describes current and potential obstacles and problems for CCFR. Current obstacles include: presence of debris from hurricane overwash within habitats, lack of infrastructure such as boundary markers, trails and hides for visitation, and location of sanctuary headquarters. These will be discussed in Section 5.2.1.

Section 5.2.2 contains information about potential problems, those with possibility to affect FR integrity in years to come. These include weakness of designation status; increased encroachment of pollution into CCMR waters and nearshore habitats including mangroves from escalating development activities adjacent to CCFR.

5.2.1 Current problems

The situations below are already impacting CCFR:

a. **Lack of platform trail infrastructure that would permit visitation and thereby fee collection.** Lack of income inhibits use and appreciation of the area as well as proposed littoral forest restoration projects.

b. **Cluttered situation of some terrestrial areas resulting from overwash events in the years 1998 and 2000.**
Land areas including small original trails cut by first rangers were obscured by debris from overwash events from Hurricanes Mitch and Keith. This material is copious and has as yet to be cleared in all but the area immediately adjacent to the Headquarters.

c. **Lack of optimal location of MR/FR headquarters**, situated in CCFR on the northwestern face of Caye Caulker. Although the Headquarters building is spacious and well-constructed, it is located on the relatively breeze-free western side of Caye Caulker's north point, facing away from the reef. Resulting conditions include:
    - Facing the wrong way to easily note reefside infractions by fishermen and guides;
    - Too far as well as facing wrong way to casually track development activities adjacent to CCFR/MR;

- Stifling, breeze-free living conditions including difficulties with insect control, particularly sandflies.

d. Lack of boundary demarcation—no-one knows exactly where the Forest Reserve begins or ends, permitting people and animals from nearby development or passing fishing boats to freely access the PA. This is urgently requires attention in the form of large, obvious signs.

e. Lack of staff to implement full monitoring and surveillance-- Encroachment by an unknown number of coconut pickers, some of whom burn or chop vegetation in the area, for their own benefit— These individuals require a licensing programme to bring their activities under control to compatibility with a protected area. Ultimately this activity should be dispensed altogether.

5.2.2 Potential impacts:
The following problems are predicted to arise if advance planning to counteract them is not conducted.

a. **Weakness of designation status:** A Forest Reserve is inherently designed for controlled extraction. It is also the only category of PA to date that has seen systematic dereservation, usually around election time for land giveaways to influence voting. This designation was selected apparently to accommodate the minimal activities by coconut pickers, in the face of recommendations by Zisman (1992a) and others (cf McRae, 1997) to afford the area greater protection, such as Wildlife Sanctuary or National Park. A higher designation status could be accomplished in the coming year under the NPAPSP.

b. Proximity to proposed development: As noted in Section 1.1.2, the area of CCFR was donated by Mr Harry Dole, who retained the land adjacent to the Reserve and to its immediate south. Development in this land was proposed, denied by Lands, then has been ammended to include a hotel, 56 housing lots, 9 commercial lots (Physical Planning, pers. com.; O'Connor, 1999); however, environmental clearance has not been granted as of early March 2004. The proximity of the development to CCFR/MR demands that it receive thorough attention as regards waste management (DOE, pers. com.; Physical Planning, pers. com.) and hotel and 4 housing lots are located on the piece of land to the immediate east of CCFR; as such it will be of profound importance. The following impacts could begin to affect CCFR resulting from inappropriate development activities adjacent:

- **Trash deposition by adjacent residents and/or businesses**;
  Future residents in Dole's development (Caye Colony) may opt to use the buffer zone or lands along the southeastern boundary of the FR to dump their trash as a matter of convenience; also, storage, dumping etc activities in these areas.

- **Entry into CCFR of exotic species including feral cats, rats and other domestic pests** that may prey on exhausted migrating birds, eggs, and nestlings (cf Atkinson, 1985; Veitch, 1985). Feral cats and rats can rapidly reproduce and are known to decimate bird populations. The southern portion of Caye Caulker is already overrun by these pests.

- **Disturbance adjacent to FR boundary** from development activity from landholders, their visitors or any hotels, including high-impact activities such as **dredging (sediment pollution); nutrient-loading** from hotel and residential sewerage and grey water**; household hazardous waste; oil/chemical inputs** from vehicle storage, spills or other action; **biocides** and **trashing;** the Harry Dole property is directly adjacent to CCFR and are located near Leslie Rocks patch reefs, a series of four patches, the closest to shore of which (Leslie 1) is in relatively good condition but is located only about 300 m from shore. Pollution from parts of this development may discharge directly into MPA waters (see above).

5.3 MARINE RESERVE

Current and past problems associated with the Marine Reserve largely arise from elements of uncontrolled development onshore and fishing activities occurring directly within the MR. In the presence of strong management along with partnerships with other resource management entities in Government and assistance by international programmes, these difficulties are less likely to be present, though development is increasing on the island. Letters c-f denote visitor/use conduct faults that requires sufficient fuel to address—another problem at this time.

5.3.1 Current Problems and Constraints for CCMR

a. **Runoff of pollution from activities occurring on or offshore Caye Caulker and Caye Chapel.** Runoff from both sources has

been documented to reach the BBR during a pulse event of a hard north (SbF video archive); however the amount and content remains to be quantified. Potential sources include: organic effluents in particular from fertilizer runoff, sewerage, solid waste, businesses such as laundromats and restaurants, as well as fishery residue including unused lobster and fish parts may at times introduce high levels of organic material into the sea surrounding Caye Caulker, generated from development within wetland areas deemed "least suitable" by CZMA/I. Additional pollution is likely from increases in dredging to fill the same swamps for development. Potential sources of pollution from Caye Chapel include quantities of: sediment, organic, and chemical pollution, principally from dredging, poorly-placed spoils, runoff from fertilisers, trash and biocides, pulse runoff, potassium permanganate from water inclusions, and hypersaline brine from the 350,000 gpd desalination plant. Additional pollution residues may arrive on pulse currents of northern origin to augment pollution problems. Coral reefs have been shown to be sensitive to even very low concentrations of nutrients and sediments; without teeth in these laws the reef will ultimately decline further even as the island's population grows, resulting in loss of livelihood and even life to Caye Caulker villagers. As living coral declines and is replaced by algae in the most heavily impacted reefs, the bulwark that keeps heavy surf and storm surge offshore erodes down.

b. **Lack of infrastructure**, including full perimeter delineation and reef mooring systems.

c **Overvisitation in some areas of the MR, principally due to large numbers of inadequately-supervised cruise ship passengers**; excessive passengers in any single area; or excessively large boats loaded with passengers. Carrying capacity studies are required to ascertain optimal visitation.

d **Inappropriate conduct by visitors, guides and/or other persons,** enhancing degradation of the marine system. These may include but not be limited to zone activity violation; boat groundings; treasure hunting; anchor damage; harassment of wildlife; collecting; prop-dredging in shallow habitat; too many passengers per guide; coral contact; sediment suspension from fins; collection and/or consumption of marine life by guides or other persons in zones, and others.

e **Inappropriate conduct with respect to wildlife encounters,** especially at Shark/Ray Alley. These include grabbing, hauling, even lifting sharks out of the water by guides; and standing,

walking, grabbing, hauling and feeding by tourists. Shark incidents are known to increase when sharks associate humans with food. Additionally, stingrays may brush up against visitors or guides while begging food, and sting inadvertently.

f **Illegal fishing** by diving fishermen, including spearfishing and hooksticking, prohibited activities within CCMR. Also, taking of fish in excess of the two fish per person within the Limited Extraction Zone, or nonpayment of ticket and day sportfish license fees, are included in this section.

5.3.2 Potential Problems and Constraints for CCMR

These threats and constraints are largely as above, however some of this would diminish given sufficient funds for fuel and adequate monitoring programmes, authority for enforcement and cooperation from Government and international entities in enforcing buffer-zone activities, including appropriate development styles. Increasing colonization of swamp lots will exacerbate existing problems, including fill requirement and pollution runoff. Cooperation with DOE in monitoring and prosecuting effluent sources is hereby recommended.

At this time the barrier reef is a mosaic of differing rates of regeneration from the impacts of 1998-2001. As development proceeds in areas deemed to be “least suitable” or “unsuitable” for development—seasonally submerged wetlands—effluents and resulting impacts may accelerate. It cannot be overstressed that water quality sampling must come on line as soon as possible to detect, trace origin if possible and staunch the flow of pollution into the system. Clearly, appropriate measures of pollution control must become the prerequisite for permitting further development on the Caye; in the case of the swamp developments this responsibility must rest squarely upon the developer—the person who stands to profit from such activity.

6 MANAGEMENT PLAN-GENERAL CONSIDERATIONS AND FRAMEWORK

The following section outlines basic management-related considerations, goals and specific objectives. It also reveals the framework upon which the IMP is based.

6.1 Responsible Parties

The **Belize Fisheries Department** has jurisdiction over marine reserves as provided under Fisheries Regulations, 1977.
The **Belize Forestry Department** has right of governance over the Forest Reserve, as delineated under Forestry Regulations, 1922.
The **Forest and Marine Reserve Association of Caye Caulker (FAMRACC)** at this time has co-management status based upon MOUs signed by respective government organizations in 2000. Following a period of inactivity this

organization is in the process of revitalization and streamlining of itself as detailed in Section 5.1.3.

6.2 GOALS AND OBJECTIVES

The following goals and objectives are based on those developed for other proposed and existing protected areas but are specific to Caye Caulker Forest and Marine Reserves.

Goal 1:

To preserve and maintain in optimal working condition, representative samples of the ecological systems (including coral reef, littoral forest, caye mangroves, and seagrass) in its natural state on and around Caye Caulker for all people, for all time.

Objectives

i. To preserve, maintain, and, where deemed necessary and possible, work toward restoration of structure and function of the outstanding living ecosystems of the area;
ii. To protect and preserve the integrity and natural production of the physical and biological resources in all zones included in both Protected Areas, all ecosystems and habitats through a mixture of sustainable usage and conservation;
iii. To safeguard critical habitat areas for endangered, threatened and rare species of flora and fauna;
iv. To assure that the quality of air and water resources entering the protected area from outside its boundaries remains suitable for the sustained existence of the ecosystems, flora and fauna existing within the protected areas; and to assure that actions resulting in impact are prevented or detected promptly, removed and penalized in an effective manner;
v. To manage the area on a scientific basis; and in such a way that the management system remains sufficiently flexible to incorporate strategies based on new scientific information.

Goal 2:

To provide natural areas for the promotion of education and research.

Objectives

i. To encourage the use of the area as a scientific study center for discerning and demonstrating optimal management of protected areas, including application of such techniques;
ii. To encourage the use of the areas as a base for pure and applied research on ecosystems, flora and fauna of the Protected Areas;
iii. To foster interest in and knowledge of the coastal and marine environment through educational and interpretive programs for schools and other

educational establishments, visitors from around Belize and abroad, and the local community;

iv. To encourage and promote the use of the area as a study center for local and international students.

Goal 3:

To preserve the value of the area for fisheries and tourism, including export of larval and adult marine and terrestrial life in addition to other important marine and terrestrial genetic resources and resource-based activities.

Objectives

i. To afford protection to all habitats supporting species of importance for commercial fisheries and tourism—endangered, threatened, charismatic and interdependent;

ii. To provide undisturbed areas that will ensure increased fisheries production based on larval recruitment from upcurrent sources as well as habitat and refuge for important species to grow and thrive;

iii. To ensure larval export supply for downcurrent habitats;

iv. To provide areas for large showy species to live and grow unmolested, providing attraction for high-grade tourism;

v. To provide undisturbed or minimally disturbed habitat bolstered by infrastructure that affords low-impact visitation while providing quality habitat for permanent and seasonal resident, migrant and transient species;

vi. To provide nondestructive, nonpolluting habitat enhancement in appropriate areas for attraction of fish and other marine life.

Goal 4:

To develop sustainable and ecologically balanced recreational and tourism services that enhance the economic and social benefits of the area.

Objectives

i. To provide well-managed zones for tourism and recreation which do not disturb or impact the Preservation Zone, or significantly reduce the quality of any other zone in both Reserves;

ii. To promote uses compatible with conservation and sustainable development objectives, primarily through education, in addition to surveillance and enforcement of the zoning scheme, including monitoring of high impact development activities on nearby cayes.

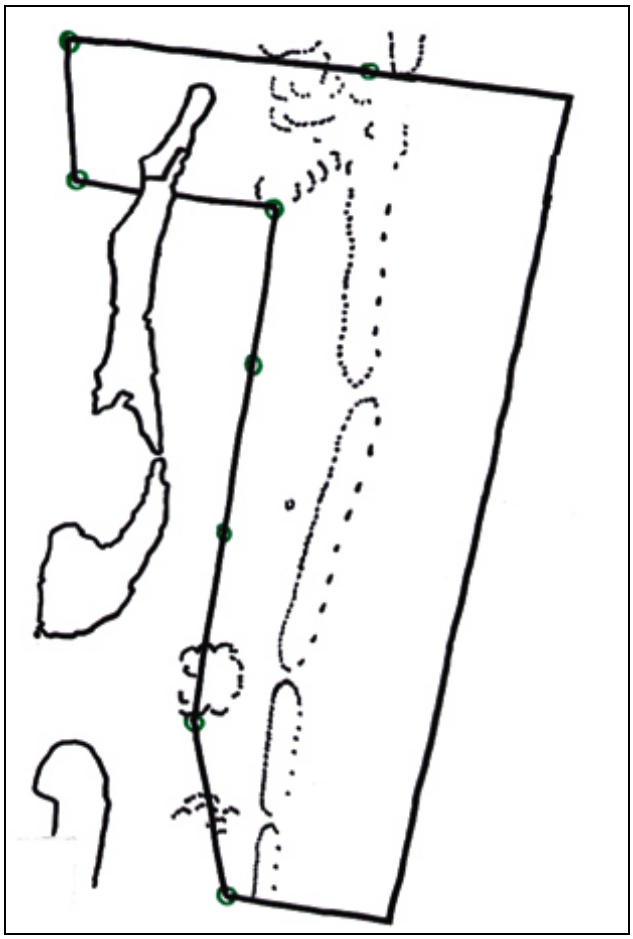
iii. To assist the local community in providing ecologically balanced recreational and tourism services, including contribution to training of tourguides and fishermen.

6.3 DEMARCATION OF PERIMETER

The Marine Reserve forms a “7” shape, with the head crossing over the northern tip of Caye Caulker. At this time the boundaries can be readily distinguished by

sea, as interim marine markers have been placed as of May 2004. However land markers and sea limits, which differ markedly, require placement. Clearly this must be addressed as soon as possible. At least 9 buoys have been used to mark the perimeter, however proper installation using Manta Ray anchors should be undertaken to enhance permanence. Already one of the smaller cement anchors have been moved from its point of placement, presumably by fishermen. Map 10 depicts location of current boundary markers.

Map 10. Current location of emplaced CCMR perimeter buoys.



The Forest Reserve, located at the northern tip of Caye Caulker, meets the Marine Reserve on three sides in addition to a 100-m buffer zone along the jogged southern-southeastern border. Signposts are recommended to mark the borders of the Forest Reserve. This is deemed essential in the face of development approaching CCFR, given the propensity for some people to dispose of waste materials randomly within mangrove and littoral forest areas such as that common in the southern portion of Caye Caulker. Additionally, it should serve as a deterrent to formation of unofficial “trails” through the Forest Reserve, cut by random entry into the area by coconut pickers, construction workers from the adjacent property inclined to shoot White-crowned Pigeons and

other species, burn or extract vegetation; or other persons exploring the area and committing random damage.

6.4 ZONING PLAN AND REGULATIONS

The following zoning scheme is recommended based on the draft plan, community consultations and baseline data. The system is designed for multiple use of the protected area. A minimum of 8 buoys equally distributed over the area should be placed as soon as possible to clearly delineate zonal boundaries, as described in the following section; however sufficient should be placed to permit viewing adjacent buoys.

6.4.1 Description of Zone Boundaries

Zone boundaries will be marked with GPS as soon as weather and other duties permit. Refer to Maps 11A and B. The designation "*" denotes an estimated point position derived from the CZMA/I GIS map of CCMR. Refer to Map 11B for preferred zone siting. The boundaries are as follows:

General Use Zones:

South: Description: This zone is in the shape of a quadrilateral widening toward the north to meet the MPA perimeter in all areas but the NE corner. Principal habitats include barrier reef (backreef, crest, forereef), patch reef (Caye Chapel Coral Gardens) and, in the northwest corner, seagrass.

NW corner: 391913E 1959275N	*NE corner: 394900E 1958800N
SW corner: 392320E 1956864N	SE corner: 394458E 1956570N

North: Description: This zone consists of a broad rectangle extending east-west across the north point of Caye Caulker, the western portion of which corresponds to the northwestern section of the MPA perimeter. This includes the section that surrounds CCFR. The northeastern point is an estimated point. There is a narrow strip extending down in front of the Preservation Zone, occupying the western section of the MPA. The only estimated points in this portion lie on the southern extent of this zone. Most of the habitat west and north of Caye Caulker, in addition to that along the eastern coast, consists of seagrass, with occasional sand patches and small laja sites with Octocorals and a few hard corals. Most of the habitat to the east contains abundant patch reefs, including the Leslie Rocks group, with seagrass interspersed. The narrow strip extending south of the main section is planned for eventual incorporation into the Preservation Zone.

(Main Section) NW corner: 390206E 1968130N SW corner: 390299E 1966280N

Western CC: 391192E 1966813N Eastern CC: 391550E 1966147N

*NE corner: 393900E 1967700N Inside corner: 392935E 1966001N

(Narrow strip) ***SW corner: 392530E 1963450 N *SE corner: 393225E 1963400N

Conservation I Zone:
(Controlled Visitation)
Description: This section consists of a large rectangle bounded to the south by the Southern General Use Zone, to the east from the dropoff line by the Limited Extraction Zone, and to the north by the Preservation Zone and the southern point of the Northern General Use Zone. Habitats include barrier reef (backreef, crest and forereef), patch reef (Caye Caulker Coral Garden), and lagoon (seagrass, bare sand, laja). Only the Southwest corner marker is noted within the SI as part of the perimeter. The remaining points are estimates based upon the CZMA/I GIS map of CCMR/FR.

NW corner: 392530E 1963500N *NW corner: 395070E 1963100N

*SW corner: 391913E 1959275N *SE corner: 394900E 1958800N

Conservation II Zone:
(Controlled visitation—Shark/Ray interaction)
Description: This is a small rectangle embedded within Conservation I. As this location implies, the new Conservation II is not related to the proposed zone of the same name, which has been altered to form the new Limited Extraction Zone.

The zone encompasses algae-rubble with a few coral colonies, sand and to the western border, seagrass. Its southern section includes a shallow-water Queen Conch nursery, in which no reef moorings will be set. Shark/ray interactive tours will take place in the northern section of this Zone. All points were measured by GPS from CCMR staff.

***NE Corner: 392950 1960260 *SE Corner: 392896 1960103

*****NW Corner: 392694 1960363	*SW Corner: 392715 1960102

Limited Extraction Zone:
Description: This is a broad rectangle occupying the NE corner of CCMR, appended by a long strip running along the eastern perimeter marked by the dropoff of the forereef into the deeper water. As the reef margin has not had the opportunity for GPS measurement, the line marking the western boundary of the narrow southern portion of this zone is regarded as representative of this feature, but not definitive of the actual location. Measurements must be made to determine the actual location of this line; enforcement will proceed accordingly.

Only the northeastern corner is part of the original boundary of CCMR; the remaining points have been extrapolated from the CZMA/I map. Habitat included is barrier and patch reef, extending past the dropoff into indigo water. Only this latter habitat is included in the narrow section. This abuts against the Southern General System to the south, and the Preservation and Conservation Zones to the west. The main section lies to the east of the Northern General use zone.

Main Section:

*NW corner: 393900E 1967700N	NE corner: 396671E 1967478N
*SW corner: 393600E 1965950N	*Inner corner: 395550E 1965700N

Offshore Trolling Section:

*****SW corner: 394250E 1958500N	*SE corner: 394800E 1958400N

Preservation Zone:
Description :
This is a moderate-sized rectangle bounded on the north and east by the Limited Extraction Zone; on the west by the Northern General Use Zone extension; and on the south by Conservation 1. The area includes barrier reef (backreef, crest, forereef), with considerable dense seagrass on the western side. The eastern portion includes all reef structures; the Limited Extraction Offshore Trolling section covers no reef structure, as the dropoff is the zone boundary.

*NW corner: 393600E 1965950N	*NE corner: 395550E 1965700N

*SW corner: 393225E 1963500N *SE corner: 395070E 1963100N

Discussion and Summary of Zone Revisions: These zones were selected through meetings with Caye Caulker and San Pedro tourguides and fishermen. They differ from the original zones proposed in the first plan in the following ways:

1. Northern General Use: The strip along the front of the Preservation Zone is proposed as temporary in nature; ultimately this should be remanded to the Preservation Zone, after management moves that permit only commercial fishermen with traps lying in the area to set lobster traps. Once these fishermen retire the section may be remanded. The southern tip has been annexed into Conservation 1.

2. Southern General Use: This zone has been extended northward into territory originally covered by Conservation 1. This is because of the need to shift Conservation 1 northward (See No. 3 for details).

3. Conservation 1: This zone was shifted north because some important sites frequented by tourguides were placed originally within the proposed Preservation Zone. Thus, all adjacent zones required adjustment to accommodate this: Southern General Use increased in size; Northern General Use saw its southernmost point remanded to Conservation 1; Preservation shifted north; and the main body of the proposed Conservation II (now Limited Extraction) shortened (See No. 5).

4. Conservation II: A new Zone created expressly to accommodate feeding encounters. The principal reasons it was deemed necessary was to keep wildlife feeding out of any other Zone, as well as to control visitation and conduct as regards feeding and resulting wildlife encounters. This Zone is principally algae/rubble, sand and seagrass, with a few coral rather poor clumps in very shallow (rough average 1.2-1.5 m) water.

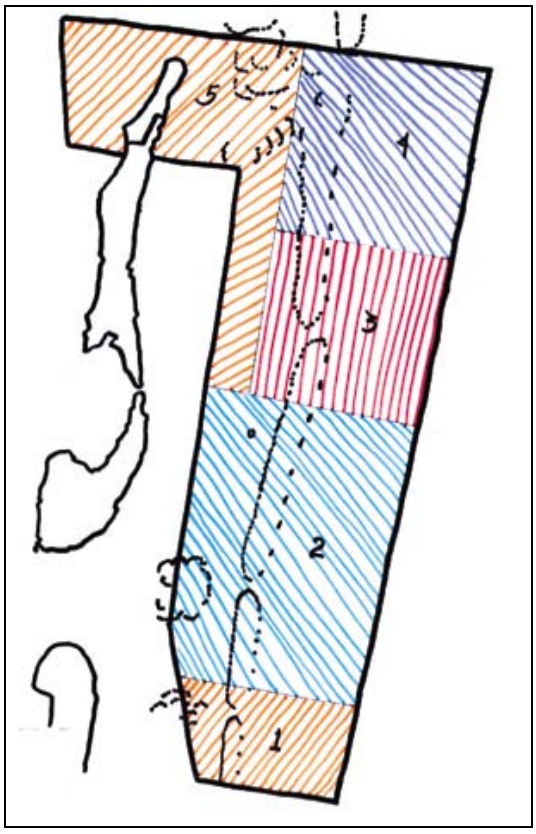
5. Preservation: This section was shifted north to accommodate snorkeling sites known alternatively as “Point of Reef” and “Swash”. It retains its original length, however has lost the strip of open water habitat down the eastern perimeter to the newly-created Limited Extraction Zone. Preservation includes the full spectrum of barrier reef and seagrass habitats.

6. Limited Extraction: This Zone, comprised of the remaining territory of the original Conservation II in addition to the seaward strip along the eastern boundary of the two Zones to the immediate south—Preservation and Conservation I. The original designation Conservation II permitted identical

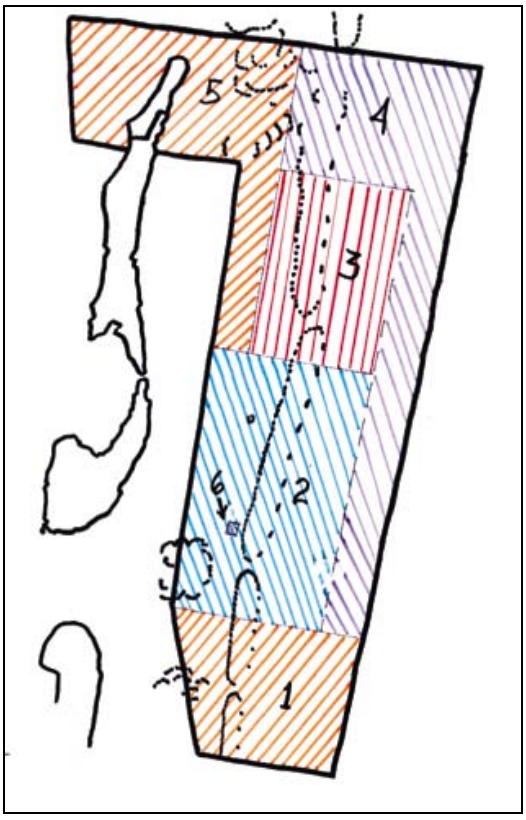
use as Conservation I with the exception of permitting catch-and-release fishing only. By popular demand the strip of sea marked on its western side by the dropoff is—in addition to the reef areas in the northern part of the old Conservation II—have been revised to permit extraction of 2 fish per person. This is a limited sportfishery that should result in minor impact to fish stocks in the MPA.

