APÉNDICE F
ESTUDIO DE COMUNIDADES MARINAS

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INTRODUCTION

Guánica Bay is a semi-enclosed estuarine system located on the southwest coast of Puerto Rico. A variety of marine habitats including coral reefs, seagrass beds, fringing mangroves, sandy beaches, rocky shores and soft sediment bottoms are found within the bay and adjacent oceanic waters. The insular shelf-edge is less than two nautical miles offshore from the mouth of the bay, facilitating the interaction of estuarine-neritic and oceanic communities. Estuarine conditions prevail at the inner bay (Bahía del Noroeste), which act as the discharge basin of Río Loco, one of the largest rivers of the island's southwest coast. The influence of freshwater runoff expands throughout the entire bay and nearby oceanic waters during the rainy season. Such estuarine conditions confer poor light penetration and pronounced fluctuations of salinity, dissolved oxygen and nutrients, which are relevant factors structuring benthic and pelagic communities in Guánica Bay. Wind, waves and surge action affect light penetration also due to the shallow nature of the bay and the soft sediment composition of the inner and mid bay sections. Maximum depth at the inner bay is about 6 meters from the shoreline to Punta Pera and less than 9 meters at mid bay up to the entrance delimited by Punta Pescadores and Punta Meseta. Another relevant oceanographic feature of Guánica Bay is the presence of a moderately deep submarine canyon that cuts through the narrow shelf, creating a neritic-oceanic interface that influences coral reefs sitting on the outer section of the bay at the edges of the canyon, such as the Corona La Laja and Cayo Coral.

Descriptions of the marine habitats of Guánica Bay are limited to recent surveys of coral reef communities at Cayo Coral, Cayos de Caña Gorda and the shelf-edge (García et al., 2000) and qualitative characterizations of the flora and fauna supporting a sport fisheries development program in the bay (Pacheco et al., 1999). A review of these studies is included as part of the characterization of marine habitats in this report.

FIELD PROCEDURES

During July 22, 2001 a general reconnaissance of marine habitats was performed in Guánica Bay. A total of 12 stations were examined to determine the type of substrate and marine communities present. The location of sampling stations is shown in Figure 1. The Environmental Sensitivity Index Atlas (NOAA, 2000) and the nautical chart for Guánica Bay (U. S. Department of Commerce; C. & G. S. 929) was used for the field location of marine habitats (e.g. coral reefs, seagrass beds) and principal substrate types distributed within the bay. Table 1 presents the list of stations with geographical coordinates and marine habitat identifications. Underwater photographs were taken at stations in which light penetration allowed. The marine habitats and marine biological resources of Guanica Bay are shown in Figure 2. Information of marine habitats and marine biological resources compiled and published by NOAA (2000) as part of the Environmental Sensitivity Index Atlas for Puerto Rico were used to prepare this figure.

Table 1. Station coordinates, depth and description of main substrate types at sampling stations in Guánica Bay, 22 July 2001

Sta.	Depth (m)	Latitude (N)	Longitude (W)	Reference	Description
1	10	17°55.486	66°55.499	Punta Brea	coral reef
2	9.5	17°56.112	66°53.878	La Laja	coral reef
3	6.1	17°56.415	66°55.495	Las Pardas	rock reef
4	10	17°56.348	66°55.101	Las Pardas	hard ground
5	8.8	17°56.200	66°54.505	Buoy #3	hard ground
6	7	17°56.760	66°54.582	S. Punta Pescadores	rock reef
7	8.2	17°57.081	66°54.452	Navigation channel	hard/sand
8	3 – 6	17°57.147	66°54.305	Playa de Guánica	rock reef & sea grass bed
9	8.8	17°57.348	66°54.506	Fertilizer Co. dock	soft bottom
10	3	17°57.755	66°55.005	E. Bahía Noroeste	silt/sand
11	4	17°57.809	66°54.784	W. Bahía Noroeste	silt/sand
12	1.5	17°56.653	66°52.432	Backreef Caña Gorda	seagrass

State Plane NAD 83 (meters)

