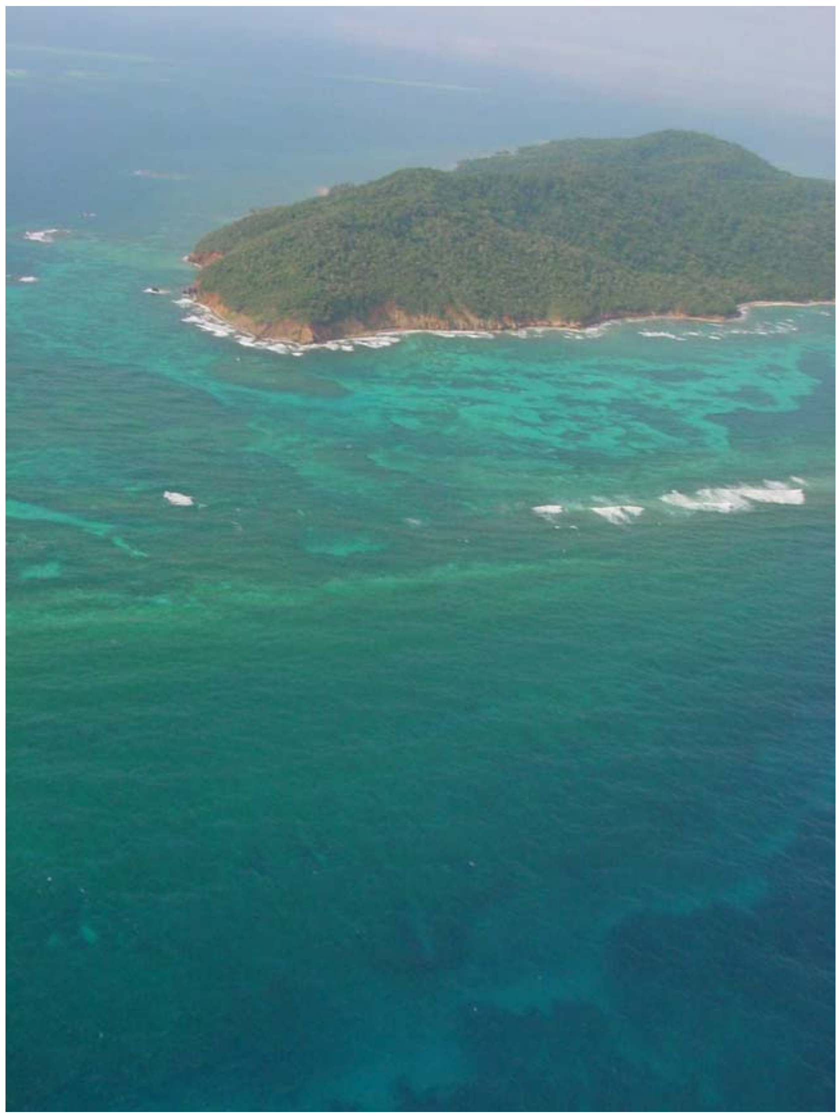
Rapid Ecological Assessment of the Reefs of Barbareta Island (Honduras) and Proposed Boundaries for a Marine Reserve



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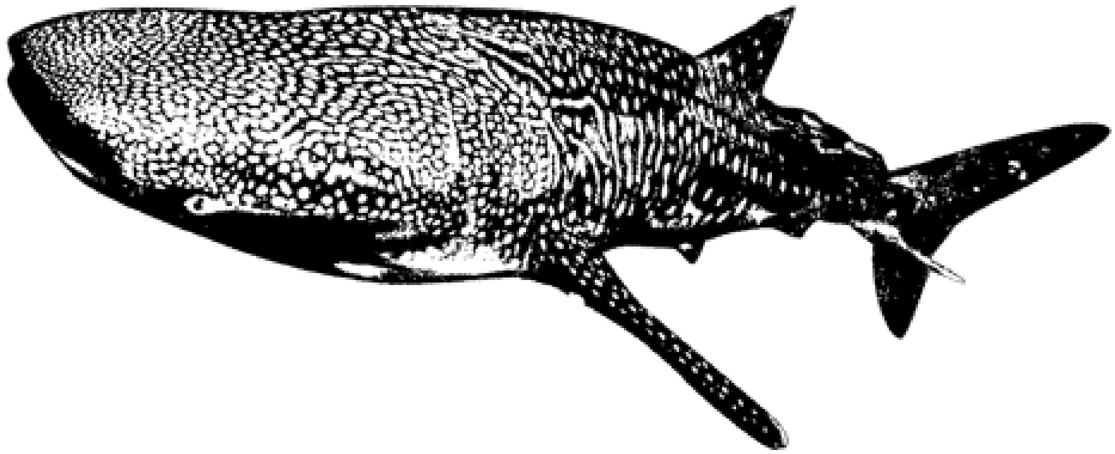
2004



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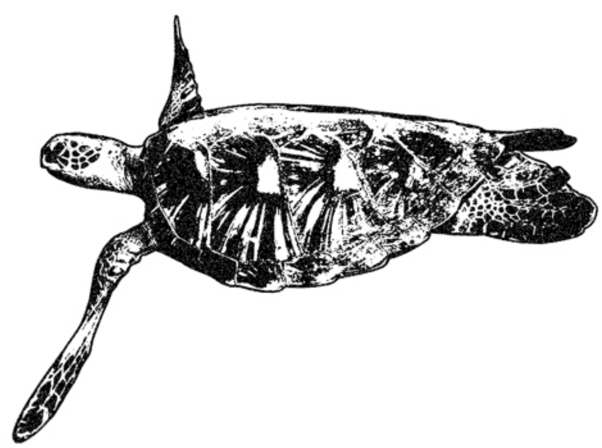
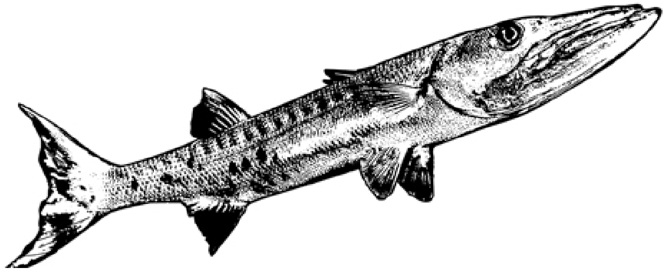




EXECUTIVE SUMMARY

World Wildlife Fund (WWF) and its partner organizations in the field have identified the Mesoamerican Caribbean Reef Ecoregion Complex (MAR) as a conservation priority, because of its biological importance and the intensity of the threats facing it. The MAR extends from the tip of the Yucatan Peninsula in Mexico through the Belize Barrier Reef Complex, to the Caribbean Coast of Guatemala and into the Bay Islands and Cayos Cochinos off the Northern Honduran coast. Within the MAR, the Bay Islands of Honduras (Roatan, Guanaja, Utila, Barbareta, Morat and Santa Elena) have been identified as a particularly high conservation priority.

The focus of this rapid ecological assessment was the Island of Barbareta, which lies near the northeastern end of Roatan, between the islands of Morat and Guanaja. Barbareta extends over 4.9 km^2 (~ 1,200 acres) of mostly hilly and broken terrain covered largely by natural forest. While Barbareta is privately owned and practically uninhabited, its reefs are subject to increasing pressure due to unsustainable fishing and, to a lesser extent, unregulated tourism activities launched from neighboring islands, most notably, Roatan.

The purpose of this rapid ecological assessment was to: (i) Carry out the first detailed description of the main coastal-marine habitats around Barbareta Island; (ii) inventory the main species found in those marine habitats (with special emphasis on hard corals and octocorals, algae, fish, crustaceans, and mollusks); (iii) provide a diagnosis of the overall health of the reef and associated habitats around Barbareta; and (iv) identify suitable borders for a future marine reserve around Barbareta.

The fieldwork was carried out between February 24-28 and March 1-5, 2001 by a team of marine biologists with expertise in hard corals and octocorals, finfish, crustaceans and mollusks. At the time of this survey, average vertical visibility under water was 20 meters. Average horizontal visibility was 40 meters. The average bottom temperature ranged from 26° to 27° C. The prevailing water current had a west to northwest (290º) direction. Seven sites were selected to layout the sampling transects, making sure they were representative of species richness and relative coverage of the substratum. The sampling transects followed the depth contour at various levels (i.e., shallow platforms between one and eight meters; deep platforms between eight and 15 meters; and walls between 15 and 30 meters). Data were also gathered in additional sampling sites, such as lagoons, reef crests, seagrass beds, "octocoral gardens," and at the base of reef walls to a depth of about 50 meters.

The reef system around Barbareta covers about 26 km^2, with a perimeter of approximately 76 km. The actual coral reefs extend 3.5 km^2, and feature a complex structure that provides shelter for a high diversity of species, including healthy populations of fish and lobster. These reefs also serve as an important role in the reproduction of key species of commercial value. This is the case of the site called Grouper´s Joy, where it takes place a grouper spawning aggregation event (Bowmann, pers. comm. 2001). The island's mangroves and seagrass meadows also play an important role as shelters and feeding areas for the juveniles of a wide range of species.

The coral reefs at Barbareta are a combination of barrier, fringing and patch reefs. The reef crests are poorly developed. The reef fronts, while considered narrow at 200 to 400 m, are structurally and ecologically well developed, thus offering a variety of habitats for marine life. The reef "walls" reach in some areas a depth of 50 m. Beyond that depth, a sandy substratum prevails, with sponges and octocoral colonies.

The marine habitats around Barbareta can be broken down as follows: seagrass beds (43% of all marine habitat identified in this survey) -- mainly in reef lagoons; octocoral gardens (14%); hard coral reef (13%); and algae beds (8%).

The ratio between live coral (27%) and non-coralline algae (42%) at Barbareta follows the general pattern of most other locations in the Caribbean Basin, which is a sign of deterioration. However, compared to other Caribbean locations, Barbareta still boasts a relatively healthy coral reef with generally good coral colony and fish densities – especially on its southern side. In addition, there is some evidence of recruitment, which may indicate potential for recovery of overexploited species.

The survey inventoried 42 species of reef-building hard corals (scleractinians), 41 species of octocorals, two species of black corals (antipatharians), eight species of sponges, 24 species of mollusks, 32 species of crustaceans, 23 species of other invertebrates, 146 species of fish, 56 species of algae, and two species of seagrasses. It must be noted that the relatively low counts for certain species may be a reflection of the brief, fast-paced nature of the sampling effort typical of a "rapid ecological assessment." Systematic studies over time will be needed to validate (or revise) the data and information generated in this survey.

The average density of reef-building hard corals was 10 colonies/m^2. As recorded in this rapid survey, the dominant hard coral species in all the reef fronts of Barbareta Island is the lettuce coral (A*garicia agaricites* -- 24%), followed by the mustard hill coral (*Porites astreoides* -- 10%), mountainous star coral (*Montastraea faveolata* -- 10%), massive starlet coral (*Siderastrea siderea* --10%), and great star coral (*Montastraea cavernosa* -- 9%). Since the massive coral deaths of 1998, the boulder star coral only accounts for 5%, and the staghorn coral accounts for only 1%.

On all reef fronts the deep platform was originally comprised mostly of the boulder star coral (*Montastraea annularis*), and the shallow platform consisted originally of the thin-leaf lettuce coral (A*garicia tenuifolia*), elkhorn coral (*Acropora palmata*), staghorn coral (*A. cervicornis*) and bladed fire coral (*Millepora complanata*). However, many of these colonies died as a result of coral bleaching events, diseases and hurricanes (especially in 1998).

The incidence of coral diseases appears to be more frequent on shallow platforms (< 8 m), although it appears to be relatively low when compared to other locations in the Caribbean basin, with which the author is familiar. The most common disease identified during the survey was the Black Band Disease (BBD). The genera most affected by diseases appear to be star corals (*Montastraea*), brain corals (*Diploria*) and starlet corals (*Siderastrea*).

The average density of octocorals and black corals combined was 4.5 colonies/m^2. The dominant species is the slimy sea plume (*Pseudopterogorgia americana*). The highest species diversity of octocorals (25) was found at Anna's Choice (on the south side of Barbareta, near Pepper's Caye). The lowest number of octocoral species (11) was recorded at Grouper's Joy (at the northwestern edge of the Northwestern Crest). The area with the largest concentration of octocoral colonies is Oda's Octocoral Garden (between the western edge of Barbareta and Morat Island). Its wall has an average density of 3.9 colonies/m^2, whereas the deep platform has an average density of 5.2 colonies/m^2 and the shallow platform features 6.9 colonies/m^2.

One hundred forty six fish species were found in the waters around Barbareta. The average total density was 0.7 fish/m^2, which is lower than the 1998 estimate of 1.9 fish/m^2 for Cayos Cochinos. However, the species density estimates for Barbareta are higher when compared to those reported in 1997 for neighboring Roatan (0.3 fish/m^2).

Fish densities were higher at the walls of exposed reefs on the northern side Barbareta. In general, fish diversity also tended to be higher on reef crests, and especially at Dolphin's Pyramids, where parrotfish and herbivore fish in the Family Acanthuridae abound.

In decreasing order, the species with the highest overall density (fish/m^2) was the blue wrasse (*Thalassoma bifasciatum*), blue reef fish (*Chromis cyanea*), creole wrasse (*Clepticus parrae*), ocean surgeon fish (*Acanthurus bahianus*), yellowhead wrasse (*Halichoeres garnoti*), striped parrot fish (*Scarus croicensis*), and three-spot damsel fish (*Stegastes planifrons*). For both exposed and sheltered reefs, the dominant species at seep and shallow platforms was the bicolor damsel fish (*Stegastes partitus*). In general, the walls featured higher concentration of fish than other areas, probably due to a greater complexity of the substratum at the edges of the platforms and the presence of schools of fish in the families Acanthuridae (surgeon fishes) and Kyphosidae (sea chubs).

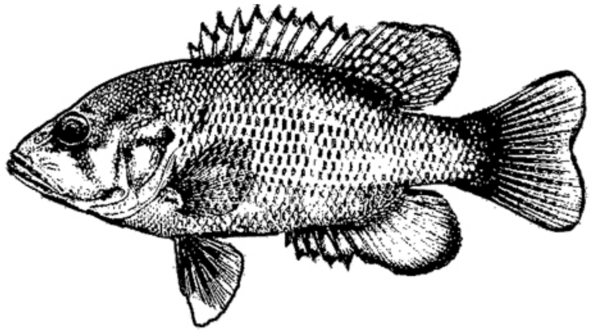
The lane snapper (*Lutjanus synagris*), which has been reported as "very abundant" at Cayos Cochinos, was not sighted around Barbareta during this survey. Other commercially important species, such as the yellow-tailed snapper (*Ocyurus chrysurus*), the white grunt (*Haemulon plumierii*), the mahogany snapper (*Lutjanus mahogoni*), and the bar jack (*Carangoides ruber*) appear to have lower densities at Barbareta than Cayos Cochinos, with juvenile specimens being more easily sighted than adults -- probably as a result of overfishing. On the other hand, there was relatively higher abundance of groupers (*Mycteroperca spp*.) and schools of large-sized individuals of certain snapper species, as well as abundant barracudas and sharks (*Carcharhinus spp.*) – which could also be an indication that overfishing is not yet a serious threat. However, during this rapid ecological assessment, at least three dug-out canoes were spotted fishing in the area.

The average density of spiny lobsters is 23.4 individuals/hectare. *Panulirus argus* is more abundant (41.1 ind./ha) than *P. guttatus* (11.1 ind./ha). The density of *P. argus* on the walls was 55.5 ind./ha, and 44.4 ind./ha on shallow platforms. No *P. argus* were reported for deep platforms. For *P. gutattus,* average density was highest on deep platforms (22.2 ind./ha), followed by the walls (11.1 ind./ha). The shallow platforms had the lowest density for *P. gutattus* (7.4 ind./ha). The inverse relationship of densities exhibited by the two species of spiny lobster may be an indication of ecological niche separation. The spiny lobster populations do not yet appear to be as over-exploited as in many Caribbean locations.

Overfishing also appears to have impacted the densities of queen conch (*Strombus gigas*), particularly in the shallowest sites (1 – 10 meters deep), where densities range from 12 to 14 individuals per ha. Whereas the highest densities of queen conch (up to 79.6 individuals per hectare) were found below 15 meters, where free diving becomes more difficult.

In general, lobster and conch fisheries at Barbareta appear to be more artisan in nature at Barbareta, when compared to the more industrial nature of finfish fisheries. Illegal capture of marine turtles with gill nets, mainly the hawksbill turtle (*Eretmochelys imbricata*) is common around Barbareta.

The MAR is thought to have a fairly high degree of larval connectivity due to the complex, stochastic current patterns. To guarantee adequate protection of "sinks" and "sources" for larvae, juveniles, and adults, as well as the recovery and protection of naturally resistant and resilient reefs, a network of marine protected areas is essential in the Mesoamerican Reef Ecoregion. This survey concludes that the reef system of Barbareta is important for maintaining the integrity and biodiversity of the Mesoamerican Reef Ecoregion and recommends the establishment of a marine reserve with both absolute protection and restricted uses zones. Proposed boundaries for the reserve are provided on the basis of habitat and species diversity and distribution, current public uses, and interpretation of photographic and cartographic materials. Additional recommendations are provided for both management and research.



1 INTRODUCTION

Coral reefs are among the most diverse and productive natural communities on Earth, and they are threatened in most oceans where they are found. In general, insular reefs tend to be in better shape than those closer to the continental shelf. The coral reefs off the Caribbean coast of Central America are under continuous stress from a number of threats, including the increasing flow of sediments from heavily deforested watersheds on the mainland (Cortés 1997). While there are a number of reef areas that have been set aside as protected areas in the Western Caribbean, only a small fraction have been declared "no-take" zones, and even fewer have adequate levels protection and management.

World Wildlife Fund (WWF) and its partner organizations in the field have identified the Mesoamerican Caribbean Reef Ecoregion Complex (MAR) as a conservation priority, because of its biological importance and the intensity of the threats facing it (Appendix A). The MAR extends from the tip of the Yucatán Peninsula in Mexico and the Belize Barrier Reef, to the Caribbean Coast of Guatemala and into the Bay Islands and Cayos Cochinos off the Northern Honduran coast.

The Tulum Declaration — signed in 1997 by the Heads of State of Belize, Honduras, Guatemala and Mexico — signaled the high level political support that exists in the region for the conservation of the MAR. The Tulum Declaration has served to highlight the MAR as a unique ecosystem in the Western Hemisphere, not only for its size, but also for the diversity of its reef formations, species richness, and relatively pristine state (Marín 2000).

Within the MAR, the Bay Islands of Honduras (Roatán, Guanaja, Utila, **Barbareta**, Morat and Santa Elena) have been identified as a particularly high conservation priority. The Bay Islands are considered a critical area to maintain the ecological functions of the entire Ecoregion in the long term (Marín 2000).

2 PURPOSE

The purpose of the Rapid Ecological Assessment was:

1. To carry out the first detailed description of the main coastal-marine habitats around Barbareta Island.
2. To inventory the main species found in those habitats, with special emphasis on hard corals and octocorals, algae, fish, crustaceans, and mollusks.
3. To provide a diagnosis of the overall health of the reef and associated habitats around Barbareta.
4. To identify suitable borders for a future marine reserve around Barbareta

Barbareta is located in the Caribbean Sea, between 86º12''W and 86º5'W, and between 16º27'N and 16º24'N, about 48 km due north of the Honduran coast. It lies near the northeastern end of Roatán, between the islands of Morat and Guanaja. Barbareta is the fourth island in size of the Bay Islands Archipelago, and extends over 4.9 km^2 of mostly hilly and broken terrain. It has as perimeter of 15.3 km, and a maximum elevation of 147 meters above sea level.

The Bay Islands Archipelago has an east-to-west geographic orientation, along the southern edge of the Cayman Trench -- a depression of about six kilometers in depth that separates the coasts of Honduras and Belize.

Barbareta is privately owned and practically uninhabited. Only one of the owners and a handful of employees live there year round. There are eight buildings that serve as living quarters for the owner and staff, and for tourists that use the lodging facilities from time to time (Kramer and Kramer 2000).

Most of the year, the prevailing winds come from the southeast. In the afternoons, the wind may flow from a northeasterly direction. From mid-October, usually until mid-January, the Northern Winds appear, resulting in temporary cold fronts. During this period, Barbareta receives approximately 50% of its annual rainfall. On average, November is the rainiest month, with an average precipitation of 409 mm (based on data collected between 1990 to 1995). Drier Northern Winds may continue until February and March, with an occasional cold front sometimes in April, but with no rainfall. From March to June there is little or no rainfall; and from July to October there is occasional rainfall associated with the tropical storms season (Fonseca 1997 and Radawsdy).

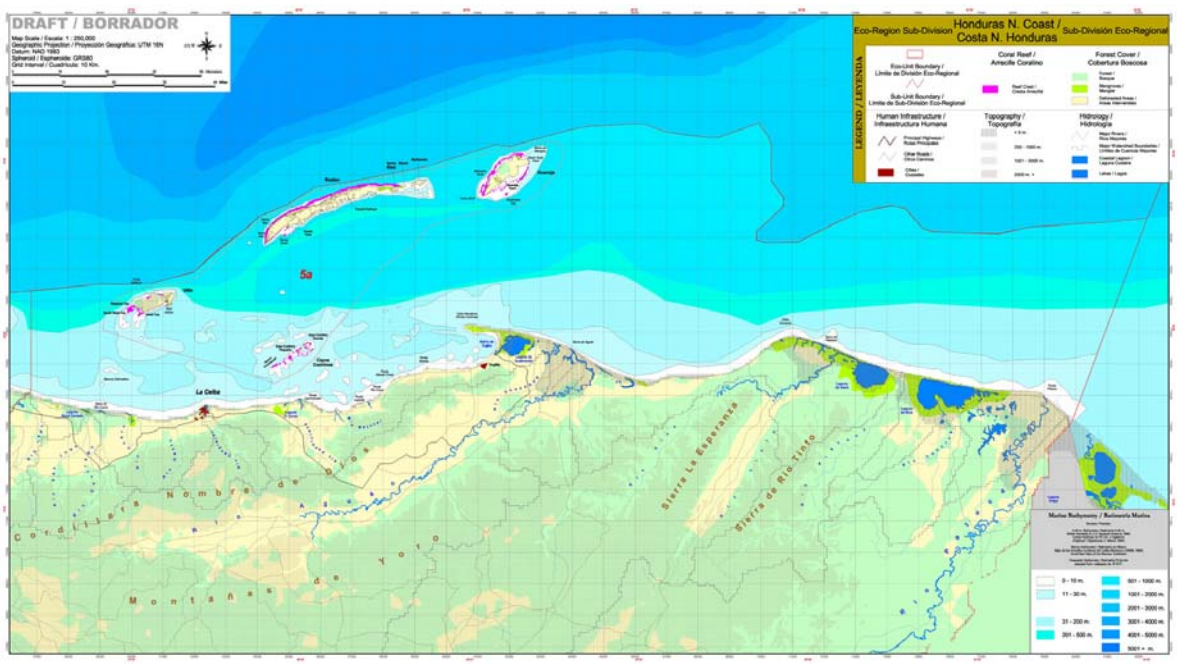


Figure 1. *Subregion of Northern Honduras Coast, including the Bay Island*

The most important surface marine current that influences Roatán and Barbareta is known as the Caribbean Current. This current flows from east to west, from the Lesser Antilles, and passes in front of the Northern Honduran Coast, where it splits into two bands: one continues towards the northeast and hits the Belize Barrier Reef and the Yucatan Peninsula; and the other continues towards the Gulf of Mexico. Part of the band that flows toward the Belizean coast reaches the Gulf of Honduras, where the superficial current runs counterclockwise and meets, in a perpendicular fashion, the band moving north from Roatán and Barbareta (Villeda *et al.* 1997). This marine current pattern suggests that there is a cyclic interchange of reef larvae between the Bay Islands and Belize. However, additional systematic studies are needed of local marine current patterns to validate this theory.