Map 11A. Original proposed zones-CCMR (CZMA/I data):1 General Use South; 2. Conservation I; 3. Preservation; 4. Conservation II (original).; 5. General Use North. Map 11B. Current proposed zones as revised by community input: 1. General Use South; 2. Conservation I; 3. Preservation; 4. Limited Extraction; 5. General Use North; Conservation II (Ref. Appendix 6).

A



B



6.4.2 Buffer Zones

Marine Reserve

Caye Caulker is located a little over a mile from the Barrier Reef, while some patch reefs are located considerable closer to the island. Seagrass and other lagoon bottom surround the island on all sides, with a fringe of mangroves remaining in undeveloped areas on the island. According to LaPointe (pers.

com.), materials such as nutrients and sediments may be carried two miles or more before settling out. By this criterion, Caye Caulker is located well within the nearshore zone; in confirmation of this, sediment plumes have been observed reaching the reef from both Caye Caulker and Caye Chapel during a Norther. CCMR's western boundaries lie approximately halfway between the Barrier Reef and the island. Thus Caye Caulker lies within a liquid buffer zone surrounding the Marine Reserve.

In recognition of this CZMA/I has set up Caye Caulker and its surrounding waters as a specific development zone. A site-specific committee has been formed—the Caye Caulker Coastal Advisory Committee (CCCAC)—having a mandate to produce a specific set of development guidelines, designed to prevent high-density congestive and polluting development styles in the future. However, the committee is in effect powerless to do more than recommend action, as many guidelines are being ignored. In view of the fact that materials from both Caye Caulker and Caye Chapel have been observed to reach the barrier reef, the islands themselves and surrounding waters must constitute the buffer zone. Research needs to be conducted on current flow in the area—particularly during storms with offshore flow.

Due to the real hazards described in 5.2.2 and 5.3.1, strong controls on dredging, waste management, and development activities in general need to be enforced to maintain water quality standards within CCMR. To assist in this a strong partnership is recommended between the CCCAC, CZMA/I, and CCFR/MR staff, with an MOU or other arrangement empowering Staff to assist in enforcement of environmental compliance plans and test water quality in general.

Forest Reserve

CCFR maintains a buffer zone of 100m outside the perimeter. Within this zone development activities may not be undertaken (Physical planning, pers. com.). Care must be taken that vegetation removal, fill, dumping, equipment, lumber, fuel and/or vehicle storage, and other high impact activities also do not occur there. Fencing is recommended in order to assure exclusion of casual entry by construction personnel as well as pets.

It is hereby recommended that, in view of the location of Headquarters, a watchtower structure be placed on the Eastern shore boundary directly adjacent to the private property immediately to the South. Height is recommended at 2 floors, with a covered observation platform on top. The first floor of the tower should be enclosed, provided with a composting toilet and utilized as a venue for collecting tickets for visitation. This would facilitate:

- Monitoring of activities within CCMR waters in the northeastern sector;
- Monitoring activities within the terrestrial buffer zone immediately to the South of CCFR, and suspected inputs to CCMR waters from development in that property;

- Starting point for platform trail/hide system envisioned to showcase habitats of CCFR for paying visitors;
- Collection point for tickets, pre-purchased before trip departure at same vending point as CCMR.

The second floor should also be enclosed to provide storage, bunk beds and table for work or eating. Thus personnel may occasionally remain in that facility for longer periods than a single day.

6.4.3 General Rules of the Marine Reserve

The rules and regulations in the following sections are based on the principals of "Do no harm".

Within any zone of the Reserve:

1. No person shall have any living thing in their possession without a special permit from the Fisheries Administrator except as stated in this Plan;
2. No person shall deposit any material in or on the Reserve waters without a special license from the Fisheries Administrator. Input to waters entering the Reserve from outside sources is strictly prohibited;
3. Blowing or otherwise moving bottom substrate with power machinery in order to collect fill material, uncover any salvage or antique items is strictly prohibited;
4. No person shall deface or interfere with any marker, buoy, sign or notice within the Reserve;
5. All users will abide by the permit and/or fee system outlined in this Plan;
6. Gloves will not be worn within any part of CCMR;
7. Scientific research will be permitted by license issued by the Fisheries Administrator;
8. No thrill craft (jet skies, cigarette boats, etc) permitted within PA boundaries;
9. Licenses and permits are not transferable;
10. No boats over 45 feet, or with greater than 40 persons. permitted within MPA waters other than passage through;
11. Set carrying capacity values for visitation sites will be strictly enforced;
12. All accidents having injury or property damage shall be reported as soon as possible to Reserve staff; however no liability whatsoever is assumed by the Reserve Management, Fisheries Department, and/or Government of Belize—visitors assume all risk while en route, within, or transiting, CCMR/FR.
13. All Fisheries Laws apply;
14. Other Statutory Instruments as required may be enforced by Reserve Staff by prior arrangement with Department;

15. The SI for CCMR/FR will establish and set meaningful penalties for violations within the PAs including but not limited to: zone activity violation; boat groundings; anchor damage; harassment of wildlife; collecting; dredging or blowing sand with power machinery; prop-dredging in shallow habitat; guide:passenger ratio of greater than 1:10; coral contact; sediment suspension by fins; inadequately-supervised passengers; excessive passengers in any single area; excessively large boats loaded with > 40 passengers; large boats mooring at systems inadequately-rated for tolerance. Penalties may include any or all of: fines, exclusion from CCMR/FR, prison time, in addition to penalties assessed under other SIs than that of CCFR/MR. Education programmes and literature will make clear these points, and a system of clear warning before actual citation is planned.
16. SCUBA diving near coral in less than 6m of water is strictly prohibited, unless at a designated spot for instruction.

6.4.4 Preservation Zone (Core)

1. No entry, except in emergency or by permit (See No. 4);
2. No removal of any marine life;
3. No tourism visitation;
4. Entry for scientific research by permit only.

6.4.5 Conservation 1 – Limited Visitation

1. No fishing of any type.
2. No collection of any item, living or nonliving, with the exception of rubbish, except by permit from Fisheries Administrator following consultation with CCMR Manager;
3. Habitat disturbance, damage and/or destruction strictly prohibited.
4. Non-extractive recreation permitted; requirements outlined for visitation.
5. Boats must use appropriate moorings if available.
6. Throwing of anchors in coral reef formations of any type or any other form of habitat destruction strictly prohibited.
7. No feeding, handling, or harassment of marine life of any type.
8. No dumping or placement of organic material or chum of any type within perimeter.
9. Visitation limits will be prescribed on a site-by-site basis as indicated in Limits of Acceptable Change (LAC) studies.

6.4.6 Limited Extraction

1. No fishing except a) Catch-and-release sport fishing; b) Two-fish per person limit except Nassau and/or Goliath Groupers (prohibited); c) Permitted extraction by remaining traditional trap fishermen—three only individuals, names to be specified, permits to be issued. Following an initial two year period, re-evaluation shall be conducted. It must be noted

that ALL traps within 100 m of coral or the Preservation Zone Boundary must at the outset be moved beyond that distance [shades may not remain within this zone].
2. No extractive activity except trolling (moving fishery)-by sportfish license from the Fisheries Department, saleable by CCMR staff or other personnel;
3. No collecting of flora or fauna except as above (6.4.3, No.2);
4. No damage, destruction or disturbance to natural habitat by any means;
5. Non-extractive activities permitted; requirements outlined for visitation (Section 6.4.10).
6. No trolling with treble hooks and leaders.
7. Boats must use appropriate moorings if available.
8. Throwing of anchors in coral reef formations of any type strictly prohibited.
9. No feeding, handling, or harassment of marine life of any type.
10. Accidentally-caught prohibited species must be returned alive promptly to the sea (Ref. Appendix 8).
11. Visitation limits will be prescribed on a site-by-site basis.
12. Limited entry of visitors as indicated by pre-set limits, changeable by application of results from LAC studies.

6.4.7 Conservation 2 – (Shark/Ray Site)

1. Rules 1-6 as Conservation Zone I;
2. Feeding of sharks and rays may be done exclusively by guides;
3. Handling, holding or grabbing of marine life strictly prohibited.
4. Guests remain horizontal in water at all times.
5. Limited entry as indicated by LAC studies.

6.4.8 General Use Zones

1. Commercial and extractive sportfishing by license from the Fisheries Department;
2. Removal of threatened/endangered species strictly prohibited;
3. No collecting of flora or fauna except as above (6.4.3, No.2);
4. No damage, destruction or disturbance to natural habitat by any means;
5. All traps and/or shades must be placed at least 100m from coral;
6. Requirements for nonextractive visitation (Section 6.4.9).
7. No trolling with treble hooks and leaders;
8. Boats must use appropriate moorings if available;
9. Throwing of anchors in coral reef formations of any type strictly prohibited;
10. No feeding, handling, or harassment of marine life of any type;
11. Preliminary visitation limits will be prescribed, then refined on a site-by-site basis via LAC studies;
12. No interference with any fish-attraction structure or other emplaced infrastructure.

6.4.9 General Use of Forest Reserve

1. No extraction of any item, living or nonliving, from area with exceptions as follows: a) Removal of trash/litter; b) (Staff only) Clearing of vegetation for platform trail construction or other necessity; c) Coconut harvest in designated areas (Permit only issued by Sanctuary Manager).
2. Soil or dirt may not be removed from the Reserve.
3. No building or other structure may be erected upon Reserve except the following as constructed by PA staff: a) Small storage facility; b) Platform trail; c) Hides along raised trail; d) Watchtower/observation platform associated with a hide.
4. No discharge or dumping of any material into or onto soil, air or water in or adjacent to protected area; effluents, emissions, runoff and litter punishable under provisions of EPA.
5. Research by permit only, accessible through the Chief Forest Officer.

6.4.10 Template Laws and Suggested Penalties

Following an education programme, proposed to be in the form of an evening seminar, for users and dispersal of literature, one warning will be issued per captain, guest or company before citation is issued. Cruise ship companies and other large-scale operations will be notified of boat size and visitor limitations. There should be an ascending penalty scale for repeat offenders, delivering ever higher punishment to those who do not respect the MPA. It is suggested that infractions within the Preservation Zone be assessed at double the normal penalty.

1. Removal or inference in any way with perimeter, zone marker or reef mooring buoys will be prosecuted by the appropriate Penal Code statute addressing burglary. The same is true for theft of equipment or materials from Headquarters, platform trail or other infrastructure of CCFR. Vandalism shall also be dealt with by appropriate law;
2. Preservation Zone boundaries will be strictly enforced with penalties commensurate with the type of activity;
3. Use of appropriate reef moorings will be strictly enforced; large boats will have specially marked buoys that will handle the weight. Boats over 45', or those carrying more than 40 people, are prohibited to operate within CCMR. Fines should be based on and charged by the foot (boat) and/or by the person (number of people over designated carrying capacity of site).
4. Permitted numbers of passengers will be noted in paint on each reef mooring buoy; guides/ captains exceeding this capacity will be charged by the person; companies routinely sending passenger loads over the limit will receive increasing charges an order of magnitude higher than that of the guides or captains;
5. Where buoys are not available, anchorage must be in sand (note: this application is only available until reef moorings are installed; once buoy

system is in place, a one buoy-one boat policy will be enforced, unless special permission is obtained from the Manager);
6. No boat will be permitted within CCMR for the purpose of visitation or extractive use without a licensed guide or permitted fisherman on board;
7. Sportfish licenses should be required by all visitors who propose to fish in the Reserve, in addition to tickets. Multiple visit licenses should offer discounts to users;
8. The Tourguide SI (1994) will be enforced to the letter of the law, in co-operation with BTB;
9. Deep-sea fishermen using the Offshore Limited Extraction Zone must re-enter the lagoon through South Caye Caulker Channel upon completing fishing activities to have staff endorse their tickets and sportfish licenses. Similar provisions need to be worked out for sportfish trips in the northern extent of the MPA (General Use North and Limited Extraction);
10. Boat groundings, collisions with coral, and prop-dredging in shallow seagrass will be charged by the square foot of damaged substrate;
11. Values for visitor limitation expressed on reef moorings in any given location will be strictly enforced;
12. Violation of the 1 guide: $\leq$10 passengers will be charged to both Captain AND parent company. If the 1:8 ratio is passed, this value will replace 1:10;
13. Removal of or mishandling of threatened, endangered or protected species from General Use or Limited Extraction Zones will be strictly prohibited;
14. Direct contact with coral by visitors without prompt attention by guide will result in citation with payable fine and/or imprisonment to tourist AND guide once due warning is issued;
15. Removal of anything other than garbage/rubbish or coconuts from the Forest Reserve will result in a citation with payable fine and/or imprisonment;
16. Setting fires within CCFR habitats is strictly prohibited and should be punishable by Arson laws. The same is true for burning of signs, ropes or PA infrastructure;

6.4.11 Expansion and Reclassification

Some recommendations are described herein which should strengthen both Reserves as well as potentially lead to an increase in revenues collected. A campaign to effect these changes is hereby recommended to be initiated as soon as possible.

Forest Reserve

It has been established within this document that CCFR was enacted at a weaker level than was originally desired by the majority of the community (cf community petitions, 1997). It is also a fact that Forest Reserves are the only category of protected area to undergo dereservation, although portions of Payne's Creek and Gragra Lagoon National Parks are now facing dereservation (see section 5.2.2).

In the case of Caye Caulker Forest Reserve, the designation category was apparently selected on the basis of the activities of a few coconut pickers. In contrast, the area has been recommended by a number of authors as being important habitat and thus suitable for designation as a Wildlife Sanctuary or a National Park under the National Protected Areas System Act of 1981 (cf Zisman, McField et al, Parham, etc, summarized by McRae, unpub, 1997). Either of these provide a superior form of protection as they are established for conservation rather than controlled extraction. By perusal of the categories under that Act, it was felt that the category "Wildlife Sanctuary" should best suit the territory now known as CCFR (McCalla, 1995).

The Wildlife Sanctuary category already encompasses areas where extraction takes place under controlled circumstances—Crooked Tree Wildlife Sanctuary is a good example. In that case, villagers are permitted to fish within the protected waterways although these days this is being discouraged (BAS AGM). It is recommended that coconut picking be phased out over time as habitat restoration gets under way.

Littoral forest habitat has been described as the most endangered habitat in Belize (Gibson, 2003). Less than 2000 ha of Caye littoral forest existed in 1995; since then the habitat at Caye Caulker at least has undergone steady attrition and is likely to continue in unprotected areas (CZMA/I, 2000). Thus the presence of this ecosystem type within CCFR alone justifies designation to protect "nationally significant biotic communities". The presence of threatened bird species (Black Catbird, White-crowned Pigeon) for which littoral forest is critical habitat justifies designation as "nationally significant species". This designation is further justified by the presence in the area of breeding American Crocodiles (CITES Appendix I).

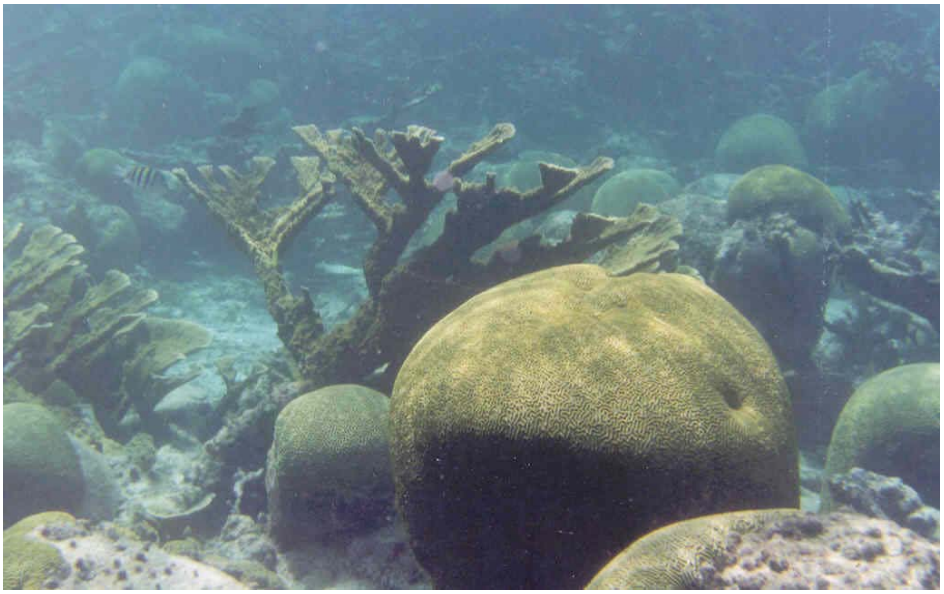
Marine Reserve

Caye Caulker Marine Reserve was initially proposed to run along the barrier mooring #1 (about 100 m south of Caye Chapel Channel) to mooring # 28 (about one mile north of Caye Caulker's north point) (Parham, 1996) (Map 12). However in a comparison of this document to the actual perimeter, it became apparent that a major snorkel site, called the "Mini-Reef" by guides who frequently visited the site on the return from Hol Chan trips, had been omitted from CCMR. Four reef moorings were originally placed at this site during the SbF GEF NGO SGP project (1993-99), two of which received "frequent use" (SbF Reef Mooring records, 1993-99). Not only is the area regenerating nicely since the hurricanes; much of it appears to have somehow been spared the full effects of the hurricane and is still visited by reef tours, with healthy intact Elkhorn, Staghorn, and Brain Corals (Figure 3). Of special note are the intact massive colonies of Clubfinger coral (*Porites porites)*, elsewhere on the reef lying in shards or regenerating in small patches.

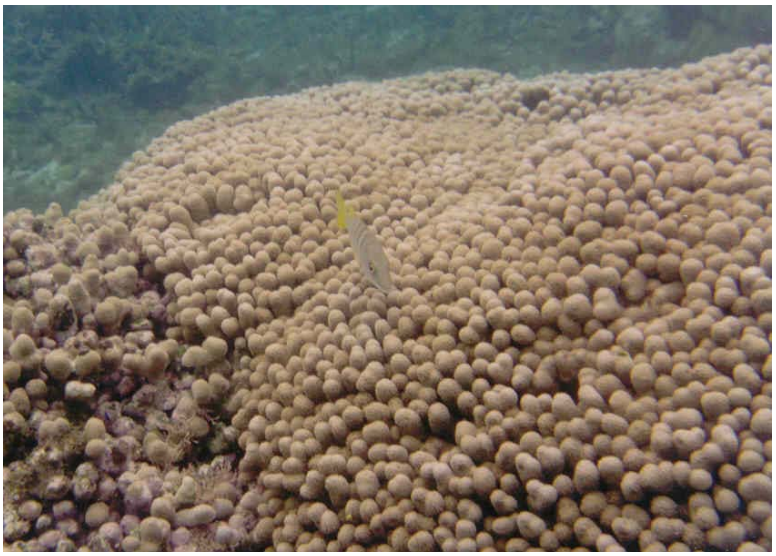
The omission of this area from CCMR this represents a source of lost revenue available to the Reserve. In line with the imminent entry fee hike, guides will visit this site in disproportionate numbers, knowing its quality, and also aware of the fact that they do not have to pay to use it; **neither will this exceptional area receive any form of protection**. Thus, expanding the northern boundary to encompass the area represents a viable means of delivering protection to this exceptional site as well as improving cash flow for the Reserves. It is also worthy of comparison with other sites. Meanwhile, it is recommended that the site be used as a companion and control in monitoring efforts for CCMR in its present form. GPS positions for the old moorings are available; however these should under no circumstances be reinstated without CCMR expansion to incorporate the site and afford it some protection.

Figure 3. Views of "Mini-Reef", a site north of North Caye Caulker Channel. This area was part of the original proposal for CCMR (Parham, 1996), however was not included in the boundary set in 1998. a. Healthy *Diploria strigosa* and *Acropora palmata* colonies; b. Portion of large (~3 X 2 m) intact colonies of *Porites porites.*

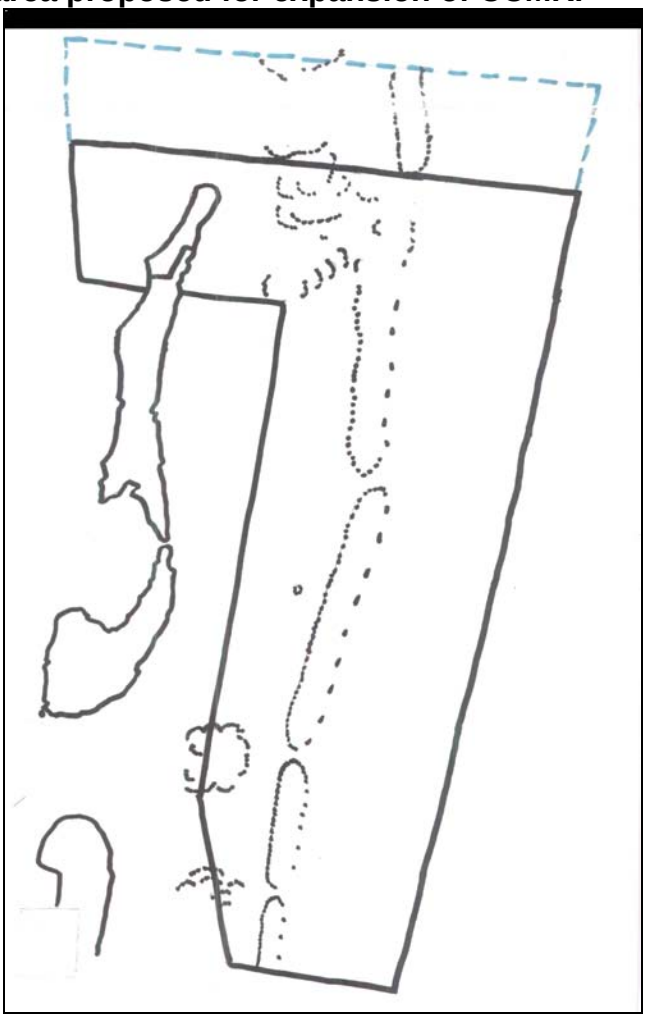
a.



b.



Map 12. General area proposed for expansion of CCMR.



6.4.12 Mapping Revisions

Additional GPS readings along the Barrier Reef collected during the REA were transposed to the existing map. During this exercise it was noted that the southern portion of the Barrier Reef lying within CCMR is actually a minimum of 500m further east than is depicted in original maps. Additionally two smaller channels (Caye Chapel and South Caye Caulker Channels) are actually present rather than the single very large one depicted. All CCMR maps should make use of the new GPS points and brief habitat descriptions appearing in Appendix 3 to reflect this. This contrast appears in Maps 3A-B.

Weather prevented detailed descriptions of northern and central Barrier Reef sections in CCMR from receiving the same detailed treatment as the south; it is recommended that staff complete these explorations once the fuel crisis is solved. Further, deeper forereef sections are also recommended, with GIS surveys conducted especially to determine the position of the dropoff for correct mapping of the deepwater trolling zone.

6.5 MONITORING AND RESEARCH

The following section outlines a plan for research and monitoring during the next five years for CCFR/MR. The monitoring programme will incorporate a methodology for evaluation of effectiveness of management techniques employed within the PAs.

The Caye Caulker Forest and Marine Reserves constitute an integrated multiple use area which is being managed to maintain, better understand, and protect the coastal flora and fauna or Belize and its resident and migrant wildlife. The reserves may best achieve goals and objectives through **ecological stability of natural populations and habitats, including threatened/ endangered species; increased revenue to the community through sustainable usage; increased knowledge of marine life, habitat and its importance;** and **increased knowledge of component ecosystems and species within the area**. Research and monitoring programmes are herein described as to the best means to demonstrate the success—or lack—of management strategies of CCFR/MR.

6.5.1 Marine Reserve

This section recommends a monitoring programme and areas of study within CCMR designed to fulfill management needs.

6.5.1.1 Monitoring

Methodologies used within CCMR will be developed and directed by the Manager along with the Biologist based upon the Synoptic Monitoring Manual developed by MBRS for regional compatibility (Almada-Villela, 2003). Input from the co-management group as well as other interested persons should also be solicited. Rangers, fishermen, tour guides, and local university students are recommended to participate in simple monitoring activities in order to engage

community understanding, knowledge and appreciation of the marine reserve. The programs will resemble efforts in other marine reserves while catering to the specific needs of Caye Caulker.

