BENTHIC HABITAT SURVEY AT ENSENADA COMEZON, RIO GRANDE, PUERTO RICO

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FINAL REPORT

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1 INTRODUCTION

1.1 PURPOSE AND SCOPE

This report summarizes the methodology, findings and conclusions of a benthic habitat classification and benthic characterization conducted at Ensenada Comezón, Río Grande, Puerto Rico. The survey was completed in partial fulfillment of the requirements for a joint permit application (JPA). The JPA is to be submitted to the US Army Corps of Engineers (USACE) for a proposed mooring dock.

The Coco Beach resort development aims to develop a temporary mooring dock in the plot known as La Marina which has a capacity of 3.4448 acres. The spring consists of the construction of a central gateway (500) feet long and eight (8) feet wide with eight floating platforms ten (10) feet long and three (3) feet wide each located at end of the pier. The dock will be built in "pre-cast concrete" and rely on pre-cast concrete beams mounted on two pre-cast concrete piles of eighteen (18) inches. These brackets occur every thirty (30) feet each for a total of 16 and a final stretch of twenty (20) feet away.

The dock was designed so that its gateway is translucent and allows the passage of sunlight. This is achieved by using the floor grills on the dock. The current depth at the end of the pier is about five (5) meters below sea level ("mean sea level or MSL"). The stop or dock level will be at a height of five (5) feet above MSL. Access to the floating platforms will be through ramps type "Gangway" or gateway. This spring is used for temporary mooring of vessels are located on land pier to be developed in the plot of La Marina as authorized in the Revised Amendment to the Environmental Impact Statement Final Coco Beach West Side (JCA-76- 015 (JP) (ER-DIAF).

The objective of the benthic and habitat study as well as the fish assemblage survey was to determine the abundance (quantity) and characterization (quality) of benthic habitats as well as the fish species richness in Ensenada Comezón Río Grande Puerto Rico during September 2016.

1.2 HISTORICAL INFORMATION

In 1985, and during the administration of the governor Rafael Hernández-Colón (1984-1988) the Puerto Rico Department of Natural and Environmental Resources designated the entire zone (Río Espíritu Santo, Punta Miquillo, Ensenada Comezón and Punta Picúa) as Río Espiritu Santo Estuary Natural Reserve, recognizing the critical ecological value of the zone (Hernández *et al.* 2012). The natural reserve consisted primarily of a coastal valley within a flood zone in which various ecological system converge. This includes flooded lands or wetlands (extensive mangrove, herbaceous and arboreal swamps) that are saturated by surface or ground water. In addition, it includes extensive seagrass meadows, and extensive coral reefs, and the estuary of Río Espíritu Santo river. The area is classified as a subtropical rainforest with an average annual rainfall of 1,973 mm (77 inches) and an average annual temperature of 26.6 ˚C.

Río Espíritu Santo Natural Reserve is located in the coastal plain of the municipality of Río Grande in the northeast sector of Puerto Rico, within the Río Espíritu Santo hydrographical basin. The reserve covers approximately 4,892 acres. Of these, 2,483 are seafront acres, 918 acres are part of the land segment of Punta Picúa (east), and 1,491 acres belong to the Río Espíritu Santo segment (west).

The Natural Reserve is considered an area of high ecological and economic value, productive marine system and of vital importance for a large number of populations of crustaceans, mollusks and fish. The reserve serves as habitat for a great variety of wildlife, some species, which have been classified as rare and endangered.

According to Goenaga and Cintrón (1979) Ensenada Comezón is lined with numerous coral patches covered principally by algae. This study, reported stony corals covering the patches to lesser extent. They described the patches as more than a couple of meters in relief but did not presented distinct zonation. Some of the coral species they recorded were *Mycetophyllia lamarckiana, A agaricites, Millepora squarrosa, Porites astreoides and Pseudodiploria strigosa.* Finally, they point out that the surrounding waters were generally very turbid. Dr. Edwin Hernandez reported similar results in 1995 & 2000 in which he points out the presence of patch reefs at Ensenada Comezón with a low (<2.5%) live coral.

Many reef fish species have a two-phase life cycle—a juvenile planktonic phase and demersal (reef associated) phase as adults. On coral reefs adult fish reproduce, releasing eggs and larvae into the open ocean, where they are later fertilized to form embryos and hatch planktonic larvae. These larvae drift with the prevailing winds and currents until they eventually settle onto nearshore seagrass, mangrove, rock/rubble and back reef environments, where they continue development while slowly migrating to offshore reefs as adults (Cocheret de la Morinière et al., 2002). These nearshore environments act as important nursery habitats and are essential for the persistence for healthy fish populations on coral reefs (NOAA, 2010). Additionally, shallow coastal habitats with seagrasses are grazing grounds for green sea turtles (*Chelonia mydas*) and the Antillean manatees (*Trichechus manatus manatus*) and serve as refuge for hawksbill sea turtle (*Eretmochelys imbricata*) all of which reside in and are currently federally protected within the coastal waters of Puerto Rico (Seminoff, 2004; Deutsch et al., 2008). Furthermore, seagrass and mangroves provide important ecosystem services by maintaining water quality and preventing coastal erosion (NOAA 2010).

Many studies have been conducted worldwide that examine the effects of coastal and aquatic habitat alterations on natural flora and fauna, in particular fish assemblages (Poe *et al*. 1986; Williams and Zedler 1999; Pérez-Ruzafa *et al*. 2006). These studies are key components to proper planning, implementation and mitigation of environmental impacts. When these activities occur in coastal areas or regions with high ecosystem value, specific regulations and measures must be taken to avoid harm. This can include establishing a monitoring program to detect detrimental changes or to observe any trends in direct relationship with the presence of these activities. However, prior to this plan of action, a preliminary assessment of the benthic and fish assemblages should be conducted to set a baseline community structure for future comparisons.

The shallow inshore reef and seagrass habitats may be considered essential fish habitat (EFH), characterized as waters and substrates necessary to all fish life history stages and associated functions (Nagelkerken *et al*. 2000, Cerveny *et al*. 2010). These can also be called habitat areas of particular concern (HAPC), which is any EFH that is important for the long term sustainability of managed species, as they are more susceptible to degradation.

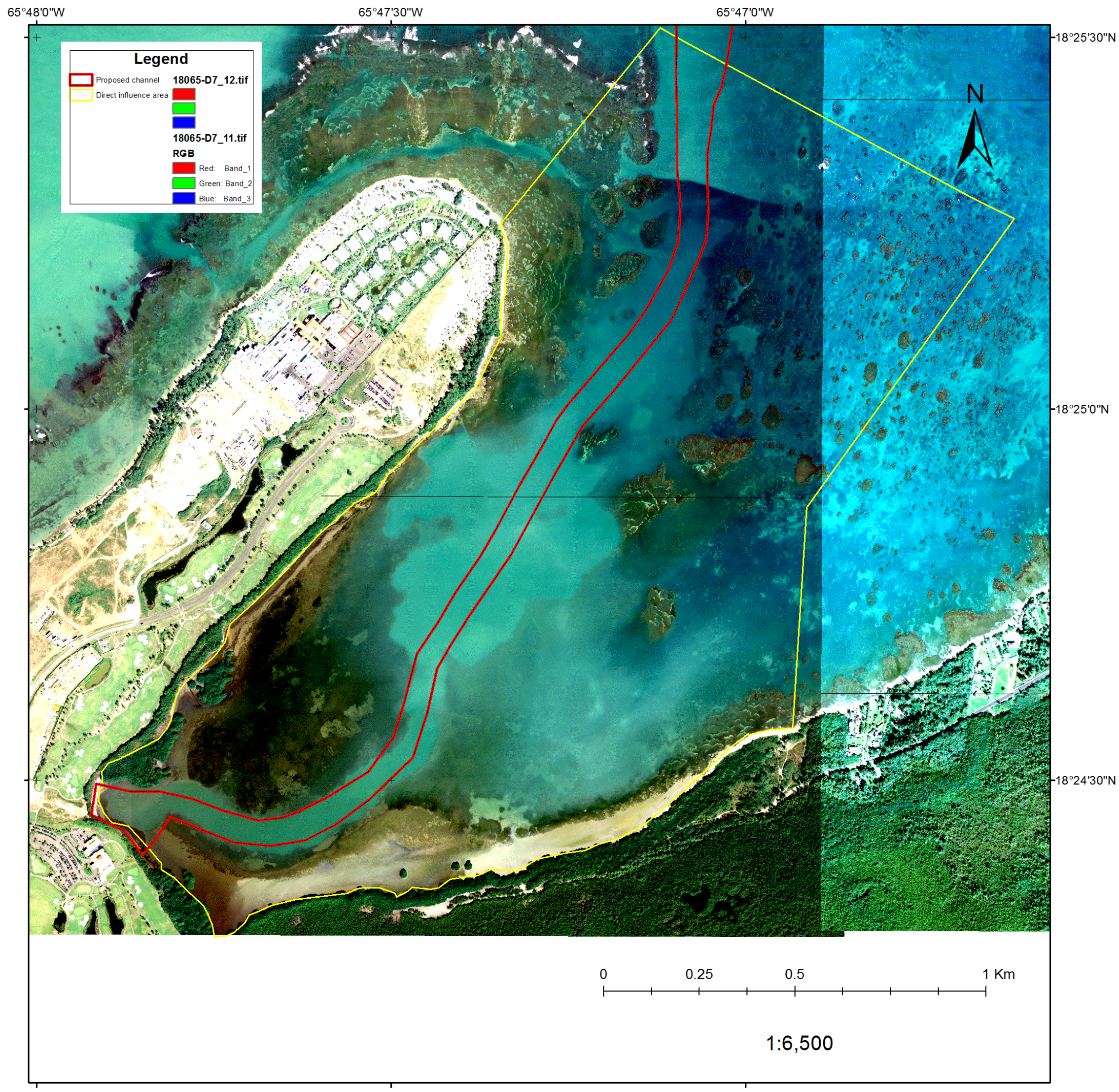
2 METHODS

2.1 STUDY AREA

The study area encompassed the zones surrounding Ensenada Comezón, including the coastline of Punta Miquillo in the municipality of Río Grande, Northeastern Puerto Rico (Figure 1). Within the bay maximum depths ranged between 0.20 and 8 meters.