According to navigational data from the Old Salt Yacht, between November and March, an occasional current appears around Barbareta. This current reaches an average speed of two knots, in a west-northwesterly (290º) direction (McNab, pers. comm. 2001). Our survey, carried out in February/March 2001, seems to confirm this anecdotal report.

4 PREVIOUS STUDIES

The marine and terrestrial resources of the Bay Islands have been generally described in existing literature (e.g., Alevizon 1992; Cerrato 1992) and in unpublished reports. However, we are not aware of any detailed studies carried out on Barbareta and its surrounding waters prior to this survey (Marín, pers. comm. 2001).

Kramer and Kramer (2000) studied the damages caused by Hurricane Mitch and the coral bleaching episode of 1998. Their study included the assessment of damages to a shallow reef (about 2 meters in depth) near the eastern tip of Barbareta, but it did not provide quantitative data. Ours appears to be the first survey of its kind for Barbareta, where the data are compared to other reefs in the wider Caribbean.

5 METHODOLOGY

Field visits were carried out between February 24-28 and March 1-5, 2001. Transportation was provided by the Old Salt Yacht, led by Captain Hubbert McNab, and by one of the boats from the Biological Station on Cayos Cochinos.

HABITAT DESCRIPTION AND SITE SELECTION FOR TRANSECTS

Maps and aerial photographs from the Geographic Institute of Honduras were interpreted and used to identify survey sites and map the various habitats described in the survey.

An over-flight at the beginning of the fieldwork allowed the researchers to take additional aerial photographs using a digital camera.

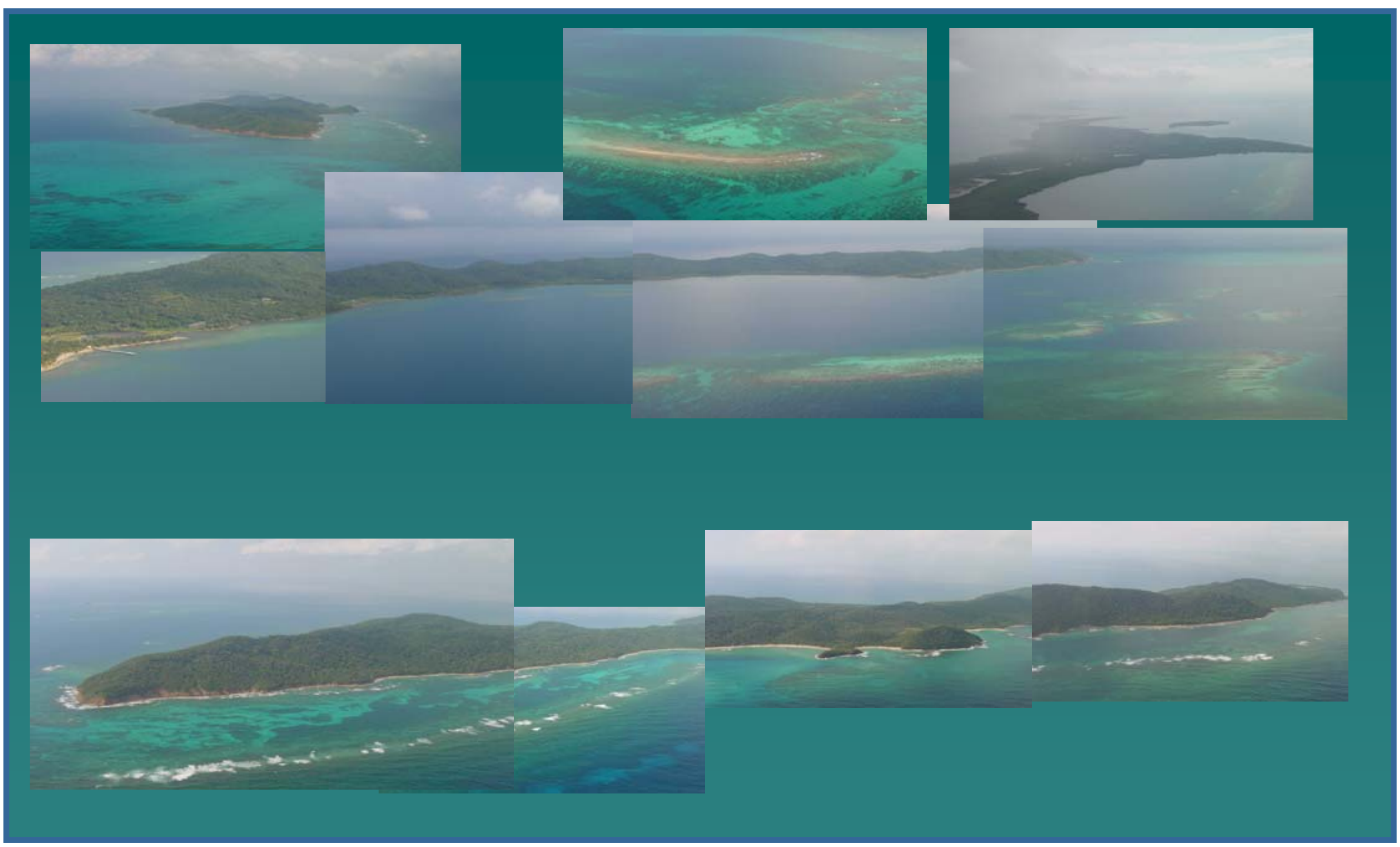
The standard methodology used for the surveys was the towed observer, applying the particular technique called “manta board” (as described in Cintrón *et al.* 1993; and Rogers *et al*. 1994), where the observer holds onto a diving plane made from marine plywood with a board for a data sheet.

The observer is towed over the reef by an outboard motor boat, stopping periodically to identify reef structure types and the prevailing composition of the substratum. During this reconnaissance tow, the observer writes down his/her observations, while personnel on the boat record positions with a GPS instrument, and document depths with an eco-probe. This method and technique are also useful in the identification of other types of coastal/marine habitats, such as seagrass beds (Rogers *et al.* 1994).

Seven sites were selected to layout the sampling transects (Figure 2), making sure they were representative of species richness and relative coverage of the substratum. The first site was located on the northwestern crest of the reef; the second and third sites were located on the northeastern crest; the fourth site was in a marginal reef next to one of the small cayes; the fifth and sixth sites were located on Boomerang's Crest; and the seventh site in the front part of the internal crest called Barbareta. Arbitrary names were assigned to the sites for reference purposes when names were missing on traditional maps.

Table1. *Location of Transects Sites in Barbareta Island*.

#	Transect Sites	General Location	Latitude	Longitude
1	Grouper`s Joy	NW Crest	16°26' 34" N	86°10' 46" W
2	Alex's Wall	Middle of the NW Crest	16°27' 08" N	86°08' 38" W
3	NE Spurs & Grooves	NE of Barbareta	16º26' 53" N	86º06' 17" W
4	Ana's Choice	Reef front of Pepper's Caye	16°24' 29" N	86°07' 48" W
5	Boomerang's Point	E limit Boomerang's Crest	16°24' 34" N	86°08' 38" W
6	Jeff's Wall	W limit Boomerang's Crest	16°24' 40" N	86°10' 44" W
7	Barbareta's crest	W limit of Barbareta's crest	16°25'40" N	86°09'46" W



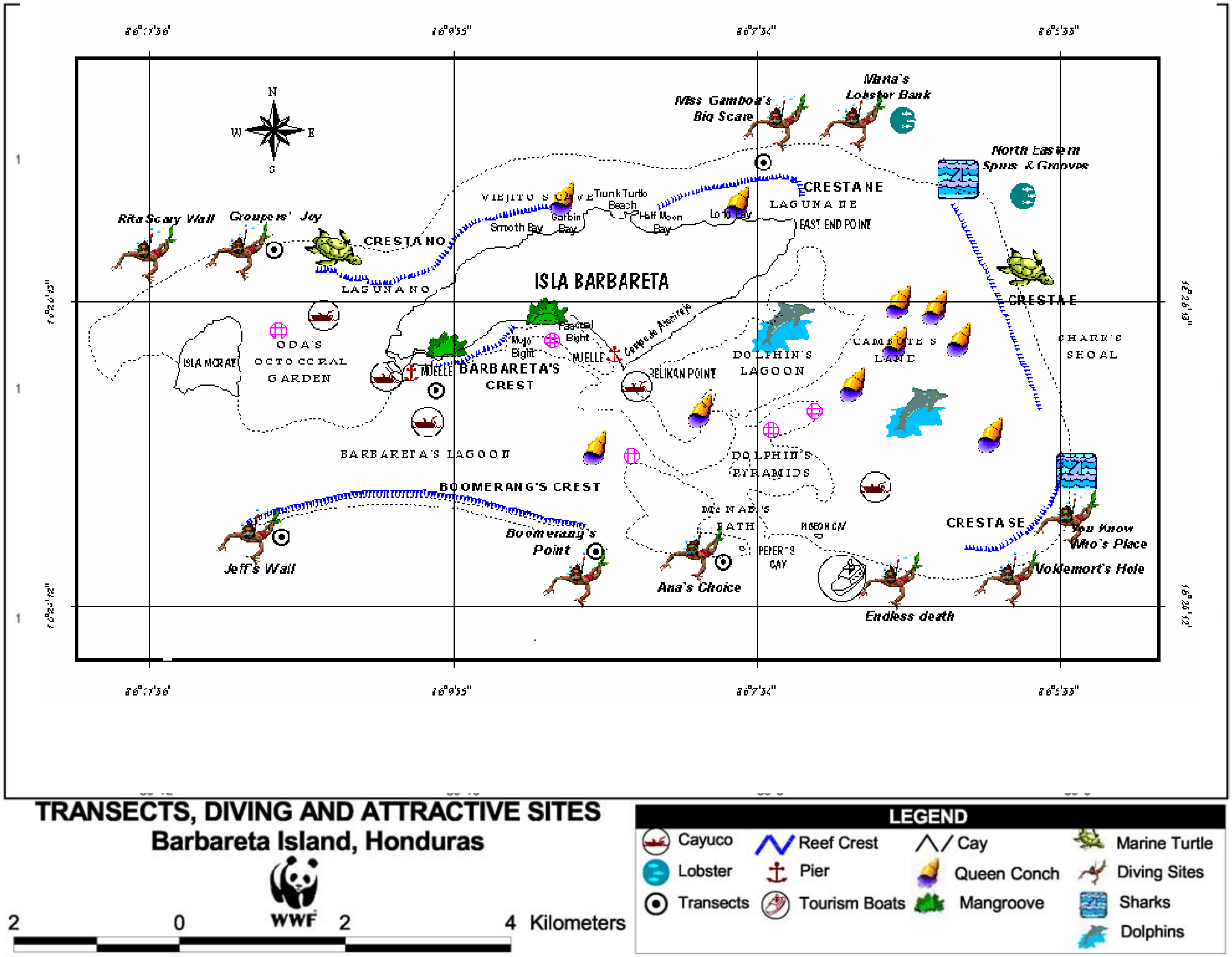


Figure 2. *Map of Transects*, Diving and Other Sites of Barbareta Island.*
*except Alex´s Wall Transect

ECOLOGICAL REEF ASSESSMENT

The reefs around Barbareta extend about 1.5 km to the north, and about 4 km to the east, west, and south, respectively (Figure 3). In order to take into account the natural variability found among reefs, for each site selected stratified sampling was carried out at different depths of the reef front: shallow platform (1-8 m); deep platform (8-15 m) and wall (15-30 m). See Figure 4.

The most recommended methods for ecological assessments of reefs are: (i) the line transects and (ii) the belt transects following the depth contour (Rogers *et al.* 1994). In each reef zone, three to five transects were established according to depth and sampling time. Transects were marked using tape measures.

The team was comprised of four researchers using regular SCUBA diving equipment. Along each transect, the relative coverage of the substratum was quantified using the following categories: live or dead coral, coralline or non-coralline algae, encrusting sponges, and others. Densities were calculated for fish, octocorals, and lobsters. In order to minimize the sampling time, the same transect was used by the four researchers.

In order to identify and describe every possible habitat type and produce as complete a biological inventory as possible, additional free dives were carried out around Barbareta. Specimens that could not be identified on-site were collected and classified later with the assistance of a stereoscope.

Measurements of visibility under water were taken with a Secchi disk. Temperature readings were taken using a thermometer, and current direction was estimated using a buoy or floating marker. Finally, available literature was reviewed to compare the results of this survey with results from other locations at a regional level in the Caribbean.

SURVEYS OF FINFISH

Using a tape measure, a researcher counted, identified, and estimated fish sizes across a six-meter wide band along 30-meter long transects. Each transect covered an estimated 180 m^2 (with a standard deviation of ± 30 m^2). Any fish, larvae or juveniles under 5 cm were excluded because of difficulties in counting and identification (Bellwood & Alcala 1988). Nevertheless, those smaller individuals were considered for the qualitative estimates of species abundance, and for the overall species inventory. To minimize counting errors and save time, the underwater writing slates used in this survey already contained the names of the most common species, so the surveyor only had to check the appropriate name. (Sale & Douglas 1981; Jones & Thompson 1978).

Seventeen SCUBA dives and three free dives were executed. Up to four transects were surveyed per dive; and a total of 46 transects were surveyed. On average, it took 10 minutes to survey each transect, making an effort to maintain an uniform speed (Brock 1982).

To minimize counting errors due to undercounting of individuals from hard-to-spot (or cryptic) species, transect areas were checked a second time. This allowed the recording of any species within the average visual range of counting that were not counted the first time, provided that they could be considered “motionless” or in some form of biological association with the substratum. Their inclusion in the survey was justified because it was assumed that, in the short period of time between the first and second count, they had remained on the same spot but were missed the first time (e.g., blennies and gobies).

CATEGORIES OF RELATIVE ABUNDANCE FOR THE SPECIES INVENTORY

Very Abundant:: Species present in large numbers in most sampling transects.
Abundant:: Species present in large numbers in specific sites.
Very Common: Species found in variable numbers, but always present.
Common: Species found several times (solitary or in schools), but in a very localized distribution.
Scarce: Species sighted more than once during this survey.
Rare: Species sighted only once during this survey.
Very Rare: Species sighted only once, and not previously reported for the study area; or reported by a third party.
Unreported: Species not reported for the study area.
Unknown: Species not reported but which might exist in the study area. Further research is needed.

SURVEYS OF HARD CORALS, ALGAE, ENCRUSTING SPONGES, AND ANEMONES

Surveys were carried out along 10 meters of the same transect used for the fish surveys. Using the point intercept technique, data on the relative cover of the substratum by hard corals, algae, anemones, sponges, and sand and gravel were collected every 30 cm, at 34 different points (Rogers *et al.* 1994).

To calculate the relative abundance of the corals, adult colonies were counted and identified in three squares of 1m^2 each, along the transect and separated by one meter from each other. Additionally, some observations were made regarding the presence of new coral recruitments and diseases, following the guide by Bruckner & Bruckner (1998).

The "Structural Complexity Index" (CI) of reef topography was estimated using a 20-m long chain laid out along depth contours. By following the surface contour of the reef, the chain transect provides data to estimate the index of structural complexity, or rugosity, which is similar to topographic complexity (Rogers *et al.* 1994). In general reefs with higher topographic complexity provide better habitat for fish.

SURVEYS OF OCTOCORALS AND BLACK CORALS, AND SPONGES

The identification of the lowest possible taxon was done according to Bayer & Deichmann (1958), Bayer (1961), Cairns (1977), Guzmán & Cortés (1985), and Humann (1993). The observer counted the octocorals and Antipatharians found within belt transects (1 m wide and 10 m long), for each zone of the selected study sites. The identification was carried out *in situ* (*sensu* Opresko 1972 and Humann 1993) and, when necessary, the specimens were further studied in the lab (*sensu* Bayer 1961). Additionally, erect sponges were counted along transects on deep platforms and walls.

SURVEYS OF LOBSTER AND SEA URCHIN

Lobster and sea urchin were counted along 30-meter long belt transects with a width of 1.5 meters on each side. A total of 30 transects were surveyed. On each transect, as the individual species were being identified, the depth was also recorded (Tewfik *et al.* 1998). Species density (# of individuals per hectare) was calculated for each zone and depth (shallow platform < 8 m; deep platform: 8-15 m, wall: > 15 m).

Surveys of Queen Conch

To assess Queen conch populations, transects were carried out in three different sites: At Site 1 (named Oda's Octocorals Garden, see Figure 2), six 60x2-meter transects were carried out, covering an estimated area of 720 m^2. At Site 2 (named McNab's Path), two 500x5-meter transects were carried out, covering an estimated of 5,000 m^2 area. At Site 3 (named Cambute´s Land), the area sampled consisted of a circle with a 100-meter radius.

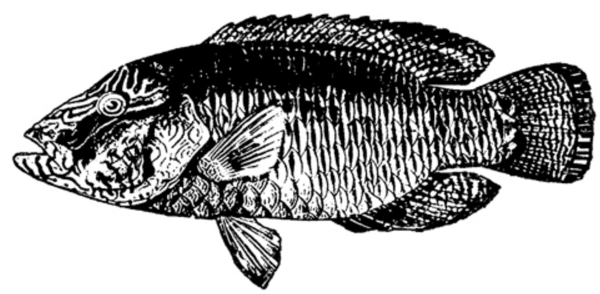
Surveys of Other Crustaceans and Mollusks

Most species of crustaceans and mollusks were collected using the naked eye. Many specimens were found in association with sea grasses, algae, sandy bottoms, or coral rocks. Others were found dead on beaches. Samples of soil and stones were taken and placed into bags to aid in the identification. Collected specimens were fixed with formaldehyde (10% concentrated), to be then washed with water and preserved in 70-degree proof alcohol.

The following guides and manuals were used to aid in the identification of crustaceans: Rathbun 1918, 1925, 1930, 1937; Holthuis 1951, 1952; Chace 1972; Gore & Abele 1976; Williams 1984; Abele & Kim 1986; and Abele 1992. For the identification of mollusks the following publications were consulted: Abbott 1974, Vokes & Vokes 1983, and Diaz-Merlano & Puyana 1994.

Statistical Analysis

Data was tested for significant differences between sites with Analysis of Variances (ANOVA).



Determination of Suggested Boundaries for a Proposed Marine Reserve

The recommendations for establishing the boundaries for a future marine reserve around Barbareta were based on a combination of inputs and materials: Interpretation of photographic and cartographic materials; literature review; the various taxonomic and ecological surveys generated in this assessment; the map of habitats developed from this assessment; and an analysis by the authors of the current uses of the marine environments around Barbareta.