Monitoring components are recommended in the following areas:

- Species of major commercial importance: Suggested stock assessments targeting Spiny Lobster, Queen Conch, "Horse Conch" (West-Indian Chank); fin fish species including groupers; snappers; large grunts such as Margate and Black Margate; Hogfish; Queen Triggerfish; and others deemed necessary by Reserve staff;
- Keystone species such as Caribbean Long-spined Urchin, parrotfishes, surgeonfishes and other essential reef-based algae-grazers;
- Reef coral cover, condition, recruitment and biodiversity over time (for hurricane recovery, bleaching events, etc) vs visitation (impacts, discerning limits of acceptable change). This should compare and contrast protected vs unprotected habitat;
- Water quality over time, weather, visitation, other factors. Suggested parameters include physical properties such as Salinity, Temperature, and Density, along with nutrients such as phosphates (PO_4), nitrates (NO_3), nitrites (NO_2), and ammonia (NH_3); other factors may be deemed essential or advisable by reserve staff in partnership with CZMA/I and DOE staff in view of the type of development in the area. These should be taken at selected reef, mangrove and lagoon locations;
- "Charismatic" species—those attracting tourism, such as Butterflyfish, Angelfish, Wrasse, etc; note that some of these are also of commercial importance;
- CITES-listed species, including migrations/ use of PA habitats by sea turtles and marine mammals.
- Population dynamics of resident Nurse Sharks and Southern Stingrays within Conservation III. If possible these should be compared with natural populations located within and outside of CCMR;
- Seagrass growth, density, condition and nursery function;
- Mangrove productivity, condition, and nursery function.

Stock surveys, with the cooperation of the Northern Fishermen's Co-operative on Caye Caulker, are essential in providing information about the economically important species and lending a qualitative assessment of the Marine Reserve. The surveys should provide essential information the community requests to demonstrate the success or progress of the Marine Reserve in stabilizing the fishing industry.

Due to growth limitations of sea grasses in relation to oceanographic and sedimentation features, they can be used as an indicator of habitat well-being

(Auil, 1998; Terrados et al, 1998). Thus monitoring should be undertaken in isolated areas as well as areas offshore developed areas, compared with heavily impacted seagrass communities located outside the protected area near to areas off Caye Caulker Village, new developments such as Eden Isles, Pelican Point, and Caye Colony in addition to Caye Chapel. Water quality as described above may be done in connection with this.

6.5.1.2 Research

While monitoring activities apply to practical informational needs, research may be applied or pure in nature. A few suggested areas include, but are not limited by, the following:

- Ecosystem dynamics—energy flow through one system, or through systems such as mangroves-seagrass-reefs;
- Status of reef fish stocks;
- Documentation of spillover effect;
- Planktonic larval studies;
- Behaviour of fish species;
- Genetic research into zooxanthellae within various coral species for bleaching resistance;
- Genetic research into confusing groups such as the Hamlets (*Hypoplectrus* spp);
- Shrimp/anemone relationships;
- Predation/ grazing experiments using exclusion cages;
- Demonstration of etiology, descriptive and epidemiology of coral disease, including links between various types of pollution and its role in reef health;
- Investigation of seasonality in currents within CCMR.

Research and monitoring will require outside funding for performance by staff. Visiting scientists may operate out of Caye Caulker or use the Headquarters as base, while bringing in funding that will help support the PAs. Yet another option is that such as the effort from University of Wisconsin (Superior), working in partnership with staff.

6.5.2 Forest Reserve

The following section addresses suggested investigative effort within the Forest Reserve. Due to the state of a large portion of the area as a relict cocal, restoration activities are also recommended for the area.

6.5.2.1 Restoration

The coconut-dominated high ground of CCFR was presumably originally covered with littoral or thicket. However the density and height of the coconut trees deter colonization by other vegetation types except for some more open patches. Thus it is recommended that two areas be selected within CCFR to be designated experimental forests. Density of coconuts on both sites should be calculated, in

addition to dbh (diameter at breast height); both sites should be otherwise representative of the higher land in the area.

From both of these areas coconut trees should be thinned, but not eradicated. Historically littoral forests grow freely associated with thin to moderate coconuts in the southern part of the island, however this has been thinned by hurricanes and Lethal Yellowing Disease. Exact specifications will be described later following consultations with the Forestry Department.
One site should be kept clear of coconut detritus, but otherwise left to recolonise over time on its own. The second site should be planted with littoral forest and thicket seedlings collected from other Caye Caulker locations. This work was first proposed for CCFR in 1996 (McRae, unpub ms.). These sites should be located away from areas of visitation; free access should be prohibited. A study is recommended to ascertain the most suitable sites, in addition to lay out the optimal route for the platform trail/hides complex.

Mangrove density monitoring, natural regeneration and restoration should also be undertaken, as considerable hurricane kill in the site resulted from Keith (30 Sep-2 Oct 2004). Techniques in accomplishing this task must be reviewed.

6.5.2.2 Monitoring

Monitoring must also be seriously undertaken within CCFR. A baseline for future comparison must be established within the Forest Reserve as well as the Marine Reserve. Essential to the evaluation effort will be surveys such as the following, made with an eye toward long-term monitoring:

- Baseline and subsequent seasonal surveys of plant communities, dragonflies, butterflies, land crabs, lizards, permanent and seasonal resident and transient birds;
- Status of American Saltwater Crocodile population and breeding in CCFR areas;
- Existence of exotic animals such as rats and feral housecats within CCFR;
- Within Experimental Forests, mangrove and littoral forest: Seasonal monitoring of status of young seedlings and use by birds and other animals; comparisons between forests treated in various ways and control; other topics as deemed necessary by personnel;
- Mangrove productivity;
- Populations of juvenile fish and invertebrates within fringing Red Mangrove communities—composition, seasonal abundance, comparisons with unprotected mangrove communities.

6.5.2.3 Research and Monitoring

The terrestrial research and monitoring program should be developed and directed by the Forest Reserve's Biologist in companionship with the Manager; however at this time, the only on-site personnel are marine scientists attached to CCMR. Therefore, research and monitoring should be designed by a

combination of CCMR Manager, Biologist, and competent and interested members of the Co-management group as well as interested local groups within the community. As with CCMR, volunteers and students from Belize and abroad may work as field assistants collecting data under the supervision of the Staff.

Topics should include investigations into essential, threatened, endangered and/or charismatic species composing or inhabiting CCFR littoral forest and mangrove habitat. Suitable topics may include but not be limited to: life studies; population dynamics; larval export; predation; habitat use and others as noted below.

- Life histories of plants of littoral forest and thicket, including seasonal succession of fruiting;
- Documentation of insect life other than Odonata and Lepidoptera;
- Land crab populations and habitat use;
- Habitat preference and usage of various bird species;
- Mangrove productivity/detrital production;
- Crocodile nesting/habitat use and or population study.

The Headquarters building should increase its capacity as a field research station by seeking to upgrade its lower level in a system of laboratories and equipment storage for marine and terrestrial research. Funding should be sought to this end; see Section 6.7.2.

6.5.3 Socioeconomic Data and Resource Use

A key element to the Caye Caulker Forest and Marine Reserves is noting the social and economic effects, positive and negative. While socioeconomic monitoring may be designed by the Manager, the Co-managers assume some responsibility for contributing to research and monitoring of social and economic results of the reserve. Survey results should enable the Staff to more clearly evaluate the needs of the stakeholders and reserves to effect better management.

Possible topics for research include:

- Collection of market and income generation data on fish, conch and lobster catch from fishermen working within General Use zones in the MPA;
- Assessment and comparison of spearfish catch adjacent to CCMR and in areas located more distant from the MPA;
- Surveys to evaluate attitudes and behavior of tourists and residents towards the forest and marine reserves before and after community education programmes;
- Effectiveness of tourguides as reflected by their customers' opinions;
- Feasibility of Staff running a weekly lecture series for guides and interested tourists as a project with dual goals of raising conscience and income generation;

- Investigation into lines of most saleable items for production for sale at ticket outlets, CCFR collection point and other selected sites.

6.5.4 Management Effectiveness

This section delineates desired methodology for evaluation of effectiveness of management actions. Evaluation of effectiveness is an essential part of protected area management, as without it management is guesswork. In this day of reduced funding, protected areas must direct precious resources where they will be most effective.

Currently the Manager is writing a grant to promote an effective evaluation programme. Two components of effectiveness analysis are herein proposed: monitoring and analysis matrix.

6.5.4.1 Monitoring

Several of the programmes proposed in Section 6.5 have effectiveness assessment as their basis. Such information as carrying capacity (limits of acceptable change--LAC)—essential for longevity particularly of reef resources—may be discerned by effective environmental monitoring, in addition to enforcement evaluation and tourist surveys of guide performance.

Water quality monitoring should discern effectiveness of the linkage between DOE and CCMR/FR, and the effectiveness of environmental legislation in a time of accelerating development in environmentally unsuitable areas. With demonstrated effects of environmentally unsound development—land-based sources of marine pollution—presented with scientific basis within this document, it is proposed that the linkage between DOE and CCFR/MR staff work in combination with Co-management members to design and present strong educational programmes as to these effects and the importance of sound development in controlling reef impacts via such mechanisms as siltation, nutrient loading and chemical/fuel impacts using data from PA monitoring schemes. This concept is further discussed in Section 6.7.

Monitoring within CCFR of plant diversity and bird abundance and use within experimental forest areas will go far to determine effectiveness of the habitat restoration project; while routine assessment of baitfish population may discern if management strategies are effective in maintaining viable populations in mangrove areas. Monitoring of perimeter and interior for exotic species such as feral cats and rats will be a measure of the effectiveness of the perimeter in screening out these species, or control measures employed once they have gained entry. Additional monitoring will include a variety of parameters, as described below.

6.5.4.2 Evaluation Matrix

The evaluation grid was formed based on a modification of the Nature Conservancy Scorecard System for Central American protected areas, presented

by Cifuentes et al (2000). A template appears in Appendix 7. This basic framework should be modified by CCFR/MR staff over time as new situations, projects and impacts arise. General areas covered include Administration, Policy, Legal, Planning, Knowledge, Illegal Use, Legal Use, Biogeographic Information, and more; it is deemed a very thorough treatment.

An essential element will be community participation. For this purpose the Co-management group—an umbrella group of primary stakeholders—may fill this role, calling for additional interested participation it deems appropriate from other key stakeholders.

6.6 SURVEILLANCE AND ENFORCEMENT

The routine surveillance of the Forest and Marine Reserves should chiefly be the responsibility of the reserve rangers, along with the Manager or Biologist, depending upon which supervisory personnel is on call. Both reserves need strict enforcement at all times to ensure the productivity and benefits of the reserve present themselves by the conservation efforts.

The Environmental Protection Act of 1992 carries along with it powerful legislation with the potential to control effluents and emissions of pollution resulting from development, however due to manpower deficiency they cannot monitor everywhere in the country at once. Thus the linkage between DOE and CCFR/MR provides a mechanism to enhance enforcement of this important legislation while protecting essential marine habitat.

Along with this, it will be education that assures the reserve users are sufficiently well-informed about the rules and regulations of the reserve to encourage compliance. This program should include the following:

- Regular patrols in the Forest Reserve, and all zones of the Marine Reserve to deter any illegal fishing and harvesting activities, damage to flora and fauna and encroachment into the Preservation Zone. Patrols to these areas should be done at irregular intervals during the day to ensure that illegal activities do not “avoid the checks”.
- “Spot” checks at night to the Preservation Zone could be carried out jointly with the Caye Caulker Police. It is extremely important that the Reserves’ regulations be strictly enforced at the outset.
- Irregular “spot” checks in General Use zones to assure that extractive fishing activities are only by persons cleared to do so by Reserve Management.
- Underwater “spot” checks should be conducted after training with residents and guides to ensure that stakeholders and tourists are not trampling on the corals or illegally removing any flora and fauna from the marine reserve. The checks can also enable patrols to evaluate possible illegal fishing activities.

- Rangers should be trained in a civil approach, and use good communication skills to educate and explain the rules to visitors of the Reserves.
- Reserve biologists, visiting researchers, guides, fishermen, volunteers and other people working in the reserves will be requested to report any evidence of illegal and potentially damaging activities.
- Guides and interested youth of Caye Caulker should be invited as non-participating “patrol officers” to enable rangers to understand the needs and objectives of enforcement and surveillance.
- Regulations governing the area must be well publicized in order to allow tour guide participation in surveillance. A seminar of one to two evenings concerning rules, regulations and codes of conduct may be conducted to assure this. Community members and tourguides have the capacity for vigilant explanation of the rules of the Reserves to their clients.
- At all levels, participation by stakeholders is encouraged; trust and willing co-operation has the potential to reduce offences to a minimum.
- Volunteer wardens should be trained and encourage to assist in patrolling CCMR due to large size of MPA. At least some of these should be guides and/or fishermen, as these are out in the area on a routine basis. This would be of special importance before the second boat and brace of rangers is acquired. Again, preference should be given for the second set of rangers to be from Caye Caulker.

6.6.1 Forest Reserve

Surveillance in the Forest Reserve will primarily entail monitoring boundaries for encroachment by persons lacking valid reasons for being within CCFR boundaries. This may be accomplished by boat and via subsequent boundary walks. Special attention must be directed toward persons who may wish to deposit rubbish or solid waste within FR boundaries; those having machetes, shovels or chain saws looking to extract plant materials or soil for fill; or those looking to store illegal materials within the perimeter. Vandalism and theft of equipment at Headquarters may also be anticipated. A close relationship with CC Police is envisioned, to address elements of conventional illegal conduct within the Forest Reserve.

Harvest of Coconuts

CCFR has been enacted for habitat and wildlife protection in addition to education, research and controlled extraction. The sole activity occurring within CCFR rendering “Forest Reserve” status is the periodic harvest of coconuts from the overgrown cocal (Manzanero, pers. com.). The principal recommendation in the literature for Caye Caulker was for Wildlife Sanctuary; while earlier recommendations from the community were for National Park status, due to rarity

of littoral forest habitat as well as rapid mangrove deforestation on other parts of the island (Zisman, 1992; McRae, unpub.).

Coconut harvesters should be surveyed as to their favoured sites for coconut collection. Area(s) within the FR must be designated for this activity and must be strictly enforced, as free passage should not be permitted throughout the area by any visitor. Those wishing to harvest coconuts within CCFR must go through a permitting process, including restriction of area of activity. Unpermitted coconut harvest or that in unauthorised areas will be considered offenses.

Harvest of timber, sticks or other wood products will be strictly prohibited, as will any farming, crop-growing or soil removal activity within CCFR.

6.6.2 Marine Reserve

Surveillance should address all elements of use, including ticket punching, zone-appropriate conduct; fishery law; tourguide law; Port Authority law and, when possible, environmental law.

Zone enforcement pertains to rules and regulations of each zone within CCMR. As shown in Section 6.4, each zone will have detailed regulations regarding visitation and conduct. Surveillance will consist of cruising into a zone and viewing activities being conducted and who is conducting them. Near the outset, licenses will need to be checked along with a list of persons permitted to conduct activities, such as guides and fishermen. Enforcement within each zone will consist of citations, which will be heard in court; and, where appropriate, confiscation of illegally collected items.

The Tourguide SI may be enforced by agreement with Mr. Anthony Mahler, Director of Product Development within BTB. An agreement with the Port Commissioner may enable an agreement with that organization regarding enforcement of laws regarding boating safety, passenger load and the like. A preliminary visit to the DOE has opened links with the Senior Environmental Officer regarding the potential for an MOU in the areas of enforcement of environmental law such as effluents, emissions, and environmental compliance of EIAs. The latter may be accomplished via simple site visits, or it may require completion of more complex tests, as detailed below.

6.6.3 Marine Buffer Zone (Waterborne Impacts)

As soon as funding permits, it is recommended that the CCFR/MR staff acquire equipment with the capacity to discern pollution as recommended in Section 6.5.1.1. This will be required for drawing connections, if present, between land-based sources of marine pollution and demonstrated effects on the reef. Detection of emissions and effluents originating from specific sources at Caye Caulker and Caye Chapel should be enabled, while the earlier-described MOU will permit a more effective means of addressing evidence of malfeasance.

6.6.4 Monitoring Potential Development

Successful operation of Caye Caulker's protected areas demands thorough knowledge of issues of use and development. Unending vigilance and prompt assessment of encroaching impacts such as the commencement of building within the recently-issued (2002-3) government housing lots, located south of CCFR/MR areas, or Harry Dole's development, which is within CCMR waters and directly south of CCFR. It is also essential to be prepared for increased demands such as volume of cruise-ship tourism or simply an upsurge in Caye Caulker based use. One projected impact is a lobster hatchery, proposed by NFC.

The initial phase, set to take place over three years, is to raise 1000 Spiny Lobsters from juvenile to adulthood (Myvette, pers. com.). This project is unlikely to result in a great increase in nutrient load; however initiating any large-scale ranch will result in impounding many thousands of lobsters in close proximity, along with introduction of uneaten fish meal pellets, animal excrement and decomposing dead animals into the environment (Myvette, pers. com.). Potential impacts include nutrient load from uneaten food, excrement and dead animals, in addition to export of disease on the sea currents, due to crowded conditions. CCFR/MR needs to follow this project closely.

6.7 INTERPRETATION AND EDUCATION

The subsequent section addresses a major aspect of this set of Integrated Reserves—the educational aspect. From the beginning of the Sanctuary movement on Caye Caulker, education was seen as the tool that could save the island from the ravages of overdevelopment that afflicts San Pedro. Thus, the teamwork between DOE and CCFR/MR permits not only linkage for enforcement, but for its partner component, education. At this juncture, education must be viewed as a tool to engender the following:

- Respect within the community—most particularly the decision makers—for the various elements of the PAs and ecosystems in general as necessary to promote physical and economic well-being over time;
- Moving stakeholders, tourists and students from the level of awareness of CCFR/MR to participation and advocacy;
- Support for the various management strategies and programmes presented by the CCFR/MR staff;
- Compliance with laws and regulations by all users when within the PA boundaries;
- Greater motivation of guides and fishermen to appropriate conduct when using marine and terrestrial habitats;
- Greater sensitivity of developers and landowners on Caye Caulker to survival requirements of marine ecosystems, especially reef habitats, resulting in motivation to develop in a "do-no-harm" manner;
- Promotion of sustainable activities within and adjacent to CCFR/MR

6.7.1 Need For Presence of CCFR/MR within the Community

At this point in time the reserves are limited to sharing space in a small office with CCTGA. The linkage should continue, however there is insufficient space in the current facility to house educational displays and programmes deemed necessary by CCFR/MR staff, especially in view of the fact that CCTGA plans to reopen snorkel gear rentals once it secures a Tour operator license in the same office. Currently HCMR tickets are sold from the facility; CCFR/MR plans to practise this method of distribution.

It is hereby proposed that CCTGA and CCFR/MR continue their association, described in Section 6.8.4 from an infrastructure perspective and herein represented from that of education:
Within a joint facility the groups along with FAMRACC:

- Design informational displays that are interactive where possible; a percentage of this should be devoted to history of NFC and fishing on Caye Caulker—a “Fishermen’s Museum”;
- Place a small bookstore/museum shop in which pertinent educational books, sanctuary-designed souvenirs such as T-shirts, checklists, calendars, and other items to generate funds for the PAs.
- A small charge—approximately 2-3$ Bz—should be charged to tourists, to encourage visitation and support displays. Schoolchildren may be free entry.

Regular presentations may be offered at this facility by staff, targeting tourists at a moderate charge. These educational programmes of local marine and terrestrial life have the capacity to enhance visitor experience, as well as enlighten people as to desired conduct in the protected areas. Charges can go toward support of the Fishermen’s Museum in addition to a stipend for the speaker.

6.7.2 Trail System and Watchtower

Within an entry point structure limited educational displays should be placed, including a map of the trail. Booklets to accompany the trail should be on sale at the site as well. The staff on duty should be able to provide a brief talk to persons or groups preparing to enter the trail.

From this facility a platform trail system is planned, with numbered self-guided elements installed along the rails that can be further explained by guides and instructors with groups of tourists or students, and detailed by the booklet mentioned above. These stations can be placed on platform rails in proximity to the described feature. The platform should be 1 m above substrate level, supported by cabbage bark or bullet tree wood posts.

A booklet should also be produced, enumerating the trail's highlights and providing additional information about the ecosystems. Additionally, at photogenic spots along the platform, such as those areas having bird congregations, crocodile basking platforms or nests, or by exemplary lagoonside habitat, hides may be constructed to enable photography without disturbing wildlife. Educational materials may be designed for those walls, protected within the small buildings which may be useful in identifying birds and other life in the area. All advertising materials promoting the area for visitation should describe appropriate clothing required for optimal visitation—lightweight long pants and long-sleeved shirts for protection from biting insects. Otherwise, these may constitute a deterrent for visitation.

During the early part of the second year funding should be sought to acquire CCFR personnel, as described above a Biologist and Ranger to specifically implement activities within terrestrial habitats. If this effort is successful, these personnel should conduct a definitive study to identify the best route for the trail in addition to experimental forests, which will be described below. If funding for the personnel does not come through, a consultant should be hired, to work along with current staff in accomplishing this goal.

6.7.3 CCF/MR Headquarters/Station

At this time there is no facilitation of visitors in CCFR. Personnel are frequently away on various duties; however the Caretaker or other personnel may be available at times. As time progresses lab facilities are planned, and visiting or local scientists may opt to use the site for their own research. The Caretaker or other staff on site may be trained to provide a short talk about ongoing activities; alternatively, tourguides should at least be able to describe the location, brief history and activities of the staff. This will be an element of tourguide training for CCFR/MR.

Visitation of the facility should be encouraged in a similar manner to the Smithsonian Research Institute at Carrie Bow Caye. The site may be shown without disrupting the scientists at work, with some opting to describe their work to interested persons. It will also be of interest to schoolchildren, both at CCRC Primary School and the new High School as it evolves. Similarly, tour and student groups also may opt to visit the station. The trail described in Section 6.7.3 may opt to place a segment near the Station to afford an opportunity to visit, if the preliminary study reveals it to be the optimal route.

6.7.4 Interpretive Materials

A series of informational pamphlets are planned for CCFR/MR. The Peace Corps Volunteer for SbF prepared the first edition of a brochure about the PAs, which Fisheries is in the act of revising. This will be followed by other informational materials, including a brief evening seminar delineating rules and regulations of CCFR/MR, prepared by the staff of CCMR/FR and/or elements of FAMRACC. Some of these—species checklists, field identification manuals—

should be salable in keeping with the financial plan (Section 7). Section 6.7.3 describes an important publication for CCFR.

6.7.5 Community Outreach

The following section outlines education activities within the community of Caye Caulker. A recommendation is also presented to make timely presentations in stakeholder communities such as San Pedro, Belize City and Sarteneja/ Chunox at least twice/year each.

6.7.5.1 Decision Makers

Presentations should be made to CCDAC membership including the Village Council, utilizing data collected from CCMR in comparison to areas where development has overwhelmed the ability of environment to cope—such as Florida, USA. Subsequently strong evening programmes for the community are recommended. Based on previous experience, politicians and government officials as guests are the best draw for community audience.

Additionally, these individuals may benefit from field trips, in order to display the best sections of the PAs and convince them of their importance and consequent requirement to control effects of runaway development and other activities.

6.7.5.2 Tourguide Training

An evening seminar is proposed as the optimal method by which to present rules and regulations of CCFR/MR to guides. This programme should be mandatory for all guides planning to work within CCFR/MR, and should produce a sticker or other non-reproducible supplement for a guide's license. The seminar should be of brief duration (two evenings or less) and feature a succinct but thorough review of zones, rules and expected conduct.

Additionally, programmes aimed at tourguides should be provided by CCFR/MR staff as part of the evening presentations.

6.7.5.3 Youth/ School

Presentations should be made in both primary and secondary schools about the importance of our natural habitat; what it does for us; proper conduct and development techniques; conservation and research programmes being undertaken within the Protected Areas; and other topics of interest. Initially, Manager and Biologist should present, with assistance by PCV. Ultimately CCFR/MR will have its own Education Officer. The Environment Club, commenced initially in 2002 by PCV Amanda French, is recommended to continue, either by a subsequent PCV or by a teacher, with input from PA staff, the PCV, or Co-management organization members.

Existing curricula should be reviewed with an eye to enhancement and inclusion of references to CCFR/MR and its importance within the community. Age-appropriate suggestions about appropriate development styles, the importance of waste management and other "unglamourous" topics not generally covered in

school presentations should be included, as inappropriate development styles are to some extent responsible for reef degradation. In particular, the role of human gut bacteria in White Band disease of corals (*Acropora* spp) should be stressed.

6.7.5.4 Community/Tourist Programmes

Evening programmes should be scheduled at least twice per month if not weekly. Admission may be charged to tourists, with free entry to Caye Caulker families, including guides. The programmes should cover a variety of topics, including fish biology and behaviour, coral spawning, invertebrate species profiles, bird migration and species profiles, and CCFR/MR research and monitoring topics. Guest speakers may be brought in from time to time, from a variety of sources including MBRS, BAS, Friends of Nature and others.