Data sources used for planning and survey design include National Oceanographic and Atmospheric Administration (NOAA) benthic habitat maps, aerial/satellite images, and previous studies in the area. The benthic habitats identified previously (Kendall *et al*. 2001) consist of mangrove 1ha (0.42%), linear reefs 3 ha (1.50%), Patchy and continuous seagrass 140 ha (64.07%) and the rest remained as ‘unknown’ 74 ha (34.43%) as noted in Figure 2. Fine sediments and high turbidity influence the areas close to shore, whereas the northern-most areas near the linear reefs supported relatively clearer waters.

General Location of the Ensenada Comezón



General location of the study area in Ensenada Comezón.

Study area is the direct influence area where benthic mapping was perfomed.

Background is the 2007 Department of Natural Resources aerial photographs utilized for the generation of the detailed benthic habitat map.

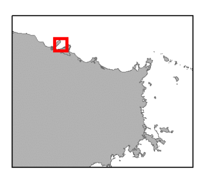


Figure 1 Study area in the bay known as Ensenada Comezón, Río Grande Puerto Rico.

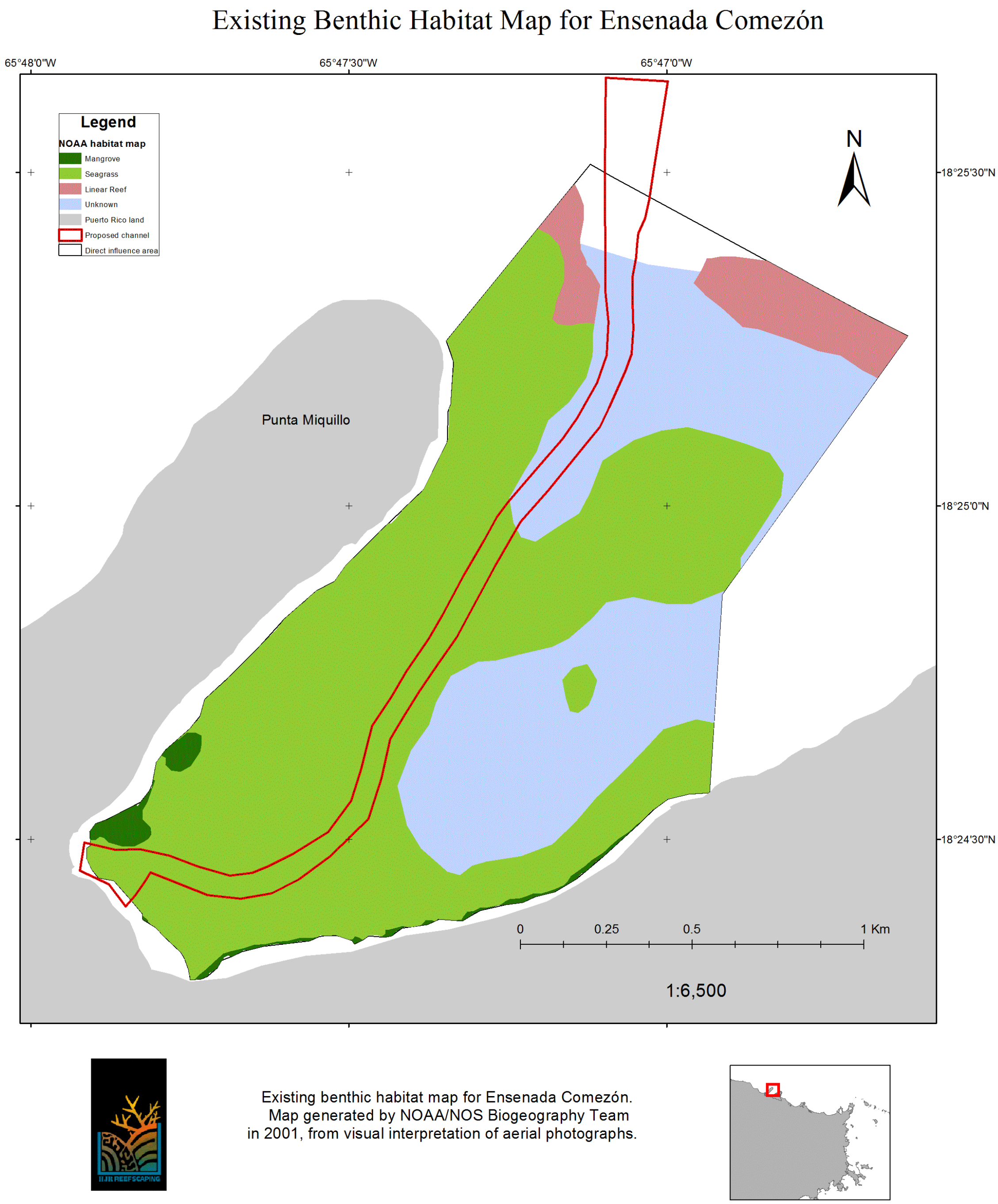


Figure 2 Benthic habitats of Ensenada Comezón as classified by Kendall *et al.* 2001.

2.2 BENTHIC HABITAT CLASSIFICATION

Benthic habitats were classified by interpreting data collected underwater at multiple stations established proportional to the habitat's distribution (sites visited in figure 3) and photointerpretation of aerial photographs (Kendall *et al.* 2001). The geographic coordinates and general description of the benthic habitat at each station can be observed in Appendix B. At each station, underwater visual surveys were performed and the dominant habitat type (linear reef, individual patch, seagrass, macroalgae and sand) was classified by divers. This information was used to create a geo-referenced database of the benthic categories using geographic information system software (QGIS 2.6).

2.3 CHARACTERIZATION OF BENTHIC HABITATS

Hardbottom and seagrass habitats were quantified by divers using line point-intercept (LPI) method. In each sampling station divers extended a tape measure for 15 meters and at regular intervals (every 15 cm) along the transect tape, the substratum type or biotic organism (if any) was identified and categorized according to type or species (Photo 1, Appendix A). Substratum (abiotic) types include hard (i.e, hard-bottom or reef), soft (i.e., sand or mud), and rubble. Biotic categories include coral species, algal turf, macroalgae, crustose coralline algae, seagrass species, gorgonians, sponges cyanobacteria, *Millepora*, *Palythoa* and others. This method was used to generate a percent cover value of each of the major benthic components. Photographs of each transect were taken for reference with a digital camera (Canon 7D in a Sea & Sea housing) fitted with a strobe, an Olympus Stylus TG-4 in a PT-056 waterproof Tough housing, or with a Gopro 3 + hero camera (Black).

In order to quantify the coral species designated as threatened under the Endangered Species Act (ESA) the methods contained in the "Recommended Survey Protocol for *Acropora* spp. in support of Section 7 Consultation" were adapted to document these species. The seven target species sought were: *A. palmata, A. cervicornis, Dendrogyra cylindrus, Orbicella annularis, O. faveolata, O. franksi,* and *Mycetophyllia ferox*. The surveys to document any of these species was carried out by conducting a 20 minutes timed swim, up to 50 m around each sampling stations in habitats deemed suitable for coral growth (i.e. hard substratum). Data were collected for each one of the colonies encountered within these timed swins. Data included the species identification, linear dimensions of the colony (length, height, and width to the nearest cm), and GPS geographical coordinate for each colony sighted. These surveys were limited to the areas of consolidated hard bottom as classified by Kendall *et al.* 2001.

2. 4 TAXONOMIC LIST

A taxonomic survey of the invertebrate fauna (motile and sessile) present within the study area, including the components observed at each sampling station, was conducted throughout the study area. The results of these observations were recorded as a species list. Marine organisms were identified during all dives performed for the benthic habitat characterization and as part of the quantitative assessment of sessile and pelagic biota within the study area. Field identification guides (Van Tussenbroek *et al.* 2010, Humann 1989, 1992 and 1993, Littler *et al.* 1989, Ruiz & Ortiz 2016) were used to aid in marine organism identification.

2.5 FISH ASSEMBLAGES

These surveys were conducted in the shallow areas (less than 10 m depth) of the bay to the east of the land development know as Coco Beach Resort. Surveys were conducted using either snorkel or scuba (depth dependent), during which fish abundances were sampled via underwater visual census (UVC) using 25x4 m belt transects conducted along the mangrove shoreline, seagrass bay, and patch reefs. This transect methodology was first described by Brock (1954) and has been shown to be more precise and accurate than other fish visual census survey methods (Samoilys and Carlos 1992). The method consisted of a diver swimming approximately 0.5 meter above a transect tape, observing fish for species, abundance and size at approximately two meters on either side of the transect tape for a period of 10 minutes. This pace allows for accurate estimates of reef dwelling fishes like damselfish, benthic-associated fishes, and transient fish like bar jacks. Belt transects were not conducted in locations with poor (less than 2m) visibility or areas that proved to be too shallow (less than 1 m). Belt transects were conducted at 15 randomly distributed locations throughout the bay. A roving snorkel survey was conducted in areas that were too shallow to conduct the transect methodology (primarily sites along the north and northwest mangroves shoreline and seagrass habitats), to record the species encountered within the habitat. The information collected during the surveys was used to generate a list of all fish species observed within the bay. Fish species richness, abundance, density and fish size were calculated from belt transects.