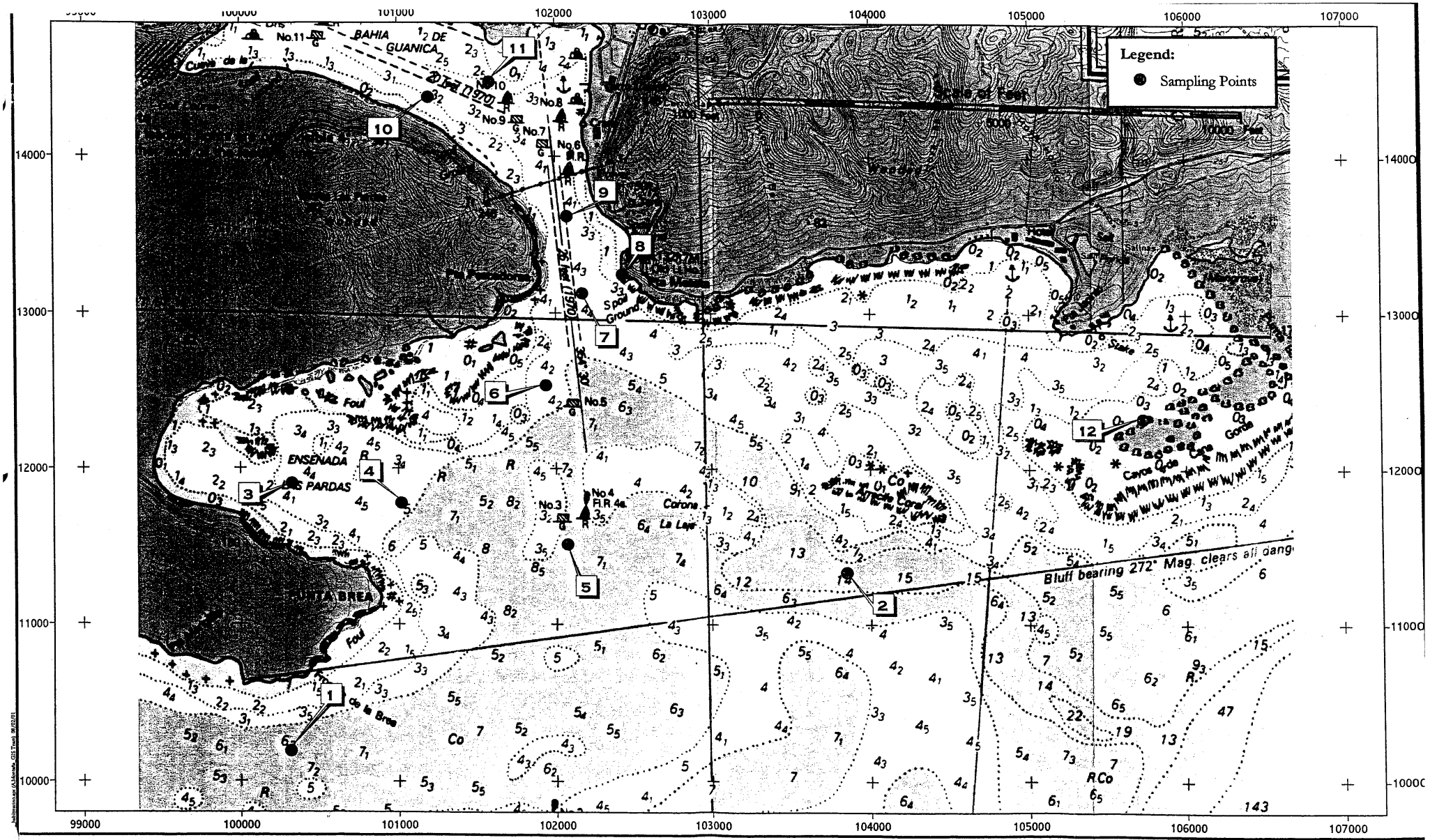

Figure 1. Location of Sampling Points in Guánica Bay

Proposed Old Guánica Sugar Mill Development

CSA Group

Source: Imray, Laurie, Norie & Wilson Ltd. Yachting Charts for the Caribbean Sea, South Coast of Puerto Rico, Ponta Figueras to Bahia de Guanica. 1996. NOAA, National Ocean Service, Office of Response and Restoration Hazardous Material Response Division, May, 2000. Coordinate System: State Plane NAD 27