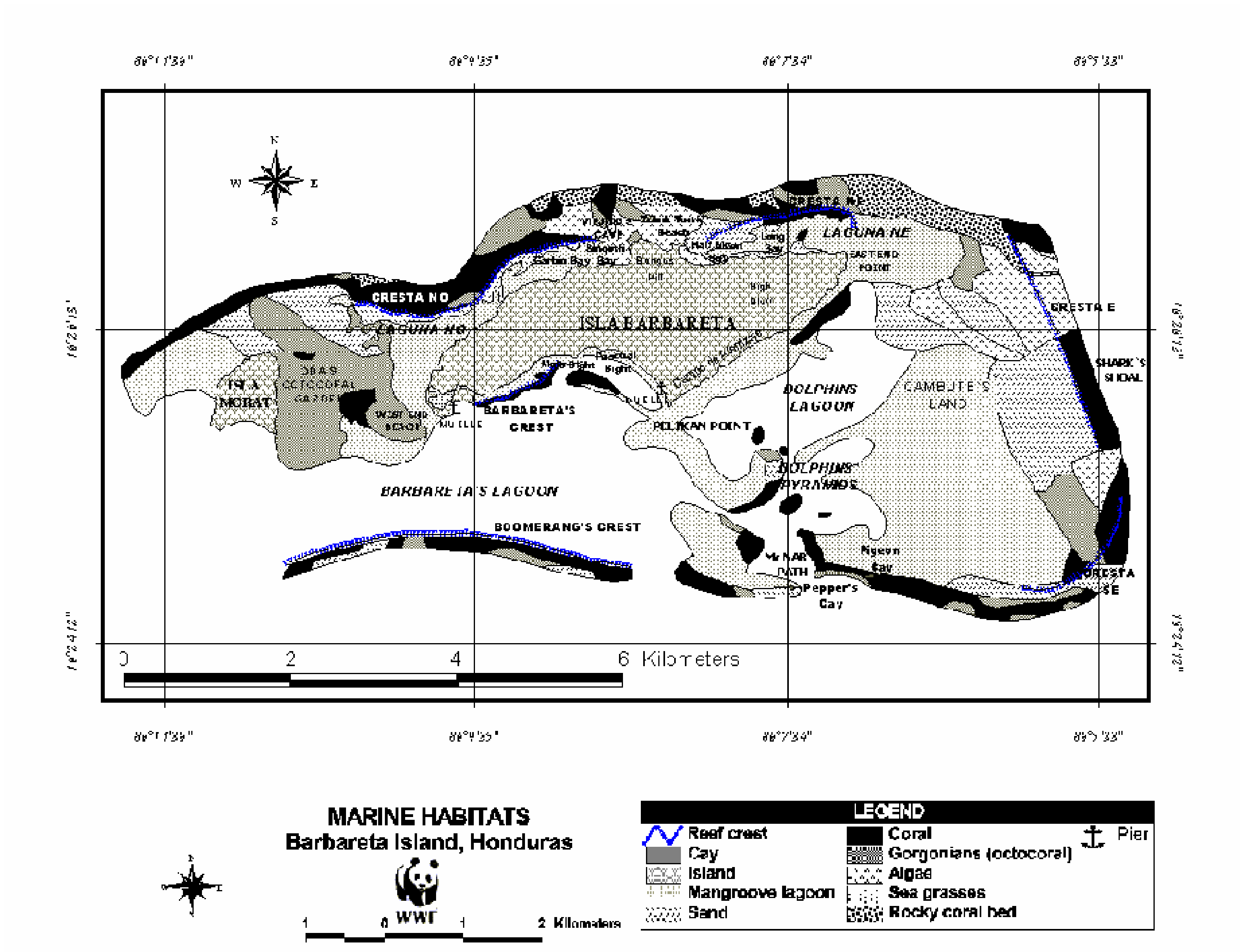


Figure 3. *Map of Marine Habitats of Barbareta Island.*

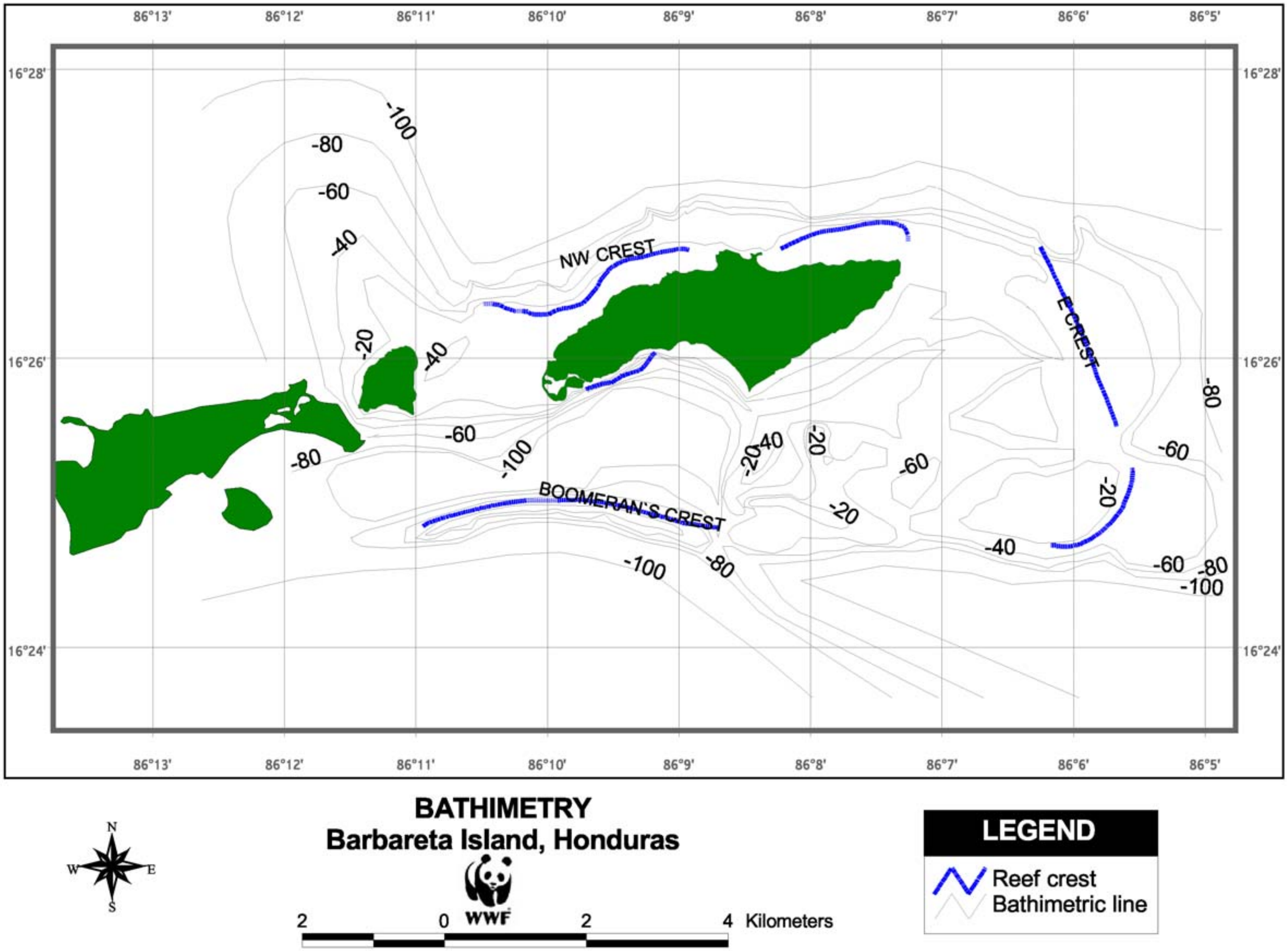
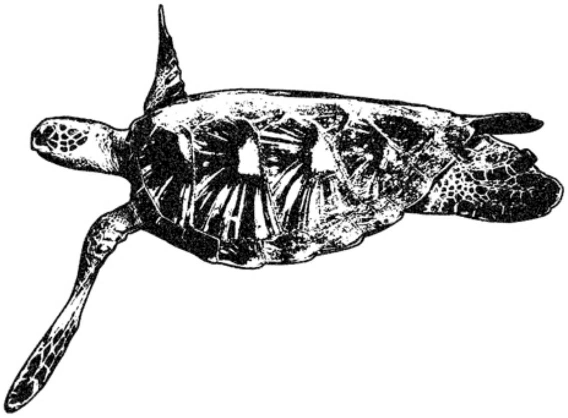


Figure 4. *Batimetric Map of Barbareta Island*



6 RESULTS AND DISCUSSION

VISIBILITY AND TEMPERATURE

At the time of this survey (February), the average vertical visibility under water was 20 m. The average horizontal visibility under water was 40 m.

The average bottom temperature ranged between 26º to 27 ºC.

MARINE CURRENTS

The prevailing current during the survey had a west-to-northwest direction (~ 290°). Marine currents often allow long distance dispersion, help re-colonize previously disturbed sites and connect genetically separated populations (Reaka-Kudla, 1997). Based on the analysis of prevailing currents in the Gulf of Honduras (Figure 5), it is apparent that the reefs around Barbareta -- and the entire Bay Islands Complex -- are linked to reefs elsewhere in the Mesoamerican Reef Ecoregion and beyond in the Caribbean Basin (Marín 2000). The system of currents guarantees a steady and cyclical flow of larvae of many species. A network of absolute protection marine areas would enhance the viability of marine biological corridors. Further research is needed to describe and understand in detail the various local currents that affect the Bay Islands and, more generally, the Mesoamerican Reef Ecoregion.

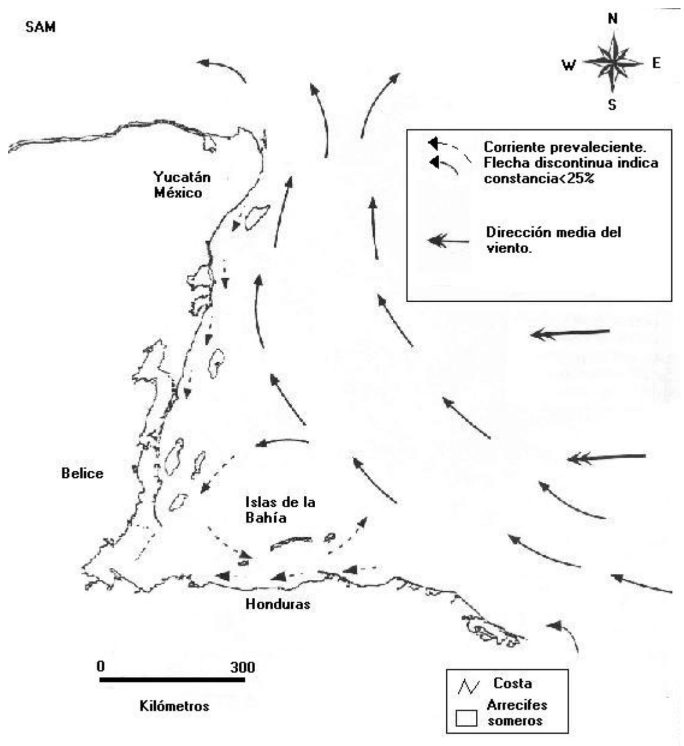


Figure 5. *Map of the prevailing currents in the Mesoamerican Reef System of the Caribbean (modified from Kramer and Kramer, 2000).*

MARINE HABITAT DIVERSITY

The reef system around Barbareta extends over an area of 26.38 km^2, and forms a perimeter of about 76 km. The following habitat types were identified in the surveyed areas (Table 2 and Figure 3):

- **Seagrass Beds:** Areas with soft, sandy substratum dominated by turtle seagrass (*Thalassia testudinum*) and/or manatee seagrass (*Syringodium filiforme*), especially in the reef lagoons, the Oda's Octocorals Garden on the west, the Barbareta's Lagoon to the southwest, Dolphin's Lagoon and Cambute's Land to the east, and the lagoons of the Norteastern Crest and the Northwestern Crest. This habitat represents 43.2% of the surveyed areas.

- **Sand:** Numerous bare sandy patches can be found interspersed with other habitat types. Barbareta's Lagoon and Dolphin's Lagoon, particularly, present large sandy patches. This habitat type represents 17.4% of the surveyed areas.

- **Octocoral "Garden:"** Sandy patches or rocky bottoms dominated by a high density of octocorals and some colonies of live corals, mainly brain corals (*Diploria spp.),* starlet corals (*Siderastrea spp.*) and *Porites spp*. This type of habitat was found in: Oda's Octocorals Garden; Jeff's Walls platform (to the west of Boomerang's Crest); the Alex Wall platform; on portions of the shallow platform of Ana's Choice; the Grouper's Joy platform; and the Peper's and Pigeon Cayes. This habitat represents 13.9% of the surveyed areas.

- **Coral reefs** extend over 63.5km^2 (or 13.2% of all the marine habitats identified in this survey).

- **Coral Bedrock:** This habitat features a relatively flat rocky bottom, with a limited cover of live coral, and presence of old dead coral. In some areas there is non-coralline algae and/or high octocorals density. This type of habitat is mainly found in the platforms of the fore reef of the Northeast Crest. This habitat represents 4.0% of the surveyed areas.

- **Algal Beds:** A deep-water area characterized by a bottom of rocky coral and sand, with abundance of non-coralline algae. This habitat represents 8.2% of the surveyed areas.

Table 2. *Relative Coverage of Marine Habitats around Barbareta Island.*

Habitat	Area (km^2)	%
Sea Grasses	11.4	43.2
Octocoral Garden	3.7	13.9
Coral Reef	3.5	13.2
Algae Beds	2.17	8.2
Sand	4.6	17.4
Coral Rock	1.1	4.0
Total	**26.38**	**99.9**

Coral Reef Structure and Types

Similar to Cayos Cochinos (Cortés 1997; Jiménez 1997), Barbareta features a combination of barrier reefs and fringing reefs, and numerous patch reefs and octocoral-dominated gardens (Brady 2001). Similar to other reefs elsewhere off the northern Honduran coast (Kramer & Kramer 2000), the reef crests off Barbareta are poorly developed. The reef fronts, while relatively narrow (i.e., 200-400 m wide; see Table 3 and Appendix B), are structurally and ecologically well developed. The relief of the reef fronts is complex and attracts a great deal of organisms (Complexity Index, CI = 1.54–1.90). See Glossary for term definitions.

Walls. — For an oceanic island, Barbareta's platforms fall off impressive walls, which may reach 50 meters in depth. Beyond that depth, the sandy substratum presents sponges and octocoral colonies. The walls extend all the way to the famous Cayman Trench, which may reach depths of up to six kilometers. The Cayman Trench separates the coasts of Belize and Honduras (Kramer & Kramer 2000).

Barrier (Emergent) Reefs. — Three barrier reefs were identified: Boomerang's Crest; Eastern Crest; and Southeastern Crest. Boomerang's Crest is located about 2 km from the south central coast of Barbareta, and is separated from the coast by a 30-m deep lagoon ("Barbareta's Lagoon"). The Eastern Crest and the Southeastern Crest are about 4 km from the coast, and are separated from the coast by a 20-m deep lagoon ("Dolphin's Lagoon"- it has a width of 4,349 m and features several spot reefs interspersed with sand and seagrass beds). The latter two crests are composed of a carbonate-type substratum covered with sand. Similar to Cayos Cochinos, these crests are covered from time to time during heavy storms by sand from the near-by cayes (Aronne, pers. comm. 2001). On the internal side of the crests there are rounded edges of sandy substratum covered with non-coralline algae. Nurse and bull sharks were observed on the deep platform. The platforms of the barrier reefs are more extensive than those of the fringing reefs found around the island. The longest emergent crest is Boomerang's Crest, followed by the Northwestern Crest, the Eastern Crest, the Northeastern Crest, the Southeastern Crest, and Barbareta's Crest.

Fringing Reefs. — Four fringing reefs were identified: Barbareta's Crest; Northeastern Crest; Northwestern Crest; and Ana's Choice. Barbareta's Crest spans both sides of the dock. Ana's Choice extends south of Pepper's Caye and Pigeon Caye. The Northeastern and Northwestern crests correspond to fringing reefs that feature 5-m deep lagoons with a maximum width of 396 m and 572 m, respectively (Appendix B). We found abundant dead coral and cavernous formations that harbor large fish between the Northwestern and Northeastern crests – at Viejito's Caves (Figure 2).

Platforms. — The platforms of the external reef fronts on the north are wider than the ones on the south. The platforms of the internal crests of Barbareta's Crest and Boomerang's Crest are the narrowest. On the west, between Morat Island and Barbareta, there is a platform named after Oda's Octocorals Garden with an average 12 m depth (Figure 2).

Table 3. *Length of the Crests, and Average Width and Surface Area of the Platforms and Reef Lagoons around Barbareta.*

Crest Name	Crest Length (m)	Lagoon Width (m)	Lagoon Depth (m)	Platform Area (km^2)	Platform Width (m)
Northwestern	3.1	574	4.5	1.4	437
Northeastern	1.9	396	4.5	0.8	408
Eastern	2.7	3,424	15.0	0.8	294
Southeastern	1.8	4,349	9.0	0.5	232
Boomerang's	4.1	2,363	30.0	0.7	34
Barbareta's	1.1	96	12.0	0.1	46

Relative Coverage of the Substratum

The reef fronts present a higher cover of non-coralline algae (42.2% ± 15.2%) than live coral (26.6% ± 6.1%). The percentage of algal cover is 11.9% ± 4.8%. The overall algal cover is 54.1 ± 20.1%. Dead coral is estimated at 5.7% ± 5.4%. Cyanobacteria cover an average of only 1.4% ± 1.9% of the substratum. There is a statistically significant difference in live coral coverage among sites (p < 0.03; F = 2.70; d.f. = 6). Ana's Choice has the highest percentage of live coral, whereas Barbareta's Crest and the Northeastern Spurs and Grooves have the lowest percentage of live coral. The relative cover of non-coralline algae is significantly different among sites (p < 0.001; F = 7.57; d.f. = 6). Sampled sites on the northern side of Barbareta have higher percentages of non-coralline algae than sites on the southern side. The most common algae are the encrusting fan-leaf alga (*Lobophora variegata*) and several "y-branched" algae in the genus *Dictyota.* Large concentrations of blue-green algae (*Schizotrix sp.*) were also observed.

Percentage of dead coral percentage is significantly different among sites (p < 0.001, F = 4.99, d.f. = 6). Ana's Choice and Boomerang's Point present a higher percentage of dead coral than Grouper's Joy and the Northeastern Spurs and Grooves. Likewise, there is a statistically significant difference in blue-green algae (Cyanobacteria) density among sites (p < 0.003, F = 4.10, d.f. = 6). The percentage of blue-green algae is higher at Boomerang's Point than the rest of the sampled sites.

Live coral cover is higher on the shallow platform and on the deep platform than at the wall (p < 0.001, F = 9.19, d.f. = 2). Non-coralline algal cover is significantly higher on the deep platform than on the shallow platform (p < 0.01, F = 6.65, d.f. =2). There are no significant differences among sites in terms of dead coral cover (p = 0.21, F = 1.60, d.f. = 2). Fire corals (millepores) do not present a significant difference among sites (P= 0.7, F= 0.63, d.f. = 6). See Table 4.

Table 4. *Relative coverage by geomorphological categories.*

	Wall (n = 14)	Deep Plataform (n = 20)	Shallow Plataform (n = 9)
Live Coral	18.3 ± 10.1	28.9 ± 10.7	30.7 ± 4.7
Dead Coral	5.7 ± 6.0	7.2 ± 6.5	11.4 ± 9.8
Coralline Algae	22.8 ± 11.9	7.6 ± 5.4	10.8 ± 6.4
Non-Coralline Algae	37.6± 14.0	47.9 ± 17.1	28.8 ± 9..0
Cyanophytes[1]	3.2 ± 5.7	1.2 ± 2.6	0
Milleporines[2]	0	0.3 ± 0.8	1.3 ± 2.1
Zooantharians[3]	0	0.2 ± 1.1	0.3 ± 0.9
Sponges	4.4 ± 5.2	1.9 ± 2.1	4.2 ± 7.5
Bedrock	0	0	0
Edges	0.2± 0.8	0	0.3 ± 1.0
Gravel	0.2± 0.8	2.2 ± 7.3	2.3 ± 3.8
Sand	3.6± 5.1	2.5 ± 4.6	9.8 ± 8.4
Mud	4.0± 9.2	0	0
Total	100.0	100.0	100.0

[1] Also known as "blue-green algae."
[2] Milleporine corals are also known as the fire corals or stinging corals.
[3] Zooantharians encompass black corals and reef-building hard corals.

SPECIES INVENTORIES

We identified 42 species of scleractinian (reef-forming) corals; 23 species of invertebrates; 56 species of algae; and two species of seagrasses. For a complete listing see Appendix C.

Scleractinians or Hard Corals

Scleractinian corals are known as "reef builders." Their protective external skeleton of calcium carbonate is a hard, stony structure easily seen in the reef. Typical reef-building corals include brain corals, finger corals, star corals, staghorn and elkhorn corals, and plate corals.

Density. — The total average density for hard corals is 10.1 colonies/m^2. The density of hard coral colonies is significantly different among sites ($p < 0.001$, $F = 4.12$; d.f. = 6). Ana's Choice presents the highest density of hard corals, whereas the Northeastern Spurs and Grooves, and Jeff's Wall present the lowest density of hard coral colonies (See Appendix D). The pillar coral (*Dendrogyra cylindrus*) has particularly high densities on the reefs south of Barbareta, i.e., Ana's Choice and Jeff's Wall. The elkhorn coral (*Acropora palmata*) was observed at these locations, but they were not counted on the official transect sampling.

Overall Relative Abundance. — As recorded in this rapid survey, the dominant live species in all the reef fronts of Barbareta Island is the lettuce coral (*Agaricia agaricites* -- 24%), followed by the mustard hill coral (*Porites astreoides* -- 11%), mountainous star coral (*Montastraea faveolata* -- 10%), massive starlet coral (*Siderastrea siderea* -- 10%), and great star coral (*Montastraea cavernosa* -- 9%). Since the massive coral deaths of 1998, the boulder star coral only accounts for 5%, and the staghorn coral accounts for only 1%.

On all reef fronts the deep platform was originally comprised mostly of the boulder star coral (*Montastraea annularis*), and the shallow platform consisted originally of the thin-leaf lettuce coral (*Agaricia tenuifolia*), elkhorn coral (*Acropora palmata*), staghorn coral (*Acropora cervicornis*) and bladed fire coral (*Millepora complanata*). However, many of these colonies died as a result of coral bleaching events, diseases and hurricanes (especially in 1998).

Relative Abundance by Sampled Site. — Grouper's Joy is located in the mid section of the reef front of the Northwestern Crest, between Morat and Barbareta (at 16º26'34" N and 86º10'46" W; Figure 2). The predominant species of hard corals are lettuce coral (*Agaricia agaricites* -- 32%), followed by great star coral (*Montastrea cavernosa* -- 11%), and massive starlet coral (*Siderastrea sidereal* -- 9%) (Appendix D) The reef base reaches up to 27 m in depth; and the limit between the wall and the deep platform up to 13 m. Octocoral gardens predominate on the shallow platform. In this site, schools of groupers have been seen spawning, mainly during the full moon of March (Bowmann, pers. comm. 2001).

Alex Wall is located on the medium front reef of the Northeast Crest (at 16º27'08" N and 86º08'38" W; Figure 2). The predominant hard corals are lettuce coral (*Agaricia agaricites* -- 21%), great star coral (*Montastrea cavernosa* -- 16%), ten-ray star coral (*Madracis decactis* --11.50%), massive starlet coral (*Siderastrea sidereal* -- 9%), and symmetrical brain coral (*Diploria strigosa* -- 8%). The reef base on the wall is 15 m deep and the limit between the wall and the deep platform is 7 m. The wall's platform is formed by octocoral gardens on coralline rock.

North Eastern Spurs & Grooves is located in the front reef of the eastern edge of the Northeastern Crest (at 16º26'53" N and 86º06'17" W; Figure 2). This reef is formed by a north-to-south system of channels and spurs that are typical of barrier reefs. The base of these spurs in the wall is 29 m distance and the edge of the Wall and the deep platform, 18 m distance. In these formations, important lobsters populations may be found (Aronne 2001). The predominant species are mountainous star coral (*Montastrea flaveolata* -- 29%), lettuce leaf coral (*Agaricia agaricites* -- 21%), great star coral (*Montastrea cavernosa* -- 16%), and mustard hill coral (*Porites astreoides* -- 11%).

Ana's Choice is located in the reef front of Pepper's Cay, to the southeast of Barbareta (at 16º24'29" N and 86º07'48" W; Figure 2). The predominant species are lettuce leaf coral (*Agaricia agaricites* -- 28%), followed by great star coral (*Montastrea cavernosa* -- 18%) and massive starlet coral (*Siderastrea sidereal* -- 10%). Ana's Choice can be considered the best site because it present the highest density of coral colonies and the highest percentage of live corals. Its shallow reef platform features pillar coral (*Dendrogyra cylindrus*), rose coral (*Manicina areolata*), barrel sponges and scattered octocoral gardens. The reef base is at 25 m, and the shallow platform begins at 8 m.

Boomerang's Point is located on the reef front of the eastern limit of Barbareta's Crest, near the exit channel of Barbareta's Lagoon, at 16º24'34" N and 86º08'38" W (Figure 2). The density of coral colonies was not estimated, but one colony of lettuce leaf coral (*Agaricia agaricites*) was observed. The rose coral (*Manicina areolata*), was also seen on the wall. The reef base is at 25 m and the shallow platform begins at 8 m.

Jeff's Wall is located in the reef front of Boomerang's Crest, to the southwest part of Barbareta, near the southeastern end of Morat Island (at 16º24'40" N and 86º10'44" W; Figure 2). This site presents one of the most vertical and deep walls encountered during this survey, with a great structural complexity and deep caves. In decreasing order, the predominant species are lettuce leaf coral (*Agaricia agaricites* -- 18%), mustard hill coral (*Porites astreoides* -- 12%), massive starlet coral (*Siderastrea sidereal* -- 12%), thin-leaflettuce coral (*Agaricia tenuifolia* -- 11%), and mountanous star coral (*Montastrea faveolata* -- 9%). The platform is 34-m wide and characterized by octocoral gardens on a sandy substratum, typically with pillar corals (*Dendrogyra cylindrus*). The reef base is 30 m away from the Wall, and the deep and narrow platform's edge is 14 m away. The shallow platform consists in octocoral gardens and dispersed colonies of lettuce coral.

Barbareta's Crest is an internal reef located to the east of the landing dock, within Barbareta's Lagoon (at 16º25'40" N and 86º09'46" W; Figure 2). It features only one wall whose base is at 18 m in depth. The Crest is 1.5 m deep and descends to a 12-m lagoon on the internal side. Barbareta's Crest features abundant mud that covers 18.9±11.42% of the substratum (Table 5). The mud probably originates from the adjacent mangrove lagoon (Figure 2). The predominant species on the wall are lettuce leaf coral (*Agaricia agaricites* -- 24%), mustard hill coral (*Porites astreoides* -- 10%), mountanous star coral (*Montastrea faveolata* -- 10%), massive starlet coral (*Siderastrea sidereal* -- 10%), and great star coral (Montastrea cavernosa -- 9%). Dead colonies were observed of boulder star coral (*Montastrea annularis*), staghorn coral (Acropora cervicornis), lettuce leaf coral (*Agaricia tenuifolia*), and fire coral (*Millepora alcicornis)*. *Agaricia undata* was observed deep on the wall. Barbareta's Crest has abundant algae that are typical of lagoons (e.g., *Avrainvillea spp., Udotea spp.*, and *Penicillus dumetosus*), and typical of reefs (e.g., *Halimeda spp., Dictyota spp*., and *Lobophora variegata*).

Dolphin's Pyramids are pyramid-shaped reefs located in the lagoon of the barrier reef of the Eastern Crest. The lagoon is 4,349 meters wide. The reference to dolphins is because during the survey a group of about 20 dolphins was observed. This location features patch reefs interspersed among seagrass beds and walls that reach 20 meters in depth.