Community members—guides and at-risk youth in particular—should be invited to participate in simple monitoring programmes within CCFR/MR. These programmes should feature training and participation in integral monitoring programmes, which may translate to superior knowledge of the area as well as a greater proprietary feel of the MPAs.

A similar scenario for tourists or university groups should translate into funds for CCFR/MR in a programme designed to involve paying tourists in simple research programmes. See Section 7 for elaboration.

6.7.6 Museum Displays

As previously mentioned, CCFR/MR requires a presence in the community to be effective. Years of isolation at the Headquarters at the North Point have done little to enhance knowledge of the importance of CCFR/MR within the community. Once the shared facility of CCTGA and CCFR/MR is built, a variety of shifting displays depicting topics of local interest is proposed. Interactive displays that demonstrate principals are envisioned as superior to simple informational displays with nice photos or illustrations, as they require action and discovery on the part of the target audience.

6.7.7 Participation of Co-Management Group

Throughout the educational programmes, involvement by FAMRACC as co-managers is integral to the success of the programme. FAMRACC must provide vital support in every possible way to these programmes, including selection of subject material, design, construction, and any other action required to accomplish education. Once the Education Officer has been hired, close liason between this person and FAMRACC membership will be required. Members will also participate in presentation of programmes to schools, community or tourist groups. FAMRACC membership may also present in other stakeholder communities in partnership alongside CCFR/MR staff. FAMRACC will also conduct competitions of posters, artworks and essays among schoolchildren, raising and offering prize money for winners.

FAMRACC should support many aspects of CCFR/MR by writing grants that provide infrastructure and equipment for research as well as education.

6.8 ADMINISTRATION AND MAINTENANCE

The following section describes CCFR/MR's actual structure in both human and infrastructural terms.

6.8.1 Organisational Structure

Management responsibility for CCFR/MR is held jointly by the Fisheries and Forestry Departments of the Belize Government, and the Co-manager, FAMRACC, the latter via MOU. The Fisheries Department is charged with ensuring that the Marine Reserve is managed in accordance with Fisheries regulations set forth by the Fisheries Act (Ammendment) of 1980. The Forestry Department will be responsible for ensuring that the Forest Reserve is managed in accordance with the Forest Regulations as set forth by the Forest Protection Act, until such time as reclassification may place the area under jurisdiction of the National Park System Act of 1981.

Day-to-day management is the co-responsibility of Manager, Biologist, Rangers, along with the Co-manager, assisted by Volunteers as available. The Co-managers form together with the Staff as an advisory committee, assisting with planning and management of the area, proposing actions and advising on proposals from Staff members.

FAMRACC is an umbrella organisation which was formed for the purpose of community involvement with MPA management. Its objectives as described by it Articles of Association are enumerated below.

- To protect and conserve the marine and terrestrial environment;
- To abide by and encourage the enforcement of all laws, rules and regulations concerning the environment and Belize's natural resources;
- To abide by and encourage the enforcement of all laws, rules and regulations concerning reproductive seasons and other aspects of the marine resources;
- To abide by and encourage the enforcement of all laws, rules and regulations governing the Forest and Marine Reserves;
- To educate the general public about our marine and terrestrial environment;
- To develop a Management Plan for Caye Caulker Forest and Marine Reserves;
- To co-manage with Government the affairs of Caye Caulker Forest and Marine Reserves, and to disperse money for the purpose of maintaining the integrity of ecosystems within the Reserves;

- To make recommendations for legislation and regulations, including admission fees and other charges to be levied in relation to the Reserves;
- To assist in ensuring that development and proposed development on the island and in nearby areas do not compromise or threaten the integrity of the functioning ecosystems within the Reserves;
- To recommend areas and assist in developing programmes for research and monitoring;
- To assist in recruiting the required human resources and, along with the Manager, assume the role of human resource manager including contributing to performance assessments;
- To obtain resources necessary to accomplish all of the above through admission fees, grant funds and other resources.

6.8.2 Staffing and Volunteers

The CCFR/MR staff is currently comprised of one Manager; one Biologist; two Rangers and a Caretaker. A PCV annexed to SbF was frequently on loan to CCFR/MR for research, monitoring or other necessary tasks; these will vary over time. Positions needed within the sanctuary structure include: 1 Biologist and 1 Ranger for the Forest Reserve; 2 more Rangers for the Marine Reserve; and 1 Education Officer. It is also recommended that a PCV be acquired directly by CCFR/CCMR to cover various duties until funding for the additional positions can be acquired.

Volunteer labour for construction may be drawn from organisations such as Trekforce—a volunteer group specializing in construction projects. Individuals for longer term projects may be drawn from the US Peace Corps and their Canadian counterparts. At times university students from abroad may opt to volunteer for varying lengths of time for specific projects or to assist the PAs in general.

6.8.3 Training, Seminars and Workshops

Training of staff has been irregularly scheduled up to now. Training in such required skills as SCUBA certification, policing skills, grantwriting, and monitoring has heretofore been sketchy and haphazard, opportunistic in nature. Training has taken place both within the nation and abroad. Past and current marine managers have attended conferences and workshops on subjects such as coral reefs and protected areas management.

It is essential that the staff continues to take advantage of these training programmes to continue to enhance their capacity to effectively manage the Reserves. However, it is recommended that the training take place in a logical sequence, and that each new staff member receive the training needed to accomplish his/her job. Table 19 shows suggested training topics for each position. It is essential to take each individual's skills into consideration when planning a training schedule for staff. It is also important to not short-staff the Reserves by sending too many staff away at the same time.

While some of these topics may find their way into occasional workshops, others may be difficult to locate. In these cases, local expertise within Belize may be sought to build a workshop on a given topic or group of topics. Funding for these may be sought from GEF NGO SGP, PACT or any similar programme that surfaces in the future. Some may be of value to MBRS, and this group may be sought in formation of some workshops, attended by their own sponsored MPAs in addition to others such as CCMR—of value in its own right.

Table 19. Suggested topics for training for various MPA staff

Position	Training Topics
Manager; Biologists	Administration; Financial Reporting; Conflict Resolution; Topics in Marine/Nearshore Management; Pollution Control in Small Island Development; Wetland Issues; Coral Reef Ecology/Management; Grantwriting; Water Quality Issues;
Manager only	Installation of Reef Moorings; GIS/mapping;
CCFR Biologist only	Coastal Forest Ecosystem Management; Forest Plant Monitoring and Management; Monitoring Birds; Detection, Population Control or Eradication of Feral Animals/Rats;
CCMR Biologist	Marine Species Identification; Monitoring; Project design; Statistical analysis; Coral reef ecology; Mangrove/seagrass ecology; Seawater analysis; Reef Fish; Economically Important Invertebrates
Rangers	Police training; Power Squadron course (Small boat handling/safety); Outboard Engine Repair;
Education Officer	Presentation Skills; Interactive Techniques For Environmental Education
Caretaker	Woodwork Repair; Outboard Engine Maintenance/Repair; Fibreglas Patching/Repair; Special Constable training
All Except Caretaker	SCUBA certification; Research Diving; Small boat handling

In addition training opportunities should be sought for FAMRACC membership serious about partnering in the management of these two important Protected Areas.

6.8.4 Infrastructure

Both marine and terrestrial protected areas require improvements to provide services as well as bring in revenue to get started and then keep the cycle going. The following sections outline infrastructural needs for CCFR/MR. Some have been mentioned in previous sections.

6.8.4.1 Forest Reserve

The highest priority for CCFR is to establish and mark its boundaries. This is especially important as people do not know where it ends and private land begins.

A platform trail system is deemed to be the optimal method to control visitation, such as minimizing impacts of animal encounters—ie, accidental meetings with crocodiles or nest disturbance; prohibiting soil compaction; and permitting water flows, vegetation, and animal life to pass unimpeded.

Initially one loop trail is envisioned. This should commence at the Southeastern point of the Forest Reserve with a short dock extending over the sea, for parking of boats, and extend into the Reserve. Rough but weatherproofed lumber may be used to construct the 4' wide platform. Unless full funding is achieved, the first year a half-kilometer of trail may be laid, with subsequent portions to complete a scenic, diverse loop placed as soon as funding for materials can be secured.

Two to three additional constructs are recommended for the trail complex. One is the Watchtower, to be placed at the southeastern margin of CCFR at the beginning of the trail. This location is advisable for two reasons: At this time there is no presence at the southeastern margin of CCFR; and once there is a presence, it will present an opportunity for tourism visitation of a working field station. It will also provide an opportunity to view development activities to its immediate south, and, when the tower is complete, enable staff to monitor a wide area of the marine reserve.

During the first year at least a single-level cabin should be constructed. Its purpose is to serve as an entry point to the trail system for visitors and as the site of ticket collection by staff. The cabin should be compact yet of sufficient strength to support a second floor and observation platform above, to be constructed at a later date. A composting toilet facility for use by staff and visitors will be required. The bottom section may be a station for CCFR ticket collection, a repository for dispersion/sales of printed informational material to guests, and limited educational displays. At least one chair and functional desk should be placed within the lower flat of the watchtower for person who will be controlling entry to CCFR facility.

The following year the next level may be enclosed. A stairway should be constructed to this room, which should contain a bunkbed set and shelves. A rainwater collection system of gutters and small plastic vat can provide fresh water for drinking and washing hands.

Additionally up to two hides may be constructed along the platform trail route. These should be simply but durably constructed of rough lumber, with benches along the wall and observation ports for observation and photography. These should be focused upon but not interfere with, areas of particular interest to birds and/or crocodiles. A laminated poster identifying common birds of CCFR may be displayed on a wall.

Due to the combination of Government's inability to support its protected areas in addition to years of inactivity of the Co-management organization FAMRACC, resources for construction of this desirable infrastructure do not currently exist. Thus, the reactivated Co-management organization should work along with CCFR/MR staff to estimate the amount of lumber required to produce a loop roughly 1.5 km in length plus watchtower and 2 hides. Crooked Tree Wildlife Sanctuary has proven helpful in this area. Width should be 4 feet and the platform should be mounted on Bullet Tree or Ironwood pilings approximately 1 m above the substrate.

Funding for at least the first portion of the trail, the watchtower base, the personnel and the study should be sought during the second 6 months of 2004.

6.8.4.2 Marine Reserve

The major essential requirement for CCMR's infrastructure is buoy systems. These are considered as immediate priority. They fall into three categories: perimeter; zonal boundary, and moorings. See Map 9 for existing positions of demarcation buoys.

- Perimeter Markers- A minimum of 12 markers should be placed behind the Barrier Reef and two in the forereef for the purpose of marking CCMR's perimeter. 8 of these are already in possession of CCMR staff and are awaiting anchor systems, while at least 4 more systems require procurement. Depth at corner points needs to be recorded, then 7/8-inch poly-line down-lines measured with 1.5:1 scope, cut, prepared with chafing hose and eye-spliced, then ultimately placed with appropriate anchors for marker systems. Manta-Ray anchors for low-weight requirement would be sufficient for this, as no boats will be tying up to these. Maintenance for their tethers and shackles will be required.
- Zonal Boundaries- At least 10 zonal boundary markers are required for clarification of zones in locations not coinciding with a perimeter marker. Small temporary buoys should also be placed at the corners of the transition zone. Maintenance for their tethers and shackles will be required.
- Reef Moorings- A total of 35 reef moorings is recommended for CCMR. These include a combination of replacements for systems lost during Keith, new backreef systems, and forereef systems, useful for SCUBA divers. At least 6 Manta Ray anchors and 1 Halas pin have been located from the initial reef mooring project. Tourguides and dive operators were interviewed as to their preferences for new system locations. All of these will require maintenance on a routine once deployed: monthly pickup line/buoy inspection; quarterly downline inspection; biannual shackle change.

However in order to accomplish this installation equipment is required. During a recent attempt to install reef moorings the machine broke again, leaving serious

doubts about its usability in the near future. Thus it may be prudent to acquire our own setup.

6.8.4.3 Headquarters/Research Station

The Headquarters building is sturdy and in good repair. Upstairs is set up for living quarters and an office/reception area, while downstairs is equipment storage.

A solar power storage system has been installed on-site, however it cannot support the use of a computer, and barely supports three resident staff at any given time. The first priority for the Headquarters to become fully functional is a stronger solar power system. A half-day consultancy with a solar power expert will inform the staff on optimizing use.

A radio affords communication with the Fisheries Department and other Reserves, however it appears impossible to contact the village, since most villagers including the police use different channels. Thus there is no easy way for rangers to contact the village in times of emergency, or simply when trying to organize an activity with village-based personnel. Apparently this can be addressed through programming the existing radio to receive and transmit at these wavelengths (Sabal, pers. com.). As with the solar power situation, a radio technician should be brought on-site to correctly programme the radio. A minimum of four handheld sets—tuned to the main frequency—should be available to be carried by field personnel, to maintain contact with base, the police, and anyone in the field. These are considered critical for health and safety and must be secured within the first six months of 2004.

Four chairs, a refrigerator, a four-burner stove, a small shelf set and dining table make up the contents of the kitchen. There is remarkably little storage space in the large room for food. Freshwater supply is by gravity feed rainwater from a tank of unknown volume, supplied by roof-runoff.

Three small staff bedrooms each with one bed line the northwestern portion of the upper floor. A fourth along the south wall contains a bunkbed. Nails have been pounded in for storing BCDs and clothing, a reflection of the lack of shelving for clothes and personal items. In the front room of the upstairs portion are 5 chairs, a rough wood platform and desk complete the furniture inventory on-site. A computer was originally assigned to the MPA however it has ceased working since 2002. At this time the Manager is using Bacalar Chico Marine Reserve's (BCMR) computer. This is located in the CCTGA office. A shower and composting toilet completes the upstairs complement.

Storage facilities are included in the lower level. Inside are 12 storage batteries, approximately 10 long perimeter mark buoys, 3-4 each of several sizes of Manta Ray anchor; 5 Halas pin anchors and two U-shaped Halas markers. There are a backpack sprayer and a nonfunctioning Malathion blower, an item considered

inappropriate for a Reserve of this nature. Insecticides as well as water sealant and other chemicals are stored on shelves along the north wall of the room. The tank for the composting toilet occupies the southwest corner of the room. Currently no area within the Headquarters is devoted to scientific research. There is neither equipment, nor seawater flow system, nor even a worktable on site. Dive equipment is limited to 6 tanks and 2 regulators, stored in the bottom floor. There is a digital video camera with an underwater housing.

Further along in the planning period (approximately Year 3) an addition may be sought on the primary building for a wetlab. In this structure a seawater flow-through system may be installed to facilitate aquaria from wet projects of visiting researchers. This facility should not be constructed on the ground, but rather raised at least one meter on posts to reduce flies and deter sea influx during overwash events.

Required accessories for the Headquarters include first and foremost a computer. However, until substantial improvements are made in the solar power system no computer can be based at Headquarters without drastically shortening its lifespan. A used computer is being offered from University of Wisconsin (Superior). Thus it is recommended that this be installed at least temporarily in the shared CCTGA office in the village.

6.8.4.4 Village Office/Fishermen's Museum

At this time the only interface between the community of Caye Caulker and CCFR/MR is the placement of the aforementioned borrowed computer within the CCTGA office. Thus an enlarged facility is envisioned to bring the protected areas into the community. This has become urgent in view of the fact that CCTGA will soon acquire a Tour Operator license and resume equipment rentals and tour bookings from the office, rendering space for CCFR/MR's computer/office presence insufficient.

The linkage with CCTGA is recommended to continue. This maintains a close-knit relationship between PA staff and the number one user group—tourguides. Fishermen are also well-represented in this scenario as approximately 40 of 101 members are also members of NFC. As previously mentioned, the property on which the current office is located belongs to the Cooperative, which plans to build an office complex upon it (Blease, pers. com.). Prompt negotiations should be undertaken to ascertain if the village-based complex proposed below can occupy the NFC land, as the opportunity to do so will likely diminish over time. It is recommended to approach this organization with a proposal to expand the building as previously noted, adding space for displays and seating for presentations. If this is not possible an alternative site should be sought.

Once this is accomplished the following course should be pursued:

- Enlarge the existing building within 1 year to include office space for the two entities, an area for displays, along with a second floor

on the joint office to function as a small sleeping area for nonresident staff. A restroom/shower facility should be added. Design specifications to be arrived upon by CCTGA and CCFR/MR to accommodate activities of both groups, along with NFC within the framework of their plans. Funding for the facility may be sought jointly;

- Due to the rich fishing heritage of Caye Caulker, it is recommended that a portion of the display space be allotted to a permanent display depicting the history of Northern Fishermen, created by Caye Caulker fishermen. To place a display of this type permanently within the birthplace of NFC would be a monument to the enterprise of those people that fought to make it happen. The remainder of the display space should remain available for shifting educational displays, available to community members, students of all ages and origin, and tourists;
- Add a second level for nonresident Staff so they can remain in the village following presentations in stormy weather, or stay for early departures. This can be in the form of two small rooms above the offices. Access may be provided such that persons staying in the upper area may use the bathroom facilities without entering the offices.

6.8.4.5 Boats

CCFR/MR's current boat is a 25-ft Mexican-style skiff, powered by 2 4-Stroke Hondas that are at least 3 years old and unreliable. The boat itself is in working condition, but is in rough condition and requires renovation to render it a better workboat for research. The engines require immediate replacement.

Ultimately CCMR will require two patrol boats due to the combination of heavy use and large size (11.1 km). The purchase of one new boat such as a 26-ft Pelican with two 60-hp Yamaha engines is recommended during the first year to provide an attractive, speedy patrol vessel with capacity to overtake fleeing vessels. Once the new rig is in possession, and sufficient funds are in place, work on renovation of the existing vessel can commence. Replacement engines are also required for this boat.

A reasonable monthly fuel allotment will be crucial in assuring patrol effectiveness. It must be remembered that current living quarters at the north point are 3.5 miles away from the village, and further distance from the reef. Sufficient fuel for patrols in addition to research and monitoring activities, as well as communication and education within Caye Caulker, is required. As long as inadequate power supply remains at the Headquarters/ station, travel to the village will be required every time staff needs to use the computer. Thus, fuel supply requires increased ration from Fisheries, as 100-200 gallons/month is insufficient for all these needs.

6.8.4.6 Equipment for Research and Monitoring

It will be necessary for both CCFR and CCMR to acquire equipment to conduct necessary monitoring activities in accordance with MBRS standards, in addition to infrastructure maintenance.

Due to the location of CCMR adjacent to an area of explosive development, it is considered necessary to acquire some water quality monitoring capacity. This is because such equipment is seldom available from owners when needed. In view of the trend toward development in seasonally-submerged lands, with its capacity to generate reef-damaging pollution, at least the following should be tested for on a routine basis at strategic points:

- Basic parameters, such as temperature (T), salinity (S), dissolved oxygen (DO); turbidity, suspended sediment,
- Nutrients, including NO_3, NO_2, NH_3, PO_4;
- Coliform bacteria.

Collaboration with MBRS should indicate the optimal choice of equipment, including that which can be shared effectively and that which should be purchased by CCMR. CCMR should pursue a closer relationship with this organization; though it is unlikely to offer financial support to an MPA located as far from the border as Caye Caulker, material support or cooperation in equipment-sharing may be possible. Some parameters will require sample collection, preparation for transport and analysis at an off-site lab.

Other necessary equipment includes at least two more regulators to supplement those already in place, completing 4 full sets in addition to the 2 extra tanks.

7 FINANCIAL SCENARIO

Every functional protected area requires a firm financial basis of support for its various activities. Without this basis a protected area descends to the level of a “paper park”—absent in effect except for the legislation that created it. The stakeholders of CCFR/MR are committed that it should assume a world-class position even in the face of increasing development pressure. The following reviews the current financial status of CCFR/MR, summarises the basic needs and requirements of the PAs not only to sustain its marginal functionality, but to implement important programmes involving stakeholders intimately with CCFR/MR personnel. It also provides a five-year budget to this end, including a sustainability plan.

7.1 Current Situation

At this time Caye Caulker’s protected areas are in a less than ideal financial situation, as initial support funding from CZMA/I’s GEF block grant has terminated and a fee structure is not yet in place. Responsibility for salaries has been remanded to Fisheries, who has made an agreement with central government to cover salaries. However, fuel for patrols, travel between

Headquarters and the village—a distance of 3.5 miles (~5km)—as well as research is in short supply. Funding will be sought in the form of grants to assist with the interim until fees come online. As monies become available from a variety of sources the programmes described can come on stream in a timely fashion.

7.1.1 Forest Reserve

At this time there is no income supporting the Forest Reserve. Forest Department Co-management schemes are generally far more reliant upon the co-management partner than are Fisheries management. Thus the reconstituted FAMRACC needs to seek funding to bring needed resources into CCFR for infrastructure development so that it can be opened to the public and collect fees. At this point there is no justification for charging entrance, as no infrastructure exists; even the old trails cut originally by the first staff are overgrown.

However visitation by tour and educational groups is encouraged and a few are beginning to stop at the station. Once infrastructure is in place CCFR is foreseen to have moderate to good earning potential.

7.1.2 Marine Reserve

Fiscal responsibility for the MPAs supported by the second BCZMA/I GEF block grant has been transferred to Belize Fisheries Department, including staff salaries. Salary needs for the first part of 2004 will be met with Central Government funds by contract to tide staff salaries until fees are implemented (Belize Fisheries Department). Distribution of the proposed 20$ fees for all MPAs is currently in a state of review process with the MPA/ICM Working Group respective Government agencies. Ultimately fees should cover salaries and expenses.

It will be essential that accounting be clear and thorough so that Reserves have timely access to funds generated by their own facility in order to facilitate proper management. Co-management can assist in procuring supplementary funds for specific projects. This will be important especially before and immediately following the inception of fee collection (November 2004), as it will take time to build up an amount sufficient to pay salaries, purchase fuel and equipment, effect repairs and maintenance and cover other various expenses of an effective working MPA. One potential concern in this system might be a tendency to disburse funds from an MPA with high earning potential such as CCMR to an area of lower potential but high value, such as Glover's Reef, to such a point that the heavily visited MPA is operating at a loss. This tendency must be avoided to avert the "Goose with the Golden Egg" scenario. Fortunately most of these MPAs already have NGO support, such as WCS (Glover's Reef), MBRS (Bacalar Chico, Sapodilla Cayes), and TNC (Port Honduras). CCMR will need all the income it can get to initiate its programmes. Once in place, controlled visitation can bring in sufficient money to share with other important MPAs in the chain.

7.1.3 Earning Potential

While Caye Caulker Marine Reserve is a relatively small-area MPA at just over 9000 acres, it has great attraction in its large and diverse sections of regenerating coral, including areas of Elkhorn and Staghorn (*Acropora* spp), and areas of considerable fish population. One area of the reef (Conservation Zone II, or Shark Ray Alley) has been developed for controlled marine life encounters. In addition, turtles, dolphins and manatees are occasional to frequent transients seen in the area. The habitat value of littoral forest far exceeds its area (Lopez Ornat & Lynch, 1990). Though most existing stands are thready, with normally short, dense trees growing tall and rangy to compete for light with high density coconut trees, habitat restoration is planned in the form of experimental forests, in a number of attempts to re-establish native vegetation in an area of thinned coconut trees.

These features, in addition to a Forest Reserve having infrastructure to view birds and crocodiles in their natural habitat, constitute considerable attraction to Caye Caulker.

In addition to the biological value, the village is easily accessible and reasonably priced, with an active and unique Belizean-oriented lifestyle distinct from other more heavily developed destinations. Thus Caye Caulker Marine Reserve is considered to have high earning potential. A well-run, effective set of Reserves has a high probability of supporting the majority of at least its basic activities from entry fees.

7.2 Sustainability Plan

Essential to keeping CCFR/MR viable for all people for all time is a powerful financial sustainability programme. While CCMR has a likelihood of deriving the bulk of its basic operating funds from entry fees, however improvements in staff, infrastructure and research and monitoring equipment will need to be financed as well.

As CCFR is a prime habitat for crocodiles and birds, mangrove and littoral forest ecosystems, building tourism here in addition to research will be considered an essential element of sustaining the Reserve. Thus the priority for placing the first level of the watchtower and at least 0.5 km of the platform trail is high.

Aside from fees, a variety of opportunities exist for supplementation of income. They will be enumerated below. Destination of funds will depend upon whether funds originate from NGO or Staff activities.

7.2.1 Sales of CCFR/MR-related items.

Along with tourism comes the desire for memorabilia of the locations visited. In this interest, a line of souvenirs is planned for CCFR/MR, salable within the gift shop at the Fishermen's Museum.