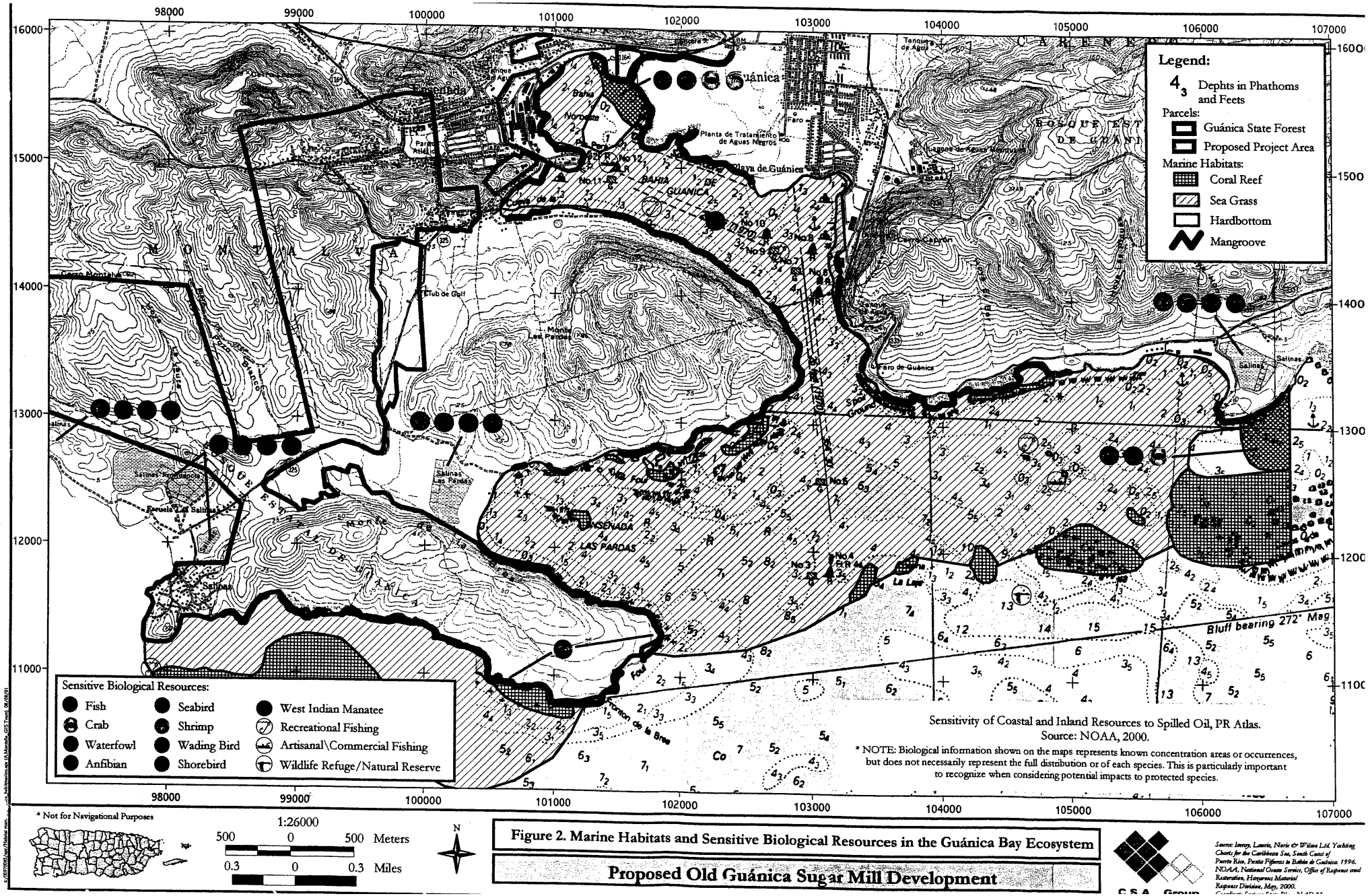

Figure 2. Marine Habitats and Sensitive Biological Resources in the Guánica Bay Ecosystem

Proposed Old Guánica Sugar Mill Development

Source: Imray, Laurie, Norie & Wilson Ltd. Yachting Charts for the Caribbean Sea, South Coast of Puerto Rico, Puesta Fijeroux to Bahia de Guánica. 1996. NOAA, National Ocean Service, Office of Response and Restoration, Hazardous Material Response Division, May, 2000.

DESCRIPTIONS OF MARINE HABITATS

1. Coral Reefs

Cayos de Caña Gorda, Cayo Coral, Corona La Laja and Frontón de la Brea are coral reef habitats in the Guánica Bay ecosystem. These reefs, located on the outer bay act as a protective barrier against wave and surge action allowing development of seagrass beds, fringing mangroves and sandy beaches at the mid and inner bay sections. Coral reefs contribute topographic relief and structural habitat by the sustained growth of scleractinian corals, creating a highly complex and biodiverse system. Development of coral reefs at the outer bay is possibly associated with higher light penetration and rather stable water temperature and salinity conditions conferred by oceanic water masses. The increasing pattern of live coral cover with distance from the shoreline has been previously reported for other coastal embayments, such as Guayanilla Bay (García and Castro, 1996) and Mayaguez Bay (García et al., 1999).

Fringing rock reefs were found at the west section of Ensenada Las Pardas, South of Punta Pescadores and off Playa de Guánica. These are hard substrates of substantial topographic relief resulting from erosional features of the shelf, with minimal or no contribution from corals to their structural habitat. These reefs are important habitats to marine communities, particularly reef fishes, but are generally overgrown by algae and other encrusting biota, resulting in communities of lower biodiversity as compared to coral reefs.