3 RESULTS

3.1 BENTHIC HABITAT CLASSIFICATION

A benthic habitat map was created by photointerpretation of aerial photography incorporating data collected *in situ* at 45 sampling stations (Figure 3). Seagrasses and sediment dominated habitats were the two dominant benthic habitat classifications present in the study area. Seagrasses were located throughout the bay. Seagrass habitats were estimated to encompass 1.01 km^2 (42% of the study area). The next most abundant habitats surveyed included unconsolidated sediments (35.5%), and coral/pavement (Table 1). The unconsolidated sediment habitat was composed of mud, sand and sand with invertebrates. The coral pavement habitat (20.60%) was composed primarily of dense stands of macroalgae including *Dictyota* spp., *Caulerpa* spp. and *Galaxaura* sp. with some isolated coral colonies of *Porites* spp., *Pseudodiplorioa* spp. and *Siderastrea* spp. (Photo 2, Appendix A). Submerged mangroves occupied the least amount of habitat (1%).

Table 1. Surface area of each benthic habitat classification (N=45).

Habitat category	Habitat type	Area (ha)	% habitat
Mangrove	Mangrove	2	1.01
Seagrass	Seagrass dense	36	15.31
	Seagrass sparse	38	15.95
	Seagrass invertebrates	27	11.55
Coral/pavement	Patch	4	1.48
	Coral Platform	6	2.58
	Pavement sand	39	16.58
Unconsolidated	Sand	47	19.76
	Sand invertebrates	7	3.00
	Mud	30	12.78
	Total	237	100

3.2 CHARACTERIZATION OF CORAL REEFS

Transects were composed mostly of macroalgae the highest percent cover estimates of any of the biological components within the coral/pavement areas sampled. The average percent cover of benthic macroalgae was 57.7%, N=14 (Table 2). Calcareous green algae, mostly *Halimeda opuntia*, fleshy green algae *Penicillu capitatus* and *Caulerpa verticillata*, calcareous red *Amphiroa rigida* and *Metapeysssonnelia tangerina,* and brown algae (*Sargassum polyceratium, Lobophora variegata and Dictyota menstrualis*) were the most abundant species of algae. Second to macroalgae, the abiotic component had the highest percent cover, average of 12%, and this included unconsolidated sediment (mostly sand and fine sediment), coral rubble, and un-colonized pavement.

Table 2 Mean percent cover estimates from photo-quadrats (N=14).

Major Category	Percent cover
Coral	4.00
Gorgonians	11.11
Sponges	0.33
Macroalgae	57.67
Others	9.11
Coralline algae	5.78
Sand, Pavement Rubble	12.00
Total	**100.00**

Percent cover of live stony corals (Order Scleractinia) was 4%. A total of 15 stony corals species were identified. The most common was *Undaria humilis* (Photo 3, Appendix A) with an average cover of 1.3%. *Porites astreoides* (Photo 4, Appendix A) and *Porites porites* (Photo 5, Appendix A) ranked second and third in terms of percent cover with 1.2% and 0.6%, respectively. Sponges, both columnar and encrusting were very rare and had an average cover of 0.33%. Gorgonians specifically encrusting species (*Briareum asbestinum* and *Erythropodium caribaeorum*) (Photo 6, Appendix A) made up a significant average cover of 11.1%. These organisms made up the benthic sessile fauna quantified with benthic transect. A total of six species of gorgonians (*Briareum asbestinum, Erythropodium caribaeorum*, *Pseudopterogorgia* sp., *Eunicea* sp., *Gorgonia ventalina,* and *Plexaura flexuosa*) were identified. Two prominent motile invertebrates in the coral reef habitats were the rock boring urchin (*Echinometra lucunter*) and the west indian sea egg (*Tripneustes ventricosus*).

Detailed Benthic Habitat Map for Ensenada Comezón

Detailed benthic habitat map for Ensenada Comezón.
Habitat delineation was generated from visual
interpretation of 2007aerial photographs from
Puerto Rico Department of Natural Resources.

Aerial photographs were coded with
numbers 18065-D7_12 and 18065-D7_11.

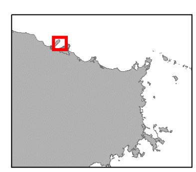
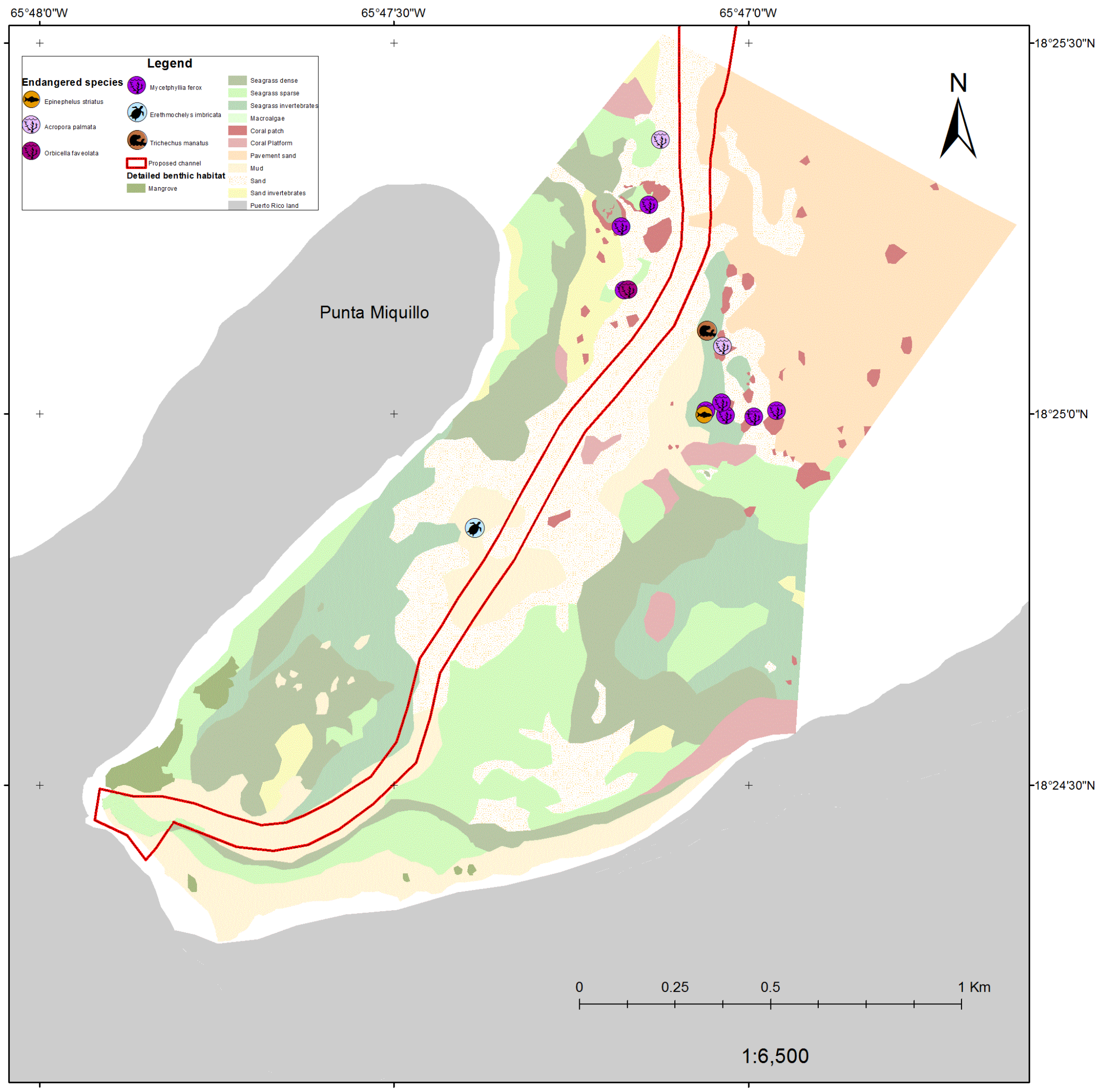


Figure 3 Detailed benthic habitats map for Ensenada Comezón.

3.3 CORALS DESIGNATED AS THREATENED BY ESA

At least three of the seven coral species designated as threatened under the Endangered Species Act were documented (GPS coordinates, size and condition) within Ensenada Comezón (Figure 4). The measurements of dimensions for each colony encountered are summarized in Appendix C. During this study, 14 colonies of *Mycetophyllia ferox* (Photo 8, Appendix A), 10 colonies *Acropora palmata* of (Photo 9, Appendix A), and 1 colony of *Orbicella faveolata* (Photo 12, Appendix A) were inspected. Upon examination 19 of the 25 coral colonies (76%) showed old partial mortality. The remaining colonies showed no bleaching disease or predation.

Observations of Endangered / Threaten Species



Location of endangered / threaten species observed during benthic surveys, conducted during September 23 - 26, 2016.

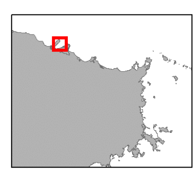


Figure 4 Observations of endangered and threatened species under the Endangered Species Act.

3.4 CHARACTERIZATION OF SEAGRASSES

Four seagrass species were identified during this study at Ensenada Comezón. The dominant seagrass observed overall was the turtle grass (*Thalassia testudinum*), followed by manatee grass (*Syringodium filiforme*) and shoal grass (*Halodule wrightii*). Paddle Grass (*Halophila decipiens*) was observed sporadically in muddy habitats at very low abundances (<1%).

Turtle grass (*Thalassia testudinum*) and the manatee grass (*Syringodium filiforme*) were found covering most of Ensenada Comezón and at the back reef areas in the coastal zone. *Halophila decipiens* was mostly distributed along the border of the navigational channel, and muddy and shallow bottoms in the bay. Halophila seagrass grows mainly on strips forming patches with other phanerogams (e.g. *Halodule*, *Syringodium*) and red (*Hypnea* spp., Acanthophora sp.), and green (*Caulerpa sertularioides*, *Udotea* sp., *Ventricaria ventricosa* and *Penicillus capitatus*) macroalgae. The structure of the community associated with the seagrasses demonstrated spatial variation within the study area, particularly in relation to associated macroalgae. In the west of bay (Punta Miquillo's border) the abundances of macroalgae was notably reduced (2.38%) when compared with the seagrasses at the east of the bay (11.67%) along Punta Picúa border. *Thalassia testudinum* dominates the seagrass beds at Ensenada Comezón and *Halodule wrightii* was only present at the borders of the seagrass beds to the west of the bay near the coast. *Syringodium filiforme* was significantly more abundant at the east area of the bay. The taxonomic compositions of organism, identified in seagrasses habitats are shown on table 4. Few megabenthic motile invertebrates (urchins, starfish mollusks and sea cucumbers) were present in the seagrass beds. Two species of stony coral, *Porites astreoides* and *Siderastrea radians* associated with the marine seagrass habitats were observed. Overall, 5 invertebrate species were observed associated to the seagrass community within Ensenada Comezón study area (Table 4).