The survey at Dolphin's Pyramids was conducted by free diving, with no transects. Hence no density or relative abundance estimates were taken. The base of the patch reefs at Dolphin's Pyramids is comprised mainly of several species of brain corals, boulder star coral, lettuce leaf coral, mustard hill coral, massive starlet coral, elliptical star coral, thin-leaf lettuce coral, elkhorn coral, several species of finger corals, yellow pencil coral, and staghorn coral. In addition, fire corals were observed. The tip of the crests features mainly mustard hill coral, lesser starlet coral, fire corals, elliptical star coral, symmetrical brain coral, finger coral, and elkhorn coral. Dead coral colonies -- mainly thin-leaf lettuce coral and horn-like corals – are also present. Debris can be seen of the staghorn coral, as well as overturned colonies of elkhorn coral and pillar coral. Live colonies of elkhorn coral have dead bases. Black Band Disease and tumors were found in colonies of brain corals. Non-coralline brown algae (Phaeophyta) were abundant. A few sea urchins were observed. The walls are sandy, with isolated coral colonies, octocorals, and barrel sponges. It is common to see hawksbill turtles grazing at Dolphin's Pyramids.

In addition to Dophin's Pyramids other sites on the northern side of Barbareta were explored where no transects were executed. Rita's Scary Wall features the most extensive wall, with a relatively deeper (52 m) reef base, showing a cut at 24 m, and the platform edge at 18 m deep. At Martha's Lobster Bank the reef base is at 47 m and the platform edge is also at 18m. Beyond the walls around Barbareta there is a sandy substratum featuring sponges and octocorals reaching depths of 100 to 120 m.

External Reefs. **—** The wall of the external reefs that were surveyed feature a reef base, on average, at 30 m (range: 15 to 52 m), and the edge between the wall and the platform has an average of 16 m (range: 7 -24 m) and a shallow platform (6-8 m) where coral composition is more complex (Figure 3). The average "complexity index" of deeper platforms was higher (CI = 1.54) than that of shallower platforms (CI = 1.90). The reef crests are poorly developed and the reef platforms and fronts are narrow (Figure 3). All the reef fronts around Barbareta appear to be composed mainly of *M. annularis,* whereas in the shallow platform by *A. tenuifolia, A. palmata, A. cervicornis* y *M. complanata.* Most of the colonies of these species are dead, and have been replaced by other species. Significant dead coral (*M. annularis*) can be found on the deep platform of the Northeastern Spur, as well as dead *A*. *palmata* on the crest. Additionally the non-coral algal coverage is very high. However, where the channels and spurs are well defined a significant lobster population is found. The platform of the Northeastern reef fronts is comprised mainly of algal banks on coral rock. The delicate pillar coral (*D. cylindrus*) can still be found, as well as barrel and vase sponges, mainly in Ana's Choice where a sponge up to 1.5 m height x 60 cm diameter was measured.

Table 5. *Coverage related to the reef substrate by site.*

	Grouper's Joy.	Alex's Wall	Spurs & Grooves	Ana's Choice.	Boomerang's Point.	Jeff'sWall	Barbareta's Crest
Live Coral	27.1±11.7	30.1±6.7	26.5±5.1	32.1±7.1	25.9±9.4	30.4±4.5	13.8±4.3
Dead Coral	0.8±1.4	1.7±2.9	0.9±1.7	12.3±5.7	13.1±6.4	2.9±2.9	7.9±3.3
Coral Seaweed	15.9±13.0	14.9±12.8	6.9±3.4	6.6±6.1	7.0±7.0	13.7±3.4	17.9±3.2
Non-coral seaweeds	51.5±14.67	49.9±2.8	64.7±5.9	34.3±9.7	46.9±12.0	24.5±10.3	23.7±15.5
Cianophytes	0.8±1.4	0.0±0.0	0. 0±0.0	0.8±1.4	4.0±4.6	0.0±0.0	4.0±1.8
Mileporines	0.8±1.4	0.0±0.0	0.0±0.0	0.5±1.1	0.0±0.0	2.0±3.4	0.0±0.0
Zoantaries	0.0±0.0	1.7±2.9	0.0±0.0	0.2±0.8	0. 0±0.0	0.0±0.0	0.0±0.0
Sponges	2.0±3.5	1.7±2.9	0.0±0.0	2.7±2.0	3.0±3.0	9.8±11.9	7.0±4.7
Pavement	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
Edges	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	1.0±1.7	1.0±1.7
Gravel	0.0±0.0	0.0±0.0	0.0±0.0	3.4±9.2	0.0±0.0	3.9±6.8	1.08±1.7
Sand	1.0±1.8	0.0±0.0	0.9±1.7	6.9±8.0	0.0±0.0	11.8±8.8	4.9±8.5
Clay	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	18.9±11.4

Diseases. — The incidence of hard coral diseases is relatively low, compared to other general observations of the authors and tends to be more frequent on shallow platforms (< 8 m). The most common disease is the Black Band Disease (BBD). Several colonies of star corals, starlet corals, and brain corals show signs of the disease. The literature also reports the white band disease (WBD), especially on fore reefs.

It is well documented that the Bay Islands and other reefs in the Caribbean were once dominated by the boulder star coral and related species on the platforms, and elkhorn coral and thin leaf lettuce coral on the reef crests. The reduction in population and potential local extinction of these reef-building species is of particular concern (Kramer & Kramer 2000).

Coral Recruitment. — Fortunately, coral recruitment can be observed on the reefs of Barbareta, which may be an indication of the recovery potential for at least certain species of hard corals. At all sampled sites, coral recruitment was visible at depths below 10 meters. Recruits were observed for the massive starlet coral, mountainous star coral, and the symmetrical brain coral, but no recruits were sighted for some of the main reef builders, such as the boulder star coral.

The natural process of coral reef recovery depends on several factors, including growth rates, regeneration of surviving colonies, potential for recruitment of new larvae, as well as the natural history and particular physiological features of a given coral species (Bak and Engel 1979).

Coral Bleaching. — It appears that the coral reefs of Barbareta – and the entire Bay Islands Archipelago – are being affected by increasingly frequent and intense bleaching events. To make matters worse, the occurrence of Hurricane Mitch in 1998 coincided with a bleaching event. The northeastern sides of the Bay Islands were the most affected by Hurricane Mitch. A study by Kramer & Kramer (2000) addressed this issue and evaluated a shallow reef to the east of Barbareta.

The boulder star coral appears to be one of the species most affected by bleaching (Mcfield, 1999). Kramer & Kramer (2000) reported that this species accounted for only 5% of the live coral. At one point, the boulder star coral was the most dominant species of deep platforms

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Octocorals or Gorgonians

The name octocoral refers to the characteristic of colonies having polyps with eight tentacles. With few exceptions -- such as the blue corals and organ-pipe corals -- octocorals do not produce substantial calcium carbonate skeletons and include the familiar sea fans and sea whips.

Although octocorals are a characteristic and important component of reef systems worldwide, they are extremely difficult to differentiate, and only a small percentage have been given common names. As a result, their diversity and abundance may be underestimated. In some areas, octocorals represent the most dominant component of a coral reef. In addition to their scenic value for underwater tourists, octocoral formations serve as habitat for conspicuous and ecologically important groups, such as sponges (Muzik 1982; Zea 1993), mollusks (Gerhardt 1990), polychaetes (Vreeland & Lasker 1989) and fish (Lasker 1985). In addition, some octocorals are rich in secondary metabolites with pharmacological potential (Bakus *et al.* 1986; Pawlik 1993; Kim 1994).

A total of 1,699 octocoral colonies were recorded along 32 sampling transects. A total of 41 octocorals species (distributed in 14 genera) were identified. Of these, seven species are either different morphotypes or, possibly, new species in the following genera: *Pseudoplexaura, Eunicea*, and *Plexaurella.*

The number of octocoral species recorded at Barbareta is higher than those reported for Roatán (Keith 1992) and the Swan Islands (Tortora & Keith 1980). Forty-four species were reported at Cayos Cochinos, based on a 20-sampling-month study (Guzmán 1998). The 41 species reported for Barbareta in this survey are the result of 12 days of sampling effort. However, it must be noted that the main emphasis of the sampling was habitat characterization, not species inventories per se. Hence, the figures for Barbareta and Cayos Cochinos from these two different studies, may not be readily comparable.

The highest number of octocoral species (25) was found at Ana’s Choice. The lowest number of species was found at Grouper’s Joy (11), at the northern limit of the northeastern crest.

Density. —The average octocoral density for Barbareta is 5.2 colonies/m² (Table 6). This is consistent with our free diving observations. Oda’s Octocorals Garden (located between Barbareta and Morat) appears to have a high abundance of octocorals, but less species richness than other sites. The results from the transect surveys in the reef fronts show a higher density of octocorals in the northeastern and southeastern sections off Barbareta (Appendix D).

Table 6. *Overall and site-specific density of octocorals***.**

SITE	# OF SPECIES	DENSITY (colonies/m^2)
Alex’s Wall	11	5.9
Grouper’s Joy	11	5.0
Boomerang’s Point	20	3.3
Ana’s Choice	25	4.4
Jeff’s Wall	21	6.1
NE Spurs & Grooves	11	6.1
OVERALL	**41**	**5.2**

The wall presents the highest number of species (24) with an average density of 3.9 colonies/m² of octocorals. Twenty-two species of octocorals were found on the deep platform, with an average density of 5.2 colonies/m². On the shallow platform, 21 species were found, with an average density of 7.0 colonies/m² (Appendix D).

Relative Abundance. — The most abundant octocoral species appears to be the slimy sea plume (*Pseudopterogorgia americana).* Its feathered colonies – in a wide range of sizes – can be found in all sites.

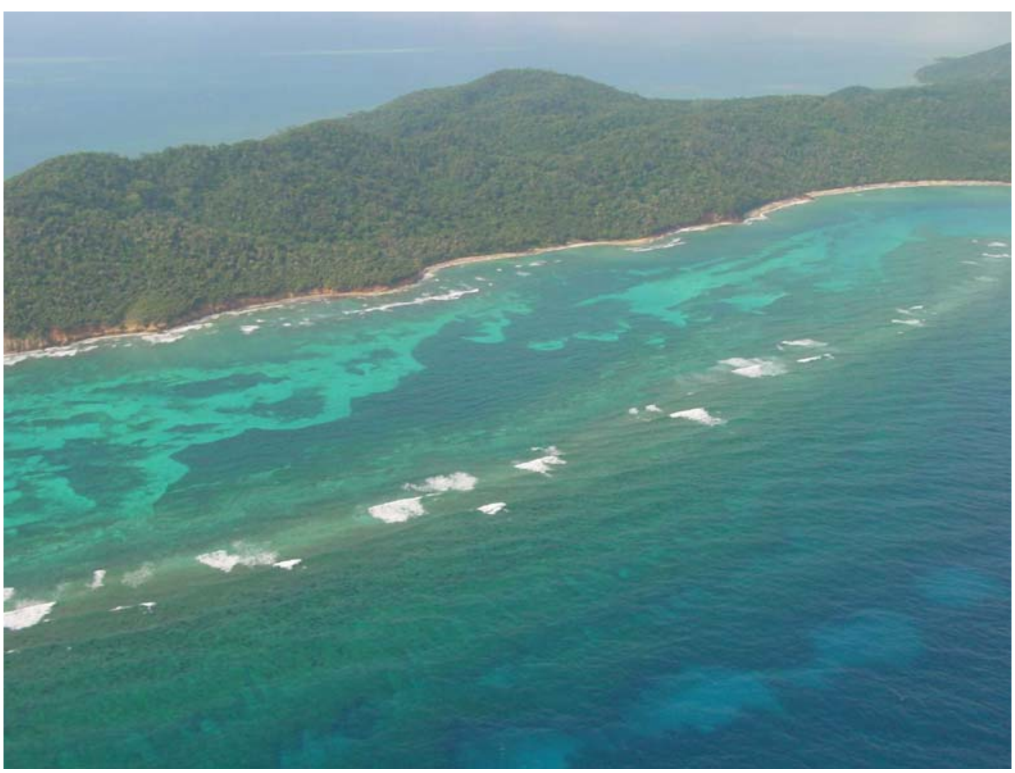
At the wall, the slimy sea plume featured a density of 0.9 colonies/m². On the deep platform, density was estimated at 2.1 colonies/m²; and on the shallow platform density was 3.5 colonies/m². The bent sea rod (*Plexaura flexuosa*) is most abundant at the wall, with a density of 1.1 colonies/m² (but it is not well represented on the deep and shallow platforms). The purple sea plume (*Pseudopterogorgia acerosa*) presents the same density on the wall and deep platform. However, the colonies are smaller and not in very good shape, particularly on the deep platform.

Isolated colonies of the angular sea whip (*Pterogorgia anceps*) appear to be the only octocoral found on sea grasses throughout the survey area.

There are small pyramid-shaped spot reefs that resemble "islands" among the extensive sea grass prairies (Dolphin's Pyramids). There, octocorals grow over the rocky coral substratum among scleractinians. The most abundant species there are *G. ventalina*, *P. flexuosa* and *Eunicea spp*.

Conspicuous sponges tended to be denser at the walls (0.3 ind./m²) than in the deep platforms (0.2 ind./m²). Densities were not estimated on the shallow platforms.

Taking into account the damage suffered by octocorals throughout the Caribbean (Cortés 1997), Barbareta appears to have relatively dense and diverse populations of octocorals.



Antipatharians or Black Corals

Black corals are related to gorgonians and stony corals. They tend to have a patchy distribution and generally occur at a low density. Black corals are commercially harvested primarily for jewelry, but have more recently also become popular with underwater tourists (Opresko 1996).

Two species of black corals were found during this study: the wire coral (*Cirripathes [*or *Stichopathes] leutkeni*) and the bottlebrush bush (*Antipathes hirta*). At depths of 18-20 m they were particularly abundant on the sampling transect at Jeff's Wall, and less so at Boomerang's point. At depths of 30-50 m, they were also observed at Martha's Lobster Bank, Rita's Scary Wall and Jeff's Wall. Populations of the wire coral were observed between 27-30 m at Barbareta's Crest (which is characterized by thick muddy sediment).

Guzman (1998) reports five species of black corals for Cayos Cochinos (at a depth range of 12-35 m): *Antipathes lenta, A. pennacea, A. atlantica, A. hirta, and Stichopathes (=Cirripathes) lutkeni.*

Regional Comparison of Living Coral

Much like the rest of the Caribbean, the Mesoamerican Reef Ecoregion is undergoing a dramatic change, whereby non-coralline algae – especially brown algae (Phaeophyta) – are increasing while the living coral cover is decreasing (Ginsburg 1994).

The decrease in living coral coverage may be attributed to a combination of natural and human-made disturbances: Water temperature increases and coral bleaching (Brown & Ogden 1993; Goreau & Hayes 1994), especially the very intense bleaching events of 1995 and 1998 (McField 1999; Kramer & Kramer 2000); mass mortality of the long-spine sea urchin (*Diadema antillarum*) in 1983 (Lessios *et al.* 1984); overfishing of reef fish (Hughes 1994); the spread of coral diseases (Goreau *et al.* 1998; Hayes & Goreau 1998), and the increased frequency and magnitude of hurricanes (Kramer and Kramer 2000). There is a need for more systematic research into these disturbances to gather evidence and establish more reliable cause-effect relationships (Soto 1997).

Table 7 shows the percentages of living coral versus non-coralline algae for selected locations in the Western Caribbean. Out of nine locations, only Bocas del Toro (Panama) shows a higher coverage of live coral (27%) than algae (21%). However, when their coral species diversity is compared, Barbareta features higher species diversity (43 species) than Bocas del Toro (33 species) (Guzmán & Guevara 1998). According to Jiménez (1997), Cayos Cochinos boast 51 coral species. Possible explanations for the apparently higher coral species diversity around Cayos Cochinos include the relatively longer term studies and monitoring carried out there, and the presence of both insular and continental underwater habitats. Nevertheless, Cayos Cochinos also has an abundance of some non-coralline algae species, such as *Dictyota spp*. and *Lobophora variegata.*

Table 7. *Regional comparison of living coral and algae in selected locations in Mesoamerica*.

Country	Site	Reef Type	Live Coral (%)	Algae (%)	Year	Source *
Panama	Bocas del Toro	Insular	27	21	1999	a
Costa Rica	Cahuita	Continental	13	60	1999	a
Nicaragua	Great Corn Island	Insular	36	37	1998	a
Honduras	Roatán	Insular	34	38	1997	b
Honduras	**Barbareta**	**Insular**	**27**	**54**	**2001**	**This study**
Guatemala	Punta Manabique	Continental	9	65	2000	c
Belize	Carrie Bow Cay	Insular	16	65	1997	a
Belize	Calabash Cay	Insular	10	58	1997	a
Mexico	Puerto Morelos	Continental	1	93	1999	a

***** Source: **a)** CARICOMP Data Base (1999) **b)** Fonseca & Radawsky (1997) **c)** Fonseca (2000)

There is some evidence that indicates that living coral cover in Belize has been reduced by approximately 20% over the last 30 years – probably due to increased anthropogenic stress and increasingly more frequent coral bleaching events (CARICOMP 1999; McField 1999).

It is important to maintain high percentages (i.e., above 40%) of live coral because scleractinian ("hard") corals are the main reef formers, and they have very slow growth rates. As a result, a reef may take many years to recover from great disturbances (Wilkinson 1992).

Fish

Species Richness and Density - One hundred forty six fish species were found in the waters around Barbareta. This is an estimated 80 species fewer than around Cayos Cochinos (Clifton & Clifton 1998). See species inventory Appendix C. However, the difference could be attributed to differences in sampling/diving frequency of previous surveys. The average total density of fish species was 0.7 ± 0.2 per square meter (Table 8), which is relatively low compared with the estimates from Clifton & Clifton (1998) of 1.9 fish/m^2 for Cayos Cochinos. However, the species density estimates for Barbareta are higher when compared to those reported for the waters around Roatan (0.3 fish/m^2) by Fonseca & Radawsky (1997).

Table 8 summarizes the fish species density at each site. Jeff's Wall presents a density of 0.8 ± 0.4 fish/m^2. According to anecdotal reports, based on fish sightings, Jeff's Wall is one of the best sites for recreational diving, followed by Ana's Choice (0.7 ± 0.2 fish/m^2). Both places are on the more sheltered (southern) side of Barbareta.

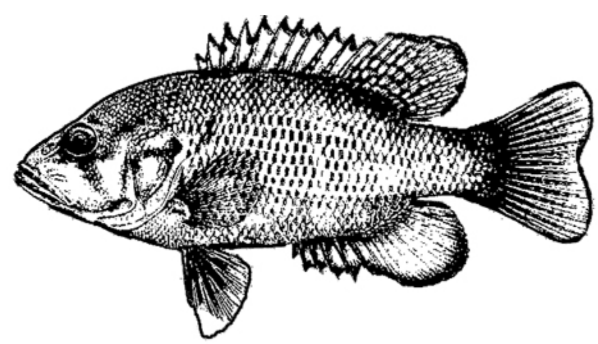


Table 8. *Average fish density (individuals per square meter) in selected Sites.*

Site	Average Fish Density (ind/m²)	N	# Species
Alex's Wall	0.7 ± 0.2	4	38
Grouper's Joy	0.7 ± 0.2	7	42
Boomerang's East Point	0.6 ± 0.2	12	34
Ana's Choice	0.7 ± 0.2	10	34
Jeff's Wall	0.8 ± 0.4	8	38
NE Spurs & Grooves	0.7 ± 0.5	5	34
Total	**0.7 ± 0.2**	**46**	**80**

In general, the walls featured higher concentration of fish (0.9 fish/m^2), probably due to a greater complexity of the substratum at the edges of the platforms and the presence of schools of Acanthuridae and Kyphosidae. Fish density on the (exposed) northern walls was slightly higher (1.0± 0.39 fish/m^2) than in the protected reef walls on the south (0.8 ± 0.4 fish/m^2). In shallow platforms, the substratum's homogeneity may have an effect on fish density because the estimate was only 0.6 fish/m^2 (Table 8). This may have been different if the transects had been carried right on the reef's crest.

Relative Abundance - In decreasing order, the species with the highest density (individuals per square meter) are the blue head wrasse (*Thalassoma bifasciatum*), blue reef-fish (*Chromis cyanea*), creole wrasse (*Clepticus parrae*), ocean surgeonfish (*Acanthurus bahianus*), yellowhead wrasse (*Halichoeres garnoti*), striped parrotfish *(* *Scarus iseri*) and threespot damselfish (*Stegastes planifrons*). The bicolor damselfish (*Stegastes partitus*) is the dominant species at deep and shallow reef platforms (for both the exposed and protected reefs). Several of these species (mainly the bicolor damsel, bluehead wrasse, ocean surgeonfish, yellowhead wrasse, and striped parrotfish) are also abundant in various other Caribbean locations.

The masked goby (*Coryphopterus personatus*), while seemingly abundant, was not included in the survey because of its small size (< 3 cm).

The stoplight parrotfish (*Sparisoma viride*), redtailed parrotfish (*S. chrysopterum*), redband parrotfish (*S. aurofrenatum*) and redfin parrotfish (*S. rubripinne*) are species most commonly associated with coral reefs throughout the Caribbean. These species are relatively abundant around Barbareta. The redtail parrotfish, in particular, is the dominant parrotfish at the shallow bottoms between Morat and Barbareta (i.e., the northwestern side of Barbareta).

The creole wrasse (*Clepticus parrae*) is also very abundant around Barbareta, and common around Cayos Cochinos. It favors the edges of reef walls of exposed reefs. The creole wrasse is particularly abundant on coral platforms, and so are the blue head wrasse and the yellow head wrasse. The ocean triggerfish (*Canthidermis sufflamen*) is a pelagic fish that in this survey was found at the walls of the reefs to the north of Barbareta (off the sampling transects). The black triggerfish or black durgon (*Melichthys niger*) is also a pelagic fish of very wide distribution (both trigger fishes are also found in the Pacific Ocean), and is very abundant at the reef walls.

The density of snappers in the Lutjanidae Family and grunts in the Haemulidae Family around Barbareta appears to be low. Among the snappers, the schoolmaster snapper (*Lutjanus apodus*) is the most common. The mahogany snapper (*Lutjanus mahogani*) seems more common around Barbareta than Cayos Cochinos. The lane snapper (*Lutjanus synagris*) was not recorded during this survey. The lane snapper is an important catch as reported in the landings from Cayos Cochinos.

The dusky damselfish (*Stegastes fuscus*) is generally dominant in coastal shallow reefs with sedimentation problems, such as Cahuita and Manzanillo in Costa Rica (Gamboa 1997). It is also common around Cayos Cochinos (which is closer to the coast), but scarce around Barbareta.

On deep reef walls of the exposed reefs north of Barbareta, only one individual was seen of the giant hogfish (*Lachnolaimus maximus*). However, this same species is reported as abundant and an important catch for artisanal fishery in other parts of the Caribbean, such as off the state of Quintana Roo in Mexico (González, pers. comm. 2001). The giant hogfish appears to be rare in Cayos Cochinos, as well as in the coastal reefs of Costa Rica and Panama (Gamboa 1997 1998).

The yellowtail snapper (*Ocyurus chrysurus*), the white grunt (*Haemulon plumieri*), and the saucer eye porgy (*Calamus calamus*) are not frequently found around Barbareta, presents a short frequency for these species, making the fishery pressure something evident. The "Yalatel" *Ocyurus* was seen few times and in juvenile sizes, the white grunt *Haemulon plumieri* was also reported as at least common, the feather fish *Calamus calamus* seems to be the most abundant and was also seen in adult sizes. However, excepting the *Ocyurus chrysurus, Lutjanus synagris, Carangoides ruber,* several species of commercial interest are at least as high or higher density in Barbareta than in Cayos Cochinos (Clifton and Clifton 1998).