1.1 Cayo Coral

Marine communities associated with Cayo Coral were reported by García et al. (2000). Cayo Coral is an emergent reef located to the west of Cayo Caña Gorda, between Punta Ballena and the mouth of Guánica Bay. The reef is about two kilometers long and sits in the same shallow platform as Cayos de Caña Gorda, at the landward's (northern) edge of Guánica's submarine canyon. A series of submerged patch reefs are found to the north and east of Cayo Coral. Stony corals and gorgonians (soft corals) were observed to be prominent features of the benthic community at Cayo Coral, providing substantial topographic relief and structural habitat for a great variety of reef populations (Plate 1). Massive and encrusting colonies of live stony corals were reported by García et al. (2000) to contribute an average of 24.5 % of the reef surface cover at a depth of 7-8 meters. A total of 26 species of stony corals were identified by

García et al. (2000) at Cayo Coral (see Table 2). The Star Coral, *Montastrea annularis*, forming large "mushroom type" colonies with its laminar growth (Plate 1) was the dominant reef building coral species in terms of linear cover with a mean of 10.5 % (García et al., 2000). Corals forming low relief, mound-shaped colonies were common at Cayo Coral. These included *Colpophyllia natans, Montastrea cavernosa, Meandrina meandrites* and *Porites astreoides*.

The encrusting gorgonian (*Erythropodium caribbaeorum*) as well as sponges and colonial zoanthids, particularly *Palythoa sp.* were also common at Cayo Coral. An assemblage of short filamentous and coralline algae forming a carpet over hard substrates not colonized by benthic invertebrates covered approximately 52 % of the surface cover at Cayo Coral (García et al. 2000).

A total of 48 fish species of diurnal, non-cryptic species were identified by García et al. (2000) during their snapshot survey at Cayo Coral (Table 3). The mean density of fishes within belt-transects was 26.8 Ind/30 m^2 (García et al., 2000). The most abundant species were the Dusky and Yellow-eye damselfishes, the Striped and Red-band parrotfishes, the Yellowhead Wrasse and the Ocean Surgeon. The most specious family of reef fishes within transect areas studied by García et al. (2000) was the Scaridae (Parrotfishes) with five species present. Parrotfishes, along with doctorfishes (Acanthuridae) and "farmer" damselfishes (e.g. Steg*astes dorsopunicans*) comprised the main herbivorous assemblage, which accounted for approximately 57.5 % of the fishes surveyed within belt-transect areas (García et al., 2000). Zooplanktivore species presented a rather low density within transect areas (approx. 8.0 %), mostly the Bicolor Damselfish and juvenile stages of grunts. However, zooplanktivore damselfishes, such as the Blue and Yellow-edge Chromis, *Chromis cyanea* and *C. multilineata* were observed. Predators of large benthic invertebrates and small fishes included the squirrelfishes (Holocentridae), grunts (Haemulidae) and Schoolmaster Snapper (Lutjanidae). The only pelagic species observed by García et al. (2000) was a juvenile Yellow Jack, *Caranx bartholomei*. However, this reef is well known for its good fisheries on pelagic species, especially Cero and King Mackerels (*Scomberomorus regalis, S. cavalla*) which aggregate at the mouth of the bay to feed upon sardines and anchovies, which are resident populations in Guánica Bay.