Table 3 Mean percent cover estimated from transects in seagrass habitats (N=31).

Major category	**West Seagrass Beds**	**East Seagrass Beds**
Thalassia testudinum	68.85	44.17
Syringodium filiforme	9.38	18.42
Halodule wrightii	6.77	0.00
Macroalgae	2.38	11.67
Sponge	1.46	0.00
Sediment	11.15	25.75
Total	100	100

3.4 TAXONOMIC LIST

The non-cryptic organisms observed during surveys of the marine communities are summarized in Table 4. All organisms listed in the table 4 were present in the seagrass and coral reef systems.

Table 4 List of non-cryptic organisms observed during surveys.

Phylum	**Class/Order**	**Taxa**
Algae		
Chlorophyta	Order Cladophorales	*Ventricaria ventricosa*
Chlorophyta	Order Cladophorales	*Dictyosphaeria cavernosa*
Chlorophyta	Order Bryopsidales	*Caulerpa mexicana*
Chlorophyta	Order Bryopsidales	*Caulerpa racemosa*
Chlorophyta	Order Bryopsidales	*Caulerpa ashmeadii*
Chlorophyta	Order Bryopsidales	*Caulerpa verticillata*
Chlorophyta	Order Bryopsidales	*Caulerpa prolifera*
Chlorophyta	Order Bryopsidales	*Halimeda opuntia*
Chlorophyta	Order Bryopsidales	*Halimeda incrassata*
Chlorophyta	Order Bryopsidales	*Codium taylorii*
Chlorophyta	Order Bryopsidales	*Penicillus capitatus*
Chlorophyta	Order Bryopsidales	*Bryopsis pennata*
Chlorophyta	Order Dictyotales	*Dictyopteris justii*
Chlorophyta	Order Siphonales	*Udotea cyathiformis*
Chlorophyta	Order Siphonales	*Udotea flabellum*
Chlorophyta	Order Cladophorales	*Chaetomorpha linum*
Phaeophyta	Order Fucales	*Sargassum polyceratium*
Phaeophyta	Order Dictyotales	*Dictyota bartayresiana*
Phaeophyta	Order Dictyotales	*Dictyota menstrualis*
Phaeophyta	Order Dictyotales	*Lobophora variegata*
Phaeophyta	Order Dictyotales	*Padina gymnospora*
Rhodophyta	Order Corallinales	*Porolithon onkodes*
Rhodophyta	Order Corallinales	*Amphiroa rigida*
Rhodophyta	Order Corallinales	*Amphiroa tribulus*
Rhodophyta	Order Corallinales	*Jania* sp.
Rhodophyta	Order Corallinales	*Lithophyllum congestum*
Rhodophyta	Order Pessonneliales	*Metapeyssonnelia corallepida*

Phylum	Class/Order	Taxa
Rhodophyta	Order Pessonneliales	*Metapeyssonnelia tangerina*
Rhodophyta	Order Pessonneliales	*Peyssonnelia simulans*
Rhodophyta	Order Gigartinales	*Hypnea musciformis*
Rhodophyta	Order Gigartinales	*Hypnea spinella*
Rhodophyta	Order Gigartinales	*Meredithia pulchella*
Rhodophyta	Order Nemaniales	*Galaxaura obtusata*
Rhodophyta	Order Ceramiales	*Dasya spinuligera*
Rhodophyta	Order Ceramiales	*Acanthophora spicifera*
Rhodophyta	Order Ceramiales	*Wrangelia argus*
Rhodophyta	Order Rhodymeniales	*Coelothrix irregularis*
Seagrass		
Magnoliophyta	Order Hydrocharitales	*Halophila decipiens*
Magnoliophyta	Order Hydrocharitales	*Thalassia testudinum*
Magnoliophyta	Order Najadales	*Syringodium filiforme*
Magnoliophyta	Order Potamogenales	*Halodule wrigtii*
Cyanobacteria		
	Oscillatoriales	*Schizothrix* sp.
Invertebrates		
Porifera	Class Demospongiae	*Mycale laevis*
Porifera	Class Demospongiae	*Clathria* sp.
Porifera	Class Demospongiae	*Ircinia strobilina*
Porifera	Class Demospongiae	*Niphates erecta*
Porifera	Class Demospongiae	*Neopetrosia carbonaria*
Cnidaria	Order Scleractinia	*Acropora palmata*
Cnidaria	Order Scleractinia	*Orbicella faveolata*
Cnidaria	Order Scleractinia	*Pseudodiploria strigosa*
Cnidaria	Order Scleractinia	*Pseudodiploria clivosa*
Cnidaria	Order Scleractinia	*Siderastrea siderea*
Cnidaria	Order Scleractinia	*Siderastrea radians*
Cnidaria	Order Scleractinia	*Porites astreoides*
Cnidaria	Order Scleractinia	*Porites porites*
Cnidaria	Order Scleractinia	*Porites furcata*
Cnidaria	Order Scleractinia	*Porites divaricata*
Cnidaria	Order Scleractinia	*Montastraea cavernosa*
Cnidaria	Order Scleractinia	*Undaria humilis*.
Cnidaria	Order Scleractinia	*Isophyllia sinuosa*
Cnidaria	Order Scleractinia	*Favia fragum*
Cnidaria	Order Scleractinia	*Scolymia cubensis*
Cnidaria	Order Milliporina	*Millepora alcicornis*
Cnidaria	Order Milliporina	*Millepora complanata*
Cnidaria	Order Gorgonacea	*Briareum asbestinum*
Cnidaria	Order Gorgonacea	*Erythropodium caribaeorum*
Cnidaria	Order Gorgonacea	*Pseudopterogorgia* sp.
Cnidaria	Order Gorgonacea	*Eunicea* sp.
Cnidaria	Order Gorgonacea	*Gorgonia ventalina*
Cnidaria	Order Gorgonacea	*Plexaura flexuosa*
Cnidaria	Order Actiniaria	*Condylactis gigantea*
Cnidaria	Order Zoanthidea	*Palythoa caribaeorum*
Annelida	Class Polychaeta	*Hermodice caruncaulata*
Annelida	Class Polychaeta	*Sabellastarte magnifica*

Phylum	Class/Order	Taxa
Annelida	Class Polychaeta	*Spirobranchus giganteus*
Arthropoda	Class Crustacea	*Paguristes punticeps*
Arthropoda	Class Crustacea	*Stenopus hispidus*
Arthropoda	Class Crustacea	*Periclimenes* sp.
Arthropoda	Class Crustacea	*Stenorhynchus seticornis*
Arthropoda	Class Crustacea	*Panulirus guttatus*
Mollusca	Class Bivalvia	*Pinna carnea*
Mollusca	Subclass Opisthobranchia	*Elysia crispata*
Mollusca	Class Gastropoda	*Cyphoma gibbosum*
Mollusca	Class Cephalopoda	*Octopus vulgaris*
Mollusca	Class Gastropoda	*Lobatus gigas*
Echinodermata	Class Echinoidea	*Echinometra lucunter*
Echinodermata	Class Echinoidea	*Tripneustes ventricosus*
Echinodermata	Class Echinoidea	*Isostichopus badionotus*
Echinodermata	Class Echinoidea	*Eucidaris tribuloides*

3.5 FISH ASSEMBLAGES

A total of 24 sites were surveyed for fishes, of these, conditions only allowed for surveys to be successfully conducted at 15 sites. In total 47 fish species were observed, with the most abundant species being *Scarus iseri* (0.30 ind/m^2), followed by *Stegastes adustus* (0.07 ind/m^2). The majority of fish observed, having the capability to obtain larger sizes, fell into size categories less than 20cm. The dominance of smaller size classes indicates the presence of juveniles rather than adults, particularly for medium-sized herbivorous fish like princess parrotfish (*Scarus iseri)*. Given the close proximity of the reef systems to inshore seagrass dominated habitats, these observations suggest the function of these areas as nursery habitat. This indicates habitats function as essential habitat and refuge for commercially important fishery species, like grey snapper (*Lutjanus griseus*) (Photo 10, Appendix A), schoolmaster snapper (*Lutjanus apodus)*, red hind (*Epinephelus guttatus*) and barracuda (*Sphyranea barracuda)*. Species which eventually migrate to offshore reefs as they achieve adult sizes. However, there was a virtual absence of these species on the reef (i.e., low densities observed; range: 0.003-0.01 ind/m^2), which can also be indicative of overfishing in the area.

Surveys did reveal the presence of red listed species as per the International Union for the Conservation of Nature (IUCN). One Hawksbill turtle (*Eretmochelys imbricata)*, a species listed as critically endangers by the IUCN (Mortimer and Donnelly, 2008) and threatened under ESA was observed on the reef near the entrance of the bay (Figure 4). Multiple spotted eagle rays (*Aetobatus narinari*), listed as near threatened by the IUCN (Kyne et al., 2006), were observed swimming in the shallow seagrass beds. Three (3) Antillean manatees (Trichechus manatus manatus) were identified at the northwestern limit of the survey area (Figure 4). A juvenile Nassau grouper (*Epinephelus striatus*) was observed inhabiting patch reefs close to the mouth of the bay. Nassau grouper were once the most commercially important species within the region, however, due to decades of over fishing throughout the Caribbean, they are now listed as threatened under the Endangered Species Act (ESA)(NMFS, 2016). This observation suggests the area may serve as recruitment for this species and are using the area as a nursery, prior to migrating offshore to deeper reefs. A full list of fish species and their densities can be found in Table 5.