On the other hand, the largest abundance of grouper *Mycteroperca* spp, the observation of a goliath grouper *Epinephelus itajara* large grouper schools, barracuda abundance, the presence of sharks of the *Carcharhinus spp.* gender could be an indication that the fishery is not still excessive in the place. Notwithstanding, during the present survey, at least three small vessels (wooden dugout canoes with motors) were seen during the study.

The marginal reef near Barbareta's Crest presented a very particular situation. It is the only site studied with high sediment deposition from the small wetland or mangrove (currently in deteriorated status). This situation is very similar for the interior reefs of the lagoon system of Bocas del Toro in Panama (Gamboa 1998), which support two species that may need this type of substratum (very fine sediment deposits on the base of the reef wall). 1- *Serranus tortugarum* (Serranidae); 2- *Odontoscion dentex* (Sciaenidae). *Haemulon aurolineatum* was also found, an important component of the ictiological fauna of the Cays and the coastal reefs.

Within the sea grasses, small madreporic coral drums are found, spread and shallow, which are a shelter to juvenile forms of several species (*Acanthurus coeruleus, Holocanthus tricolor, Pomacanthus paru*, *Pomacanthus arcuatus*, Pomaceous species additionally to other species).

In the reef crests and in Dolphin's Pyramids, the roughly surface of the substratum formed out mainly by dead structures of *A. palmata* is very high, finding a high diversity of fish, mainly abundant we can list parrot fish (corallivorous) and *acanturides hervibores*).

The structure of the fish communities of Barbareta is quite different than that of Cayos Cochinos, likely due to its more "oceanic" character versus the moral coastal waters of Cayos Cochinos (Clifton and Clifton, 1998 and Gamboa, 1997 b). The differences are higher when these are compared with coastal reefs such as the ones of Costa Rica and Panama (Gamboa 1997 , 1998 b).

Large predators, such as sharks, snappers, and groupers of considerable size (reproductive adults larger than 60 cm) that are very important in fishery and therefore its protection in this area is advisable.

Crustaceans

Two species of spiny lobsters – *Panulirus argus* and *Panulirus guttatus* – were recorded. Lobsters were observed in 10 of the 30 sampling transects. When compared by depth and location, the density of *P. argus* was higher at the wall below 15 m (55.5 ind./ha) and at the shallow platform above 8 m (44.4 ind./ha). No specimens of *P. argus* were recorded at the deep platform. The average density of *P. gutattus* was higher at the deep platform, 22.2 ind./ha, intermediate in the wall (11.1 ind./ha) and shorter at the shallow platform (7.4 ind./ha). This may indicate a separation of ecological niches between the two species.

The average density for both species combined was 23.4 individuals per hectare. Overall, the average density was 41.1 individuals per hectare for *P. argus,* and 11.1 individuals per hectare for *P. guttatus.* In 1998, Tewkif et al. carried out a study of spiny lobsters at Cayos Cochinos, where the density of *P. argus* was lower (19.9 ind/ha) than at Barbareta. The density of *P. guttatus* at Cayos Cochinos (9.3 ind/ha) is only slightly lower than at Barbareta.

Lobster fishing was observed during this survey, but the data seems to indicate that Barbareta does not yet suffer from the levels of overexploitation of spiny lobsters reported for many other Caribbean locations.

In addition, thirty-two species belonging to 16 decapod families were recorded in a variety of habitats, including coral reefs, sea grasses, inter-tidal zones and land environments. Given the size of Barbareta Island and its surrounding marine environment, it is anticipated that future studies will result in longer species inventories.

For neighboring Cayos Cochinos, Jácome (1998) reported 45 species belonging to 11 families of anomurous and brachyrus (based on a 3-month survey and using fish traps, dragging and lures in addition to observations additionally to lung and autonomous diving).

Several crustacean species found during this survey have a wide vertical distribution and can be found all the way from the shallow platform to the reef walls, including the banded coral shrimp (*Stenopus hispidus*), anemone shrimp (*Periclimenes yucatanicus*), Pederson cleaner shrimp (*Periclemenes pedersoni*), the yellow-line arrow crab (*Stenorhynchus seticornis*), batwing coral crab (*Carpilius corallinus*), the tropical hermit crab (*Calcinus tibicen*) and the scarlet hermit crab (*Paguristes cadenati*).

The giant red hermit crab (*Petrochirus diogenes*) was found in a variety of habitats from shallow sea grass prairies to deep sandy bottoms (25 m).

Species associated with shallow seagrass prairies include the blue-legged hermit crab (*Clibanarius tricolor*), nodose box crab (*Calappa angusta*), winged mime crab (*Epialtus dilatus* f. *elongata*), sponge spider crab (*Macrocoeloma trispinosum*), spotted decorator crab (*Microphrys bicornutus*), *Mithrax sculptus*, *Pitho quadridenata* and *Callinectes similis*. Under the coral rocks in the zone within the tides, the *Axiopsis serratifrons*, *Clibanarius antillensis*, *Petrolisthes politus*, *Percnon gibbesi*, and *Pachygrapsus transversus* species are found. Inside of holes, in the sandy beaches, it was very common to find the *Ocypode quadrata* species, the coast shore where flora began and it has an inland extension, the *Gecarcinus lateralis* species is found. Associated to small mangrove spots and a lagoon the *Uca burgesi*, *Cardisoma guanhumi* y *Callinectes sapidus* species were found. The small *Dissodactylus rugatus* pinnotheryd was found inside the oral cavity of the *Cypeaster rosaceus* sea urchin, which is common related to sandy bottoms in prairies of sea grasses or in the reef.

All the crustaceous species with a commercial value are over exploited and in all this survey these were seen as just two types of specimens, *Mithrax spinosissimus* known as monster and *Carpilius corallinus.* Likewise, these populations were found in Cayos Cochinos before its declaration as a biological reserve. Nowadays, after the usage of the different areas in Cayos Cochinos was fragmented, and at the same time a closed area for exploitation was implemented, the availability of sea resources of a commercial concern has improved.

Echinoderms

Four species of sea urchin were recorded (Appendix C). The sea urchin density; *Diadema antillarum* is sow low (1.4 ind/ha) as in other Caribbean reefs after the massive death that these suffered in 1983 (Lessios *et al.* 1984).

Mollusks

Eighty-two species of mollusks were recorded during the survey. Of these, 24 species (distributed in 12 families) are bivalves, 56 species (distributed in 24 families) are gastropods, one species is a cephalopod, and one species is an opistobranchian. A previous study of mollusks carried out in the waters around the Bay Islands archipelago yielded 111 species of bivalves, and 210 species of gastropods (Cerrato 1986). A more recent study carried out in Cayos Cochinos yielded 85 bivalves and 106 gastropods (Álvarez 1998). Both studies were longer in duration than this rapid ecological assessment, which may help explain, at least in part, the lower number of species reported here for Barbareta.

During the survey, special emphasis was placed on the economically important queen conch (*Strombus gigas*) population. This species is under increasing pressure due to elevated market demand, to the point that is has been included in Appendix II of CITES. Once abundant in shallow waters, the queen conch is so scarce that fishermen are being forced to use diving equipment to search for it in deeper waters (Tewfik *et al*. 1998).

DESCRIPTION OF THE CONCH SURVEY SITES

NOTE: The names below were arbitrarily chosen when they were missing from traditional maps

Oda's Octocoral's Garden is located between Barbareta and the Island of Morat. The site begins in-between tidal areas with a rocky platform dominated by algae of the species *Padina pavonica* and *Cymopolia barbata*. The site covers an area of about 5 to 10 meters to a depth of 50 cm. Beyond the platform, the area is covered by seasgrass reaching out to about 60 meters and 5 meters in depth, until they begin to intersperse with sandy patches and octocorals.

McNab's Path is located in front of the cayes off the southeastern portion of Barbareta. It is an area with a patch reef dominated by the species *Porites astreoides*, and the genera *Diploria* and *Siderastrea*, and surrounded by seagrasses and sandy patches with a depth ranging from the surface down to 10 m

Cambute´s Land is an extensive seagrass prairie reaching more than 15 meters deep, featuring small sandy patches and some spread out, solitary octocorals dominated by *Pterogorgia anceps.*

Table 9 shows queen conch densities in selected sites around the island. Overfishing around Barbareta has significantly diminished densities in shallow areas (1 – 10 m), but the queen conch still is relatively high below 15 m, where free diving becomes a limiting factor. Increasingly, local fishermen are using scuba diving equipment to capture this species, which is likely to cause significant and rapid declines in abundance.

Table 9. *Queen conch densities in selected sampling sites.*

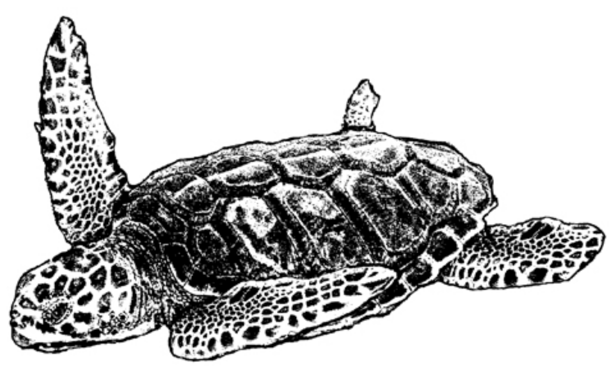
Site	Depth	# Individuals	Surveyed Area	Density (individuals per hectare)
Oda's Octocoral Garden	1 – 5 m	1	720 m^2	13.9
McNab's Path	1 – 10 m	6	5,000 m^2	12.0
Cambute Island	> 15 m	10	1,256 m^2	79.6

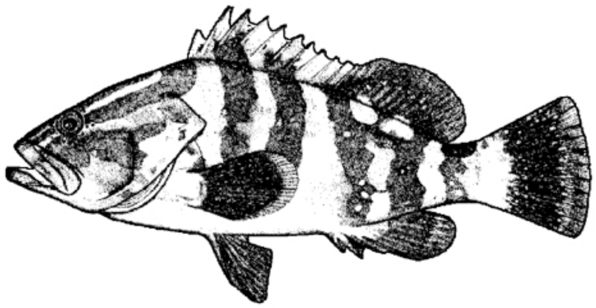
The average density of queen conch around Barbareta is 35.14 individuals per hectare. Table 10 compares relative densities of queen conch in selected locations in the Caribbean Basin.

The average density for Barbareta is the second highest after the Jamaican sites.

Table 10. *Regional comparison of queen conch densities in the Caribbean (modified from Tewfik et al 1998).*

Location	Density (individuals per hectare)
Little Bahamas Bank	28.5
Great Bahamas Bank	20.8
Bermuda (1988)	0.5
Bermuda (1989)	2.9
Florida Cayes (1987-88)	2.4
Florida Cayes (1990)	1.5
Cayos Cochinos (Honduras)	14.9
Barbareta (Honduras)	**35.2**
St. Croix (US Virgin Islands)	7.7
St. Thomas/St. Johns (US Virgin Islands)	9.7
St. Thomas/St. Johns (US Virgin Islands)	12.2
Pedro Bank (Jamaica) – Artisanal Zone (0-10 m)	88.6
Pedro Bank (Jamaica) – Industrial Zone (10-20 m)	203.6
Pedro Bank (Jamaica) – at 20-30 m	276.6
Puerto Rico	8.1
Venezuela (Protected Area)	2,130.0
Venezuela (Area under Exploitation)	900.0





7 SUMMARY OF THREATS

FISHING

The waters around Barbareta are subject to unregulated fishing. Lobster and queen conch are important targets of artisanal fishermen. There is also illegal capture of sea turtles (mainly the hawksbill) with gill nets. Finfish are the primary target of the industrial fishing fleet. In contrast to the ravaging effects caused by industrial fishing, the approximately 100 fishermen from the Santa Elena Island community (~10 km west of Barbareta) use line fishing, gill nets, and free diving. Every day during the survey, on average, three small dugout canoes were seen fishing -- mostly on the northern, southern and eastern sides off Barbareta. Some sport fishing boats were also observed.

Compared to Cayos Cochinos, the waters around Barbareta show a significantly lower abundance of certain commercial fish species, such as the yellow-tail snapper or "yalatel" (*Ocyurus chrysurus*), the white grunt or "ronco" (*Haemulon plumieri*), the saucer-eye porgy (*Calamus calamus*), lane snapper *(Lutjanus synagris*), and the bar jack (*Caranx ruber*). However, several other finfish species of commercial value found around Barbareta present average densities that are similar or higher than those reported for Cayos Cochinos (Clifton & Clifton 1998). For instance, the presence of groupers or "meros" (*Mycteroperca spp*,) in large numbers, the spotting of a jewfish (goliath grouper) (*Epinephelus itajara*) and sharks of the genus *Carcharhinus* might be an indication that fishing activities have not yet depleted all commercial fish populations.

TOURISM

One of the problems associated with tourist (and fishing) boats is the lack of mooring buoys. Boat anchors and chains cause unnecessary damage to the reef-building coral polyp. Most physical damage caused by boats could be avoided through the installation of a mooring system.

Almost of a daily basis, and especially during the weekends, a boat with an average of 20 tourists visits Barbareta – mooring primarily at Pigeon Cay. Figure 2 shows diving sites often used by the guides of Santa Elena. The northern reefs show more damage and are seldom visited. Likewise, the reef front of the Eastern Crest is seldom visited for its being so far away from the coast (Bowmann, pers. comm. 2001).

DISEASES

Several diseases currently affect corals and other reef organisms in the Caribbean. The frequency and variety of diseased corals and other reef species have increased over the past 10 years. The origin, distribution, and causes of these diseases are not well understood, but there is some literature available on the topic (Goreau *et al.* 1998; Hayes & Goreau 1998), and several studies underway. This survey did not carry out a systematic analysis of diseases affecting the reefs of Barbareta.

HURRICANES

The entire Mesoamerican-Caribbean Reef Ecoregion is located on the main path of hurricanes, especially during the months of October and November. Until 1998, the most devastating hurricane recorded for Honduras was Fifi in 1974. But when Hurricane Mitch hit in late 1998, it replaced Fifi as the deadliest and most costly hurricane ever to hit Honduras. Kramer & Kramer (2000) quantified some of the preliminary effects of Mitch on the marine environment of northern Honduras.

The areas most affected by Hurricane Mitch were the northeastern beaches and shallow reefs of Barbareta, Guanaja, Roatán, and Utila. The damage to the coral reefs of Honduras was relatively less than average, when compared to the entire area affected by the hurricane. An estimated 11% of the shallow reef colonies and 2% of the deep reef colonies of Honduras were affected by Mitch (Kramer & Krame, 2000).

Both types of colonies, fragile corals such as *Agaricia tenuifolia, Acropora palmata, A. cervicornis*, fire coral M. complanata, and the mass corals such as *M. annularis* were affected. Also octocorals were destroyed (Kramer and Kramer 2000). Kramer and Kramer (2000) found as a result of the hurricane that the reef exposed to wind remained as naked pavement, with short spurs and in blocks, low coral coverage and destroyed crests. This situation was found in the northeastern part of Barbareta. More dramatic damage occurred on the reef fronts composed of an unstable layer of fragments of dead *A. cervicornis* cover, on which mass corals were growing.

In addition to the immediate physical destruction caused by the energy of the waves, removal of bottom sediments also happened. This was very hard to quantify and distinguish from the fading phenomena by high temperatures. Additionally, it was reported that in the Gulf of Honduras, a lot of fresh water runoff occurred, which was full of sediment, fertilizers, and pesticides from the mainland. The satellite images show that these sediment plumes affected the Bay Islands for several months, but the measure in which this affected the reefs is still unknown. On the other hand, some people suggest that the pass of the hurricane helped to diminish the water temperature, to remove macroalgae and to help the fragments recruitment and survival, diminishing the competence to corals. It is being reported that some branched coral colonies were recovered while the mass coral were still faded in 1999 (Kramer and Kramer 2000).

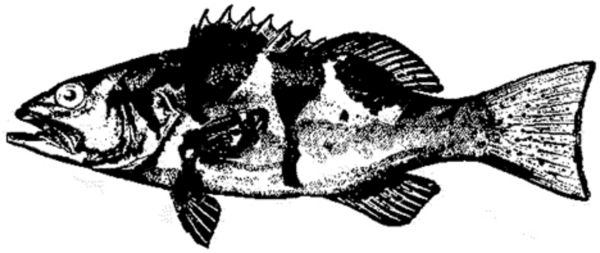
The unusual warming of the water just before and after Hurricane Mitch presented ideal environmental conditions for a lot of marine pathogens (fungus, bacteria, cyanobacteria, and protozoa). The hurricane must have acted as a diseases vector extending them and increasing the number of infected colonies, mainly the BBD cyanobacterias (Kramer and Kramer 2000).

Sedimentation

Barbareta's Crest presents a serious sedimentation problem. Apparently, the mangrove from the lagoon has been dying over the last three years, and the loss of plant cover has resulted in mud beaches that are causing sedimentation (Tonsmeire, pers. comm. 2001). In addition, sediments are carried to the Bay Islands during periodic strong storms or hurricanes affecting the heavily deforested Northern Honduras coast. This was confirmed through satellite images after Hurricane Mitch (Kramer & Kramer 2000).

Global Climate Change

Global climate change has become a major threat to the survival of coral reefs and other natural ecosystems around the world. As a result, physical and biological processes in the marine environment influenced by water temperature and water circulation in particular are being disrupted at an unprecedented scale. The threat of global warming must be addressed at a global scale, and its various effects should be discerned from those caused by more local threats (Wilkinson 1992).



8 CONCLUSIONS AND RECOMMENDATIONS FOR A MARINE RESERVE

For a Caribbean island of its size (about 1,200 acres), Barbareta is uniquely well preserved. It is practically uninhabited (except for one of its owners who resides there with a few staff). Barbareta is located within a globally important reef system (i.e., the Mesoamerican-Caribbean Reef Ecoregion) but currently lacks adequate legal protection.

Like most of the world's reefs, the reefs of Barbareta are no longer pristine. However, the reefs around Barbareta appear healthier than many other reef areas off the Central American Coast. Except for Barbareta's Crest in front of the mangrove lagoon, the reefs around Barbareta do not yet show significant sedimentation or runoff pollution that is more prevalent in reefs closer to the mainland.

Barbareta has 27% of live coral, and 42% of non-coralline algae. A greater percentage of non-coralline algae than live coral – which is a sign of disturbance – has become the prevalent condition of the reefs in the Caribbean, with a few exceptions.

This survey shows a particularly rich diversity of octocoral species around Barbareta, making it one of the most developed reefs of Honduras. Barbareta boasts Queen conch, lobster banks, turtle nesting beaches, spawning aggregation sites of groupers, and healthy dolphin and shark populations. It also has a great abundance of the attractive big barrel sponges.

The waters surrounding the Island of Barbareta support a significantly rich and diverse assemblage of coral reef and associated species, as demonstrated by the findings of this nine-day rapid ecological assessment. Notwithstanding the short duration of this assessment, it is clear that the waters around Barbareta offer great potential for responsible recreational diving and as a marine protected area.

The significant diversity of marine habitats around Barbareta helps explain, at least in part, its relatively high species diversity. However, it is the authors' estimation that a longer, in-depth study of marine life around Barbareta is needed to provide the most accurate possible inventory of species and populations present in the waters of Barbareta Island.

Barbareta features a rather complex reef structure that provides food and shelter to significant populations of fish and lobsters. The reefs of Barbareta also harbor spawning aggregation sites. J. Bowmann (personal communication) reported during this survey that groupers are known to spawn at Grouper's Joy, mainly during full moon in March. The reefs of Barbareta are associated with extensive seagrass beds, and a few mangrove patches that play a key role as shelters and feeding sites for larvae and juveniles of numerous species, including the Queen conch.

Unlike the already protected Cayos Cochinos, which is a continental reef system, Barbareta is a more oceanic reef system, which is also in need of protection.

Because of it's climatology and oceanographic patterns, the rough waters around Barbareta preclude fishery activities at certain times of the year. This is a helpful natural protection tool.

Ultimately, the likelihood and extent of future extinctions of coral reef species will depend on the scale and intensity of the disturbances. At this time, the long-term ecological consequences (including changes in species composition and structure) of natural and human-made disturbances are not well understood. In spite of the dearth of information and limited understanding of the impact of human disturbances on coral reef ecosystems, the creation of viable networks of marine protected areas and "biological corridors" is one of the strategies that should be pursued to offer a type of insurance or natural buffering capacity to protect and maintain the biological integrity of the Mesoamerican Reef.

RECOMMENDATIONS FOR A MARINE RESERVE

While the waters around the Bay Islands are, in theory, a national park, currently there is no adequate representation of protected coral reef areas in the Bay Islands. The Bay Islands need a network of protected areas to guarantee the maintenance of viable populations of marine species that have commercial and recreational value, as well as essential ecological processes vital for the survival of the coral reef ecosystem.

To begin, it may be advisable to explore a possible public-private partnership with the owners of Barbareta to ensure that the waters around it (which are of public domain) be protected while, at the same time, allowing for well planned, regulated public uses, including low-impact, responsible tourism. Until now, Barbareta has been well protected by its owners as a *de facto* biological reserve, with limited tourism development. There is some basic infrastructure on the island that could eventually be improved and used for a combination of research, management and small-scale, responsible tourism activities.

Any future declaration of a marine reserve around Barbareta, including the final determination of its boundaries, should involve advance consultations with the neighboring fishing community on Santa Elena. Depending on how much community involvement there is from the beginning, the design and implementation of a marine reserve around Barbareta could benefit or hurt the local subsistence fishermen.

Based on the findings of this rapid ecological assessment, the authors recommend – on a preliminary basis -- that the boundaries be established by an imaginary line beginning on every reef crest around the island and extending it 1 Km out around the perimeter. The entire Barbareta reef systems (including the island of Morat and all the spectacular reef walls – see below).

Figure 6 shows the proposed boundaries of a marine reserve. We drew a rectangle, roughly based in the 1 km border in front of the reef crests, in order to facilitate the process of boundary demarcation and management. The western border was adjusted to the western border of Morat so this is not included in Santa Elena, Roatán. The area of the rectangle corresponds to the proposed area of the reserve and is of 7522 ha. Additionally, four reference points were located in the island from which straight lines were drawn to make the reserve borders to the North, South, East, and West (Figs. 5 and 6).

Geographic Reference Points for the Proposed Reserve Boundaries

The geographic coordinates for the four reference points on Barbareta are:

- West End Beach (86.167º - 16.429º)
- Trunk Turtle Beach (86.140º - 16.447º)
- East End Point (86.123º - 16.446º)
- Pelican Point (86.141º - 16.430º)

The coordinates of the four corners of the imaginary rectangle that delimits the proposed area for the reserve are:

- Northwest Border (86º 11’ 28” – 16º 27’ 36”)
- Northeast Limit (86º 04’ 59” – 16º 27’ 36”)
- Southeast Limit (86º 04’ 58” – 16º 24’ 04”)
- Southwest Limit (86º 11’ 28” – 16º 24’ 04”)

Once the reserve is established, its boundaries should be properly demarcated using buoys and other suitable markers. This would serve the dual purpose of educating visitors and resource users about the reserve and its borders, and facilitating patrolling and monitoring activities. The proposed marine reserve should be regulated by a management plan and properly trained personnel.