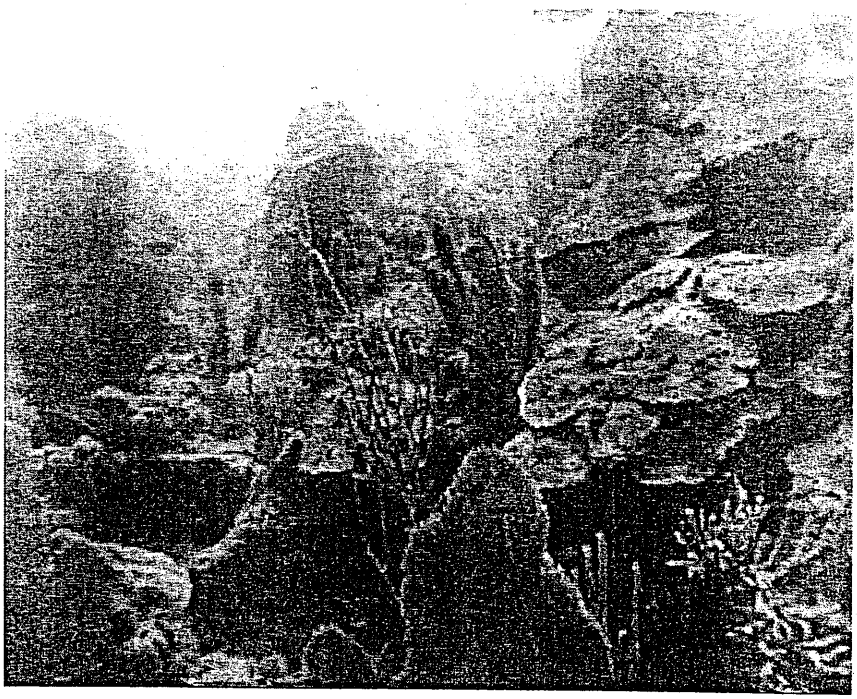

Plate 1. Cayo Coral, sitting at the edge of Guánica's submarine canyon is a well developed coral reef system with live stony corals providing plenty of topographic relief.

1.2 Cayos de Caña Gorda

Marine communities associated with Cayos dę Caña Gorda were reported by García et al. (2000). Caña Gorda Reef, also known as "Cayo de Caña Gorda" is an elongated fringing reef aligned east-southwest from the tip of Punta Ballena towards Guánica Bay (Figure 1). The reef forms a physical barrier against wave action, allowing growth of seagrass and mangoves at the leeward section of the reef. The fore reef drops down to a depth of 10 meters. At the base of the reef several submerged "patch reefs" are found. According to García et al. (2000), the high abundance of soft corals was the most prominent feature of this submerged patch reef. The mean abundance of soft coral (gorgonian) colonies per transect was 37% (García et al., 2000). Both encrusting and massive growth of hermatypic (stony) corals was observed by García et al. (2000) on Caña Gorda Reef, averaging a reef surface cover of approximately 29 %. A total of 21 species of stony corals were identified during the survey by García et al. (2000) at Caña Gorda Reef (Table 2). Four species represented approximately 90% of the total linear cover by stony corals. The Boulder Star Coral, *Montastrea annularis* was the dominant scleractinian species in terms of linear cover with a mean of 14.1% (García et al., 2000). Other dominant species were the Great Star Coral, *M. cavernosa*, Mustard Hill Coral, *Porites astreoides* and the Symmetrical Brain Coral, *Diploria strigosa*. Stony corals seem to grow over rock outcrops of low vertical relief, but colonies were observed by García et al. (2000) to be moderately large and contribute, in conjunction with gorgonians, substantial rugosity and habitat complexity to the reef. The colonial zoanthid, *Palythoa sp.* was found overgrowing hard substrates, including dead coral colonies with a mean linear cover of 5.3% (García et al., 2000). A varied assemblage of erect and encrusting sponges was present, but along with hydrocorals (*Millepora* spp.) and fleshy algae represented minor constituents of the reef community. Linear cover by the mixed assemblage of short filamentous red and brown macroalgae or "algal turf" averaged 49.2 %. Unconsolidated substrates, such as sand and silt were common between coral boulders in the reef.

A total of 29 fish species were identified by García et al. (2000) during their snapshot survey at Caña Gorda Reef (Table 3). This survey was probably biased by the limited underwater visibility and also by the strong surge (García et al., 2000). The mean number of species per transect was 10 and the mean density of fishes within belt-transects was 23.3 Ind/30 (García et al., 2000). The combined abundance of three species, the Bluehead Wrasse, (*Thalassoma*

bifasciatum), Bicolor Damselfish (*Stegastes partitus)* and the Striped Parrotfish, (*Scarus iserti)* represented approximately 80% of the total individuals within belt-transect areas (García et al., 2000). The most specious family of reef fishes identified was the Scaridae (Parrotfishes) with five species present. Parrotfishes, along with doctorfishes (Acanthuridae) and "farmer" damselfishes (e.g. Steg*astes dorsopunicans*) represented the main herbivorous assemblage, which accounted for approximately 32% of the fishes occurring within belt-transect areas. Zooplanktivore species represented another 35% of the total fish community within belt-transect areas. Predators of large benthic invertebrates and small fishes included the squirrelfishes (Holocentridae), grunts (Haemulidae), and small groupers (Serranidae), such as the Coney (*Cephalopholis fulva*) and the Red Hind (*Epinephelus guttatus*). Pelagic predators could not possibly be detected due to the low underwater visibility. Two Spiny Lobsters (*Panulirus argus*) were present within transect areas during the survey by García et al. (2000) at Caña Gorda Reef.