Table 5 Species list and total densities of fish observed at Ensenada Comezón surveys. Species in bold indicate listing under the International Union for the Conservation of Nature (IUCN) or ESA.

Species Name	Common Name	Total Density (ind/m^2)
Scarus iseri	Princess Parrotfish	0.3
Stegastes adustus	Dusky damsel	0.07
Thalassoma bifasciatum	Bluehead	0.06
Acanthurus coeruleus	Blue tang	0.05
Haemulon flavolineatum	French grunt	0.04
Acanthurus chirurgus	Doctorfish	0.03
Sparisoma viride	Stoplight parrotfish	0.03
Acanthurus bahianus	Ocean surgeonfish	0.01
Sparisoma radians	Bucktooth parrotfish	0.02
Stegastes leucostictus	Beaugregory	0.01
Lutjanus griseus	Grey Snapper	0.01
Stegastes variabilis	Cocao damsel	0.01
Abudefduf saxatilis	Sergeant major	0.01
Halichoeres poeyi	Blackear wrasse	0.01
Sparisoma rubripinne	Yellowtail parrotfish	0.005
Gerres cinereus	Yellowfin Mojarra	0.004
Chaetodon capistratus	Foureye butterflyfish	0.003

Holocentrus adscensionis	Squerrelfish	0.003
Stegastes planifrons	Threespot damsel	0.003
Epinephelus guttatus	Redhind	0.003
Ocyurus chrysurus	Yellowtail snapper	0.003
Cephalopholis fulva	Coney	0.003
Anisotremus virginicus	Porkfish	0.003
Microspathodon chrysurus	Yellowtail damsel	0.003
Synodus intermedius	Sand diver	0.003
Halichoeres bivittatus	Slippery dick	0.003
Lutjanus apodus	Schoolmaster	0.003
Chaetodon striatus	Banded butterflyfish	0.003
Lachnolaimus maximus	Hogfish	0.002
Anisotremus surinamensis	Black margate	0.002
Odontoscion dentex	Reef croaker	0.001
Caranx crysos	Blue runner	0.001
Cephalopholis cruentatus	Graysby	0.001
Bodianus rufus	Spanish hogfish	0.001
Halichoeres radiatus	Puddingfwife	0.001
Canthigaster rostrata	Sharpnose puffer	0.001
Hypoplectrus puella	Barred hamlet	0.001
Haemulon sciurus	Bluestriped grunt	0.001
Pseudupeneus maculatus	Spotted goatfish	0.001
Epinephelus striatus	**Nassau grouper**	**0.001**
Halichoeres maculipinna	Clown wrasse	0.001
Holocentrus rufus	Longspine squirrelfish	0.001
Mulloidichthys martinicus	Yellowtail goatfish	0.001
Sphyraena barracuda	Barracuda	N/A
Aetobatus narinari	**Spotted eagle ray**	**N/A**
Elacatinus genie	Cleaning goby	N/A
Coryphopterus glaucofraenatum	Bridled goby	N/A

4 CONCLUSIONS

The study area at Ensenada Comezón is characterized by large extensions of seagrass and a limited amount of hardbottom habitats to the northern entrance to the bay. The major benthic biothic component in terms of percent cover was seagrass (42.8%), followed by coral/pavement (20.6%). In the coral/pavement habitat located to the north of the bay the average coral cover was 4%. Three coral species designated as threatened under the Endangered Species Act were documented during benthic surveys. These were *O. faveolata*, *A. palmata*, and *Mycetophyllia ferox*. These colonies were located an average distance of 155.9 m (range 49.5 to 315 m) on either side of the limits of the proposed navigational channel. No threatened coral colony was present in the proposed navigational channel delimitated area or within the proposed mooring dock construction area. The closest ESA coral colony was located 1,720 meters from the mooring dock construction area. A preliminary estimate of the critical habitat for threatened corals amounts to 0.49 Km^2.

The average coral cover for this study was relatively low (4%) with a range between 1 and 21%. The mean percent cover estimated for macroalgae (57.67%) is similar to Caribbean coral reefs that over the past several decades have declined in coral cover and have been replaced by macroalgae. The mean coral cover of 4% at Ensenada Comezón is lower than the average live coral cover (8.6%) documented most recently for reefs the Puerto Rico archipelago (Scharer 2016). The combined effects of sedimentation and eutrophication associated with river loadings, domestic inputs via sewage treatment plant outfalls and dredging of the navigation channel represent potential causes that may result in reef community degradation in coastal environments. Mechanical damage caused by hurricanes and coral bleaching induced by elevated water temperatures and diseases represent natural causes of coral mortality that add to the overall reef community degradation (Matos *et al.* 2000).

High macroalgae cover reported for the survey area is expected since over the past several decades coral population have suffered declines (Gardner et al. 2003). This macroalgae dominance in coral reef ecosystems has highlighted the importance of competition for space between corals and macroalgae. Worldwide coral reefs are slowly shifting to macro algal-dominated reefs. Some possible reasons for this change are low herbivory, due to low densities of the echinoid *Diadema antillarum*, overfishing of parrotfish and surgeonfish plus the increase in nutrients concentrations, that have favored macroalgae populations over scleractinians corals.

Benthic seagrass communities at Ensenada Comezón are largely dominated by continuous (30-100%) and highly productive seagrasses. Seagrasses are considered ecosystems engineer species because they can construct an entire biotope (Coleman and Williams 2002). They possess a high economic value because they can stabilize unconsolidated sediments, damp wave action and reduce shoreline erosion rates (Fonseca & Calahan 1992). Seagrass communities also support a high faunal and algae diversity and constitute foraging grounds for several endangered marine species. These habitats are also major sites of human recreation and scientific studies (Kemp 2000). Therefore, special conservation measures may be required to offset development projects that have negative environmental impacts.

Overall the fish census showed low diversity and the small sizes of species of fish observed indicate that this area is utilized as a nursery habitat for both piscivorous and herbivorous fishes of ecological and commercial importance. The coastal habitats provide a combination of recruitment and nursery habitat types that favor the ontogenetic connectivity for coral reef species. The presence of at least one Nassau grouper support the importance of these habitats in this area for the recovery of this threatened species.

To minimize the possibility of negatively impacting coral reefs, seagrass beds and other habitats and marine organisms near the construction site, we recommend the use of floating turbidity curtains or an equivalent in-water barrier. These should be installed prior to any construction activities. These barriers should be monitored continuously throughout construction. All in-water barriers should remain in place until all sediments have been stabilized.

Additional measures during construction activity should be implemented for the protection of sea turtles and marine mammals (i.e., manatee). To avoid and minimize potential injury to marine mammals and sea turtles, The National Marine Fisheries Services (NMFS) recommends "*Sea Turtle and Smalltooth Sawfish Construction Conditions"* and *"Vessel Strike avoidance Measures and Reporting for Mariners*". Furthermore, a 500 meters safety zone shall be established around the project area for sea turtles and marine mammals. Trained observers can be use to visually monitor the safety zone for at least 30 minutes prior to the beginning of any construction activities. If at any time a sea turtle or a marine mammal is observed in the safety zone the operation should be shut down until the animal has left the safety zone on its own accord.

The aforementioned measures are subject to the approval of the government agencies concerned and may include modifications or additional requirements. The USACE will include all special conditions that must be followed to comply with the construction permit requirements.

5 LITERATURE CITED

Brock, V. E. (1954) A preliminary report on a method of estimating reef fish populations. Journal of Wildlife Management 18:297-308

Cerveny, K., Appeldoorn, R. S., & Recksiek, C. W. (2010). Managing habitat in coral reef ecosystems for fisheries: Just what is essential? In Proceedings of the Gulf and Caribbean Fisheries Institute (Vol. 63, pp. 23-36). Gulf and Caribbean Fisheries Institute, c/o Harbor Branch Oceanographic Institution, Inc. Fort Pierce FL 34946 United States.

Cocheret de la Morinière E, B. J. A. Pollux, I. Nagelkerken, and G. van der Velde. (2002). Post- settlement life cycle migration patterns and habitat preference of coral reef fish that use seagrass and mangrove habitats as nurseries. Estuar. Coast. Shelf Sci. 55:309-321.

Coleman, F.C. & Williams S.L. (2002). Overexploiting marine ecosystems engineers: potential consequences for biodiversity. Tree. 17:40-44.

Deutsch, C.J., Self-Sullivan, C. & Mignucci-Giannoni, A. (2008). *Trichechus manatus*. The IUCN Red List of Threatened Species 2008

Fisheries, N. O. A. A. "Habitat Areas of Particular Concern." (2010).

Fonseca, M.S. & Calahan, J.A. (1992). A preliminary evaluation of wave attenuation by four species of seagrass. Estuar.Coast.Shelf Sci. 35:565-576.

Gardner T.A., Cote I.M., Gill J.A., Grant A., Watkinson A.R. (2003). Long-term region-wide declines in Caribbean corals. Science 301:958-960.

Goenaga, C. & Cintrón. (1979). Inventory of the Puerto Rican Coral Reefs. Report submitted to the coastal zone management of the Department of Natural Resources, San Juan, P.R. 190pp.

Hernández Delgado, E.A.(1995). Inventario preliminar de las comunidades coralinas de la costa de Río Grande, incluyendo la Reserva Natural del Espíritu Santo del Río Espíritu Santo. Informe sometido a la Junta se Planificación, San juan, P.R., 3 de agosto de 1995. 8 pp.

Hernández Delgado, E.A. (2000). Effects of anthropogenic stress gradients in the structure of coral reef fish and epibenthic communities. Unpublished Ph.D. Dissertation, Dept. Biology, University of Puerto Rico, San Juan, P.R. 330 pp.