- First and foremost, T-shirts will be designed, having scenes from reef, threatened and endangered species from all habitats.
- Secondarily, cards with photos taken on the MPA will be produced. A 2005 calendar—computer-produced—with views from various habitats—should be produced. There is a large library of existing photos from the Siwa-ban Foundation, in addition to other photos, as well as the presence of a digital video with still capacity and underwater housing associated with CCMR.
- Books including field guides about the Reserves and the life within them should be written and sold with at least some profits going to the CCPAs Trust;
- Other items, such as hats, bags, cups, polo shirts, sweatshirts and other useful items impressed with designs and logo of CCFR/MR.
- Original children's books may be written about subjects surrounding the Reserves;
- Products designed for the express purpose of supporting conservation activities within CCFR/MR;
- Existing items such as local handcrafts or paintings may be obtained and sold at a profit.

7.2.2 Design of itineraries based around CCFR/MR

Nature tour itineraries may be designed that showcase the marine habitats of Belize. These can also visit other destinations briefly, then concentrate several days in Caye Caulker Village, from where they hear lectures by staff then visit selected prime sites showcasing the various habitats. A lump sum from the base price of each tour sold is sent to the Trust for use by the PAs.

7.2.3 Simple research and maintenance activities with tourists

Interested persons may be recruited to perform simple tasks related to research and pay for the privilege. This type of programme is offered by several organizations for profit. The opportunity is two-sided: tourists get to do something meaningful while on holiday, and the fees they pay go to support the Protected Areas.

7.2.4 Visiting Researchers

Small numbers of persons desiring to conduct research on any aspect of the Reserves may opt to pay for the opportunity to stay onsite. Payment will be for use of living quarters as well as boat trips if necessary, if it coincides with patrol and research schedule. Once appropriate lab infrastructure is in place, applicants for research may be selected on the basis of their schedule's coincidence with ongoing programmes. A copy of all research goes to the Fisheries and the CCFR/MR libraries in Belize.

7.2.5 Student groups

Student groups from abroad may use the area for a blanket fee. They can be directed toward activities that need to be done in the Reserves, such as trash

pickup, backsplicing reef mooring lines, and participation in simple monitoring such as single-species surveys. UB groups may also use the facility. Small groups may be permitted to camp by permission and under conditions specified by the Manager.

7.2.6 Video programmes

Video programmes may be created for educational purposes that also have commercial value. These may be sold in the Museum Bookstore and later distributed for public sale in a variety of venues, in addition to donation to CCRC School and other schools.

At least one programme unique to CCFR/MR may be created that is of sufficient technical merit to warrant airing on Discovery, TLC or other educational venue. The final panels of this may have contact information for FAMRACC in the manner of “Free Willy”; this could result in donations from all over the world.

7.2.7 Partnerships

Partnerships should be fostered with conservation organizations that will assist in furthering some element of the Reserves. This is working very well for such PAs as Half-Moon Caye (BAS, with assistance from EU); Glover’s Reef (Fisheries, with assistance from WCS); and Bacalar Chico (Fisheries, with assistance from ITCF and MBRS); and Port Honduras (TIDE, with help from TNC. The challenge is in locating a partner in the current scenario of almost overwhelming need for conservation support, and few available donors.

7.2.8 Website

Considered integral to all of this is a solid website, well-endowed with photos that illustrate the brightest points of the PAs. Such a website will also delineate needs of CCFR/MR, from single microscopes or donations of mosquito nets and line to large equipment donations or partnership offers.

One benefit available to the PAs is the value of the FAMRACC member organization The Siwa-ban Foundation’s status as a US Public Benefit Charity, permitting tax deduction of US-based donations. Thus, US donors receive some tangible benefits if they donate to the PAs.

7.2.9 Lectures by Staff and Others Directed at Tourists

Many protected areas in other countries offer lectures and programmes directed at visitors in the evenings. This provides something more interesting to do in the evenings than party for family, student, and ecotourism groups. This could be made available for CCFR/MR, with a small charge. Areas of presentations may be cultural, historical, biological or physical in nature.

7.3 Statement of Financial Need and Budget Presentation

A number of requirements for fulfillment of stated goals and objectives in CCFR/MR have been outlined in the above sections. They fall into 6 basic

categories, including staff, infrastructure, boats and fuel, scientific/ monitoring equipment, habitat restoration and maintenance/repairs of existing gear and infrastructure. These will be here presented in terms of their priority for each category.

In Section 7.1.3 the attributes of CCFR/MR were briefly described in relation to its earning potential. The biological value as stated above in addition to the total dependence of the host community on the well-being of the barrier reef makes it essential that this protected area receive the support it needs. Material needs have been discussed in the text above; in this section these are summarized.

7.3.1 Forest Reserve

Required for functional setup of CCFR are the following:

Immediate priority:

- Boundary markers and signage for CCFR perimeter;
- Rough lumber, outdoor quality, for the first floor of the Watchtower-perimeter facility, bunk and the first half-kilometer of platform trail in the following amount:
    - Posts, Bullet Tree or Cabbagebark;
    - 2”X6”X10 ft. Sapodilla or Santamaria beams;
    - 2”X6”X 8 ft. “ “ “ “ Crossbeams;
    - 1”X6”X 8 ft Treated Santamaria or other for slats.
    - 3/8” bolts for crossbeams to posts;
    - 3” nails for remainder of slats and crossbeams.
    - Pimento slats for Rail supports.
    - Composting toilet;
    - Small desk or table with at least one drawer and chairs; Ice chest;
    - Bunk (double tier, built-in to wall);

Intermediate priority:

- Rough outdoor-treated lumber, for completion of watchtower and for construction of 1.5 km of platform trail with one 10’ X 12’ hide;
- GPS for trail measurement,
- Nails sufficient to accomplish the above;
- 2 Reel tapes;
- Tools (hammers; machetes;)
- 2 Chain saws plus maintenance items, for use in establishing experimental forests;
- Survey tape of various colours;
- Pots/trays for moving plants (can re-use milk pans, etc);

Longer range:

- Replacement lumber/nails to maintain trail and lower floor of watchtower;
- Cleaning supplies;
- Sawdust for composting toilet.

Budget 1 for the Forest Reserve appears in Table 20.

Table 20. Budget 1: Caye Caulker Forest Reserve.

1. Forest Reserve-Infrastructure	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
10 Signposts-Cabbage Bark or Bullet Tree 2X4X8' + 10 Metal plate signboards 1 X 0.5 m, painted-contract	2500				2500
*1495- 6"X1"X8' sapodilla slats + *350-4X 8' cabbagebark posts + *350- 2X6X10' Sapodilla beams	45000 (0.5* km)		75000 (1.0 km)		
350- 3/8" bolts + 3" nails (pounds)	500	250	750		
Design consultant, platform and watchtower base	200				
15 local builders (5/yr) Salary @ Total time=2 months	10000	10000	10000		
Siding + floor-Entry point building, CCFR platform trail @ 1.50/ft + 9- 6X Bullet Tree Posts-8' + 3-2X6X12' beams-building width + 6-2X6X 8' beams-1/2 building length + 1-2X6X12' beam for 6 sills, 24" ea + 6 window boards-24"X52" ea + Roof-flat	12000				
8-Hardwood squares for post stabilization; side posts 10"X10"X2"	50				
1-As above 20"X20"X2" for center post	35				
Cement-for posts	75				
1' wooden boxes for posts groundlevel (n=9) – 4-20"X10"	400				
Transport of wood from Shipyard → Belize	2000	1000	2000		
Boat transport of materials from Belize → Caye Caulker	1000	500	1500		
1 Door	200				
15 Hinges for door (3), windows (12)	60				
1 Composting toilet	1500				
1 Table with at least 1 drawer, chairs	150				
Beams, Second level, watchtower+		10000			

Siding- " " " " + Roof					
Light shelter - Top level, watchtower			4000		
Siding, posts, beams for 2 hides				7000	
" " " for maintenance/repairs, all structures			1500	2000	5000
Principal building labour-Trekforce	0	0	0	0	0
Forest Reserve-Infrastructure (continued)	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Fuel, chain saw-coco thinning, experimental forests		300	150	150	150
2 Hammers	10				
15 rolls Survey tape, various colours		75	75		
Fuel-transport of builders, supplies CC→Site @ 8.00/gallon	3000	3000	3000		
300m 1/8th to1/4"-inch line for experimental forest perimeter		150			
Grantwriting to obtain materials (donation)	0				
Total	**78680**	**25275**	**97975**	**9150**	**7650**

7.3.2 Marine Reserve

Required for appropriate function of CCFR are the following:

Immediate priority:

- 30 Manta Ray anchors as follows: 15 No. 2, no locked rating, for perimeter buoys, and 15 No. 2, no locked rating, for zone marker buoys;
- 30 Manta Ray anchors as follows: 26 No. 7, locked rating 17,500 lbs, and 4 No. 10, locked rating at 25,000 lb, both for reef mooring systems;
- 40 -18" Buoys with through-line pipes
- Fuel: needed each month for patrols: Total (gallons) 340
  - for research/monitoring: 80
  - for transport to/from Station 25
  - for patrols 200
  - for reef mooring inspections 20
  - for reserve in event of emergency 15
- Slates for research dives.

Intermediate priority:

- Monthly allotment of fuel continues 340 g;
- Replacement line for reef moorings;

- Additional

Budget 2 for CCMR is presented in Table 21.

Table 21. Caye Caulker Marine Reserve Budget (Budget Section 2)

2. Marine Reserve-Fuel, Equipment, Infrastructure	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
6 rolls 7/8th" poly line (in 3 installments)	500		500		500
4 rolls chafing hose (in 3 installments)	300		150		150
100 Stainless shackles (in 3 installments)	495		550		575
45 Buoys 18" with thru-line tube	3000				1500
36 Manta Ray anchor	5400				
45 Halas Pins	2250				
Underwater hydraulic Jackhammer with gads	10000				
Hydraulic load locker/table	3500				
4 line cutting gun	40				40
Shipping of materials Florida→Belize	01600		1000		1000
Truck – port→dock + loading	00200		200		300
Transport BC→ CC	01000		1000		1000
Fuel	36240	38680	38680	41220	41220
Grantwriting to obtain materials	02000				
Total	**66525**	**38680**	**42080**	**41220**	**46285**

7.3.3 Headquarters/Research Station

Equipment and other infrastructure needed for the Headquarters/ Research Station include:

Immediate priority:

- Upgrade of solar power system;
- Half-day consultancy with solar power expert to optimize use of system;
- Computer, monitor, printer; 50 CD-R;
- 4 handheld radio sets;

Intermediate priority:

- Materials to maintain Headquarters—paint/varnish;
- Conversion of two bedrooms to single drylab space, once dorm facility in village is in place;
- Purchase (or contribution) of Binocular Scope and 900X Microscope, with anti-humidity cases;
- Slides and coverslips in anti-humidity storage;
- Cleaning supplies;

Longer range:

- Design and construction of Wetlab facility, including seawater flow system;
- Aquaria

Table 22 below indicates the budget required for the Headquarters/Station.

Table 22. Budget for CCFR/MR Headquarters and Station

3. Headquarters/Station	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Consultancy-Solar power Expert-1/2 day	200				
10 storage batteries; replacements	700				1000
Entire desktop computer setup	0				
Repairs/maintenance		200	200	300	400
Laptop computer				4000	
Printer	250			350	
15 reams paper	25	25	25	25	25
100 CD-R	50		50		50
4 Radio Handsets-VHF	600				
Paint			500		
Conversion of 2 existing Bedrooms for drylab			1000		
Lab Tables (lining walls)			200		
Humidity-free storage for Binocular and Compound Scopes (scopes from U Wisc (Superior)	350				
Slides, cover slips (2 box ea)	60				
Cleaning supplies	85		100		
Door				200	
6 panels for windows				200	

Seawater flow system				3000	
3. Headquarters/Station	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
4 Aquaria, 25” X 18” X 16”				800	
Grantwriting to obtain materials	2000		2000		
Interior Design of Wetlab (12’ X 16’)-adjoining HQ + 5 Sapodilla posts, 4X4, 8’ long + 4 “ “ 2X4, 8’ long + 2X6X12’ Sapodilla beams (n=3) + 2X6X 8’ Sapodilla beams (n=6)+ Siding				14000	
Total	**4320**	**225**	**4075**	**22875**	**1475**

7.3.4 Village Office/Fishermen’s Museum

Materials ands equipment for construction of this facility is noted below:

Immediate priority:

- Build linkage with CCTGA;
- Ascertain land status for linked facility of CCTGA-CCFR/MR from NFC. If unacceptable locate other site, preferably on Front Street in Village;
- Write grant to assess design and material needs, as well as...
- Acquire materials.
- If above positive, review design proposal with CCTGA and arrive at mutually acceptable design;
- Contact Trekforce or similar organization about labour on building;

Intermediate priority:

Construct facility as agreed upon by participant parties:

- Dressed lumber for construction of main building for displays (octagon); two offices for CCFR/MR staff and CCTGA; upper level small dorm, divided in two sections for male and female; stairway to reach from toilet/shower facilities to upper level.
- Office equipment, fittings, corkboard wall panels in museum, shower, toilet/shower and septic;

Long-range:

- Maintenance of facilities;
- Increase variety of displays;
- Foster linkage with other museums, exchange displays.

Budget for the Village Office/Fishermen's Museum appears in Table 23.

Table 23. Budget for Village Office/Fishermen's Museum

4. Village Office and Fishermen's Museum	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Production of design proposal for buildings-with NFC, CCTGA— 4 meetings (if acceptable to NFC) transport, refreshments, design	500				
Telephone/Internet hookup + service	2000	1800	1800	1900	2000
Fax donation of CCVC	0	0	0	0	0
Addition on CCTGA office as temporary village presence* (*larger facility in other part of Caye Caulker—est. cost as follows-Yr 2- offices, restroom/shower facility; Yr 3- display center, upper level)	3000	* 25000	* 35000		
Grantwriting to discern design, assess and obtain materials for construction of facility		2000			
Total	**5500**	**3800 (*28800)**	**1800 (*36800)**	**1900**	**2000**

7.3.5 Education

Immediate priority:

- Design and presentation of seminar for guides using CCMR;
- Brochures for rules and regulations.
- Powerpoint setup for presentations.

Intermediate priority:

- Design permanent NFC displays, once Fishermen's Museum facility in place;
- Design interactive displays for Fishermen's Museum;
- Set up presentations/ slide shows/ lectures for community and tourists;
- Production of educational materials such as field guides, ecosystem overviews, species profiles etc.

Table 24 below indicates Budget requirements for the education programmes associated with CCFR/MR.

Table 24. Budget for Educational Programme, CCFR/MR

5. Education	Year 1	Year 2	Year 3	Year 4	Year 5
Design/presentation of tourguide seminar for FR/MR use	0				
Handout material for above	5000		2500		2500
Powerpoint projector/laptop	7234				
Brochures, rules, regs and conduct	5000	3000		3000	
Design of permanent NFC displays and framework for Fishermen's Museum, if on (Partnership)	3000				
Design/construction of interactive displays for Fishermen's Museum		5000			
Design presentations for community/tourists "Campfires" (with co-management entities)	2000	500	500	500	500
Design of presentations for school-age children based on PAs (with co-management entities)	800	500	500	600	600
Grantwriting for educational programmes (should combine with Village office/Fishermen's Museum)	2000				
Total	**25034**	**9000**	**3500**	**4100**	**3600**

7.3.6 Boats

Immediate priority:

- 2 new engines Yamaha 60 hp.
- 200' line for bow, stern, anchor + spare.
- New boat-26 ft Pelican

Intermediate priority:

- Renovation of existing boat;
- 2 new engines Yamaha 60 hp;
- Use line above for bow, stern and anchor.

At this point a grant has been penned to acquire new engines, as the old ones have given up. A new boat is also being requested, as the old one has seen recent emergency repairs courtesy of BFD.

Below find the Equipment Budget for boats required to maintain the enforcement, education, monitoring and research programmes of CCFR/MR (Table 25).

Table 25. Boats-equipment budget for CCFR/MR.

6. Boats	Year 1	Year 2	Year 3	Year 4	Year 5
2 new engines-Honda 50	38000				
200' ½ " line for boats, anchor	400			300	
New boat-26-ft Pelican			18000		
2 new engines- Honda 90			40000		
Renovation/repair of existing boat			2500		
Grantwriting for boats	0				
Total	**38400**	**0**	**60500**	**300**	**0**

7.3.7 Research Equipment/Items

Immediate priority:

- Acquisition of water quality monitoring equipment as determined by review of Synoptic Monitoring Plan (Almada-Villegas, 2003)- including capacity to monitor for basic parameters in addition to turbidity, suspended solids, nutrients and bacteria.
- Rite-in-the-Rain paper, survey notebook size and 8.5 X 11 for printing field forms.

Intermediate priority:

- Replacement reagents and batteries for water quality equipment;
- Meter/equipment repair
- Plankton tow;
- Replacement Rite-in-the-Rain paper/notebooks;
- Replacement digital tapes;
- Camera repair;

Following is the budget for research/monitoring for CCFR/MR (Table 25).

Table 26. Research/monitoring budget for CCFR/MR.

7. Research/Monitoring	Year 1	Year 2	Year 3	Year 4	Year 5
Study to determine the best water quality monitoring equipment (travel expenses to Belize for conference)	200				
Water quality testing equipment	19000				
Water quality reagents/meter service		1800		2500	1000
Construction of seagrass monitoring grid (2m 1" PVC, strong twine)	20				
Bacteria sampling kits		3000			
Plankton tow set		600			

Miscellaneous glassware and plastic squeeze bottles		1000			
6. Research/Monitoring (continued)	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Rite-in-the-Rain Paper (8.5X11; 5X7 survey notebooks)	800		800		800
Tapes for UW video-digital-(n=10/yr); camera maintenance	200	200	600	200	600
Continuation of U Wisc (Superior) monitoring programme-extra fuel; boat captain/technician		5000	5000	5000	5000
4 slates for underwater writing	60				
Grantwriting for monitoring/research equipment (may combine with Headquarters funding)	2000				
Total	**22280**	**11600**	**6400**	**7700**	**7400**

7.3.8 Sustainability

Immediate Priority

- First line of T-shirts geared at CCFR/MR, depicting typical scenes and species from the two protected areas. Design of logo on chest pocket + scenes. From this comes staff uniform shirt;
- Website, for promotion of visiting researchers, student groups, and search for sponsors;
- Production of photos, cards and calendars;
- Setup of facility for vending, possibly in CCTGA office;
- Itinerary production;

Intermediate

- Book production;
- Gift items;
- Handicrafts;
- Video production;
- Design of tourism-based simple research programmes;
- Other ideas as they arise

Refer to Table 27 for the budget for the sustainability programme for CCFR/MR.

Table 27. Budget for sustainability programme for CCFR/MR.

8. Sustainability	Year 1	Year 2	Year 3	Year 4	Year 5
Line of T-shirts in adult and children sizes with typical scenes or organisms from FR/MR; including staff uniform models; new designs through year, depicting specific programmes, etc	2000	2000	2500	1000	1500
Production of books such as field guides, ecosystem overviews, species profiles, colouring books, children's stories, etc (+ donations)		5000	5000	5000	5000
Bags, cups etc with FR/MR logos, fish designs, etc			1500	2000	2500
Glass-faced cabinet for museum shop			500		
Website production & maintenance	1500	420	420	500	500
Video productions about local habitat, life		10000		10000	
Consultation for design of itineraries featuring CCFR/MR in the context of other parts of the country (1 mo.).	3000				
Total	**6500**	**17420**	**9920**	**18500**	**9500**

7.3.9 Personnel

Immediate Priority:

- Security of salary for existing staff;

Intermediate Priority:

- Add CCFR Biologist and Ranger;

Longer Range:

- Add 2 Rangers for increased coverage at CCMR.

Budgetary requirements for staff may be viewed in Table 28.

Table 28. Budget for staff of CCFR/MR.

9. Personnel	Year 1	Year 2	Year 3	Year 4	Year 5
Manager, CCFR/MR	22000	22960	23920	24880	25840
Biologist, CCMR	22000	22960	23920	24880	25840
Biologist, CCFR		22960	23920	24880	25840
Environmental Educator			23920	24880	25840
Rangers, CCMR	15600X2	16320X2	17040X2	17760X2	18480X4
Ranger, CCFR		16320	17040	17760	18480
Caretaker	10400	10760	11120	11480	11840
Total	**85600**	**128600**	**157920**	**164280**	**207600**

Below find a summary of total funds required for the various components of Caye Caulker Forest and Marine Reserves. Please refer to Table 29.

Table 29-Budget Summary: Total annual budgetary requirement-CCMR.FR

Budget Category	Year 1	Year 2	Year 3	Year 4	Year 5
Budget 1- Forest Reserve	78680	25275	97975	9150	7650
Budget 2-Marine Reserve	31065	4580	11500	10600	15265
Budget 3-Headquarters/Station	4320	225	4075	22875	1475
Budget 4-Village Office/ Fishermen's Museum	5500	28800	36800	1900	2000
Budget 5-Education	25034	9000	3500	4100	3600
Budget 6-Boats	38400	0	60500	300	0
Budget 7-Research/Monitoring	22280	11600	6400	7700	7400
Budget 8-Sustainability	6500	17420	9920	18500	9500
Budget 9-Personnel	85600	128600	157920	164280	207600
Total Budget requirement By year	**297,379**	**225,500**	**388,590**	**239,405**	**254,490**

8 Implementation

Support for CCFR/MR will be through user fees supplemented by grants, including PACT. As desirable as it would be to secure a large grant and implement the desired improvements all within the calendar year 2004, an alternate timeline based upon piecemeal funding has been presented in the event that a larger grant is not feasible.

The greatest impediment to implementation is lack of finance. Thus the Co-management organization, FAMRACC, is considered to be essential in filling the gap between funds generated by fees, upcoming projects related to sustainability and actual requirements of the PAs. In the event that this organization flags, the Caye Caulker Tourguide Association buttressed by the Siwa-ban Foundation will work to ensure that CCFR/MR will be working for all people for all time. The sustainability programmes described in Section should bring increasing amounts of funding over the years, however at the outset a "lean time" is projected. It is essential that fees be implemented as soon as possible, and that all monies brought in by ticket sales should be made available to CCMR as soon as possible following collection. Meanwhile, required actions for CCFR will be carried out by CCMR personnel until funding comes on-stream for the CCFR Biologist and Ranger.

Priorities

These are the items required in order to begin collecting fees and imparting full enforcement to the zones, with existing staff, within the first six months of 2004. Summarized, they include:

- 4 VHF Handsets;
- Upgraded solar capacity;
- Consultant to explain/interpret solar power system to staff and to optimize system use (half-day);

- Boundary/sign markers for CCFR;
- Sufficient small Manta Rays to install perimeter and zone marks (n=20);
- Sufficient large Manta Rays (n=20) to install first selection of reef moorings for small to medium boats;
- Sufficient deluxe Manta Rays (n=6) for large watertaxis 7holding large numbers of cruise-ship tourists;
- Fuel: 340 gallons/month based on usage described Section 7.2.2;
- Slates for research dives (n=4);
- Computer setup—so as to return Bacalar Chico's computer;
- Complete study for trail route within CCFR (hire consultant if CCFR staff not on stream);
- Work with CCTGA to establish long-term site for village presence/Fishermen's Museum;
- Design and present seminar for Tourguides and Fishermen who will work within CCMR/CCFR;
- Design and print brochures with rules and regulations for both PAs;
- 100' of ¼" line for bow, stern and anchor of existing boat (20' bowline, 20' stern line, and 60' anchor).

While these are being secured, grants must be written to assist with expenses classified as Year 1-immediate needs.

Caye Caulker's protected areas are thus designed for multiple use with the objective of maintaining optimal ecosystem function while providing some area for tourism, recreation and commercial fisheries. Timely acquisition of equipment, materials and a full complement of personnel will assure that Caye Caulker's marine habitats continue their post-hurricane recovery and perform their dual duties of protection and production.

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APPENDICES

Appendix 1

KNOWN SPECIES OCCURRING AT CAYE CAULKER

Key: Habitat of protected area: F1=Forereef groove/spur; F2=Gorgonian plain; F3=Forereef crest; C1=Reef crest; B1=Backreef flat; B2=Backreef coral; B3=Backreef Gateway (coral near breaks in the reef); B4=Patch reef behind Barrier; A1=Algae/rubble Zone; L1=Lagoon bare substrate; L2=Lagoon sparse algae bottom; L3=Lagoon –moderate to dense algae bottom; L4=Lagoon-algae/seagrass; L5=Lagoon-sparse seagrass mixed or monoculture (*Halodule, Syringodium)*; L6=Lagoon-moderate-dense seagrass mixed (*Syringodium, Thalassia);* L7=Lagoon-moderate-dense small patches (*Thalassia)*; L8=Lagoon-moderate-dense large patches or expanse (*Thalassia);* L9=On other substrates in seagrass beds; L10-Infauna; L11=intertidal mud/seagrass; M1=Mangrove roots 20 cm to ≥ 1m depth (*Rhizophora mangle)*; M2=Mangrove roots 20 cm to surface (*Rhizophora mangle)*; M3=Lagoons within caye; M4=Other subtidal shoreline habitat; M5=Sealevel mangrove roots/stems-20cm above and below waterline; M6=intertidal mud; E1=Emergent mangroves (>20 cm above water line-*Rhizophora mangle*); E2= Emergent mangroves other species; E3=Emergent mixed vegetation (other mangroves, associates, littoral forest growing together); E4=Emergent littoral thicket (1-3m); E5=Emergent littoral forest/coconut woodland (>3m); E6=Saltmarsh (dominated by *Salicornia* or *Batis);* E7= Strand vegetation; E8= Developed areas; E9=Wrackline; E10=Other low emergent vegetation; E11=Epiphyte; E12=bare sand; W1=water column over forereef; W2=Water column over backreef or crest; W3=Water column over seagrass/other lagoon bottom; W4=air over sea. **Lifestage**: No mark=all stages; A=Adult; I=Immature; L=Larval forms/eggs. **Residence:** No mark=Resident; SR=Seasonal resident; T=Transient; I=Introduced species; H=Historic resident but no recent records. **List**: A=Observed within Caye Caulker Marine/Forest Reserves by scientists—NOTE: * following the letter "A" indicates organism was noted during the between 26 Aug and 25 Dec, 2003 during the REA; B=Observed by scientists at Caye Caulker area in general, therefore likely to occur in CCMR/FR at some place and time; C=Organisms reported Caye Caulker area by nonscientists; D=Organisms observed in areas of Northern Belize similar to Caye Caulker, therefore may be expected to be found at Caye Caulker. (*With several bacteria species, the causative agent of Black Band Disease in reef corals).