1.3 La Laja Reef

La Laja Reef is a submerged path reef located to the west of Cayo Coral that sits at the western margin of the submarine canyon on the outer section of Guánica Bay. The reef platform is approximately one kilometer in length, but its best development occurs along its eastern margin, adjacent to the canyon's edge. The top of the reef is mostly colonized by soft corals (gorgonians) and encrusting, massive and branching coral colonies. Large massive colonies of Boulder Brain Coral, *Colpophyllia natans*, Great Star and Boulder Star Corals (*Montastrea cavernosa, M. annularis*) were present at the top of the reef. Branching coral types were represented by Finger Coral, *Porites porites* at substrate depressions on the top of the reef. The fore reef slopes down abruptly to an almost vertical wall colonized by plate and cactus corals (*Agaricia* spp., *Mycetophyllia* spp.) and massive laminar colonies of Boulder Star Coral (*M. annularis*) (Plates 2-5). A total of 14 species of corals were identified in the short bounce dive designed to provide only a snapshot characterization of the most prominent reef biological components. Live coral cover was visually estimated to be at approximately 15 – 20% at the top of the reef. The encrusting colonial zoanthids, *Zoanthus sp.* and *Palythoa sp.* were common at the reef top where they formed large mats overgrowing available hard substrates, most of which appeared to be dead coral colonies. Coral growth was observed to decline sharply beyond a depth of approximately 15 meters. This is probably associated with reduced light

penetration due to the proximity of this reef to the mouth of Guánica Bay. La Laja Reef is a fairly well developed coral reef system that undoubtedly serves as an important habitat to marine communities in Guánica Bay.

A total of 38 fish species were quickly identified during the bounce dive at La Laja Reef. Large aggregations of Blue-head Wrasse (*Thalassoma bifasciatum*) were observed. Territorial damselfishes (*Stegastes* spp.) were also common as well as zooplanktivore damselfishes (*Chromis* spp). Five species of parrotfishes and two species of doctorfishes appear to represent the main herbivorous assemblage of the reef fish fauna. The commercially important Nassau Grouper (*Epinephelus striatus*) was observed, as well as many juvenile Yellowtail Snappers (*Ocyurus chrysurus*). A taxonomic account of fish species observed at La Laja is included in Table 3.

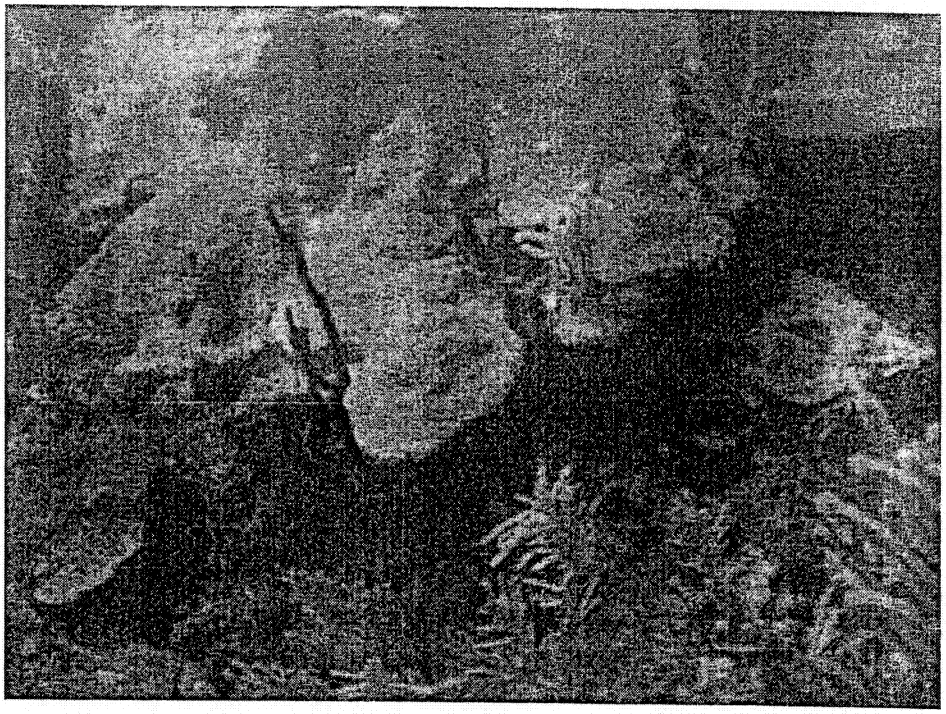

Plate 2. Laminar growth of Boulder Star Coral, *Montastrea annularis* at La Laja Reef