Hernández-Delgado E.A., Ramos-Scharrón, C.E., Guerrero, C., Lucking, M.A., Laureano, R., Méndez-Lázaro, P.A. and Meléndez-Díaz, J.O. (2012) Long-Term Impacts of Non-Sustainable Tourism and Urban Development in Small Tropical Islands Coastal Habitats in a Changing Climate: Lessons Learned from Puerto Rico. In: Kasimoglu, M., Ed., Visions for Global Tourism Industry-Creating and Sustaining Competitive Strategies, InTech Publications, Rijeka, 357-398.

Humann, P. (1989). Reef Fish Identification. New World Publications, Inc., Florida, USA

Humann, P. (1992). Reef Creature Identification. New World Publications, Inc., Florida, USA

Humann, P. (1993). Reef Coral Identification. New World Publications, Inc., Florida, USA

Kemp, W.M.(2000). Seagrass ecology and management: an introduction. 1-6 In, S.A. Bortone (ed), Seagrasses Monitoring, Ecology, Physiology and Management. CRC Press, Boca Raton, FL 318pp.

Kendall, M.S., M.E. Monaco, K.R. Buja, J.D. Christensen, C.R. Kruer, and M. Finkbeiner, R.A. Warner. (2001). (On-line). Methods Used to Map the Benthic Habitats of Puerto Rico and the U.S. Virgin Islands URL: http://biogeo.nos.noaa.gov/projects/mapping/caribbean/startup.htm. Also available on U.S. National Oceanic and Atmospheric Administration. National Ocean Service, National Centers for Coastal Ocean Science Biogeography Program. 2001. (CD-ROM). Benthic Habitats of Puerto Rico and the U.S. Virgin Islands. Silver Spring, MD: National Oceanic and Atmospheric Administration.

Kyne, P.M., Ishihara, H, Dudley, S.F.J. & White, W.T. (2006). *Aetobatus narinari.* The IUCN Red List of Threatened Species *2006*

Littler, D.S., M.M. Littler, K.E. Bucher, & J.N. Norris. (1989). Marine Plants of the Caribbean. A Field Guide from Florida to Brazil. Smithsonian Institution Press, Washington, D.C. 263 pp.

Matos, C.A., J.R. Garcia and E. Diaz. (2000). Puerto Rico's coral reef- status and trends report-2000. A report to the National Oceanic and Atmospheric Administration (NOAA) prepared by the Department of Natural and Environmental Resources. San Juan, P.R. 41pp.

Mortimer, J.A & Donnelly, M. (IUCN SSC Marine Turtle Specialist Group). (2008). *Eretmochelys imbricata*. The IUCN Red List of Threatened Species 2008

Nagelkerken, I., Van der Velde, G., Gorissen, M. W., Meijer, G. J., Van't Hof, T., & Den Hartog, C. (2000). Importance of mangroves, seagrass beds and the shallow coral reef as a nursery for important coral reef fishes, using a visual census technique. Estuarine, coastal and shelf science, *51*(1), 31-44.

NMFS. 2016. Endangered and Threatened Wildlife and Plants: Final Listing Determination on the Proposal To List the Nassau Grouper as Threatened Under the Endangered Species Act. Federal Register; vol. 81

Pérez-Ruzafa, A., Garcıa-Charton, J. A., Barcala, E., & Marcos, C. (2006). Changes in benthic fish assemblages as a consequence of coastal works in a coastal lagoon: The Mar Menor (Spain, Western Mediterranean). Marine pollution bulletin, *53*(1), 107-120.

Poe, T. P., Hatcher, C. O., Brown, C. L., & Schloesser, D. W. (1986). Comparison of species composition and richness of fish assemblages in altered and unaltered littoral habitats. Journal of Freshwater Ecology, *3*(4), 525-536.

Ruiz, H. & Ortiz, A. (2016). Tarjetas de identificación de corales de Puerto Rico,. Sea Grant Puerto Rico. 50 pp.

Samoilys, M. and G. Carlos (1992). Development of an Underwater Visual Census Method for Assessing Shallow Water Reef Fish Stocks in the South West Pacific, Report to AIDAB.

Scharer, M. (2016). "National Coral Reef Monitoring Program". NOAA in the Caribbean Partner's Meeting. NOAA.

Seminoff, J.A. (Southwest Fisheries Science Center, U.S.). 2004. *Chelonia mydas*. The IUCN Red List of Threatened Species 2004

Van Tussenbroek, Brigitta I., M. Guadalupe Barba Santos, J. Gonzálo Ricardo Wong, Jent Kornelis van Dijk, and Michelle Waycott. (2010). Guía de los pastos marinos tropicales del Atlántico oeste = A guide to the tropical seagrasses of the western Atlantic. http://www.icmyl.unam.mx/personal-academico/VanTussenbroekRibbinkBrigitta/CaribbeanSeagrassGuide.pdf.

Williams, G. D., & Zedler, J. B. (1999). Fish assemblage composition in constructed and natural tidal marshes of San Diego Bay: relative influence of channel morphology and restoration history. Estuaries, *22*(3), 702-716.