ORGANISM	Habitat Observed	Lifestage	Residence	List
FUNGI				
Pycnoporus cinnabarinus (Orange-Bracket Fungi)	E3, 4, 5, 10			B
PLANTS				
Phycophyta—Algae				
Division Cyanophyta				
Phormidium corallyticum (Black Band Disease-primary component)*	B2, B4		-	A*
Division Phaeophyta				
Padina gymnospora (Petticoat Algae)	B2, B4		-	A*
Padina sanctae-crucis (" ")	B2, B4			A*
Dictyota spp				*A**
Dictyota mertensii				
Dictyota divaricata	C1, B2		-	A*
Dictyota bartrayresi	C1, B2, 4			A*

Division Phaeophyta	Habitat	Lifestage	Residence	List
Dictyota linearis	B2, 4			A*
Dictyota ciliolata	B4			A*
Sargassum spp	B2	-		A
Sargassum polyceratium	C1			A*
Turbinaria turbinata	B2, 4	-		A*
Division Rhodophyta				
Coelothrix irregularis	B2			A*
Laurencia intricata	L5	-		A*
Laurencia poitei	C, B4			A*
Echeuma ----------	L7-8 ----------	all ----------		D
Jania adherens	B2			A*
Amphiroa fragilísima	B2,4			A*
Amphiroa rigida	B2			A*
Amphiroa tríbulus	B4			A*
Porolithon pachydermum --	C1, B2,4	-		A*
Galaxaura subverticillata	B4			A*
Wrangelia argus	B4			A*
Division Chlorophyta				
Acetabularia calyculus	M			A*
Avrainvillea longicaulis	L			A*
Cladophora prolifera	B2			A*
Ulva sp	L	-		B
Ventricaria ventricosa --------	L9, B2 ----------	- ----------	----------	A*
Dictyosphaera cavernosa (Green Bubble Weed)	B2, L5	-		A*
Halimeda discoidea	B3, 4	-		A*
Halimeda incrassata	L5, B4	-		A*
Halimeda monile	L5	-		A*
Halimeda opuntia	B2, 4	-		A*
*Caulerpa sertularioloides (*Feather Algae)	M2	-		A*
*Caulerpa racemosa (*Grape Algae)	C, M2			A*
Caulerpa cupressoides	B2			A*
Caulerpa paspaloides	L5	-		A*
Caulerpa prolifera	L6			A*
Cladocephalus luteofuscus	B4			A*
Cladophora prolifera	L			A*
Penecillus capitatus	L4, 5	-		A*
Penecillus pyriformis	L5	-		A*
Rhipocephalus phoenix	L1			A
Acetabularia calyculus	M2			A*
Batophora oerstedi	L5	-		B
Udotea flabellum	L5	-		A*
Neomeris annulata	C1, B2			A*

Vascular Plants	Habitat	Lifestage	Residence	List
Division Coniferophyta-Conifers				
Casaurina equisetifolia	E8	-	I	B
Division Anthophyta-Flowering plants				
Zosteraceae—Seagrasses				
*Halodule wrighti (*Shoalgrass)	L4, 5	-		A*
*Syringodium filiforme (*Manateegrass)	L5-9	-		A*
Hydrocharitaceae—Seagrasses				
Thalassia testudinum (Turtlegrass)	L5-9	-		A*
Graminae—Grasses				
Cenchrus tribuloides (Sandspur, Burbur)	E7	-		B
Distichlis spicata (Seashore Saltgrass)	E7			B
Sporobolis virginicus (Seashore Dropseed)	E7			B
*Eragrostis dominguensis (*Love Grass)	E7			B
Eustachys petraea	E7			B
Cyperaceae				
*Cladium jamaicense (*Pinchehuevos)	E10			B
Cyperus ligularis (Caribbean Sedge)	E10, E7			A*
Cyperus sp	E10, E7			B
Fimbristylus spathacea	E10, E7			B
Palmae—Palms				
*Cocos nucifera (*Coconut Palm)---------	E4, 5-------	----------	I---------	A*
*Thrinax radiata (*Chit, Fan Palm)	E5			A*
Liliaceae—Lilies				
Crinum latifolium (Milk & Honey Lily)----------	E8----------	- ----------	---------	B
Hymenocallis (Spiderlily)	E8	-		B
Tillandsia sp. 1 (Bromeliad)	E11			B
Tillandsia sp. 2 (Bromeliad)	E11			B
Orchidaceae				
Brassavola nodosa (Dama de Noche Orchid)----------	E7,8, 11			B
Schomburgia tibicinis (Cowhorn Orchid)	E11			B
Moraceae				
Ficus sp (Fig)	E5			B
Polygonaceae				
Coccoloba uvifera (Seagrape)	E5			A*
Bataceae				
*Batis maritima (*Saltwort)	E6			A
Chenopodiaceae				
Salicornia perennis (Glasswort)	E6			A
Amaranthaceae				
Philoxerus vermicularis	E	-		B

Division Anthophyta- Portulacaceae-	Habitat	Lifestage	Residence	List
*Portulaca oleracea (*Iceplant; Purslane)	E7			B
Azoaceae				
Sesuvium portulacastrum (Seaside Purslane)	E7			B
Rosaceae				
Chrysobalanus icaco (Cocoplum)	E4,5			B
Fabaceae				
Canavalia maritima (Seaside Bean)	E7			B
Crotalaria verrucosa (Cascabel)	E7			B
Pithecellobium keyense (Blackbead)	E4, 5			A*
Sophora tomentosa (Necklace-Pod)	E4,5, 8			B
Vigna luteola (Beach Pea)				B
Surianaceae				
*Suriana maritima (*Bay Cedar)	E3,4, 5			A*
Burseraceae				
*Bursera simaruba (*Gumbolimbo)	E5			B
Euphorbia blodgetti	E7			B
Chamaesyce buxifolia				B
Malvaceae				
*Hibiscus tiliaceus (*Caye Mallow)	E4			B
*Sida acuta (*Broomweed)				B
Turneraceae				
Turnera ulmifolia (Ramgoat Dashalong)				B
Rhizophoraceae				
*Rhizophora mangle (*Red Mangrove)	M1-3, E1	-		A*
Combretaceae				
Bucida spinosa		-		B
Conocarpus erectus (Buttonwood)	E2,3,5			A*
Laguncularia racemosa (White Mangrove)	E2, E3	-		A*
Terminalia catappa (Tropical Almond)	E3,5,8		I	B
Apocynaceae				
Catharanthus roseus (Madagascar Periwinkle)	E8		I	B
Convolvulaceae				
Ipomoea macrantha (Moonflower)	E7	-		B
I*pomoea pes-caprae (*Seaside Morningglory)	E7			B
*Ipomoea stolonifera (*Beach Morningglory)	E7			B
Ipomoea sp (Epiphytic Morningglory)	E11			B
Merremia dissecta (Noyo)	E7			B

Division Anthophyta- Boraginaceae-	Habitat	Lifestage	Residence	List
Cordia sebastena (Island Ziricote)	E4, 5			A*
Mallotonia gnaphalodes (Seaside Lavender)	E4, 7			B
Verbenaceae				
Avicennia germinans (Black Mangrove)	E2, E3	-		A*
Lantana involucrata				B
L. sp. (Cimarron)	E4			B
Lippia nodoflora (Lippia)	E2,7			B
Stachytarpheta jamaicense (Vervaine)	E4			B
Solanaceae				
Solanum blodgetti (Nightshade)	E4			B
Rubiaceae				
*Erithalis fruticosa (*Seaside Cherries)	E4, 5			A*
Ernodea littoralis (Beach Creeper)	E4			A*
Hamelia patens (Ixcanan, Firecracker)	E4, 5, 8			B
Spermacoce (Borreria) sauveolens				B
Compositaceae				
Ageratum littorale (Ageratum)	E7			B
Borrichia arborescens (Seaside Oxeye)	E7			B
Wedelia trilobata (Seaside Marigold)	E7			B
ANIMALS				
Phylum Porifera				
Spheciospongia vesparium **(**Loggerhead Sponge)	L5			A*
Chondrilla nucula (Chicken Liver Sponge)	L3-L9			B
Cliona spp. (Boring Sponges)	B2, 3			B
*Amphimedon compressa (*Red Finger Sponge)	L4-L8			A*
Ulosa ruetzleri (Orange Lumpy Encrusting Sponge)	B4			A*
Calyspongia vaginalis (Tube Sponge)	B4			A*
Phylum Cnidaria				
Class Anthozoa				
Octocorallia				
Briareum asbestinum (Corky Seafinger)	B2,3,4, F2			A*
Pseudopterogorgia bipinnata (Bipinnate Feather-coral)	B2, 4			A*

Phylum Cnidaria—Octocorallia	**Habitat**	**Lifestage**	**Residence**	**List**
Pseudopterogorgia spp (Sea Plumes)	B4			A*
*Gorgonia ventalina (*Common Seafan)	B2, 3, 4, F2			A*
Eunicea mammosa (Knobby Candelabrum)	B4			A*
Muricea sp	B4			A*
Erythropodium caribaeorum (Encrusting Gorgonian)	B4			A*
Pseudoplexaurella sp. (Searods)	B2			A*
Hexacorallia				
Acropora cervicornis (Staghorn Coral)	B2, 4			A*
Acropora prolifera (Fused Staghorn Coral)	B2			A*
Acropora palmata (Elkhorn Coral)	B1, 2, 3, 4; C			A*
Porites porites (Finger Coral)	L5, B2			A*
Porites branneri (Blue Finger Coral)	B2, 4			A*
*Dendrogyra cylindricus (*Pillar Coral)	B2, 4			A*
Montastraea annularis (Knobby Boulder Coral)	B2, 3, 4, C			A*
Montastraea faveolata (Mountainous Boulder Coral)	B4			A*
Montastraea franksi (Boulder Star Coral)	B2, 4			A*
Montastraea cavernosa (Great Boulder Coral)	B2			A*
Dichocoenia stokesii (Elliptical Star Coral)	B2			A
Favia fragum (Golfball Coral)	B2, 4			A*
Porites asteroides (Mustard Hill Coral)	B2, 3, 4, C			A*
Siderastraea siderea (Massive Starlet Coral)	B2			A*
Siderastraea radians (Lesser Starlet Coral)	B2			A*
Diploria strigosa (Smooth Brain Coral)	B1, 2, 3, 4, C			A*
Diploria clivosa (Knobby Brain Coral)	B2, 3, 4, C			A*
Diploria labrynthiformis (Grooved Brain Coral)	B2, 4			A*
Meandrina meandrites (Maze or Butterprint Coral)	B4			A*

Class Anthozoa-(Hexacorallia)-----	Habitat	Lifestage	Residence	List
Manicina aureolata (Rose Coral)		L5		A*
Colpophyllia natans (Boulder Brain Coral)		B2		A
Agaricia agaricites (Lettuce Coral)		B2, 4		A*
Agaricia humilis (Low Lettuce Coral)		B2, 4		A*
Agaricia tenuifolia (Thin-leaf Lettuce Coral)		B2, 3		A*
Agaricia [Sheet Coral]		F1		A*
Agaricia fragilis (Saucer Coral)		B2, 4		A*
Mycetophyllia (Cactus Coral)		B2, 4		A*
Antipatharia				
Antipathes spp (Black Corals)		F1		D
Actinaria				
Condylactis gigantea (Giant Caribbean Anemone)		B2, 4, L9		A*
Stichodactyla helianthus (Carpet or Sun Anemone)		B2		A
Bartholomaea annularis (Ringed Anemone)		B2, A		A*
Lebrunia danae (Branching Anemone)		B2		A
Calliactis tricolor (Tricolour Anemone)		B4		B
Zoanthus pulchellus (Green Zoanthid)		B4		A*
Palythoa caribaeorum (Encrusting Zoanthid)		B4		A
Class Scyphozoa				
Aurelia aurita (Moon Jelly)		W1,2		A
Carybdea spp (Sea Wasps)		W3		B
Linuche unguiculata (Thimble Jellyfish)		W2, 3		B
*Casseiopeia xamachana (*Mangrove Upside-Down Jellyfish)		L		B
Chrysaura quinquecirrha (Sea Nettle)		W2		
Class Hydrozoa				
Millepora alcicornis (Branching Fire Coral)		B2, 3, 4, C		A*
Millepora complanata (Crenelated Fire Coral)		B4, F3		A*
[Unk. Stinging hydroids]		L9		B

Class Scyphozoa-(Siphonophora)-Habitat	Lifestage	Residence	List
Physalia physalia (Portuguese Man o' War)	W2, 3		B
Porpita porpita (Blue Button)	W2, 3		B
Phylum Ctenophora			
Beroe spp(Comb Jelly)	W2		B
Phylum Platyhelminthes			
Class Turbellaria			
Pseudoceros crozieri (Lined Flatworm)	L9		D
Pseudoceros sp (Black Flatworm)	L9		D
Phylum Nemertinea			
[unk Purple Nemertine]	L9		D
Phylum Annelida			
Class Polychaeta			
Family Sabellidae			
*Sabellastarte magnifica (*Magnificent Featherduster)	B2		A
Bispira brunnea (Social Featherduster Worms)	B2		A*
*Anamobea orstedii (*Split-crown Featherduster)	B2		A*
Family Serpulidae			
Pomatostegus stellatus (Red Horseshoe Worm)	B2, C		A*
Spirobranchia gigantea (ChristmasTree Worm)	B2, 4		A*
Spirobranchia sp *(*Horned Christmas Tree Worm)	B2		A*
Family Amphinomidae			
Hermodyce carunculata (Green or Bearded Fireworm)	B2		A
Family Arenicolidae			
*Arenicola cristata (*Southern Lugworm)	L4-L9		A*
Family Terrebellidae			
Eupolymnia crassicornis (Spaghetti Worm)	B2		A*
Family Scyllidae			
Odontosyllis enopla (Luminescent Threadworm)	W3		B

Phylum Mollusca	Habitat	Lifestage	Residence	List
Class Bivalvia				
Tellina persica (Puerto Rican Tellin)		L10		B
Arca zebra (Turkey Wing)		L10		B
Brachidontes sp (Dwarf Mussel)		L10		B
Isognamon alatus (Mangrove Oyster)		M2		D
Dendostraea frons (Frons Oyster)		B2		A
Lima scabra (Rough File Shell)		B2		A
Atrina seminuda (Spiny Pen Shell)		L10		A
Phacoides pectinatus (Thick or Tiger Lucine)		L10		A
Anodontia alba (Butter Lucine)		L10		B
Americardia sp (Strawberry Cockle)		L10		B
Laevicardium laevigatum (Egg Cockle)		L10		B
*Pteria colymbus (*Hammer Oyster)		L9		A*
Tellina radiata (Sunrise Tellin)		L		B
Class Gastropoda				
Family Cymatiidae				
Charonia variegata (Triton)		L4-9		B
*Cymatium caribbeum (*Doghead Triton)		L		B
Cymatium femorale (Angular Triton)		L		B
Family Cassidae				
Cassis tuberosa (King Helmet)		L		D
Cassis madagascarensis (Queen or Emperor Helmet)		L		D
Cassis flammea (Flame Helmet)		L		D
Cypraecassis testiculus (Reticulated Cowrie-Hemet)		L, C		A*
Family Strombidae				
Strombus gigas (Queen Conch)		L4-9; B2		A*
Strombus costatus (Milk Conch)		L, B2		A*
Strombus raninus (Hawkwing Conch)		L1		A*
Strombus gallus Roostertail Conch)		C		A*
Strombus pugilis (West-Indian Fighting Conch)		L1, 2		A*
Family Fasciolariidae				
Fasciolaria tulipa (True Tulip)		L, B2		D
Xana americana (West-Indian Chank)		L1		A*

Class Gastropoda-Family Cypraeidae---	Habitat	Lifestage	Residence	List
*Cypraea zebra (*Measled Cowrie)		L		D
Cypraea cervus (Atlantic Deer Cowrie)		M2		D
Family Tonnidae				
Tonna maculosa (Partridge Tun)		L10		B
Tonna galea (Giant Tun)		L		D
Family Muricidae				
Murex pomum (Apple Murex)		L4-9		D
Murex recurvirostris) (Rose Murex)		L4-9		D
Family Ovulidae				
Cyphoma gibbosum (Flamingo Tongue)		B2, 4		A*
Family Naticidae				
Polinices lacteus (Milk Moonshell)		L		B
*Natica canrena (*Colourful Atlantic Natica)		L		B
Family Columbellidae				
*Columbella mercatoria (*Common Dove Shell)		L		B
Family Xancidae				
Vasum muricatum (Caribbean Vase)		B2, 4		A*
Family Marginellidae				
Prunum apicinum (Common Atlantic Marginella)		L		B
Family Conidae				
Conus spurius (West-Indian Alphabet Cone)		L		B
Conus verrucosus (Warty Cone)		L		B
Family Trochidae				
Tegula fasciata (Smooth Turban)		L4-9		B
Tegula lividomaculata (West-Indian Tegula)		L4-9		B
Turbo canaliculatus (Channeled Turban)		L4-9		B
Calliostoma javanicum (Chocolate-lined Top Shell)		L4-9		D
Astraea phoebia (Long-spined Starshell)		L4-9		B
Astraea tecta (Imbricated Star-(=*Lithopoma)* Shell)		B2, 4		D
A. caelata (Carved Starshell)		B4, L4-9		A*
Family Neritidae				
Neritina virginea (Virgin Nerite)		L1, M2		B
Nerita tesselata (Checkered Nerite)		L		B

Class Gastropoda- Family Littorinidae ---	Habitat	Lifestage	Residence	List
Littorina angulifera (Mangrove Periwinkle)	M5, E1			B
*Tectarius muricatus (*Beaded Periwinkle)	L4-9			B
Family Cerithiidae				
Cerithium littoratum (Stocky Cerith)	L5-9			B
Family Bullidae				
Bulla striata (Striated Bubble)	L10			B
Opisthobranchia				
Aplysia dactylomela (Spotted Sea Hare)	L5-9			B
Tridachia crispata (Lettuce Slug)	M2			B
Class Cephalopoda				
Sepioteuthis sepioides (Caribbean Reef Squid)	B2			A
[Octopus]	L			B
Phylum Arthropoda				
Class Insecta				
Order Lepidoptera				
Automerus rubescens	E			B
Ascia monuste (Cabbage Butterfly)	E	A	T	B
Agraulis vanillae	E			B
Euptoieta hegesia	E			B
Danaus gilippus	E			B
D. plexippus	E			B
Phocides pigmalion	E			B
Papilio sp (Swallowtail Butterfly)	E	A	T	B
Order Coleoptera				
[Longhorn Beetle]				B
[Brown Beetle]				
[Fireflies]				
Order Hymenoptera				
[Killer Bees]				
[Digger Bees]				
Order Odonata				
Erithrodiplax berenice	all		PR	B
Anisoptera	?		?	B
Order Diptera				
[Mosquitos]				
[Sandflies]				
[Doctorflies]				
Class Arachnida				
[Mangrove Orb Weaver]	E1			B

Arachnida	Habitat	Lifestage	Residence	List
[Grey Jumping Spider]	E1			B
Gasteracanthus aculeatus)				
*(*Spinning Burr)	E1			B
Class Crustacea				
Entomostraca				
Subclass Cirripedia				
Lepas spp (Pelagic Barnacle)	W1-3			B
*[*Sessile barnacles]	M2			B
Malacostraca				
Subclass Peracarida				
Mysidacea				
Mysidium spp Ref. Mysids	B2			A*
Isopoda				
Anilocra laticaudata				
(Parasitic Isopod)	B2			A
Ligia spp (Sea Roach)	E10			B
[Stinging Isopod]	W3			A*
Amphipoda				
Orchestia, Talorchestia spp				
(Beach Hoppers)	E9			B
Subclass Eucarida				
Decapoda-Natantia				
Caridea				
Alphaeus armatus (Red				
Snapping Shrimp)	B2			A
Synapheus sp (#42 Snapping				
Shrimp)	L-; B2			D
[Yellow Snapping Shrimp]	L			D
Stenopus hispidus (Banded Coral				
Shrimp)	L, B2			A
Stenopus scutellatus (Golden				
Coral Shrimp)	L, B2			D
Stenopus sp. (Slender Coral				
Shrimp*)	L			D
Lysmata wurdemanni (Veined				
Shrimp)	L, B			D
Thor amboinsis (Spotted				
Anemone Shrimp)	B2			A
Tozeuma sp (Ocellated Grass				
Shrimp)	L			D
Periclemenes pedersoni				
(Pederson's Cleaning Shrimp)	L, B2			A
Periclemenes yucatanicus				
(Spotted Cleaning Shrimp)	L, B			A

Decapoda---Reptantia---------Habitat	Lifestage	Residence	List
Gnathophyllum americanum (Banded Bumblebee Shrimp)	L		D
Panulirus argus (Caribbean Spiny Lobster)	L, B		A*
Panulirus guttatus (Spotted Spiny Lobster)	L, B2		A
Scyllarides acquinoctialis (Spanish Lobster)	B2		A
Brachyura			
Dromidia antillensis (Lesser Sponge Crab)	L		D
Dromia erythropus (Round Sponge Crab)	L		D
Uca spp (Fiddler Crab)	E1,2,6		B
Sesarma sp (Marsh Crab)	E1,2,3,6,7,9		B
Gecarcinus sp (Land Crab)	E1,2,3		B
Ucides cordatus (Mangrove Crab)	E1		B
Ocypode quadrata (Ghost Crab)	E12		B
*Cardisoma guanhumi (*Great Land Crab)	E		B
Calappa flammea (Flaming Shamefaced Crab)	L		B
Percnon gibbesi (Nimble Spray Crab)	C, B2, 4		A*
Grapsus grapsus (Sally Lightfoot)	E1, 8 (piers)		B
Stenorhynchus seticornis Arrow Crab	L, B2, 4		A*
Pitho aculeatus (Grey Pitho)	L		A*
Microphrys bicornutus (Spotted Decorator)	L		B
Mithrax sculptus (Green Spider Crab)	L, B2		B
M. spinosissimus (Spiny Spider Crab)	L		D
M. cinctimanus (Banded Spider Crab)	B		A
M. forceps (Rock Mithrax)	L		D
M. spp (Spider Crabs)	L, B		D
Dissodactylus primitivus (Heart Urchin Pea Crab)	L		A*

Decapoda---Brachyura---------Habitat	Lifestage	Residence	List
Portunus sebae (Eyed Swimming Crab (Rati)	L		B
P. spp. (Swimming Crabs)	L		B,D
Callinectes spp. (Blue Crabs)	L		D
Carpilus corallinus (Red Coral Crab)	B		A
Panopeus spp (Mud Crabs)	L		B
Menippe mercenaria (Stone Crab)	L		D
Anomura			
Petrolisthes galathinus (Lined Porcelain Crab)	L		D
P. politos (Smooth Porcelain Crab)	L		D
Dardanus venosus (Star-Eyed Hermit Crab)	L		B
Clibinarius tricolor (Tricolour Hermit Crab)	L, M6		B
Coenobita clypeatus (Soldier)	E		A
Petrochirus diogenes (Conch Hermit Crab)	L1, A		A*
Paguristes punticeps (White-Specked (Blueyed) Hermit)	L		B
Hoplocarida			
Squilla spp, *Gonodactylus* sp	L		B,D
Phylum Echinodermata			
Class Asteroidea			
Oreaster reticulata (Cushion Sea Star)	F1; L		A*
Class Ophiuroidea			
Ophiothrix sp (Sponge Brittle Star)	B2,4		A*
Ophionereis reticulata (Reticulated Brittle Star)	L		D
Astrophyton muricatum (Basket Star)	L, B, F		B
Class Echinoidea			
Diadema antillarum (Long-spined Black Sea Urchin)	B		A*
Echinometra lucunter (Rock-Boring Urchin)	B		A*
E. viridis (Reef Urchin)	B		A*
Tripneustes ventricosa (Sea Egg)	B, L		A*