INCLUSION OF MORAT ISLAND IN THE PROPOSED MARINE RESERVE

We recommend that Morat Island be included as part of the design of a future marine reserve around Barbareta. Morat covers 0.5 km^2, and has a perimeter of 3.2 km. It is located immediately to the west of Barbareta and to the east of Roatán. There are several reasons for recommending the inclusion of Morat in a future marine reserve:

- Boomerang’s Crest extends from Barbareta to Morat, and it is an important element of the reef system.
- A sizable octocoral garden (described earlier as “Oda’s Octocoral Garden) is found on the shelf between the two islands.
- Morat features an interesting tropical humid forest and abundant mangrove forests, both in relatively pristine condition. These mangroves (if protected) will help sustain fisheries and contribute to the overall success of the reserve.
- The southeastern and northeastern sides of Morat feature impressive coral walls.
- Morat is uninhabited.

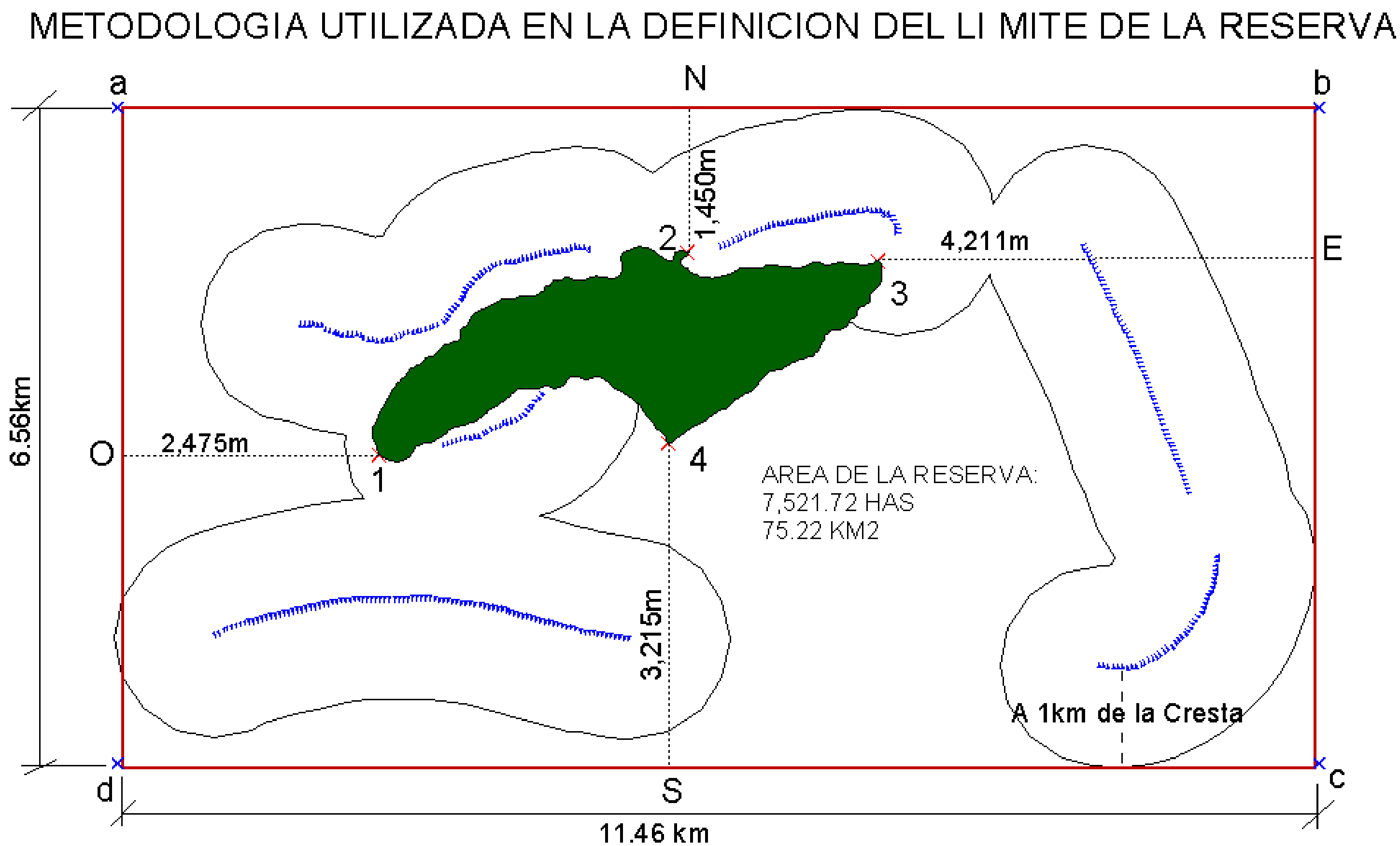


Figure 5. *Methodology for the Proposed Boundaries for a Future Marine Reserve, Barbareta Island.*

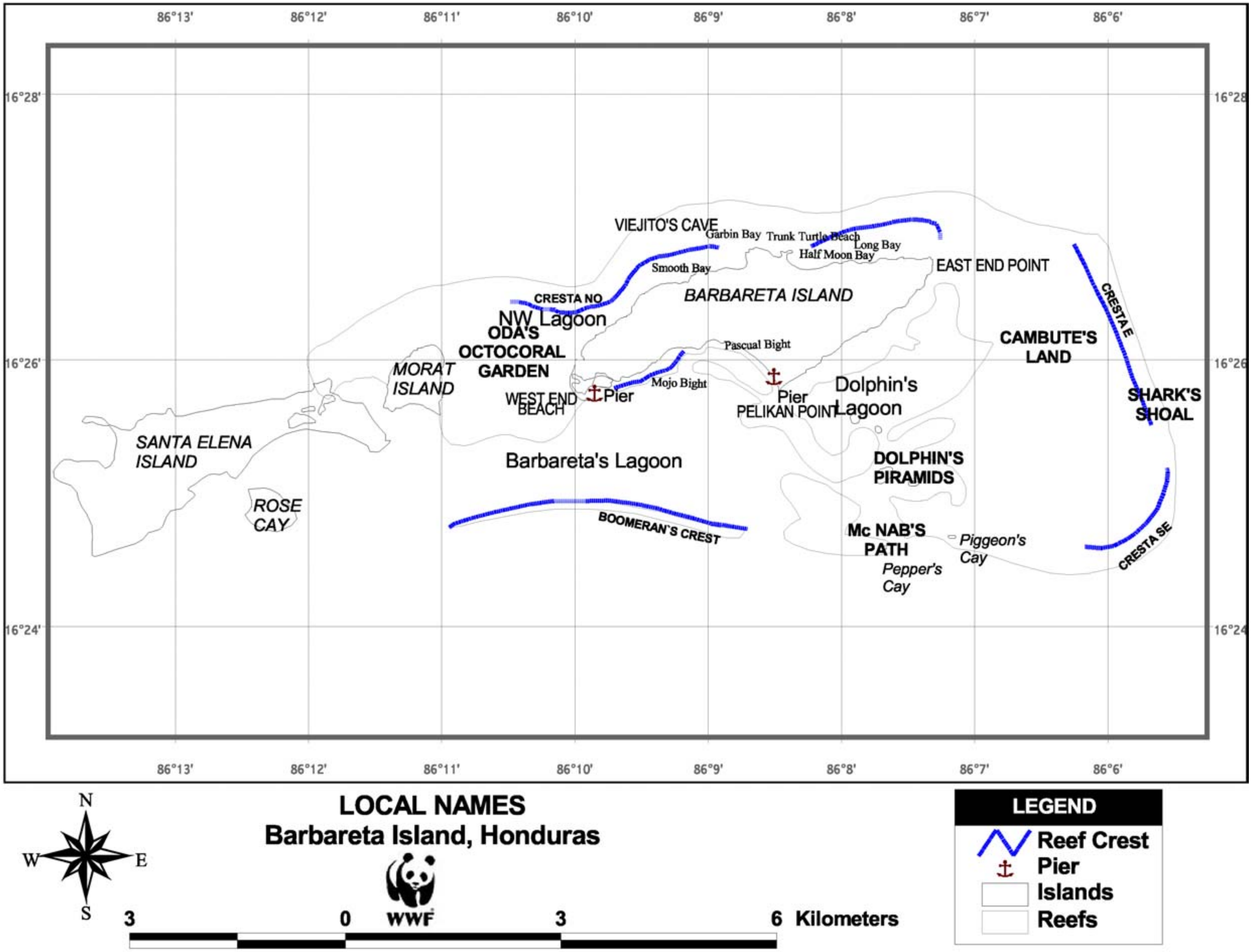


Figure 6. *Map of Proposed Marine Reserve, Barbareta Island*

RECOMMENDED RESERVE ZONING

As part of a comprehensive management plan, the reserve should be "zoned" to guarantee both multiple uses and the protection of core and sensitive areas. Zoning could help recover degraded and overexploited, and guarantee the integrity of the reserve over time.

Core or Nuclear Area. -- We recommend that the lagoon and the barrier reef to the east and southeast of Barbareta (including the cays) be given absolute protection and be declared restricted areas, such as to serve as "reservoirs" of coral species, finfish, conch, lobster, dolphins, and sharks.

Restricted Use Area.—Diving may be restricted to the East Cay, Pigeon Cay and the reefs around it, whereas Peper's Cay and Ana's Choice should be off limits. Additional sites on the north side of the island might be suitable for regulated diving.

In all cases, tourism activity must be well planned to reduce the negative impacts (Pendleton 1994). The undesirable side effects of SCUBA diving and free diving are well documented (e.g., Hawkins and Roberts 1992, Allison 1996). Studies of carrying capacity and/or acceptable limits of change should be carried out, and certain extractive activities may have to be regulated or banned altogether in the Restricted Use Area.

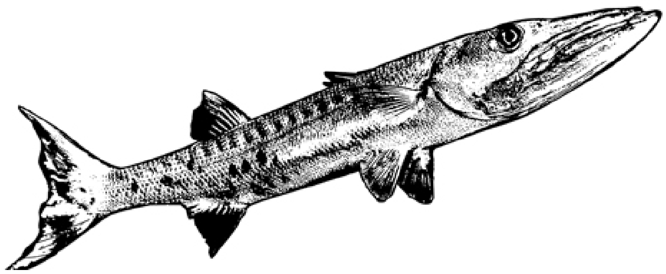
Fishing Area. - Subsistence fishing in the waters around Barbareta is an important activity for neighboring communities. It should be allowed, but regulated. Commercial fishing should be banned. Subsistence fishing may take place to the west and south of Barbareta. No fishing should be allowed to the east and north to protect conch and lobster populations and spawning sites for groupers. Allowable fishing techniques, fishing seasons, and limits to sizes and volumes of certain species (e.g., lobster) should be studied and recommended as part of a future management plan.

OTHER MANAGEMENT RECOMMENDATIONS

- An integrated coastal zone management plan should be developed for Barbareta and Morat, which involves the participation of neighboring communities.
- The reserve management plan should include details for long-term oceanographic, biological, and fisheries monitoring.
- The reserve management plan should include details for ongoing public awareness and environmental education programs targeted to neighboring communities and visitors.
- Soil management and reforestation efforts may be advisable in affected areas of Barbareta (including mangrove areas).
- Promote research, training, and sustainable management of the marine and coastal resources.
- Regulate artisanal (subsistence) fishing activities and ban commercial fishing in reef areas.
- Promote a closed seasons berried female lobsters.

RECOMMENDATIONS FOR FUTURE RESEARCH

- Conduct a more detailed and longer-term inventory of marine species and their habitats. (Special emphasis should be placed on invertebrates and algae).
- Analyze the changes in species composition of the reef over geological time.
- Study the marine currents of the Bay Islands to better understand the potential flow of pollutants and sediments from the mainland and the islands themselves.
- Study the migratory habits of commercially important species.
- Study coral recruitment and larvae dispersion by the currents.
- Conduct genetic studies of key populations throughout the MAR and wider carribean to better understand connectivity amoung reefs.
- Carry out intensive surveys of the condition and localized extinction risks for the main reef builders coral species (e.g., *Acropora*, *Agaricia*, *Montastraea*, *Millepora*).
- Carry out surveys of herbivore biomass (e.g., food habits of the herbivores, diet preferences, herbivorous rates, etc.).
- Carry out studies of octocoral populations, in particular their distribution, abundance, and population dynamics so these may be used as issues bio-indicators of reef disturbance.
- Assess the actual and potential impacts of fishing and tourism.



9 GLOSSARY

Barrier Reef: A reef separated from the shoreline by a deep lagoon or channel. Barrier reefs are usually located between 1.5 and 4 km from the shoreline. The lagoons may be more than 20 meters deep.

Back Reef: Shoreward side of the reef.

Black Band Disease (BBD): A disease that eventually kills coral tissue while advancing in the shape of a band around the coral and leaving the white coral skeleton behind.

Bleaching: The process by which a coral polyp expels its symbiotic zooxanthellae from its body.

Crest: Shallow portion of the reef that separates the fore and back reef areas. It is usually characterized by branched corals or vertical laminates that provide great structural complexity and protection for fish.

Deep Platform: Deep part of the fore reef, usually with a depth of 10 to 20 m, facing the wall's edge.

Fore Reef (or Reef Front): Seaward side of the reef crest that may have a shallow, flat platform, and another deeper more inclined platform with a vertical wall.

Fringing Reefs: A reef separated from the shoreline by narrow, shallow lagoons (< 20 meters deep). Fringing reefs are the most common type of reef and are considered geologically young.

Gorgonians: Octocorals that include sea fans, whips and branching octocorals.

Hard Corals: Reef-building corals whose skeletons are made of calcium carbonate. Examples include the brain coral and elk-horn coral. Also see below: **Scleractinians**.

Hydrozoans: A class of organisms that group species as diverse as jelly fish, hydras and fire corals, and lace corals. The latter two families are called hydroids, and they are colonial like corals, but are not closely related to corals (even though they secrete calcareous skeletons).

Lagoon: relatively calm area of water on the landward side of a barrier reef. It often has significant areas of sand, seagrasses, and isolated coral spots or colonies.

Millepores: Any of the genus of marine invertebrates comprising the Order Milleporina (Phylum Cnidaria). They are collectively called fire corals (or sometimes stinging or pepper corals). Millepores are common in shallow tropical seas to depths of about 100 feet. Unlike the "true" corals, which belong to the Class Anthozoa, millepores are more closely related to the hydra.

Octocorals: Collective name for several orders of "octocorals" that include sea fans, sea whips, sea pens, sea pansies, etc. Unlike "true corals," few octocorals produce calcium carbonate skeletons

Patch Reef: An isolated complex of corals that differs from an otherwise homogenous. Underwater topography. They usually occur between fringing reefs and barrier reefs. Patch reefs vary greatly in size, and they rarely reach the surface of the water.

Sand Flats: Extensive sandy areas found between patch reefs, or in depressions and gullies on the reef proper, or in deeper areas below or beyond a reef. Sand flats are often textured with ripple marks due to the action of strong bottom currents.

Seagrass Beds (or Meadows): Seagrass beds are ecologically important habitats in marine environments. Seagrasses and their associated micro-algae are highly productive, and provide food for small invertebrates and fishes. They also provide protection against predators and serve as nursery grounds for the juvenile stages of commercially important species. Despite their name, "seagrasses" are not true grasses but are flowering plants in the families Potamogetonaceae and Hydrocharitaceae.

Scleractinians: Commonly known as "stony corals" or "hard corals" (and sometimes referred to as "hexacorals" because of their six-rayed appearance). They belong to the Order Scleractinia. Colonial scleractinians from modern tropical seas are now the world's primary "reef formers" or "builders." Some scleractinians, however, do not form colonies.

Spots Reefs: Smaller reefs, mainly in a circular shape, that grow in an isolated and spread out way. They are usually found in the lagoons of marginal and barrier reefs.

Stony corals: Members of the order Scleractinia, which secrete a heavy, external, calcareous skeleton, and many of which are primary contributors to the building of coral reefs. lso see: **Scleractinians** and **Hard Corals**.

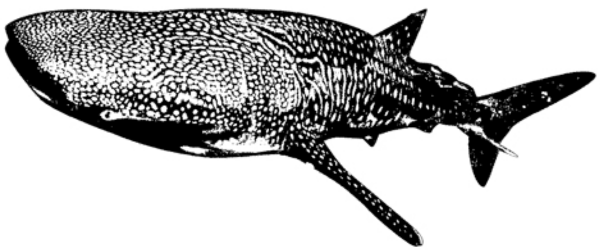
Shallow Platform: Upper portion of the fore reef, usually of less than 10 m in depth, characterized by a complex coral structure similar to the reef crest.

Spurs: Reef structures shaped as bridges or fingers that develop in the fore reef. They are usually perpendicular to the coastline or in the direction of the waves. Spurs are often separated from one another by sandy channels.

Transect: A sampling unit comprised of a line or narrow belt used to estimate relative abundance and density in a given area.

Wall: Underwater steeps that fall in near 90º and.f.es, from depths of about 60 m to 100 m or more. Walls are usually associated with the outer limit of an insular or continental platform.

Zooxanthellae: Unicellular yellow-brown (dinoflagellate) algae that live symbiotically inside reef-building corals. Zooxanthellae provide corals with food (through photosynthesis) and, in turn, the coral provides rotection and access to light for the zooxanthellae.



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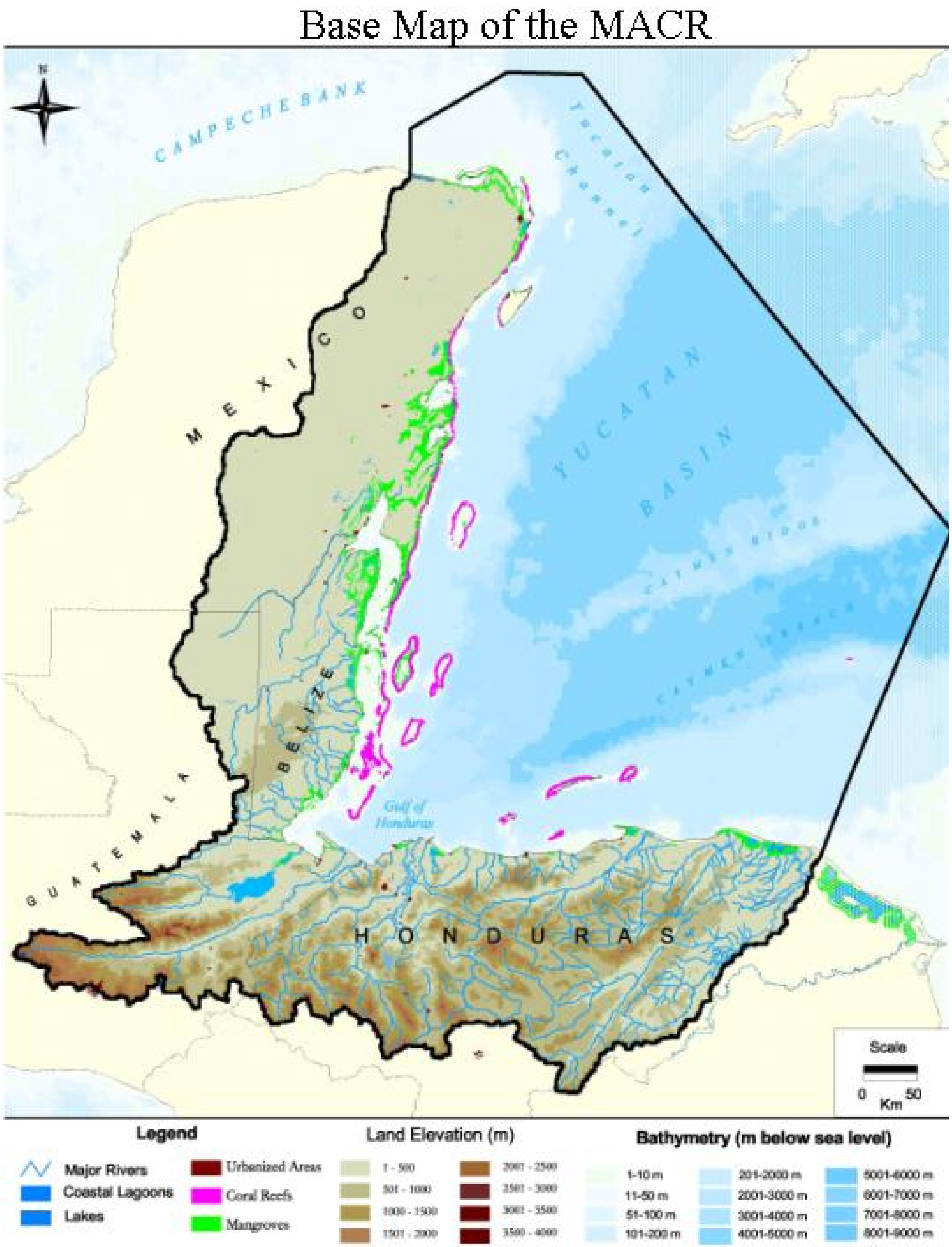
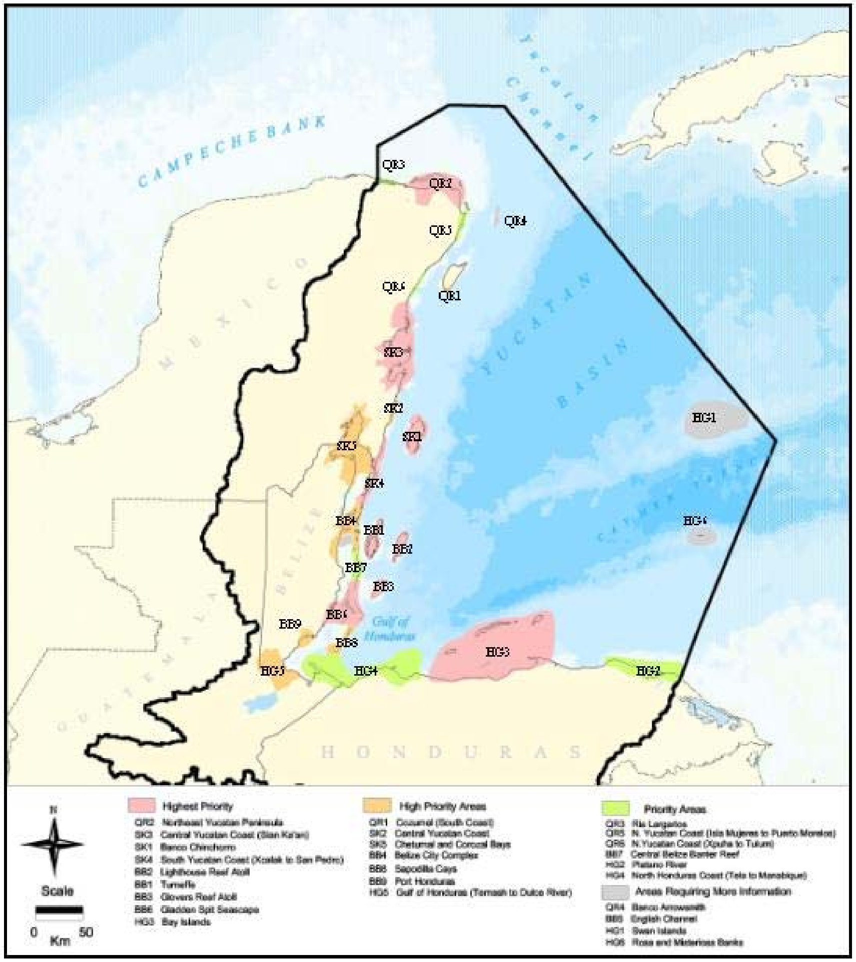
APPENDIX A