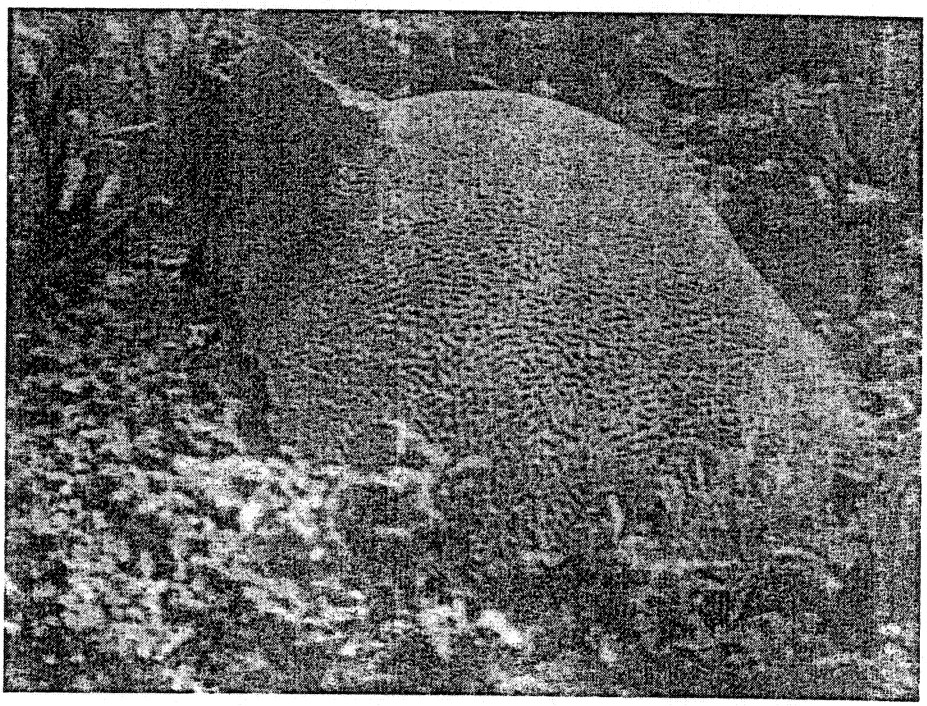

Plate 3. Massive colony of Boulder Brain Coral, *Colpophyllia natans* at La Laja Reef