Echindermata---Echinoidea-------Habitat	Lifestage	Residence	List
Eucidaris tribuloides (Slate-pencil Urchin)	B		A*
Lytechinus variegatus (Variable Urchin)	L		D
Meoma ventricosa (Biscuit Urchin)	L		A*
Plagiobrissus grandis (Great Biscuit Urchin)	L		B
Leodia sexiesperforata (6-holed Keyhole Urchin)	L		A*
Class Holothuria			
*Holothuria mexicana (*Donkey Dung Sea Cucumber)	B		A*
*Euapta lappa (*Beaded Sea Cucumber)	B		D
Holothuria thomasi (Tigertail or Vacuum-cleaner Sea Cucumber)	B2		A
Phylum Chordata			
Subphylum Urochordata			
Class Ascidiacea			
Ecteinascidia turbinata (Mangrove Tunicate)	M1,4		B
Subphylum Vertebrata			
Class Chondricthyes			
Ginglymostoma cirratum (Nurse Shark)	M2, L, B2,4		A*
Carcharhinis limbatus (Blacktip Shark)	L, B2,3,4		A
Rhinobatus lentigenosus (Guitarfish)	L		A*
Dasyatis americana (Southern Stingray)	L, B2		A*
Aetobatis narinari (Spotted Eagle Ray)	L, B2,4		A*
*Narcine brasiliensis (*Lesser Electric Ray)	L		B
Urolophus jamaicensis (Yellow Stingray)	L, B2		A
Rhincodon typus (Whaleshark)	W1	T	C
Class Osteichthyes			
Family Elopidae			
Megalops atlanticus (Tarpon)	M1, B2, C, W1		A
Family Albulidae			
Albula vulpes (Bonefish)	L		B

Osteichthyes---Synodontidae -Habitat	Lifestage Residence	List
Synodus intermedius	B2, 4	A
Family Muraenidae		
Gymnothorax funebris (Green Moray)	B2,4	A*
*G. moringa (*Spotted Moray)	B2	A
Muraena miliaris (Goldentail Moray)	B2	A
Family Ophichthidae		
Myrichthys acuminatus (Sharptail Eel)	L	B
Family Clupeidae		
Harengula humeralis (Redear Herring)	W3	B
*H. jaguana (*Scaled Sardine)	W3	A
Family Atherinidae (Silversides)	W3	A
Family Exocoetidae		
Cypselurus heterurus (Atlantic Flyingfish)	W1	D
Family Hemirhamphidae		
Hemirhamphus brasiliensis (Ballyhoo)	W2	A*
Family Belonidae		
Tylosurus crocodilus (Houndfish)	W2	A*
Strongylura sp (Needlefish)	W3	
Family Aulostomidae		
Aulostomus maculatus (Trumpetfish)	B2,4	A*
Family Fistulariidae		
Fistularia tabacaria (Cornetfish)	L	B
Family Syngnathidae		
Hippocampus erectus (Lined Seahorse)	L, B2	A
Family Holocentridae		
Holocentrus rufus (Squirrelfish)	B2,3,4, F,C	A*
*H. adscionalis (*Longjaw Squirrelfish)	B2, C, F	A*
H. vexillarius (Dusky Squirrelfish)	F	A*
H. marianus (Longspine Squirrelfish)	F	A*
Myripristis jacobus (Blackbar Soldierfish)	L	D
Family Serranidae		
Epinephalus striatus (Nassau Grouper)	B2	A
E. morio (Red Grouper)	L	D

Osteichthyes---Serranidae -Habitat	Lifestage	Residence	List
E. itijarra (Goliath Grouper)	B3		A
E. guttatus (Red Hind)	B2		A*
E. adscensionalis (Rock Hind)	F		A*
E. fulvus (Coney)	B2, F		A*
E. cruentatus (Graysby)	B3, 4		A*
Mycteroperca bonaci (Black Grouper)	B2, 3, C, F		A*
M. venenosa (Yellowfin Grouper)	F		A*
M. tigris (Tiger Grouper)	B2, B4, F		A*
Hypoplectrus puella (Barred Hamlet)	B2		A
H. nigricans (Black Hamlet)	B2, 4		A*
H. indigo (Indigo Hamlet)	B3, F		A*
H. unicolor (Butter Hamlet)	L		D
Serranus tigrinus (Harlequin Bass)	A, F		A*
Rypticus saponaceus (Greater Soapfish)	B2		D
R. bistrispinis (Freckled Soapfish)	L		D
Family Grammatidae			
Gramma loreto (Fairy Basslet)	B2, F		A*
G. melacara (Blackcap Basslet)	F		A*
Family Apogonidae			
Apogon maculatus (Flamefish)	B4, L		D
Apogon sp (Cardinalfishes)	L		D
Astrapogon stellatus (Conchfish)	(in Queen Conch)		B
Family Priacanthidae			
Priacanthus cruentatus (Glasseye Snapper)	B4		A*
P. arenatus (Bigeye)	B		A
Family Echineidae			
Echineis spp (Sharksuckers)	L, B		A
Family Inermidae			
Malacanthus plumieri (Sand Tilefish)	A, B2		A
Family Carangidae			
Caranx ruber (Barjack)	B2, 3, 4, C, F		A*
C. bartholomei (Yellow Jack)	B3,4		A*
C. hippos (Crevalle Jack)	B3	T	A
Trachinotus goodei (Palometa)	B3	T	D
T. falcatus (Permit)	B3, 4	T	D
Family Lutjanidae			
Lutjanus apodus (Schoolmaster)	B2, 4, C, F, M1		A*
L. griseus (Grey Snapper)	B4, M1		A*
L. analis (Mutton Snapper)	B2, 4, L7-8		A*
L. mahogani (Mahogany Snapper)	B2, 3, 4, F		

Osteichthyes---Lutjanidae ----Habitat	Lifestage	Residence	List
L. jocu (Dog Snapper)	B3, 4, F		A*
Ocyuris chrysurus (Yellowtail Snapper)	B2, 3, 4, C, F		A*
Family Haemulidae			
Haemulon flavolineatum (French Grunt)	B2, 3, 4, C, F		A*
*H. sciurus (*Bluestriped Grunt)	B2, 4, C, F, L, M1		A*
H. chrysargyreum (Smallmouth Grunt)	B2, 3		A*
H. plumieri (White Grunt)	B2, 3, 4, C, F, L, M1		A*
H. carbonarium (Caesar Grunt)	B2, 4, F		A*
*H. bonariense (*Black Grunt)	B4, F		A*
H. album (Margate)	B4		A*
Anisotremus virginicus (Porkfish)	B2, 3, 4, F, L		A*
Family Lobotidae			
Lobotes surinamensis (Tripletail)	L		B
Family Gerreidae			
Gerres cinereus (Yellowfin Mojarra)	A, B2, L		A*
Eucinostomus sp. (small Mojarras)	L1, M1		B
Family Sparidae			
Calamus spp (Porgies)	B4, F		A*
Family Kyphosidae			
Kyphosus sectatrix (Bermuda Chub)	B2, 3, 4, L9, M1		A*
Family Sciaenidae			
Equetus punctatus (Spotted Drum)	B4, F		A*
E. acuminatus (Highhat)	L		D
Family Mullidae			
Mulloidichthys martinicus (Yellow Goatfish)	B3, 4		A*
M. maculatus (Spotted Goatfish)	B2, 4, F		A*
Family Pempheridae			
Pempheris schomburgki (Glassy Sweepers)	C		A
Family Chaetodontidae			
Chaetodon ocellatus (Spotfin Butterflyfish)	B2, 4, C, F		A*
C. striatus (Banded Butterflyfish)	B4, F		A*
C. capistratus (Foureye Butterflyfish)	B2, 3, 4, F, L, M1		A*
Family Ephippidae			
Chaetodipterus faber (Spadefish)	B3, 4		B
Family Pomacanthidae			
*Holacanthus tricolor (*Rock Beauty)	F		A*
H. ciliaris (Queen Angelfish)	B2, 3, 4, F, L9		A*

Osteichthyes--Pomacanthidae---Habitat	Lifestage	Residence	List
Pomacanthus paru (French Angelfish)	B4, L9		A*
P. arcuatus (Grey Angelfish)	B2, 3, 4, F, L9, M1		A*
Family Pomacentridae			
Microspathodon chrysurus Yellowtail Damselfish)	B2, 3, 4, L9, F		A*
Stegastes partitus (Bicolor Damselfish)	B2, 4, L9, F		A*
S. dorsopunicans (Dusky Damselfish)	B2, 3, 4, C, L9, M1		A*
S. diencaeus (Longfin Damsel)	B2, 3, 4, C, L9		A*
S. leucostictus (Beaugregory)	A, B2, 3, 4, C, F, L9, M1, 2		A*
S. planifrons (3-Spot Damselfish)	B2, 3, 4, L9, F		A*
Chromis insulatus (Sunshinefish)	F		A*
*C. cyanea (*Blue Chromis)	B2, 4, F		A*
C. multilineatus (Brown Chromis)	B2, 3, F		D
Abedefduf saxatilis (Sergeant Major)	A, B2, 3, 4, C, F, L9, M1, 2		A*
Family Labridae			
Halichoeres radiatus (Puddingfish)	B2, 3, 4, C, F, L9		A*
*H. maculipinna (*Clown Wrasse)	B2, 3, 4, C		A*
H. garnoti (Yellowhead Wrasse)	B2, 3, 4, F, L9		A*
H. poeyi (Blackear Wrasse)	B2, 4, C, L		A*
H. bivittatus (Slippery Dick)	A, B2, 3, 4, C, F, L1-7		A*
Bodianus rufus (Spanish Hogfish)	B2, 3, 4, C, F, L		A*
*Lachnolaimus maximus (*Hogfish)	B2, 4, F		A*
Clepticus parrai (Creole Wrasse)	B2, 3, F		A*
Thalassoma bifasciatum (Bluehead Wrasse)	B2, 3, 4, C, F, L9		A*
Hemipteronotus splendens (Green Razorfish)	L5		A*
Family Scaridae			
Scarus vetula (Queen Parrotfish)	B2, 3, 4, F, L9		A*
S. croicensis (Striped Parrotfish)	B2, 3, 4, C, F, L9		A*
S. taeniopterus (Princess Parrotfish)	F		A*
S. coeruleus (Blue Parrotfish)	B2	I	A
S. coelestinus (Midnight Parrotfish)	B2, 3		A
S. guacamaia (Rainbow Parrotfish)	B2, 3		A
Sparisoma chrysopterum (Redtail Parrotfish)	A, B2, 3, 4, C, F, L		A*
S. viride (Stoplight Parrotfish)	B2, 3, 4, C, F, L9		A*
S. rubripinne (Yellowtail (Redfin) Parrotfish)	B2, 3, 4, C, F, L		A*
S. aurofrenatum (Redband Parrotfish)	B2, 3, 4, C, F, L9		A*

Osteichthyes--Sphyraenidae---	Habitat	Lifestage	Residence	List
Sphyraena barracuda (Great Barracuda)	B2, 3, 4, C, F, L9, M1			A*
Family Mugilidae				
Mugil sp (Mullet)	L			B
Family Gobiesocidae				
Acyrtops beryllina (Emerald Clingfish)	L			D
Family Opistognathidae				
Opistognathus sp (Jawfishes)	A, B2			A
Family Gobiidae				
Gobiosoma oceanops (Neon Goby)	B2			A
Coryphopterus sp (Goby)	A, B2			A
Family Labrisomidae				
Malacoctenus sp (Blenny)	L			D
Family Blenniidae				
Ophioblennius atlanticus (Redlip Blenny)	B4, L			A*
Family Batrachoididae				
Sanopus sp (Toadfish)	L, F			A
Family Antennariidae				
Antennarius ocellatus (Ocellated Frogfish)	L			D
Family Ogcocephalidae				
Ogcocephalus nasutus (Shortnose Batfish)	L, M1			B
Family Scombridae				
Scomberomorus cavalla (Kingfish)	B3, F			A
S. sp (Mackerel)	B4			A*
Family Dactylopteridae				
Dactylopterus volitans (Flying Gurnard)	A, B2			A
Family Scorpaenidae				
Scorpaena grandicornis (Plumed Scorpionfish)	L			D
S. plumieri (Spotted Scorpionfish)	A, B2			A
Scorpaenodes caribbaeus (Reef Scorpionfish)	L	I		D
Family Soleidae				
Trinectes inscriptus (Scrawled Sole)	L1			B

Osteichthyes—Bothidae ---	Habitat	Lifestage	Residence	List
Bothus lunatus (Peacock Flounder)	A, B2			A
B. ocellatus (Eyed Flounder)	B2			A
Family Balistidae				
Balistes vetula (Queen Triggerfish)	B2, 4, C, F			A*
B. capriscus (Grey Triggerfish)	L			D
Melichthys niger (Black Durgon)	F			A*
Canthidermis sufflamen (Ocean Triggerfish)	B2, C			A
Family Monacanthidae				
Aluterus scriptus (Scrawled Filefish)	B2, L			A
Cantherhines macroceros (White-spotted Fliefish)	B4			A*
C. pullus (Orange-spotted Filefish)	B4			D
Monacanthus sp (small Filefishes)	L			D
Family Acanthuridae				
Acanthurus coeruleus (Blue Tang)	B2, 3, 4, C, F, L2, 4			A*
A. bahianus (Ocean Surgeon)	B2, 4, C, F, L9			A*
A. chirurgus (Doctorfish)	B2, 3, 4, C, F, L2, 3, 8			A*
Family Ostraciidae				
Lactophrys polygonia (Honeycomb Cowfish)	B2			D
L. quadricornis (Scrawled Cowfish)	L			B
L. triqueter (Smooth Trunkfish)	B2, 4			A*
L. bicaudalis (Spotted Trunkfish)	B2			A
L. trigonus (Trunkfish)	B4, L			A*
Family Tetraodontidae				
Sphoeroides splengleri (Bandtail Puffer)	L			B
S. testudineus (Checkered Puffer)	L, M1,2			B
Canthigaster rostrata (Sharpnose Puffer)	B2			A

Osteichthyes—Diodontidae ---	Habitat	Lifestage	Residence	List
Chilomycterus antennatus (Bridled Burrfish)	B3			A
Diodon holacanthus (Balloonfish)	A			A
D. hystrix (Porcupinefish)	B2			A
Class Amphibia				
[Accidental occurrences only]				
Class Testudinea				
Eretmochelys imbricata (Hawksbill Turtle)	B2, 4			A*
Caretta caretta (Loggerhead Turtle)	L, B2			B
Chelonia mydas (Green Turtle)	L, B, F			A
Class Crocodilia				
Crocodilus acutus (American or Saltwater Crocodile)	E1, M1, 3, 5			A
Class Lepidosauromorpha				
Aristrelliger georgensis (Gecko)	E5			A
Phyllodactylus tuberculosis (Gecko)	E5			A
Sphaerodactylus glaucus (Dwarf Gecko)	E		?	A
(Asian House Gecko)	E8		I	B
Ctenosaura similis (Spiny-tailed Iguana or Wishwilly)	E			A
Anolis saigre (Brown Anole)	E1, 2, 3, 4, 5, 6, 7, 8, 10,12			A*
A. limifrons (Forest Gecko)	E5			A
Cnemidophorus sp. (Garden Lizard or Whiptail)	E4, 5, 8, 10			B
Boa constrictor (Boa Constrictor)	E1, 2, 3, 4, 5, 10			B
Drymarchon corais (Blacktail Indigo)	E4, 5		H	B
Class Aves				
Family Procellariidae				
Puffinus lherminieri (Audubon's Shearwater)	W4		V	B
Family Sulidae				
Sula leucogaster (Brown Booby)	W4		V	B
S. sula (Red-footed Booby)	W4		V	B
Family Pelecanidae				
Pelecanus occidentalis (Brown Pelican)	W4			A*

Aves— Phalacrocoracidae---Habitat	Lifestage	Residence	List
Phalacrocorax auritus (Double-Crested Cormorant)	W4		A*
Family Fregatidae			
Fregata magnificens (Magnificent Frigatebird)	W4		A*
Family Ardeidae			
*Ardea herodius (*Great Blue Heron)	L11		A*
A. alba (Great Egret)	L11, M3		A*
Egretta thula (Snowy Egret)	M3		B
E. caerulea (Little Blue Heron)	L11, M3		B
E. tricolor (Tricolour Heron)	L11, M3		B
E. rufescens (Reddish Egret)	L11		B
Bubulcus ibis (Cattle Egret)	E, L11, M3		A
Butorides virescens (Green Heron)	L11, M3		B
Nyctanassa violacea (Yellow Crowned Night-heron)	L11, M3		B
Cochlearius cochlearius (Boat-billed Heron)	L11, M3	V	B
Family Threskiornidae			
Eudocimus albus (White Ibis)	L11, M3		B
Ajaia ajaja (Roseate Spoonbill)	L11, M3	O	B
Family Anatidae			
Anas discors (Blue-winged Teal)	M3	V	B
Family Accipitridae			
Pandion haliaetus (Osprey)	W4		A*
Elanoides forficatus (Swallow-Tailed Kite)	E13	T, V	B
Buteogallus anthracinus (Common Black Hawk)	E13		A*
Buteo brachyurus (Short-tailed Hawk)	E13	V	B
Family Falconidae			
Falco sparverius (American Kestrel)	E4, 10	SR	B
F. columbarius (Merlin)	E	T	B
F. peregrinus (Peregrine Falcon)	E	T	B
Family Rallidae			
Rallus longirostris (Clapper Rail)	E1, 2		B
Aramides axillaris (Rufous-necked Woodrail)	E1, 2, 3, 4, 5		B
Porzana carolina (Sora)	E1	T	B
Family Charadriidae			
Pluvialis squatarola (Black-Bellied Plover)	E7, L11	SR	B
Charadrius alexandrinus (Snowy Plover)	E7	V	B

Aves—Charadriidae ----------	Habitat	Lifestage	Residence	List
Charadrius wilsonia (Wilson's Plover)	E7		O	B
Charadrius semipalmatus (Semipalmated Plover)	E7		SR	B
Charadrius vociferus (Killdeer)	E7, 8		SR	B
Family Recurvirostridae				
Himantopus mexicanus (Black-Necked Stilt)	M3		SR	B
Family Scolopacidae				
Tringa melanoleuca (Greater Yellowlegs)	M3		O-T	B
T. flavipes (Lesser Yellowlegs)	M3		O-T	B
T. solitaria (Solitary Sandpiper)	M3		O	B
Catoptrophorus semipalmatus (Willet)	E7		SR	B
Actitis macularia (Spotted Sandpiper)	E7, M3		SR	B
Numenius phaeopus (Whimbrel)	E7, M3		SR	A*
Numenius americanus (Long-Billed Curlew)	E7		O-T	B
Limosa fedoa (Marbled Godwit)	E7		SR	B
Arenaria interpres (Ruddy Turnstone)	E7, 9, M3		SR	B
Calidris alba (Sanderling)	E7		V	B
C. pusilla (Semipalmated Sandpiper)	E7		T	B
C. mauri (Western Sandpiper)	E7, M3		T	B
C. minutilla (Least Sandpiper)	E7, M3		T	B
C. fuscicollis (White-rumped Sandpiper)	E7		V	B
Limnodromus griseus (Short-billed Dowitcher)	E7		SR	B
L. scolopaceus (Long-billed Dowitcher)	E7		V	B
Gallinago gallinago (Common Snipe)	M3, E8		V	B
Laridae				
Larus atricillus (Laughing Gull)	W4			B
L. argentatus (Herring Gull)	W4		V	B
Sterna nilotica (Gull-billed Tern)	W4		V	B
S. maxima (Royal Tern)	W4			B
S. sandvicensis (Sandwich Tern)	W4		SR	B
S. hirundo (Common Tern)	W4		O	B
S. antillarum (Least Tern)	W4		O	B

Aves—Columbidae ----------	Habitat	Lifestage	Residence	List
Columba livia (Rock Dove)	E8		I	B
C. leucocephala (White-crowned Pigeon)	E1, 2, 3, 5		SR	B
Zenaida asiatica (White-winged Dove)	E8, 10			B
Z. macroura (Mourning Dove)	E8		V	B
Columbina passerina (Common Ground Dove)	E1, 2, 3, 4, 5, 8, 10			B
Leptotila jamaicensis (Caribbean Dove)	E1, 2,10		O	B
Family Psittacidae				
Aratinga nana (Aztec Parakeet)	E3, 4, 5, 10, 13		OSR	B
Family Cuculidae				
Coccyzus americanus (Yellow-Billed Cuckoo)	E5, 8, 10		T	B
C. minor (Mangrove Cuckoo)	E1, 5, 10			B
Crotophaga ani (Smooth-billed Ani)	E8, 10		O	B
C. sulcirostris (Groove-billed Ani)	E4, 8, 10		SR	B
Family Caprimulgidae				
Chordeiles acutipennis (Lesser Nighthawk)	E4, 5, 10		T	B
C. minor (Common Nighthawk)	E		V	B
Family Apodidae				
*Chaetura pelagica (*Chimney Swift)	E13		T	B
Family Trochilidae				
Anthracothorax prevostii (Green Breasted Mango)	E1, 2, 3, 4, 5, 8,10			B
Chlorostilbon caniveti (Canivet's Fork-tailed Emerald)	E10		O	B
Amazilia rutila (Cinnamon Hummingbird)	E3, 4, 5, 8, 10			B
Archilochus colubris (Ruby-throated Hummingbird)	E6, 8, 10		T	B
Family Trogonidae				
Trogon melanocephalus (Black-Headed Trogon)	E5, 10		O	B
Family Alcedinidae				
Ceryle alcyon (Belted Kingfisher)	E1, 2, 3, 8		SR	A*
Chloroceryle aenea (Pygmy Kingfisher)	E		T	B
Family Picidae				
Melanerpes pygmaeus (Yucatan or Red-vented Woodpecker)	E1, 2, 3, 5, 10			B
M. aurifrons (Golden-fronted Woodpecker)	E1, 2, 3, 5, 8, 10			B

Aves—Picidae ----------	Habitat	Lifestage	Residence	List
Sphyrapicus varius (Yellow-bellied Sapsucker)	E1, 2, 3, 5, 8, 10			A*
Family Tyrannidae				
Elaenia martinica (Caribbean Elaenia)	E1, 2, 3, 5			B
E. flavogaster (Yellow-bellied Elaenia)	E8		O	B
Contopus virens (Eastern Wood-Pewee)	E1, 2, 3, 4, 5, 8, 10		T	B
Empidonax spp. (Flycatchers –small Transient)	E1, 2, 3, 4, 5, 8, 10		T	B
Pyrocephalus rubinus (Vermillion Flycatcher)	E8		V	B
Myiarchus tuberculifer (Dusky-Capped Flycatcher)	M1, 2, 3		?	B
Myiarchus crinitus (Great-crested Flycatcher)	E5, 10		T	B
M. tyrannulus (Brown-crested Flycatcher)	E4, 5, 10		SR	B
Pitangus sulphuratus (Kiskadee)	M1, 2, 3, 4, 5, 10		SR	B
*Tyrannus melancholicus (*Tropical Kingbird)	E1, 2, 3, 4, 5, 8, 10			B
T. couchi (Couch's Kingbird)	E8, 10		O	B
T. tyrannus (Eastern Kingbird)	E1, 2, 3, 5, 10		T	B
T. dominicensis (Grey Kingbird)	E1, 2, 3, 5, 10		T	B
T. forficatus (Scissortail Flycatcher)	E8		T	B
Family Vireonidae				
Vireo griseus (White-eyed Vireo)	E8, 10		T	B
V. flavifrons (Yellow-throated Vireo)	E5		O	B
V. philadelphicus (Philadelphia Vireo)	E8, 10		O	B
V. olivaceus (Red-eyed Vireo)	E4, 5		T	B
V. magíster (Yucatán Vireo)	E1, 2, 3, 4, 5, 10			A*
Family Hirundinidae				
*Progne subis (*Purple Martin)	E8, 10, 13		SR	B
Tachycineta bicolor (Tree Swallow)	E13		T	B
T. albilinea (Mangrove Swallow)	E7, 8, W4		O	B
Stelgidopteryx serripennis (Northern Rough-winged Swallow)	E13		O	B
Petrochelidon pyrrhonota (Cliff Swallow)	E13		T	B
P. fulva (Cave Swallow)	E13		V	B
Hirundo rustica (Barn Swallow)	E8, 10		T	B
Family Turdidae				
Catharus fuscicens (Veery)	E3, 4, 5, 8, 10		T	B
C. ustulatus (Swainson's Thrush)	E1, 2, 3, 4, 5, 7, 8, 9, 10		T	B
Hylocichla mustelina (Wood Thrush)	E1, 2, 3, 4, 5, 8, 10		T	B