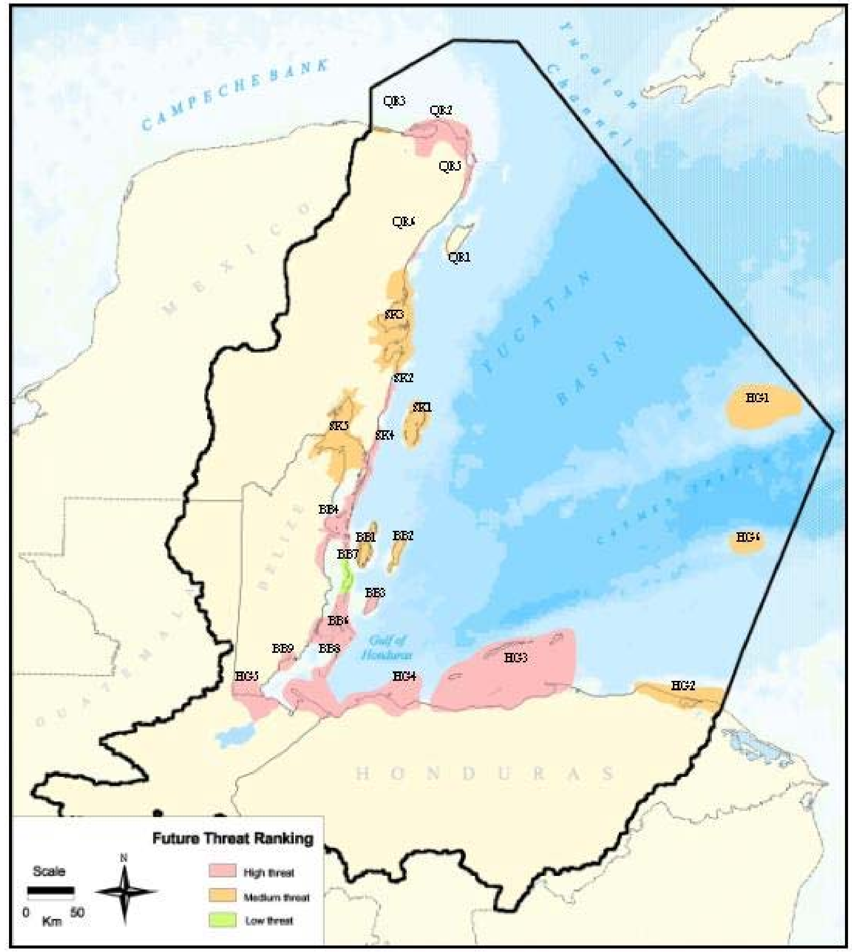


Map A1. Base map of the Mesoamerican Caribbean Reef Ecoregion (Kramer and Kramer 2002)

Biological Priority Areas



Future Threat Ranking



Map A2. Biodiversity Priority areas (Kramer and Kramer 2002)

Map A3. Future Threat Ranking (Kramer and Kramer 2002)

APPENDIX B

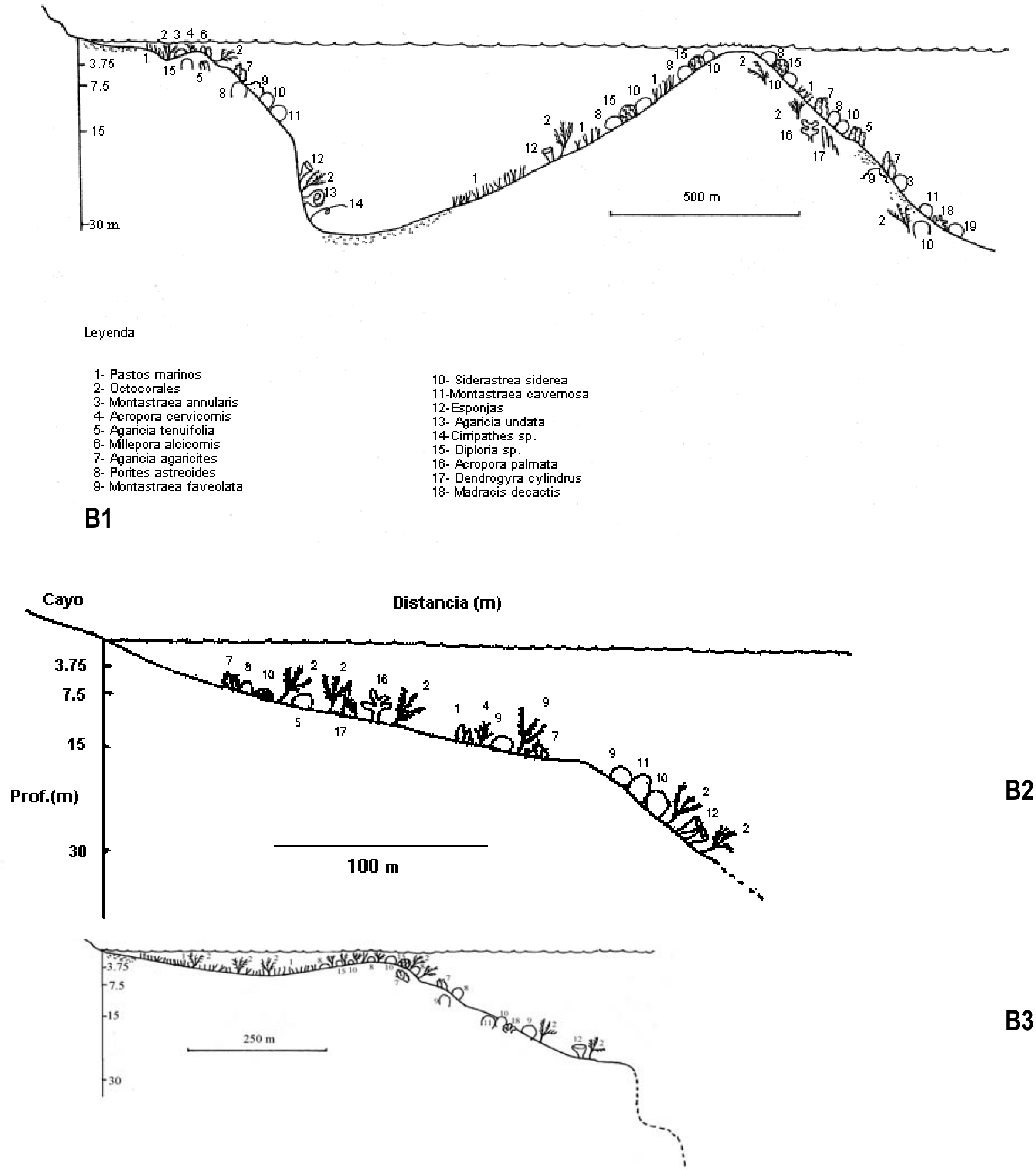


Figure B. *Typical Profiles of the reefs of Isla Barbareta. (**1**) Profile of the internal reef of Barbareta's Crest followed by the profile of the reef of the Boomerang's Crest barrier, southeast part; (**2**) Typical Profile of the marginal reef in front of the cays, southeast side; (**3**) Typical Profile of the marginal reefs of the north part crests.*

APPENDIX C

Table C1. *Coral inventory for Barbareta Island.*

CLASS HIDROZOA

Hydrozoans form colonies that secrete hard, calcareous skeletons, however, they are different from hard or stony corals. Hydrozoans are represented in two families, fire corals and lace corals.

Fire Corals
- *Millepora alcicornis*
- *Millepora complanata*

Lace Corals
- *Stylaster roseus*

CLASS ANTHOZOA

The name for this class of corals means "flower-like animal." Anthozoans are very diverse and encompass hard or stony corals, octocorals, and black corals.

HARD ["STONY"] CORALS

Hard or stony corals are also known as scleractinians ("hard-rayed") or hexacorals ("six-rayed"). Colonial hard corals from tropical seas are the world's primary reef builders thanks to their hard skeletons of calcium carbonate.

Horn-like Corals
- *Acropora cervicornis*
- *Acropora palmata*

Finger-like Corals
- *Porites porites* f. *porites*
- *Porites porites* f. *furcata*
- *Porites porites* f. *divaricata*

Pilose Coral
- *Dendrogyra cylindrus*

Pencil-like Corals
- *Madracis mirabilis*
- *Madracis decactis*

Red Corals
- *Stephanocoenia michelinii ?*

Mountain Corals
- *Montastraea annularis*
- *Montastraea faveolata*
- *Montastraea franksi*
- *Montastraea cavernosa*

Elliptical Coral
- *Dichocoenia stokesii*

Gulf Ball Coral
- *Favia fragum*

Mustard Coral
- *Porites astreoides*

Star Corals
- *Siderastrea siderea*
- *Siderastrea radians*

Brain Corals
- *Diploria strigosa*
- *Diploria clivosa*
- *Diploria labyrinthiformis*
- *Colpophyllia natans*

Intrincated Corals
- *Meandrina meandrites*
- *Meandrina brasiliensis*

Rose or Pink Coral
- *Manicina areolata*

Lettuce Corals
- *Leptoseris cucullata*
- *Agaricia grahamae*
- *Agaricia undata ¿*
- *Agaricia agaricites* f. *agaricites*
- *Agaricia agaricites* f. *danai ¿*
- *Agaricia humilis ¿*
- *Agaricia tenuifolia*

Cactus Corals
- *Mycetophyllia danaana*
- *Mycetophyllia lamarckiana*
- *Mycetophyllia aliciae*
- *Mycetophyllia ferox*
- *Isophyllia sinuosa*
- *Isophyllastrea rigida*

Artichoke Corals
- *Scolymia cubensis*
- *Scolymia wellsi*

Spine Flower Corals
- *Mussa angulosa*
- *Eusmilia fastigiata*

OCTOCORALS

Octocorals are also known as octocorals because of the eightfold radial symmetry of their polyps. All octocorals are colonial and most of them lack the hardened calcium carbonate skeletons (hence their common name).

Sea Fingers
- *Briareum asbestinum*

Sea Fans
- *Iciligorgia schrammi*

Encrusting Gorgonians
- *Erythropodium caribaeorum*

Sea Rods
- *Plexaura flexuosa*
- *Plexaura homomalla* f. *homomalla*
- *Plexaura homomalla* f. *kükenthali*
- *Pseudoplexaura flagellosa*
- *Pseudoplexaura porosa*
- *Pseudoplexaura wagenaari*
- *Pseudoplexaura sp.*
- *Eunicea fusca*
- *Eunicea tourneforti f. tourneforti*
- *Eunicea tourneforti f. atra*
- *Eunicea mammosa*
- *Eunicea calyculata* f. *coronata*
- *Eunicea succinea* f. *succinea*
- *Eunicea succinea* f. *plantaginea*
- *Eunicea sp. # 1*
- *Eunicea sp. # 2*

Sea Plumas
- *Muriceopsis flavida*
- *Plexaurella fusifera*
- *Plexaurella nutans*
- *Plexaurella grisea*
- *Plexaurella dichotoma*
- *Plexaurella sp.*

Spiny Sea Fans
- *Muricea atlantica*
- *Muricea pinnata*
- *Pseudopterogorgia americana*
- *Pseudopterogorgia acerosa*
- *Pseudopterogorgia bipinnata*
- *Pseudopterogorgia sp.*
- *Gorgonia flabellum*
- *Gorgonia ventalina*
- *Gorgonia mariae ??*
- *Pterogorgia citrina*
- *Pterogorgia anceps*
- *Pterogorgia guadalupensis*
- *Ellisella barbadensis*
- *Ellisella sp.*
- *Nicella schmitti*

BLACK CORALS

Black corals are more closely related to stony corals than octocorals. They have a rigid, erect skeleton that forms a branched, tree-like colony (bushy black corals) or a long, unbranched whip-like coil (wire corals). However, black corals lack symbiotic algae (zooxanthellae) and must rely entirely on external food sources.

Wire Corals
- *Cirrhipathes [= Stichopathes] leutkeni*

Bottle-brush Bush
- *Antipathes hirta*

Table C2. *Other Invertebrates*.

Sponges
- *Callyspongia plicifera* (azure vase sponge)
- *Cribrochalina vasculum*
- *Xetospongia muta*
- *Ircinia strobilina (*black ball sponge)
- *Neofibularia nolitangere*
- *Halisarca* sp.
- *Cliona langae*
- *Cliona delitrix* (red boring sponge)

Hydroids
- *Solanderia gracilis*

Sea Anemones
- *Actinoporus elegans*
- *Condylactis gigantean*

Zoanthids
- *Palythoa caribaeorum*

Bryozoans
- *Hippopodina feegeensis*

Squids
- *Sepioteuthis sepioidea (Caribbean Reef Squid)*

Table C2 (continued).

Crinoids (sea lilies and feather stars) *Davidaster rubiginosa* **Sea Cucumbers** *Holothuria mexicana* (Donkey dung sea cucumber) *Holothuria thomasi* (Tiger-tailed sea cucumber) *Eostichopus arnesoni*	**Sea Urchins** *Echinometra viridis* *Diadema antillarum* *Eucidaris tribuloides* *Meoma ventricosa* **Tunicates** *Ascidia sydneiensis*

Table C1. *Inventory of Algae and Seagrasses.*

ALGAE

Brown Algae (Phaeophyta)

Hincksia onslowensis
Chnoospora minima
Sargassum hystrix buxifolium
Sargassum ramifolium
Siphonocladus rigidus
Dictyota caribaea
Dictyota cervicornis
Dictyota pulchella
Dictyota humifusa
Dictyota pinnatifida
Stypopodium zonale
Padina profunda
Padina gymnospora
Padina pavonica
Lobophora variegata
Turbinaria turbinata

Red Algae (Rhodophyta)

Martensia pavonia
Bryothamnion triquetrum
Galaxaura
Jania adherens
Amphiroa tribulus
Chondria curvilineata
Laurencia gemmifera
Porolithon pachydermum
Liagora ceranoides
Peyssonnelia stoechas
Ceramium cimbricum f. flaccidum

Cyanobacteria (Blue-green Algae)

Schizotrix sp.
Hydrocoleum coccineum

Green Algae (Chlorophyta)

Halimeda opuntia
Halimeda simulans
Halimeda discoidea
Halimeda copiosa
Halimeda tuna
Halimeda incrassata
Halimeda goreaui
Halimeda copiosa
Halimeda monile
Penicillus dumetosus
Penicillus capitatus
Penicillus pyriformis
Caulerpa sertularoides
Ventricaria ventricosa
Dictyosphaeria cavernosa
Acetabularia crenulata
Acetabularia polyphysoides
Avrainvillea asarifolia
Avrainvillea longicaulis
Avrainvillea nigricans f. parva
Udotea diyonii
Udotea caribaea
Udotea flabellum
Cymopolia barbata
Dasycladus vermicularis
Rhipocephalus phoenix f. brevifolius
Rhipocephalus phoenix f. longifolius

SEA GRASSES

Thalassia testudinum
Syringodium filiforme

Table C3. *List of the total number of sea fish reported for Isla de Barbareta (the list of Cayos Cochinos was used as a reference, Honduras)***.**

FAMILY AND SPECIES	CAYOS COCHINOS	BARBARETA
ACANTHURIDAE		
Acanthurus coeruleus (Bloch & Schneider, 1801)	Abundant	Abundant
Acanthurus bahianus (Castelnau, 1855)	Abundant	Abundant
Acanthurus chirurgus (Bloch, 1787)	Very Common	Common
ALBULIDAE		
Albula vulpes (Linnaeus, 1758)	Scarce	Prospect
ANTENNARIIDAE		
Antennarius multiocellatus (Valenciennes, 1837)	Very Scarce	Non Reported
Antennarius striatus	Very Scarce	Non Reported
APOGONIDAE		
Apogon lachneri	Scarce	Non Reported
Apogon maculatus (Poey, 1860)	Scarce	Non Reported
Apogon pseudomaculatus	Scarce	Non Reported
Apogon planifrons	Scarce	Non Reported
Apogon robinsi	Scarce	Non Reported
Apogon townsendi	Scarce	Non Reported
Astrapogon puncticulatus	Scarce	Non Reported
Phaeoptryx xenus	Scarce	Non Reported
ATHERINIDAE		
Allanetta harringtonensis (Goode, 1877)	Scarce	Prospect
Atherinomorus stipes (Müller & Troschel, 1847)	Scarce	Prospect
AULOSTOMIDAE		
Aulostomus maculatus (Valenciennes, 1842)	Common	Common
BALISTIDAE		
Balistes vetula Linnaeus, 1758	Common	Common
Canthidermis sufflamen (Mitchill)	Scarce	Common
Melichthys niger (Bloch)	Scarce	Very Abundant
Xanthichthys ringens (Linnaeus, 1758)	Very Scarce	Non Reported
BATRACHOIDIDAE		
Batrachoides gilberti	Scarce	Very Scarce
Batrachoides sp	Very Scarce	Non Reported
BELONIDAE		
Tylosurus crocodilus (Peron & Lesueur)	Common	Common
Platybelone argalus (Lesueur, 1821)	Scarce	Prospect
BLENNIIDAE		
Scartella cristata (Linnaeus, 1758)	Scarce	Very Scarce
Ophioblennius atlanticus (Valenciennes)	Common	Very Scarce
BOTHIDAE		
Bothus ocellatus (Agassiz, 1831)	Scarce	Very Scarce
Bothus lunatus (Linnaeus)	Scarce	Non Reported
CARANGIDAE		
Alectis ciliaris (Bloch, 1788)	Scarce	Non Reported
Caranx bartholomaei Cuvier, 1833	Common	Scarce
Caranx crysos (Mitchill)	Common	Prospect
Caranx hippos Linnaeus, 1766)	Scarce	Non Reported
Caranx ruber (Bloch, 1793)	Abundant	Very Common
Caranx latus (Agassiz, 1831)	Scarce	Scarce
Decapterus spp (Cuvier, 1833)	Abundant	Prospect
D. macarellus and *D. punctatus*.		
Elagatis bipinnulatus (Quoy & Gaimard, 1824)	Scarce	Prospect
Selar crumenophthalmus (Bloch, 1793)	Scarce	Non Reported
Seriola dumerili (Risso, 1810)	Scarce	Prospect
Seriola rivoliana Valenciennes, 1833	Very Scarce	Prospect

FAMILY AND SPECIES	CAYOS COCHINOS	BARBARETA
Trachinotus falcatus (Linnaeus, 1758)	Very Scarce	Prospect
Trachinotus goodei Jordan & Everman, 1896	Common	Prospect
CHAETODONTIDAE		
Chaetodon aculeatus Poey, 1860	Scarce	Scarce
Chaetodon ocellatus Bloch, 1787	Common	Very Common
Chaetodon striatus Linnaeus, 1758	Common	Very Common
Chaetodon capistratus Linnaeus, 1758	Scarce	Common
Chaetodon sedentarius Poey, 1860	Very Scarce	Scarce
CENTROPOMIDAE		
Centropomus undecimalis (Bloch, 1792)	Very Scarce	Non Reported
CHAENOPSIDAE		
Acanthemblemaria aspera	Scarce	Scarce
Acanthemblemaria maria	Scarce	Scarce
Acanthemblemaria spinosa	Scarce	Prospect
Chaenopsis limbaughi	Scarce	Prospect
Emblemaria pandionis Evermann & marsh, 1900	Scarce	Prospect
Hemiemblemaria simulus	Common	Prospect
CIRRHITIDAE		
Amblycirrhitus pinos (Mowbray, 1927)	Scarce	Prospect
LABRISOMIDAE		
Coralliozetus bahamensis	Scarce	Non Reported
Labrisomus filamentosus	Scarce	Non Reported
Labrisomus muchipinnis (Quoy & Gairmard)	Scarce	Non Reported
Lucayablennius zingaro	Scarce	Non Reported
Malacoctenus boehlkei	Scarce	Scarce
Malacoctenus macropus (Poey, 1868)	Scarce	Non Reported
Malacoctenus triangulatus	Common	Common
Malacoctenus versicolor (Poey, 1876)	Scarce	Non Reported
CLUPEIDAE		
Harengula clupeola (Cuvier, 1829)	Common	Prospect
Harengula humeralis (Cuvier, 1829)	Common	Prospect
Jenkinsia lamprotaenia (Gosse, 1851)	Common	Prospect
Opisthonema spp	Common	Prospect
CORYPHAENIDAE		
Coryphaena equiselis Linnaeus, 1758	Scarce	Non Reported
Coryphaena hippurus Linnaeus, 1758	Common	Very Scarce
DACTYLOPTERIDAE		
Trachinotus falcatus (Linnaeus, 1758)	Very Scarce	Non Reported
CONGRIDAE		
Nystactichthys halis	Scarce	Non Reported
DIODONTIDAE		
Chilomycterus antennatus (Cuvier, 1818)	Scarce	Prospect
Trachinotus falcatus (Linnaeus, 1758)	Common	Prospect
Diodon hystrix Linnaeus, 1758	Scarce	Scarce
ECHENEIDAE		
Echeneis naucrates (Linnaeus)	Scarce	Scarce
ENGRAULIDAE		
Anchoa lyolepis (Evermann & marsh, 1902)	Common	Prospect
Anchoa spp	Common	Prospect
EPHIPPIDAE		
Chaetodipterus faber (Broussonet, 1782)	Scarce	Prospect
FISTULARIIDAE		
Fistularia tabacaria Linnaeus, 1758	Scarce	Non Reported
GERREIDAE		
Eucinostomus melanopterus (Bleeker)	Scarce	Non Reported

FAMILY AND SPECIES	CAYOS COCHINOS	BARBARETA
Eucinostomus jonesi (Günther, 1879)	Scarce	Non Reported
Gerres cinereus (Walbaum, 1792)	Common	Common
GOBIIDAE		
Coryphopterus dicrus	Scarce	Non Reported
Coryphopterus eidolon	Scarce	Very Scarce
Coryphopterus lipernes	Scarce	Non Reported
Coryphopterus glaucofraenum	Common	Scarce
Coryphopterus personatus	Very Abundant	Very Abundant
Ioglossus helenae	Common	Very Scarce
Gnatholepis thompsoni	Common	Scarce
Gobiosoma dilepsis	Scarce	Non Reported
Gobiosoma oceanops	Common	Very Common
Gobiosoma xanthiprora	Scarce	Scarce
GRAMMIDAE		
Gramma melacara Böhlke y Randall, 1963	Scarce	Common
Gramma loreto Poey, 1868	Abundant	Abundant
GRAMMISTIDAE		
Rypticus saponaceus (Bloch & Schneider, 1801)	Common	Scarce
HAEMULIDAE		
Anisotremus surinamensis (Bloch, 1791)	Scarce	Scarce
Anisotremus virginicus (Linnaeus, 1758)	Abundant	Scarce
Haemulon aurolineatum Cuvier, 1829	Abundant	Scarce
Haemulon carbonarium Poey, 1860	Scarce	Scarce
Haemulon chrysargyreum Günther, 1859	Scarce	Prospect
Haemulon flavolineatum (Desmarest, 1823)	Abundant	Abundant
Haemulon macrostomun Günther, 1859	Common	Scarce
Haemulon plumieri (Lacépede, 1802)	Abundant	Abundant
Haemulon sciurus (Shaw, 1803)	Abundant	Common
Haemulon striatum (Linnaeus, 1758)	Scarce	Non Reported
HEMIRHAMPHIDAE		
Hemiramphus brasiliensis (Linnaeus, 1758)	Common	Prospect
HOLOCENTRIDAE		
Adioryx coruscus (Poey, 1860)	Scarce	Common
Holocentrus vexillarius (Poey, 1860)	Scarce	Non Reported
Holocentrus ascensionis (Osbeck, 1765)	Common	Common
Holocentrus marianus (Cuvier, 1829)	Common	Very Common
Holocentrus rufus (Walbaum, 1792)	Abundant	Very Common
Myripristis jacobus Cuvier, 1829	Common	Common
INERMIDAE O EMMELICHTHYDAE		
Inermia vittata (Poey, 1860)	Common	Non Reported
Emmelichthyops atlanticus	Common	Non Reported
KYPHOSIDAE		
Kyphosus incisor (Cuvier, 1831)	Common	Abundant
Kyphosus sectatrix (Linnaeus, 1758)	Common	Abundant
LABRIDAE		
Bodianus pulchellus (Poey,1860)	Scarce	Prospect
Bodianus rufus (Linnaeus, 1758)	Abundant	Common
Clepticus parrai (Bloch y Schneider, 1801)	Very Abundant	Very Abundant
Halichoeres bivittatus (Bloch, 1791)	Abundant	Very Abundant
Halichoeres garnoti (Valenciennes, 1839)	Very Abundant	Very Abundant
Atherinomorus stipes (Müller & Troschel, 1848)	Common	Scarce
Halichoeres poeyi (Steindachner, 1867)	Common	Scarce
Halichoeres radiatus (Linnaeus, 1758)	Common	Abundant
Hemipteronotus splendens (Castelnau, 1855)	Common	Prospect
Hemipteronotus martinicensis (Valenciennes, 1839)	Scarce	Common