6 APPENDIX A- PHOTOGRAPHIC RECORD

Photo 1 Transect

Photo 2 Coral/pavement

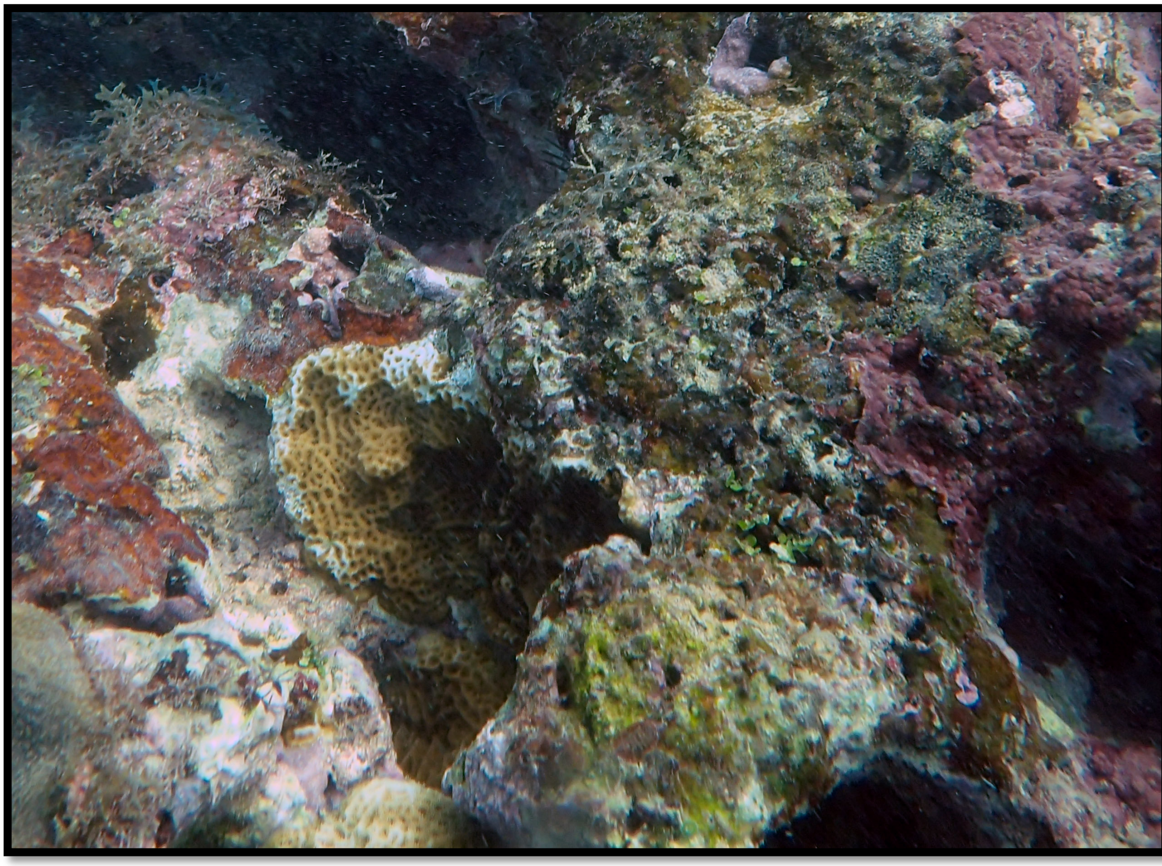


Photo 3 *Undaria humilis*

Photo 4 *Porites astreoides*

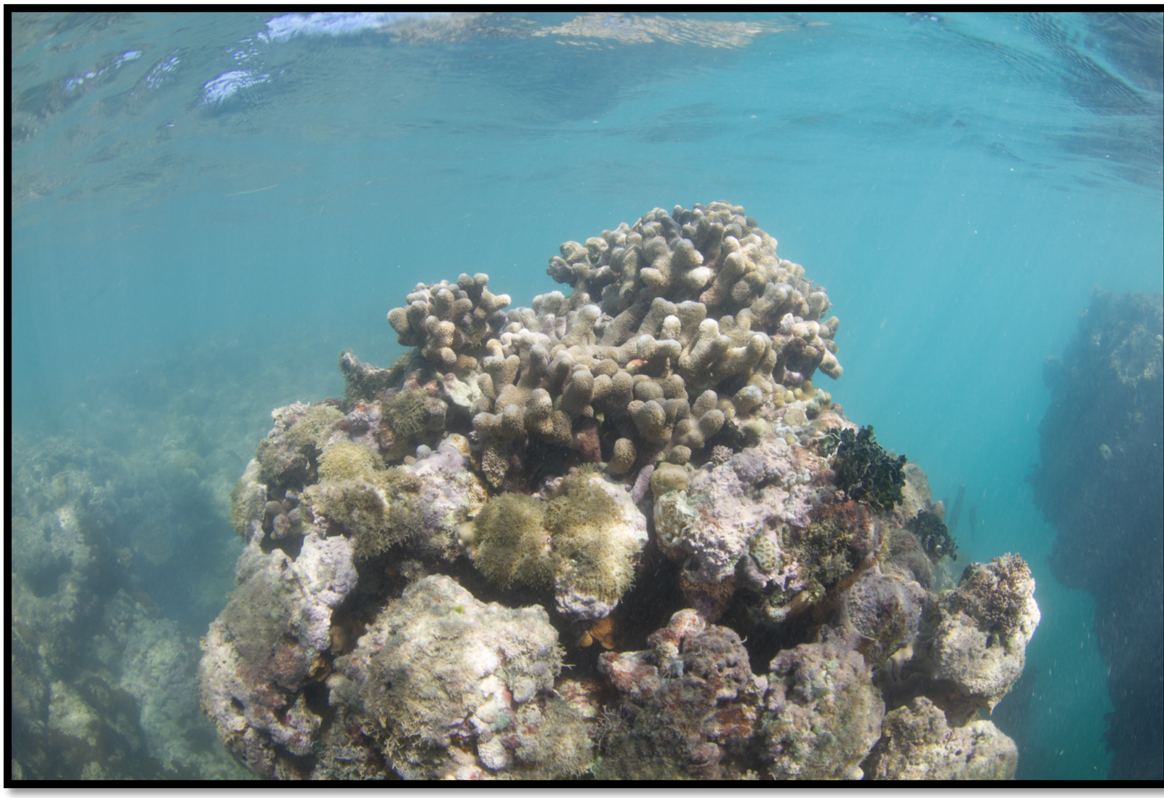


Photo 5 *Porites porites*

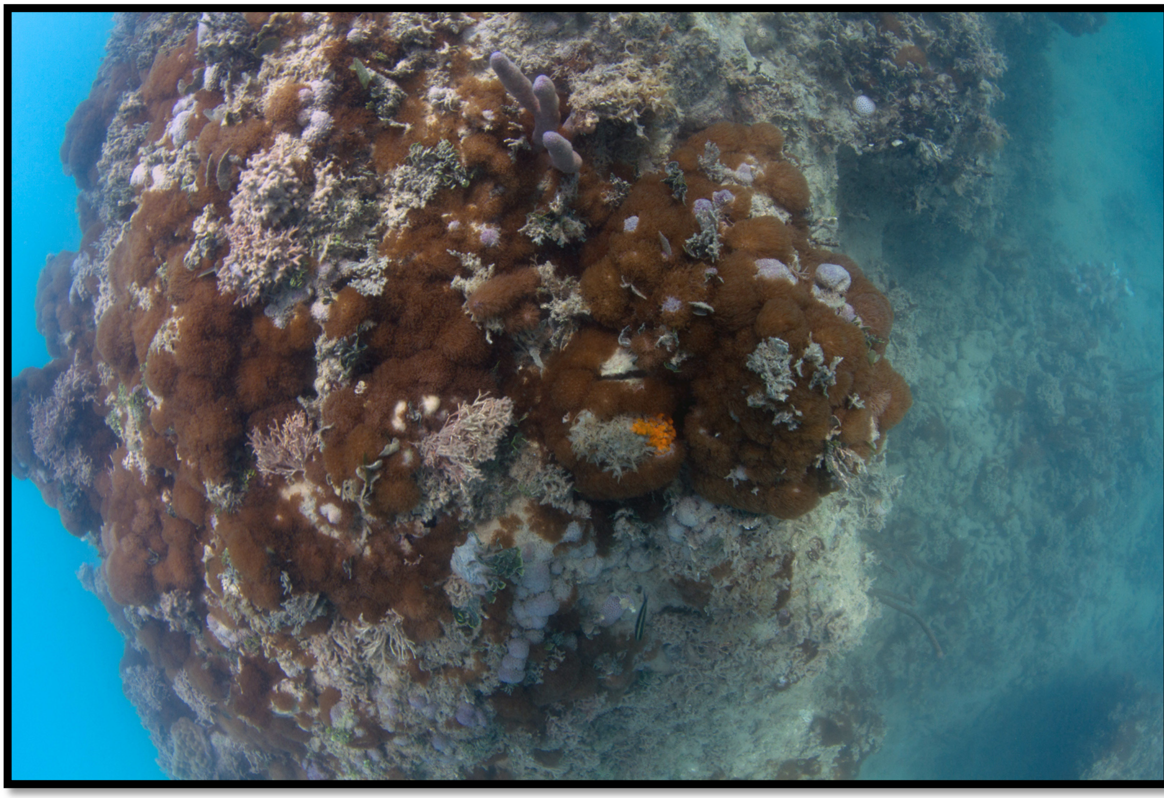


Photo 6 Encrusting gorgonians

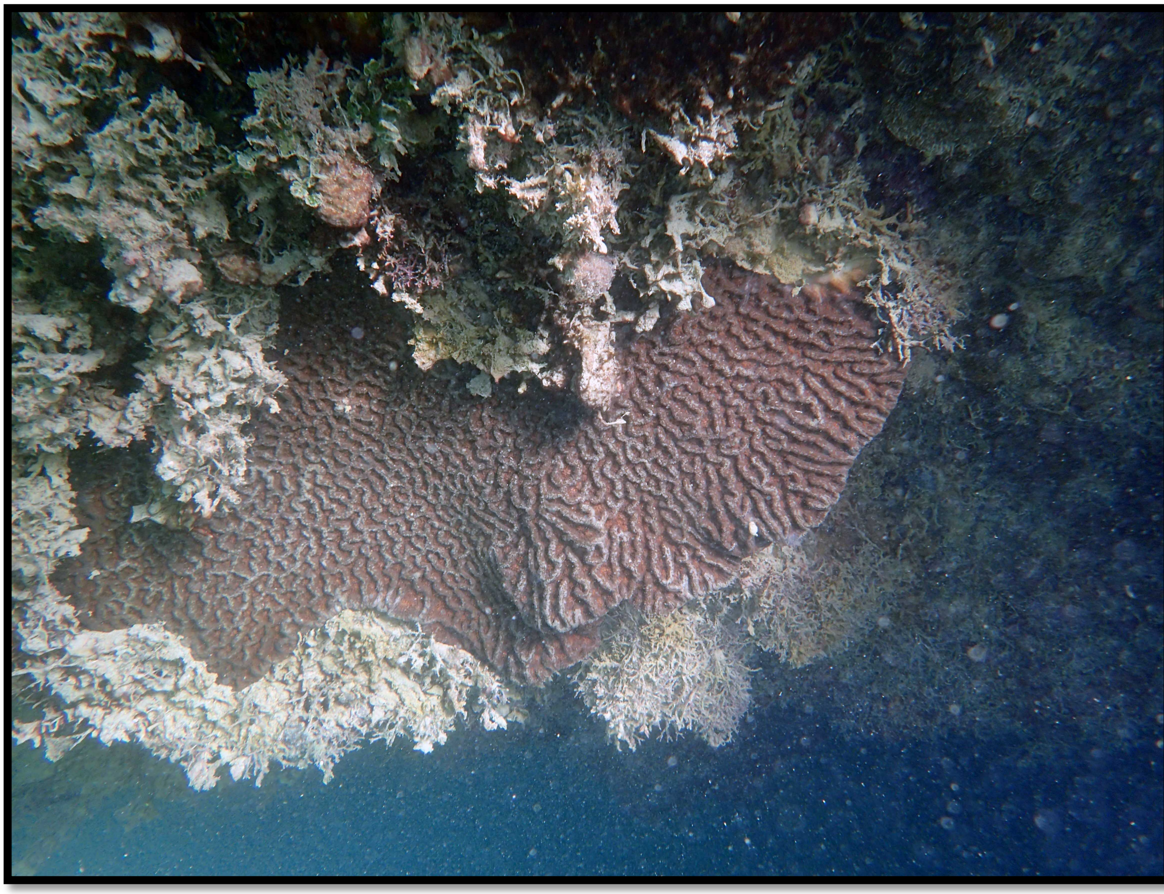


Photo 7 Mycetophyllia ferox

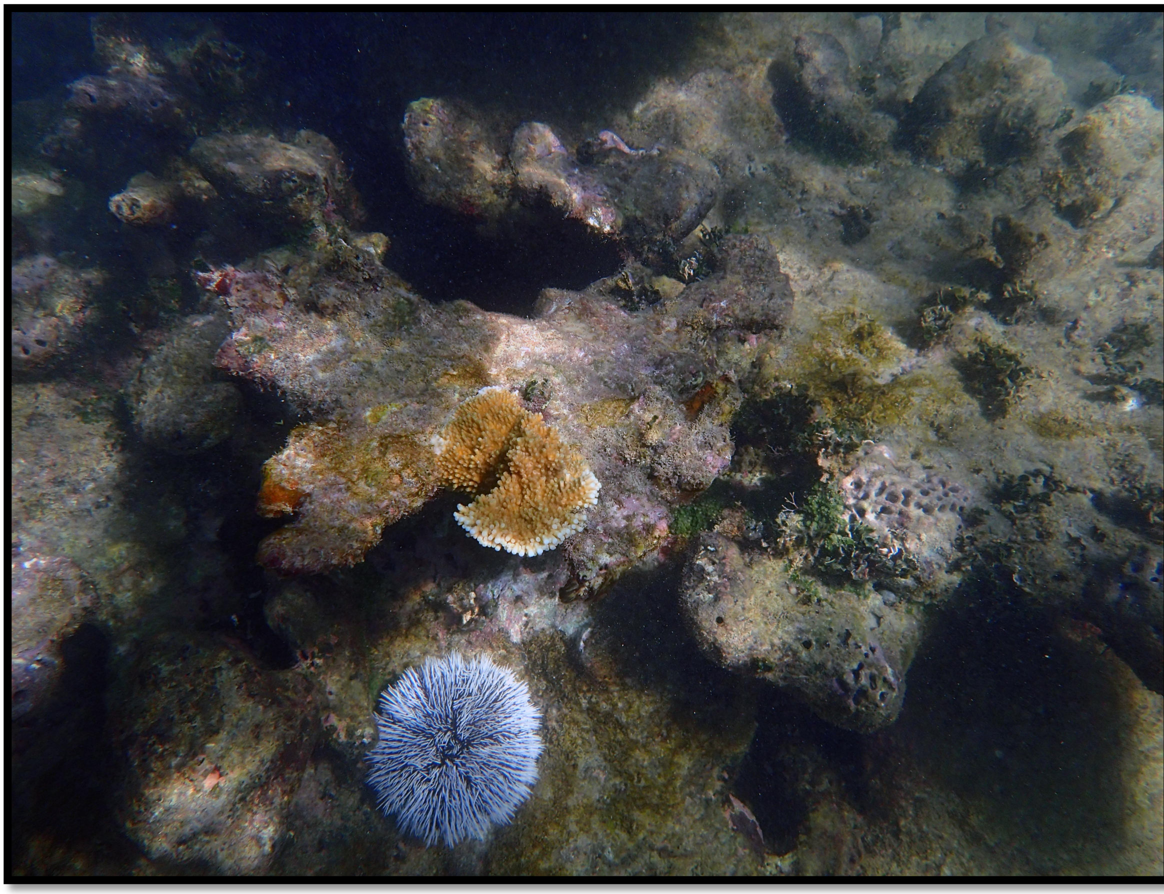


Photo 8 *Acropora palmata*

Photo 9 *Orbicella faveolata*

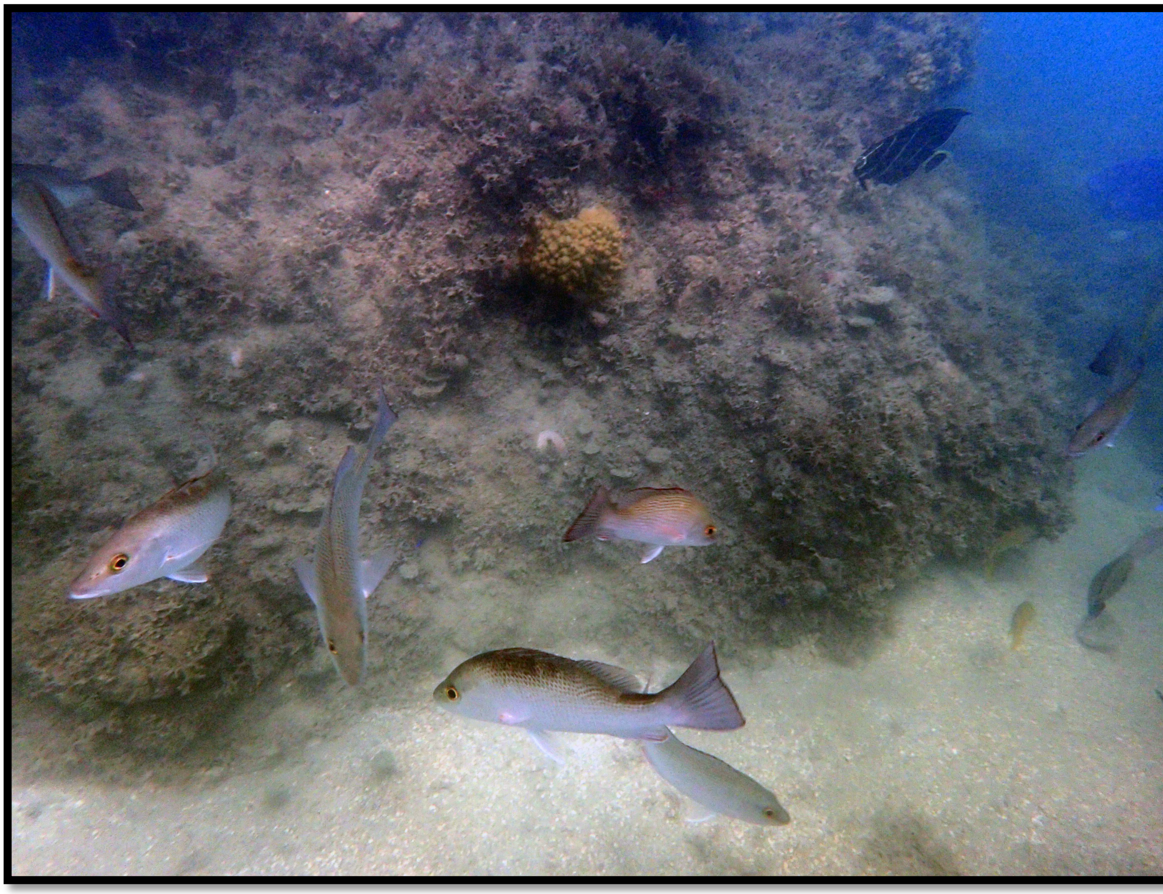


Photo 10 Grey snapper (*Lutjanus griseus*)

7 APPENDIX B- GEOGRAPHIC RECORD OF SAMPLING STATIONS.

Stations IDs	Latitude	Longitude	Habitat Description
1	18.41557341920	-65.78427111740	Structure
2	18.40755693330	-65.79157976900	Mud
3	18.41160303710	-65.79391695300	Mud
4	18.41428778180	-65.78777689340	Patch
5	18.41750185710	-65.78825225280	Patch
6	18.41084676330	-65.78868799900	Macroalgae
7	18.41269962810	-65.78991601090	Sand
8	18.41738842020	-65.78615274860	Sand
9	18.40770819120	-65.79732369580	Sand
10	18.40884262150	-65.78738076050	Sand
11	18.41390965130	-65.79094595640	Seagrass2
12	18.41595420170	-65.78695378030	Structure
13	18.41206215080	-65.78539795140	Structure
14	18.41487877620	-65.78561254850	Structure
15	18.40945032990	-65.79296249890	Mud
16	18.40699210950	-65.79618145580	Mud
17	18.41605662280	-65.78893880350	Macroalgae
18	18.40970639290	-65.78958259490	Macroalgae
19	18.41124276050	-65.78759757170	Macroalgae
20	18.41267669180	-65.78384212150	Macroalgae
21	18.41882197250	-65.78840231020	Structure
22	18.41508361930	-65.78335927820	Seagrass invertebrates
23	18.41646630720	-65.78266183780	Patch
24	18.41702962180	-65.78899245250	Patch
24	18.41119154870	-65.79188951330	Seagrass2
25	18.41257426800	-65.79215775950	Seagrass2
26	18.41165245660	-65.79441102970	Seagrass
27	18.40863092700	-65.79462562690	Seagrass
28	18.40970639290	-65.79441102970	Seagrass
29	18.41380334270	-65.78502240620	Seagrass
30	18.41667114940	-65.78437861480	Sand invertebrates
31	18.40929669240	-65.78539795140	Sand invertebrates
32	18.41006487980	-65.78405671860	Sand invertebrates