Aves—Mimidae ----------	Habitat	Lifestage	Residence	List
Dumatella carolinensis (Grey Catbird)	E3, 4, 5, 8, 10		SR	B
Melanoptila glabirostris (Black Catbird)	E4, 5, 10			A*
Mimus gilvus (Tropical Mockingbird)	E2, 3, 4, 5, 8, 10			B
Family Bombycillidae				
Bombycilla cedrorum (Cedar Waxwing)	E5, 10		T, SR	B
Family Parulidae				
Vermivora chrysoptera (Golden-Winged Warbler)	E8, 10		O-T	B
V. peregrina (Tennessee Warbler)	E4, 5, 8, 10		SR	B
V. ruficapilla (Nashville Warbler)	E8		T	B
V. virginiae (Virginia's Warbler)	E8, 10		T	B
Parula americana (Northern Parula)	E4, 5		SR	B
Dendroica petechia (Yellow Warbler)	E1, 2, 3, 4, 5, 8, 10		SR	B
D. petechia erythacoides (Mangrove {Yellow} Warbler)	E1, 2, 3, 4, 5, 8, 10			A*
D. pensylvanica (Chestnut-sided Warbler)	E8, 10		T	B
D. magnolia (Magnolia Warbler)	E8, 10		SR	B
D. tigrina (Cape May Warbler)	E8, 10		SR, T	B
D. caerulescens (Black-throated Blue Warbler)	E1, 2, 3, 4, 5, 8, 10		T	A*
D. coronata (Yellow-rumped Warbler)	E1, 2, 3, 4, 5, 6, 7, 8, 10		SR	B
D. virens (Black-throated Green Warbler)	E2, 3, 4		T	B
D. fusca (Blackburnian Warbler)	E1, 2, 10		T	B
D. dominica (Yellow-throated Warbler)	E3, 5, 8, 10		SR	A*
D. discolor (Prairie Warbler)	E4, 5, 7		SR	B
D. palmarum (Palm Warbler)	E1, 2, 3, 4, 6, 7, 8, 9, 10, 12		SR	B
D. castanea (Bay-breasted Warbler)	E4, 5, 8, 10, 12		T	B
D. striata (Blackpoll Warbler)	E8, 10		T	B
D. cerulea (Cerulean Warbler)	E8		T	B
Mniotilta varia (Black-and-white Warbler)	E1, 2, 3, 5, 8, 10		O	B
Setophaga ruticilla (American Redstart)	E1, 2, 3, 4, 5, 8, 10		SR	A*
Protonotaria citrea (Prothonotary Warbler)	E1, 2, 3, 8, 10		T	B
Helmitheros vermivora (Worm-Eating Warbler)	E3, 4, 5		O	B
Limnothlypis swainsoni (Swainson's Warbler)	E5		?	B

Aves—Parulidae ----------	Habitat	Lifestage	Residence	List
Seiurus aurocapillus (Ovenbird)	E1, 2, 3, 4, 5, 8, 10		T	A*
S. novaboracensis (Northern Waterthrush)	E1, 2, 3, 6, 8, 9		SR	B
S. motacilla (Louisiana Waterthrush)	E1, 2, 6		T	B
S. sp. (unk. Waterthrush)	E1			A*
Oporornis formosa (Kentucky Warbler)	E1, 2		V	B
O. philadelphia (Mourning Warbler)	E1, 7, 9		T	B
Geothlypas trichas (Common Yellowthroat)	E3, 4, 10		SR	B
G. poliocephala (Grey-crowned Yellowthroat)	E8		V	B
Wilsonia citrina (Hooded Warbler)	E1, 2, 3, 8, 10		T	B
Wilsonia pusilla (Wilson's Warbler)	E3, 10		T	B
*W. canadensis (*Canada Warbler)	E7		T	B
Icteria virens (Yellow-breasted Chat)	E8		T	B
Family Coeribidae				
Coereba flaveola (Bananaquit)	E3, 4, 5, 8, 10			A*
Family Thraupidae				
Piranga rubra (Summer Tanager)	E1, 2, 3, 5, 8, 10		T	B
P. olivacea (Scarlet Tanager)	E5, 8, 10		T	B
*Thraupis episcopus (*Blue-grey Tanager)	E5, 8		V	B
Euphonia affinis (Scrub Euphonia)	E5		V	B
Family Emberizidae				
Sporophila torqueola (White-Collared Seedeater)	E3, 4, 8, 10			B
Spizella passerina (Chipping Sparrow)	E4, 10		T	B
Chondestes grammacus (Lark Sparrow)	E		V	B
Family Cardinalidae				
Pheucticus ludovicianus (Rose-breasted Grosbeak)	E8, 10		T	B
Guiaraca caerulea (Blue Grosbeak)	E10		T	B
Passerina cyanea (Indigo Bunting)	E10		SR	B
Spiza americana (Dickcissel)	E4, 7, 9,10		T	B
Family Icteridae				
Dolychonyx orizivous (Bobolink)	E10		T	B
*Quiscalus mexicanus (*Great-tailed Grackle)	E8, 10			A*
Molothris aeneus (Bronzed Cowbird)	E8		V	B
*Icterus spurius (*Orchard Oriole)	E4, 5, 8, 10		T	B
*I. cucullatus (*Hooded Oriole)	E4, 5, 8, 10			B

Aves—Icteridae ----------	Habitat	Lifestage	Residence	List
I. galbula (Baltimore Oriole)	E4, 5, 8, 10		T	B
Class Mammalia				
Order Rodentia				
Rattus rattus (Roof or Brown Rat)	E		I	B
Order Chiroptera				
[unk. Bats]	E5, 8, 10			B
Order Carnivora				
Felis catus (Housecat)	E		I	B
Order Sirenia				
Trichechus manatus (West-Indian Manatee)	B2, 3, L			A
Order Cetacea				
Tursiops truncatus (Bottlenosed Dolphin)	L			A

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Appendix 2

BELIZE:

STATUTORY INSTRUMENT

No. 28 of 1998

ORDER made by the Minister of Natural Resources in exercise of the powers conferred upon him by section 3 of the Forests Act, Chapter 176 of the Laws of Belize, Revised Edition 1980-1990, and all other powers thereunto him enabling.

(Gazetted 4th April, 1998.)

1. This Order may be cited as the — Short title.

FORESTS (CAYE CAULKER FOREST RESERVE) ORDER, 1998.

2. The area of land described in the Schedule to this Order is hereby declared to be a forest reserve. — Declaration of forest reserve.

3. A map of the said area may be seen at the office of the Chief Forest Officer, Ministry of Natural Resources. — Map of forest reserve.

4. This Order shall not affect any freehold or leasehold rights or any other right, interest or privilege with respect to any of the land in the area declared under paragraph 2 above and subsisting at the commencement of this Order. — Existing rights, etc. not to be affected.

MADE by the Minister of Natural Resources this 31st day of March, 1998.

(EDUARDO JUAN)
Minister of Natural Resources

Printed in Belize by the Government Printer

SCHEDULE

CAYE CAULKER FOREST RESERVE (para. 2)

All that piece or parcel of land containing approximately 100 acres and being the northern portion of Caye Caulker in the Belize District, bounded on the north east and west by the Caribbean Sea; on the south by land now or formerly owned by Harry L. Dole and is being more particularly described as follows:

Commencing at a point on the West Coast of Caye Caulker having a scaled UTM coordinate of 391 200 East and 1966 300 North;

thence due North Easterly along the West Coast of said Caye Caulker, around the Northern Coast to a point on the East Coast having a scaled UTM coordinate of 391 750 East and 1966 700 North;

thence West inland for a distance of approximately 125 meters to a point having a scaled UTM coordinate of 391 625 East and 1966 700 North;

thence South West on a bearing of 203° 37' 46" for a distance of approximately 436.606 meters to a point having a scaled UTM coordinate of 391 450 East and 1966 300 North;

thence West for a distance of approximately 250 meters back to the point of commencement.

BELIZE:

STATUTORY INSTRUMENT

No. 35 of 1998

ORDER made by the Minister of Agriculture and Fisheries in exercise of the powers conferred upon him by section 13A of the Fisheries Act, Chapter 174 of the Laws of Belize, Revised Edition 1980-1990, and all other powers thereunto him enabling.

(Gazetted 25th April, 1998.)

Short title.

1. This Order may be cited as the

FISHERIES (CAYE CAULKER MARINE RESERVE) ORDER, 1998.

Declaration of marine reserve Schedule CAP. 174.

2. The area known as the "Caye Caulker", as more fully described in the Schedule hereto, is hereby declared to be a Marine Reserve for the purpose of the Fisheries Act.

MADE by the Minister of Agriculture and Fisheries this 14th day of April, 1998.

(RUSSELL GARCIA)
Minister of Agriculture and Fisheries

Printed in Belize by the Government Printer

SCHEDULE (Paragraph 2)

CAYE CAULKER MARINE RESERVE

ALL THAT portion of the Caribbean Sea which encompasses that area around the most Northern portion of Caye Caulker and extending in a southeasterly direction for an approximate distance of 2.8 miles from the island's most Northern tip and includes most of the reef in front of Caye Caulker which is located in the Northern Reef Province, in the Belize District. The Marine Reserve in its entirety, comprises approximately 39133460 sq meters and its geographical boundaries are more particularly described as follows:-

Commencing at a point, northwest of Caye Caulker, having the scaled UTM coordinate of 390206 East and 1968130 North;

thence in a southeasterly direction for an approximate distance of 6498 meters to a point having the scaled UTM coordinate of 396671 East and 1967478 North;

thence in a southwesterly direction for an approximate distance of 11130 meters to a point having the scaled UTM coordinate of 394458 East and 1956570 North;

thence in a northwesterly direction for an approximate distance of 2158 meters to a point having the scaled UTM coordinate of 392320 East and 1956864 North;

thence continuing in a northwesterly direction for an approximate distance of 2445 meters to a point having the scaled UTM coordinate of 391913 East and 1959275 North;

thence in a northeasterly direction for an approximate distance of 6803 meters to a point having scaled UTM coordinate of 392935 East and 1966001 North;

thence in a northwesterly direction for an approximate distance of 1393 meters to a point on the east coast of Caye Caulker having scaled UTM coordinate of 391550 East and 1966147 North;

thence in a northeasterly direction along the East Coast of said Caye Caulker, around the Northern Coast to a point on the West Coast having a scaled UTM coordinate of 391192 East and 1966183 North;

thence in a northwesterly direction for an approximate distance of 898 meters to a point having scaled UTM coordinate of 390299 East and 1966280 North;

thence continuing in a northwesterly direction for an approximate distance of 1852 meters to the point of commencement.

Appendix 3

Appendix 4. Rare and threatened species.

Table 4A. Resident land bird species known to breed at Caye Caulker assessed to be at risk (after Miller & Miller, 1997; additional refs as noted in text). Key: RD=Restricted distribution; CZ=Habitat destruction for development in coastal zone; H=hunted illegally; I=Insufficient knowledge-priority species for research; NR=Not rated regionally; T=Threatened; C=Conservation concern; Hr= Population on Caye Caulker temporarily declined due to hurricane; SEC=apparently secure in Belize; R=rare; *A.R. Abundance Rank=Species ranked lower than 15 are of conservation concern pending further study, while those ranked over 27 are probably secure in Belize.

Species	A.R.*	Regional Status	Status in Belize as of 1997	Reason for Concern
Caribbean Elaenia	6	NR (not reported) (Guat); only offshore cayes (Bz, Mex)	Occ. on Caye Caulker; INV	RD, CZ, Hr
White-winged Dove	12	NR Guat-Common in Bz	SEC ; common on Caye Caulker	RD, CZ, H
Black Catbird	14.5	Yucatan Endemic; Threatened resident; locally common on coast/ cayes; occ. Inland.	R nationwide but common on Caye Caulker	RD; CZ
Mangrove Warbler	16	Resident; Common in littoral forest as well as mangrove	SEC Common on Caye Caulker	CZ
Yucatan Vireo	17	As above; distribution restricted to Caribbean coast of Yucatan Peninsula-principally offshore islands; Fairly common resident within range.	SEC Common on Caye Caulker	RD; CZ
Cinnamon Hummingbird	19.5	NR	Common in range, including Caye Caulker; replaced inland by Rufous-tailed Hummingbird	CZ; Hr
Yucatan Woodpecker *(Melanerpes pygmaeus)*	22	Fairly common throughout range	Uncommon Caye Caulker	RD
Common Ground Dove	28	Locally common in north; occasional to fairly common in other areas.	Resident?	Hr Possibly extirpated on CC

Table 4B. Transient migrant and seasonal resident landbird species known to stop or overwinter at Caye Caulker assessed to be at risk (after Sauer et al, 2001; Miller & Miller, 1997; additional refs as noted in text). Key: RD=Restricted distribution; CZ=Habitat destruction for development in coastal zone; I=Insufficient knowledge-priority species for research; NR=Not rated regionally; D= Declining in all or part of breeding range; % decline = * throughout survey (1966-2001); or ** last 20 years only (1980-2001).

Species	Status-North America (% Decline/yr)	Status-Belize	Reason for Concern
Yellow-billed Cuckoo	D (* 1.8)	U-O-?	F in CZ; I
Cape-May Warbler	D (**1.5)	U-R-?	CZ; I
Black-throated Blue Warbler	___	U-O-?	CZ; I
Prairie Warbler	D (* 2.2)	U-O-?	CZ; I
Palm Warbler	___	C-O-?	CZ; I
Blackpoll Warbler	D (*3.9-**10.8)	O-?	CZ; I

Table 4C. Migrant (transient and seasonal resident) birds observed in mangroves at CCFR actually or potentially under threat (REA, Oct 03; Sauer et al, 2002; Jones & Vallely, 2001; McRae, unpub data; Miller & Miller, 1997). Key: RD=Restricted distribution; CZ=Habitat destruction for development in coastal zone; H=hunted illegally; I=Insufficient knowledge-research required-priority species for research; NR=Not rated regionally; T=Threatened; C=Conservation concern; R=Rare; VR=Very rare; D=% Decline/year as indicating by the Breeding Bird Survey North America (Sauer et al, 2002); -* decline rate 1966-2002; ** decline rate 1980-2002; SEC=apparently secure in Belize. *=Species ranked lower than 15 are of conservation concern pending further study, while those ranked over 27 are probably secure in Belize.

Species	Abundance Rank*	Regional Status	Status in Belize as of (1997)	Reason for Concern	D
Lesser Yellowlegs	8	?	VR	CZ; D; I	19.3 **
Ruddy Turnstone	9	R (Mex)	R	CZ; I	
White-crowned Pigeon	10.5	T (Mex); C (BZ)	SEC	RD, CZ, H	
Semipalmated Plover	11	NR	F	CZ; I	
Sandwich Tern	11	NR	R	CZ; I	
Black-bellied Plover	12	NR	F	CZ; I	
Royal Tern	14	NR	F	CZ; I	
Least Sandpiper	18	NR	R	CZ; I	

Table 4D. Bird species noted in Caye Caulker mangroves that have known susceptibility to chlorinated hydrocarbon biocides.

Common Name	Species	Status
Osprey	*Pandion haliaetus*	Resident
Brown Pelican	*Pelecanus occidentalis*	Resident
Peregrine Falcon	*Falco peregrinus*	Transient

Table 4E. Bird species known from mangrove and littoral forest habitats at Caye Caulker assessed to be potentially or actually at risk (after Miller & Miller, 1997; additional refs as noted below). Key: RD=Restricted distribution; CZ=Habitat destruction for development in coastal zone; H=hunted illegally; I=Insufficient knowledge; INV=Priority species for research; NR=Not rated regionally; T=Threatened; C=Conservation concern; SEC=apparently secure in Belize. *=Species ranked lower than 15 are of conservation concern pending further study, while those ranked over 27 are probably secure in Belize. (Jones & Vallely, 2001; McField et al, 1996; McKinnon de Montes, 1992; McRae, unpub ms).

Species	Abundance Rank*	Regional Status	Status in Belize as of 1997	Reason for Concern
Rufous-necked Woodrail	4	R (Mex)	R	CZ; RD; I
Caribbean Elaenia	6	A or O (Mex)	R	CZ; RD; I
Mangrove Cuckoo	8	NR	R?	CZ; I
Clapper Rail (Yucatan subspecies)	11	R (Mex)	?	CZ; RD; I
Wilson's Plover	11	C (Guat)	R	CZ; I

Appendix 5. Biocides found in water samples in Florida golf courses (after Swancar, 1996).

Name	Brand Name	Use	Solubility in water (mg/L)	Half-life (days in field soil)
Acephate	Orthene	I	650,000	3.0
Atrazine	-	H	30	81.4
Betazon	Basagran	H	500	22.4
Bromacil	-	H	815	265.0
Chloradane	-	I	0.05	1772.8
Chlorpyrifos	Dursban	I	0.3	32.2
2,4-D	Roundup	H	620	11.7
Diazinon	-	N	40	32.2
Ethoprop	Mocap	N	750	48.0
Fenamiphos	Nemacur	N	400	15.5
Fonophos	Crusade	I	13	42.3
Gamma-BHC	Lindane	I	6.5	449.8
Isofenphos	Oftanol	I	23.8	14.2
Malathion	-	I	145	1.0
Metalazyl	Subdue	F	7100	21.0
MSMA	-	H	1,000,000	-
Oryzalin	Surflan	H	24	41.5
Oxydiazon	Ronstar	H	(low)	72.0
Pronamide	Kerb	H	15	60.0
Seimazine	Princep	H	3.5	72.0

Appendix 6

Interviews and Meetings Undertaken During CCFR/MR IMP Update
Fall 2003 - Winter 2004

Date	I=Interview M= Meeting	Person or Group/Affiliation	Topic	Number of People
28 August 2003	I	George Myvette/Fisheries	Lobster Aquaculture	1
5 September	I	Natalie Rosado/Forestry	Site visit records,update	1
	I	Beverley Vansen/DOE	EIAs, current scene-CC	1
	I	Martin Alegria/DOE	MOU of co-operation w PA staff-potential	1
14 September	I	Miguel Alamilla/HCMR	Trust fund formation	1
16 September	I	Anthony Mahler/BTB	MOU of co-operation potential-enforcement	1
20 September	M	Sarteneja Community	MPA use, zones, --bare coverage with few guys	6
25 September	M	San Pedro Community	MPA use, sustainability, zones, cruise ship pax, et	13
26 September	M	Caye Caulker Community	As above	11
6 October	I	Isais Majil/Fisheries	Exact location of boundaries	1
7 October	I	Nelson Garcia family/Sarteneja	As above	8
23 October	M	FAMRACC meeting	Progress report on IMP; introductory material	5
4 January 2004	M	Caye Caulker Development Advisory Committee	Presentation of Guidelines; discussion relative to impacts	8
[Late March]	M		of development on protected areas.	8
13 Jan	M	FAMRACC	Various, including member contributions to issues	7
3 February	M	Caye Caulker Tourguide Assoc.	Discussion/comment on MPA zones, activities, use, cruise ship passengers, boat size	13
23 March	M	Caye Caulker Watertaxi Assoc Board	As above	7

17, 18, 19* May M Tourism Business meetings Zones, boat size, visitation
(*with V. Alegria)
2, 9, 9

Principal Opinions from Community Meetings regarding PA use

San Pedro:

1. Interest in trolling and other hook-and-line fishing seasonally in proposed Conservation II Zone for commercial purposes, principally around the southern gateway of North Caye Caulker Channel. Species targeted include: Horse-eye Jacks, Mackerel species including Kingfish, Barracuda, and Yellowtail Snapper. They fish when the water is rough and turbid. This area includes the Mackerel Hole, also a favourite for SCUBA divers.
2. Some San Pedrano diving fishermen have shades among coral in same area; this practice is apparently growing;
3. Want to troll outside reef;
4. Do not want large numbers of cruise ship tourists in areas favoured for carrying locally-based tours based on overnight visitation. Strict controls needed;
5. Want staff to sign an MOU with Port Authority to enforce licensing of boats, but problem with perceived slowness of Port Authority to come up with up-to-date lists of licensed boats;
6. Want Tourism Police, etc personnel to police what cruise ship pax bring onto ship—ie, be there when the pax are returning to the ship, as they are taking seafans etc onto ship.

Caye Caulker:

1. Unanimous in 7 meetings covering over 40 persons, including snorkeling, SCUBA, natural history and sportfish guides, hook-and-line fishermen, lobster trap fishermen:

a. Strict controls on number, boat size and guide:tourist ratio on cruise ship tourism; some vote to ban them altogether. No more than 4 buoys at any given site, some with less;

b. Overall, maximum boat size preferred in CCMR ranged from 35-45 ft while numbers of people in any one location varied from 30-45;

c. Fear of losing business due to 20$ fee; they see that there will be overall less trips to the reef, therefore they will be hurt economically by the higher price. Many are in debt since the hurricane and are living on the edge anyway, with recent increases in government fees, insurance requirements and frequently-rising fuel prices. Some guides that have traditionally supported the MPA are wavering in support on this account. Therefore, most guides are supporting a 10-12$ entry for trips entering the PAs from Caye Caulker, while retaining the 20$ fee for cruise ship passengers and other persons purchasing tickets from other locations;

d. There must be reduced prices for entering the PAs multiple times during a stay, and for visiting HCMR and CCMR/FR in the same day.

2. Many persons want to troll among the patch reefs in the northeastern portion of the MPA; some want seasonal closure fishery in this area. Most of this area is in proposed Conservation II. However there was concern about the fish population in the area;
3. Most meeting attendees want to be able to troll outside the dropoff for Kingfish and other pelagic species;
4. Do not want too many mooring buoys near each other at sites;
5. Harassment including chasing, grabbing, touching, of sharks, rays, etc wildlife by guides or tourists must be stopped;
6. Only guides will feed animals
7. Some watertaxi members seasonally fish an aggregation of prereproductive snappers in deeper water off the Barrier (outside the dropoff).
8. There is an increase in use of shades in recent years, some are near the reef; most guides see this as a problem, especially those who understand what heavy items can do in very large waves.
9. Many are concerned that Caye Caulker's dredging and waste along with Caye Chapel's effluent will damage reefs if it continues uncontrolled. Many believe that reefs off Caye Chapel appear to be in worse condition than reefs further north in MPA waters. [At least for Caye Chapel Coral Gardens, this appeared to be borne out by REA visits during Fall 2003].
10. Some fishermen are worried about the increase in curio trade. A few carry persons to leeward mangroves to view Seahorses; concern was voiced that these are being collected and sold to Chinese. More large shells are also being taken, and Chanks ("Horse-Conchs") are growing rarer due to collection for ceviche.
11. SCUBA professionals would like reef moorings in some forereef spots, in addition to designated areas for instruction drills.

Sarteneja (mainly Garcia family vessel crew):
1. These fishermen had one major message: "Just tell us where we can fish".
2. As much illiteracy in village, other interviewees that are from Sarteneja but guide at CC believe that Sarteneja needs literacy training before tourguide training, or use Grandfather Clause to license experienced fishermen for guiding. Then they can carry tourists to Bacalar Chico MR, HCMR and CCFR/MR. They believe this will reduce need for Sarteneja guys to spear out declining fish and shellfish.

Caye Caulker Coastal Advisory Committee with Imani Fairweather in attendance (some comments):
1. Building standards are desired;
2. In 1st scenario, land deemed highly suitable for development was assigned residential, while moderately suitable was industrial, while in the 2nd scenario this was reversed. Caye Caulker CAC selected #2.
3. Bahia Puesta del Sol and Northern lots in most recent development areas are below government standards;
4. Public Health and safety must be balanced against private interests;

5. In existing developed areas, cannot recommend a different use than the existing one;
6. An EIA is being done for Harry Dole's property adjacent to CCFR;
7. Education programmes to help CCCAC members understand consequences of different development styles should be run;
8. The steps of Development Plan Guidelines were outlined by Ms Fairweather;
9. Waste management is deemed essential by all members;
10. There is a persistent problem with not making quorum.

Appendix 7

Appendix 8
Existing and Suggested Restricted Species

A variety of measures ranging from limited take, through phasic moratoria to permanent restrictions.

Species	Group	E/S	Rationale
Nassau Grouper (*Epinephalus striatus)*	Fish	E	Overfishing a spawning population
Goliath Grouper (*E. itijarra)*		S	Extreme large adult size; juveniles taken routinely in fishery
Seahorses (*Hippocampos* spp)		S	Attractiveness; curio trade; Chinese potion trade
Bonefish (*Albula vulpes)*		E	Value as sportfish; mass capture by net
Baitfishes (*Harengula* spp)		S	Potential for overharvest as sportfishing grows in importance
West-Indian Chank (*Xana Americana)*	Gastropod	S	Overharvest for ceviche
Roostertail Conch (*Strombus gallus)*		S	Rarity; value as curio
Triton Horn (*Charonia variegata)*		S	Large size and beauty; uncommon carnivore--value as curio
Helmets (*Cassis* spp)		S	Beauty; uncommon carnivore--value as curio