FAMILY AND SPECIES	CAYOS COCHINOS	BARBARETA
Hemipteronotus novacula (Linnaeus, 1758)	Scarce	Prospect
Lachnolaimus maximus (Walbaum, 1792)	Common	Scarce
Thalassoma bifasciatum (Bloch, 1791)	Very Abundant	Abundant
LOBOTIDAE		
Lobotes surinamensis (Bloch, 1790)	Very Scarce	Non Reported
LUTJANIDAE		
Lutjanus analis (Cuvier, 1828)	Common	Very Common
Lutjanus apodus (Walbaum, 1792)	Common	Abundant
Lutjanus cyanopterus (Cuvier, 1828)	Scarce	Very Scarce
Lutjanus griseus (Linnaeus, 1758)	Scarce	Scarce
Lutjanus jocu (Bloch & Shneider, 1801)	Common	Common
Lutjanus mahogoni (Cuvier, 1828)	Very Abundant	Scarce
Lutjanus synagris (Linnaeus, 1758)	Very Abundant	Prospect
Ocyurus chrysurus (Bloch, 1791)	Very Abundant	Scarce
Rhomboplites aurorebens (Cuvier, 1829)	Very Scarce	Non Reported
MUY ABUNDANTELACANTHIDAE		
Malacanthus plumieri (Bloch, 1786)	Common	Common
MEGALOPIDAE		
Megalops atlanticus (Valenciennes, 1846)	Scarce	Non Reported
MONACANTHIDAE		
Aluterus scripta (Osbeck, 1757)	Scarce	Scarce
Cantherhines macrocerus (Hollard, 1854)	Scarce	Scarce
Cantherhines pullus (Ranzani, 1842)	Common	Scarce
Monacanthus tuckeri Bean, 1906	Scarce	Prospect
Monacanthus ciliatus (Mitchill, 1818)	Scarce	Prospect
MUGILIDAE		
Mugil cephalus Linnaeus, 1758	Common	Prospect
MULLIDAE		
Mulloidichthys marttinicus (Cuvier, 1829)	Abundant	Scarce
Pseudupeneus maculatus (Bloch, 1793)	Very Common	Common
MURAENIDAE		
Echidna catenata (Bloch, 1795)	Scarce	Prospect
Enchelycore nigricans (Bonnaterre, 1788)	Scarce	Prospect
Gymnothorax moringa (Cuvier, 1829)	Scarce	Prospect
Lycodontis funebris Ranzani, 1840	Scarce	Prospect
Muraena miliaris (Kaup, 1856)	Scarce	Scarce
OGCOCEPHALIDAE		
Ogcocephalus spp	Very Scarce	Very Scarce
OPHICHTHIDAE		
Myrichthys oculatus (Kaup, 1856)	Scarce	Prospect
Myrichthys breviceps	Very Scarce	Scarce
Ophichthus ophis (Linnaeus, 1758)	Scarce	Prospect
OPISTOGNATHIDAE		
Opistognathus aurifrons (Jordan & Thompson, 1905)	Very Scarce	Scarce
OSTRACIONTIDAE		
Lactophrys bicaudalis (Linnaeus, 1758)	Scarce	Scarce
Lactophrys polygonius Poey, 1876	Scarce	Common
Lactophrys quadricornis (Linnaeus, 1758)	Common	Common
Lactophrys trigonus (Linnaeus, 1758)	Scarce	Scarce
Lactophrys triqueter (Linnaeus, 1758)	Common	Common
PEMPHERIDAE		
Pempheris schomburgki Müller & Troschel, 1848	Common	Prospect, It must exists there
POMUY ABUNDANTECANTHIDAE		

FAMILY AND SPECIES	CAYOS COCHINOS	BARBARETA
Centropyge argi	Scarce	Non Reported
Holocanthus tricolor (Bloch, 1795)	Very Abundant	Abundant
Holocantus ciliaris (Linnaeus, 1758)	Abundant	Common
Pomacanthus arcuatus (Linnaeus, 1758)	Abundant	Common
Pomacanthus paru (Bloch, 1787)	Common	Common
HAEMULIDAE		
Abudefduf saxatilis (Linnaeus, 1758)	Abundant	Abundant
Chromis cyanea (Poey, 1860)	Very Abundant	Very Abundant
Chromis insolata (Cuvier, 1830)	Scarce	Common
Chromis multilineata (Guichenor, 1853)	Abundant	Scarce
Microspathodon chrysurus (Cuvier, 1830)	Abundant	Common
Stegastes dorsopunicans (Poey, 1860)	Common	Scarce
Stegastes leucostictus (Müller & Troschel, 1848)	Scarce	Very Scarce
Stegastes partitus (Poey, 1868)	Very Abundant	Very Abundant
Stegastes planifrons (Cuvier, 1830)	Abundant	Abundant
Stegastes variabilis (Castelnau, 1855)	Scarce	Very Scarce
PRIACANTHIDAE		
Priacanthus arenatus (Cuvier, 1829)	Scarce	Non Reported
Priacanthus cruentatus (Lacépede, 1802)	Scarce	Common
RACHYCENTRIDAE		
Rachycentron canadum (Linnaeus, 1766)	Very Scarce	Non Reported
SCARIDAE		
Chryptotomus roseus Cope, 1871	Common	Common
Scarus coelestinus Valenciennes, 1839	Scarce	Scarce
Scarus coeruleus (Bloch, 1786)	Scarce	Prospect
Scarus iserti Bloch, 1790 (*S. croicensis* es sinónimo)	Very Abundant	Very Abundant
Scarus guacamaia Cuvier, 1829	Very Scarce	Non Reported
Scarus taeniopterus Desmarest, 1831	Common	Abundant
Scarus vetula Bloch & Schneider, 1801	Common	Scarce
Sparisoma viride (Bonnaterre, 1783)	Very Abundant	Very Abundant
Sparisoma radians (Valenciennes, 1839)	Common	Abundant
Sparisoma aurofrenatum Valenciennes, 1839	Very Abundant	Very Abundant
Sparisoma chrysopterum Bloch & Schneider, 1801	Abundant	Abundant
Sparisoma rubripinne Valenciennes, 1839	Abundant	Abundant
SCIAENIDAE		
Equetus punctatus (Bloch & Schneider, 1801)	Scarce	Scarce
Equetus lanceolatus (Linnaeus, 1758)	Scarce	Prospect
Equetus acuminatus (Bloch & Schneider, 1801)	Common	Scarce
Odontoscion dentex (Cuvier, 1830)	Common	Scarce
SCOMBRIDAE		
Acanthocybium solanderi (Cuvier, 1831)	Scarce	Prospect
Euthynnus alletterarus (Rafinesque, 1810)	Scarce	Non Reported
Scomberomorus cavalla (Cuvier)	Scarce	Prospect
Scomberomorus regalis (Bloch, 1793)	Scarce	Common
SCORPAENIDAE		
Scorpaena plumieri Bloch, 1789	Scarce	Very Scarce
Scorpaena grandicornis (Cuvier, 1829)	Scarce	Scarce
SERRANIDAE		
Epinephelus adscensionis (Osbeck, 1757)	Scarce	Scarce
Epinephelus afer (Bloch, 1793)	Scarce	Scarce
Epinephelus cruentatus (Lacépede, 1802)	Abundant	Abundant
Epinephelus fulvus (Linnaeus, 1758)	Abundant	Abundant
Epinephelus guttatus (Linnaeus, 1758)	Scarce	Common
Epinephelus itajara (Lichtenstein, 1822)	Very Scarce	Scarce
Epinephelus morio (Valenciennes, 1828)	Scarce	Non Reported

FAMILY AND SPECIES	CAYOS COCHINOS	BARBARETA
Hypoplectrus indigo (Poey, 1852)	Scarce	Common
Hypoplectrus puella (Cuvier, 1828)	Very Abundant	Abundant
Hypoplectrus nigricans (Poey, 1852)	Scarce	Common
Hypoplectrus sp (probably is the juvenile)	Scarce	Common
Liopropoma carmabi	Scarce	Prospect
Liopropoma rubre Poey, 1861	Scarce	Prospect
Mycteroperca bonaci (Poey, 1860)	Scarce	Scarce
Mycteroperca intersticialis (Poey, 1860)	Very Scarce	Non Reported
Mycteroperca rubra (Bloch, 1793)	Very Scarce	Non Reported
Mycteroperca tigris (Valenciennes, 1833)	Scarce	Common
Mycteroperca venenosa (Linnaeus, 1758)	Common	Scarce
Paranthias furcifer (Valenciennes, 1828)	Very Scarce	Non Reported
Serranus baldwini	Scarce	Prospect
Serranus tortugarum	Common	Scarce
Serranus tabacarius (Cuvier, 1829)	Common	Scarce
Serranus tigrinus (Bloch, 1790)	Common	Common
SPARIDAE		
Calamus calamus (Valenciennes, 1830)	Abundant	Common
Archosargus rhomboidalis (Linnaeus, 1766)	Non Reported	Scarce
SPHYRAENIDAE		
Sphyraena picudilla (Poey)	Scarce	Scarce
Sphyraena barracuda (Walbaum, 1792)	Common	Common
SYNGNATHIDAE		
Micrognathus ensenadae	Very Scarce	Non Reported
Hippocampus reidi	Very Scarce	Non Reported
Cosmocampus elucens Poey, 1868	Very Scarce	Non Reported
Cosmocampus albirostris	Very Scarce	Non Reported
SYNODONTIDAE		
Synodus intermedius (Agassiz, 1829)	Common	Non Reported
Synodus synodus (Linnaeus, 1758)	Scarce	Scarce
TETRAODONTIDAE		
Canthigaster rostrata (Bloch, 1782)	Abundant	Abundant
Sphoeroides spengleri (Bloch, 1782)	Common	Very Scarce
Sphoeroides testudineus (Linnaeus, 1758)	Scarce	Non Reported
TRIPTERYGIIDAE		
Enneanectes sp	Scarce	Non Reported
URANOSCOPIDAE		
Astroscopus guttatus	Very Scarce	Non Reported
RHINCODONTIDAE		
Rhincodon typus Smith, 1829	Very Scarce	Very Scarce
CARCHARHINIDAE		
Carcharhinus perezi (Poey, 1876)	Very Scarce	Scarce
Carcharhinus leucas	Non Reported	Very Scarce
Carcharhinus limbatus (Valenciennes, 1841)	Very Scarce	Prospect
Carcharhinus porosus (Ranzani)	Very Scarce	Non Reported
MYLIOBATIDAE		
Aetobatus narinari (Euphrasen, 1790)	Scarce	Very Scarce
DASYATIDAE		
Dasyatis americana (Hildebrand & Schoroeder, 1928)	Scarce	Common
ORECTOLOBIDAE		
Ginglymostoma cirratum (Bonnaterre, 1788)	Scarce	Scarce
UROLOPHIDAE		
Urolophus jamaicensis (Cuvier, 1817)	Scarce	Very Scarce
TORPEDINIDAE		
Narcine brasiliensis (Olfers, 1831)	Scarce	Non Reported

APPENDIX D

Table D1. *Total Density and of the key coral species (nº colonias/m2) by site (the first letter belongs to the gender and the other letters to the first three initials of the species, see inventory in Appendix C) **

	Grouper's Joy (N=12)	Alex's Wall (N=9)	NE Spurs & Grooves (N=12)	Ana's Choice (N=21)	Jeff's Wall (N=21)	Barbareta's Crest (N=9)
Mcav	1.17±1.59	1.89±1.96	0.83±1.70	0.43±0.68	0.33±0.80	0.44±1.01
Mann	0.50±1.17	0.78±1.99	0.33±0.65	0.52±0.68	0.52±0.81	0.22±0.67
Mfav	0.33±0.65	0.44±1.01	1.50±2.47	1.00±1.26	0.71±1.49	0.78±1.30
Aaga	3.33±2.35	2.44±1.67	1.08±1.38	3.90±2.30	1.38±1.46	2.56±2.46
Aten	0.00±0.00	0.00±0.00	0.00±0.00	0.43±0.81	0.86±1.06	1.11±1.27
Ssid	0.92±1.24	1.00±1.32	0.00±0.00	1.33±1.88	0.90±1.30	2.22±3.70
Past	0.25±0.62	0.56±0.88	0.58±0.90	2.48±2.14	0.90±1.22	1.56±1.81
Ppor	0.00±0.00	0.00±0.00	0.08±0.29	0.43±0.75	0.48±1.21	0.78±0.97
Dstri	0.50±0.90	0.89±1.05	0.08±0.29	0.43±0.67	0.48±0.81	0.00±0.00
Dlab	0.17±0.39	0.22±0.44	0.00±0.00	0.10±0.44	0.14±0.66	0.00±0.00
Mdec	0.33±0.65	1.33±1.94	0.00±0.00	0.29±0.56	0.10±0.44	0.11±0.33
Smic	0.42±0.52	0.11±0.33	0.00±0.00	0.19±0.40	0.00±0.00	0.44±0.53
Acer	0.17±0.39	0.00±0.00	0.08±0.29	0.10±0.30	0.19±0.51	0.00±0.00
Dcyl	0.00±0.00	0.00±0.00	0.00±0.00	0.10±0.30	0.05±0.22	0.00±0.00
Total	**10.42±5.87**	**11.56±3.61**	**5.08±4.66**	**13.76±5.22**	**7.76±6.26**	**11.78±5.72**

* the Density of the coral colonies was not estimated in Bomerang's Point.

Table D2. *Total Density and of the key coral species (nº colonias/m^2) by species (the first letter belongs to the gender and the other letters to the first three initials of the species, see inventory in Appendix C) and the reef zone.*

	Wall (n=20)	Deep Plataform (n=34)	Shallow Plataform (n=27)
Mcav	1.10±1.62	0.81±1.43	0.33±0.62
Mann	0.15±0.49	0.78±1.32	0.33±0.48
Mfav	1.15±2.16	1.08±1.40	0.22±0.51
Mfra	0.05±0.22	0.22±0.53	0.07±0.27
Aaga	2.10±2.02	2.68±1.89	2.52±2.71
Aten	0.50±1.00	0.11±0.52	0.85±0.99
Agra	0.10±0.31	0.00±0.00	0.00±0.00

	Wall (n=20)	Deep Plataform (n=34)	Shallow Plataform (n=27)
Ahum	0.00±0.00	0.08±0.28	0.00±0.00
Ffra	0.10±0.45	0.05±0.33	0.00±0.00
Dsto	0.10±0.31	0.24±0.76	0.26±0.66
Acer	0.05±0.22	0.16±0.44	0.07±0.27
Ssid	1.45±2.66	0.51±0.90	1.44±1.87
Srad	0.00±0.00	0.03±0.16	0.00±0.00
Past	0.75±1.41	0.95±1.22	1.85±2.09
Ppor	0.35±0.74	0.46±1.04	0.11±0.32
Pdiv	0.00±0.00	0.16±0.55	0.00±0.00
Dstri	0.10±0.31	0.38±0.79	0.67±0.83
Dlab	0.05±0.22	0.16±0.55	0.07±0.38
Mmea	0.10±0.45	0.16±0.44	0.00±0.00
Mbra	0.05±0.22	0.05±0.23	0.04±0.19
Scub	0.05±0.22	0.03±0.16	0.00±0.00
Mdec	0.70±1.42	0.16±0.44	0.18±0.56
Mmir	0.05±0.22	0.32±0.82	0.07±0.38
Mlam	0.30±0.66	0.16±0.50	0.18±0.79
Mdan	0.05±0.22	0.03±0.16	0.00±0.00
Mfer	0.00±0.00	0.11±0.32	0.00±0.00
Mali	0.00±0.00	0.03±0.16	0.00±0.00
Lcuc	0.10±0.31	0.03±0.16	0.04±0.19
Irig	0.00±0.00	0.08±0.36	0.04±0.19
Isin	0.00±0.00	0.00±0.00	0.04±0.19
Smic	0.30±0.47	0.11±0.32	0.15±0.36
Cnat	0.05±0.22	0.08±0.28	0.00±0.00
EfaS	0.10±0.31	0.05±0.23	0.04±0.19
Mare	0.10±0.31	0.03±0.16	0.04±0.19
Dcyl	0.00±0.00	0.00±0.00	0.11±0.32
Total	10.35±5.46	10.19±5.78	9.78±7.09

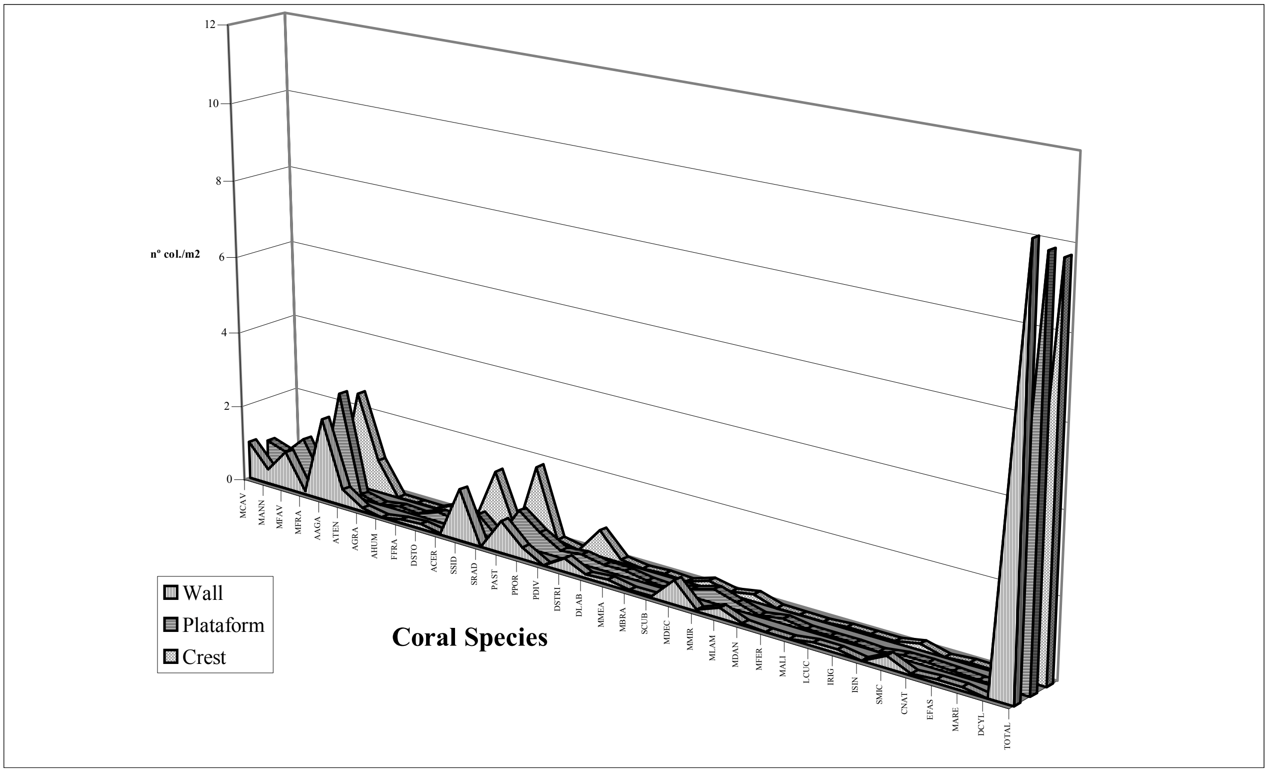


Figure D1. *Density of coral colonies by species and reef zone. Isla Barbareta, 2001.*

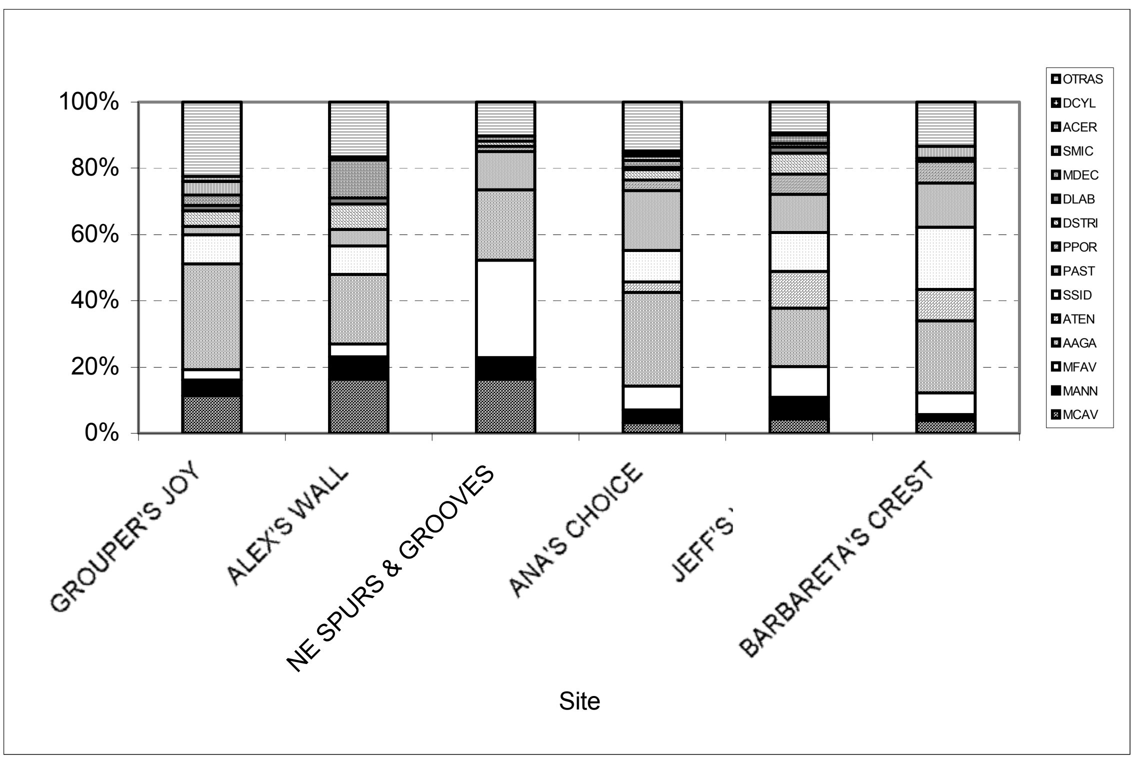


Figure D2. *Relative abundance of coral species by site. Isla Barbareta, 2001*

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