33	18.40724817530	-65.79526941820	Sand
34	18.41006487980	-65.79087017670	Sand
35	18.41339365200	-65.78818771310	Sand
36	18.40918294920	-65.79558071110	Seagrass
37	18.40642249440	-65.79486767190	Mud
38	18.41481716310	-65.78963871790	Sand
39	18.41629185940	-65.78532086950	Sand

40	18.41436340780	-65.78433053730	Seagrass
41	18.40986360240	-65.79245126140	Mud
42	18.40808633550	-65.79399617960	Mud
43	18.40736786060	-65.79332275370	Sand
44	18.41636748450	-65.78393440450	Sand invertebrates
45	18.41765310620	-65.78916335850	Structure

8 APPENDIX C- THREATENED CORAL MEASUREMENTS AND CONDITION

ID	Coral	Dimensions L x W x H (cm)	Percent of live tissue
44	*Acropora palmata*	10 x 15 x 8	80%
	Acropora palmata	40 x 60 x 20	30%
	Acropora palmata	34 x 13 x 18	70%
	Acropora palmata	16 x 24 x 13	85%
	Acropora palmata	70 x 46 x 34	100%
46	*Mycetophyllia ferox*	42 x 27 x 1	80%
	Mycetophyllia ferox	27 x 16 x 1	90%
47	*Mycetophyllia ferox*	23 x 8 x 1	100%
	Mycetophyllia ferox	32 x 16 x 2	70%
	Mycetophyllia ferox	27 x 18 x 2	100%
48	*Orbicella faveolata*	98 x 68 x 54	65%
49	*Mycetophyllia ferox*	30 x 22 x 2	100%
50	*Mycetophyllia ferox*	42 x 27 x 1	80%
	Mycetophyllia ferox	27 x 16 x 2	90%
53	*Acropora palmata*	12 x 3 x 6	10%
	Acropora palmata	10 x 5 x 5	100%
	Acropora palmata	13 x 6 x 3	5%
	Acropora palmata	9 x 8 x 3	60%
	Acropora palmata	13 x 10 x 4	30%
56	*Mycetophyllia ferox*	14 x 14 x 2	100%
58	*Mycetophyllia ferox*	19 x 16 x 1	95%
	Mycetophyllia ferox	32 x 30 x 2	95%
59	*Mycetophyllia ferox*	17 x 10 x 1	95%
	Mycetophyllia ferox	12 x 6 x 1	90%
	Mycetophyllia ferox	33 x 24 x 2	80%

9 APPENDIX D- LOCATION AND DISTANCE OF THREATENED CORALS TO THE NAVIGATION CHANNEL.

Site ID	Latitude	Longitude	No. Species	No. Colonies	Distance to Channel (m)
44	18.422815	-65.785397	1	5	49.5
47	18.420874	-65.786323	1	3	161
46	18.421362	-65.785667	1	2	69
53	18.418186	-65.783939	1	5	141.2
50	18.416918	-65.783960	1	2	228.3
49	18.419439	-65.786245	1	1	86.8
48	18.419457	-65.786158	1	1	79.8
56	18.416741	-65.784322	1	1	210.3
59	18.416734	-65.782669	1	3	315.3
58	18.416595	-65.783197	1	2	217.7