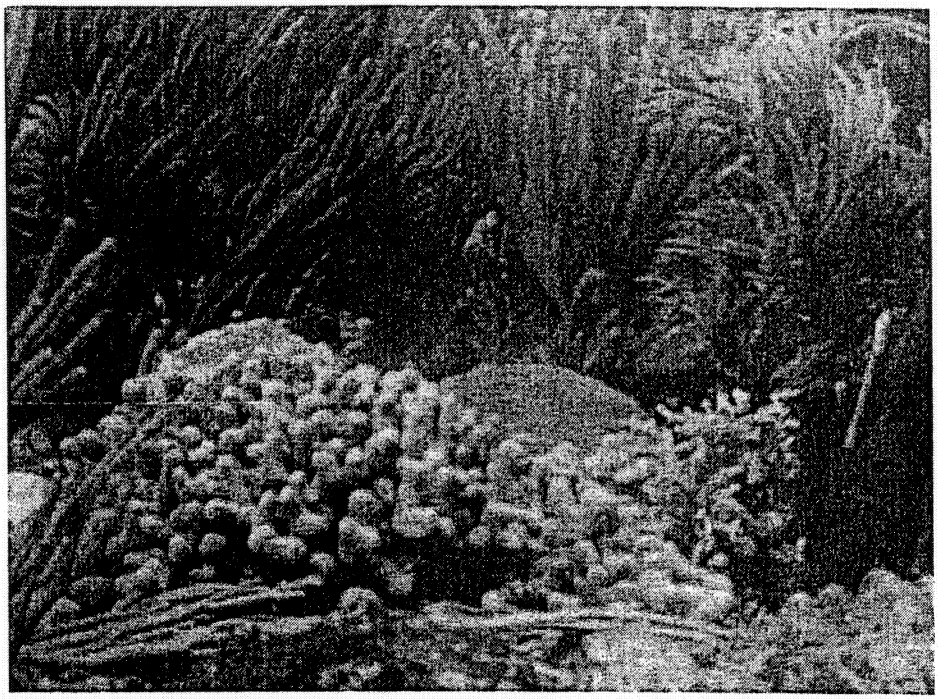

Plate 4. Finger Coral, *Porites porites* growing on top of the reef at La Laja

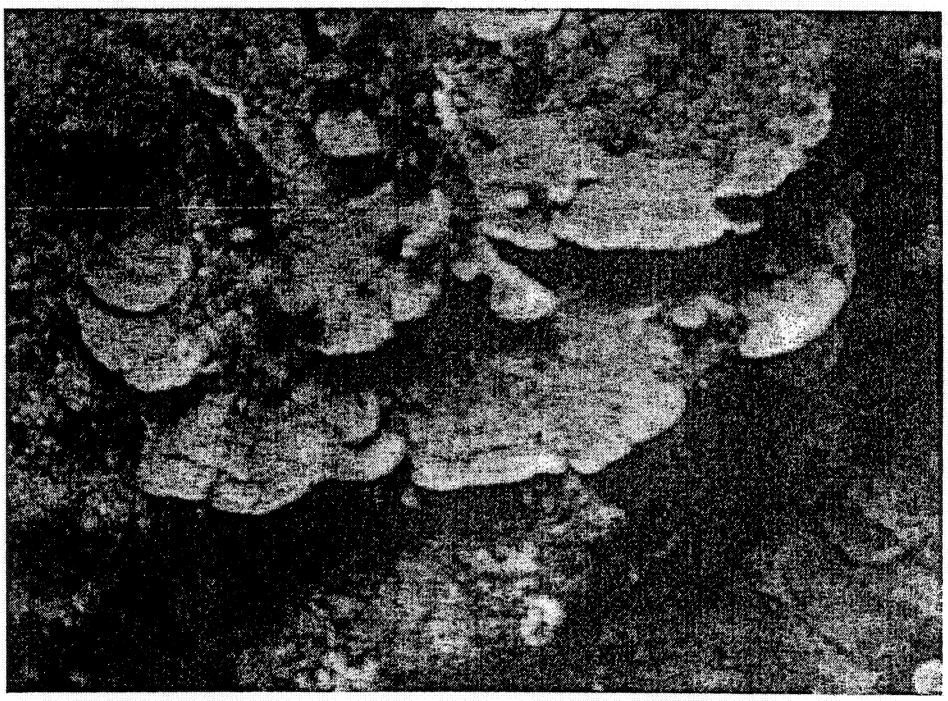

Plate 5. Colonies of Lettuce Coral, *Agaricia agaricites*, growing off the wall down a vertical slope at La Laja Reef

1.4 Frontón de La Brea Reef

El Frontón de la Brea is a narrow fringing reef associated with the rocky shore of Punta Brea, at the western margin of Guánica Bay. This reef is subjected to very strong wave and surge action due to the shallow conditions and direct exposure to wind driven swells. The reef extends from the rocky shoreline to a depth of 8-9 meters. As the fore reef slopes down gently, a low relief "spur and groove" formation with sand channels cutting through the reef was found (Plate 6). The reef is essentially a soft coral (gorgonian) dominated environment, indicative of conditions of severe sand abrasion associated with waves and surge. Sea Fans (*Gorgonia* spp) were abundant and provided substantial rugosity and habitat complexity that created an adequate environment for a diverse assemblage of fishes and other reef organisms. Stony corals were mostly present as encrusting forms with a surface cover visually estimated around 3-5%. The most abundant stony coral species was the Symmetrical Brain Coral (*Diploria strigosa*), which occurred in its typically encrusting growth form. Small mounds of the Great Star Coral (*Montastrea cavernosa*) and the Grooved Brain Coral (*Diploria labyrinthyformis*) were present. A total of 13 species of stony corals, including the hydrocoral, *Millepora alcicornis*, were identified during a 20-minute bounce dive at Punta Brea (Table 2). Encrusting sponges, *Anthosigmella varians* and *Chondrilla nucula* were observed. Other encrusting biota, such as the colonial zoanthid, *Palythoa sp.* was present. A mixed assemblage of short articulated coralline algae, or "algal turf" was found overgrowing most of the hard ground substrate at Punta Brea Reef.

A total of 22 species of reef fishes were identified during the spot dive at Punta Brea Reef (Table 3). Juveniles of the commercially important Yellowtail Snapper, *Ocyurus chrysurus* were common. Gorgonian dominated environments are natural habitats for juvenile Yellowtail Snappers because the vertical projection of sea fans provides a protective environment for these small fishes that have to swim actively above the reef substrate. Another commercially valuable fish species observed at Punta Brea was the Red Hind (*Epinephelus guttatus*). Small wrasses, such as the Bluehead, Yellow and Clown (*Thalassoma bifasciatum, Halichoeres garnoti, H. maculipinna*) were abundant. These are opportunistic carnivores typical of high-energy reef environments. A rich assemblage of herbivorous fishes, dominated by doctorfishes (Acanthuridae) and parrotfishes (Scaridae) was also present. Territorial damselfishes, mostly the Dusky and Bicolor Damselfishes (*Stegastes dorsopunicans, S. partitus*) occupied demersal

Plate 6. "Spur and groove" formation with sparse gorgonians and encrusting corals at Frontón La Brea Reef