

FINAL REPORT

**MONITORING OF CORAL REEF COMMUNITIES AT ISLA DESECHEO,
RINCON, MAYAGUEZ BAY, GUANICA, PONCE AND ISLA CAJA DE
MUERTOS, PUERTO RICO, 2005**

by:

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Executive Summary

A total of 12 coral reef stations from six Natural Reserves were included as part of the 2005 Puerto Rico - U.S. National Coral Reef Monitoring Program (NOAA/DNER). The study included the third annual monitoring cycle of Puerto Botes Reef (Isla Desecheo) at 20 m, and the second monitoring of Tourmaline Reef (Mayaguez Bay) at 10 m, after the initial (baseline) characterizations of 1999. The report also presents the first monitoring observations of Cayo Coral Reef (Guánica), Derrumbadero Reef (Ponce), West Reef of Isla Caja de Muertos (Ponce), Puerto Botes Reef at 15 and 30 m, Tourmaline Reef at 20 and 30 m, and Tres Palmas Reef (Rincon) at 5, 10, and 20 m. The initial (baseline) characterizations of Cayo Coral and West Reef were performed during the summer of 1999, whereas baseline characterizations of the Tres Palmas Reef at 5, 10, and 20 m, Tourmaline Reef at 20 and 30 m, and Puerto Botes/Puerto Canoas Reefs at 15 and 30 m were performed during the summer of 2004.

The sessile-benthic community structure at the reef systems of the west coast (e.g. Isla Desecheo, Mayaguez Bay and Rincon) did not exhibit any major structural changes, nor statistically significant variations in percent substrate cover by live corals between the initial baseline characterization and the current monitoring survey. In contrast, the three reefs of the south coast included in this monitoring survey (e.g. Cayo Coral-Guánica, West Reef of Caja de Muerto-Ponce, and Derrumbadero Reef-Ponce) presented statistically significant reductions of live coral cover. The decline of live coral cover varied between 17 % in a four year period at Derrumbadero Reef (Ponce), to a maximum of 41 % in a six year period at Cayo Coral (Guánica). In all cases, the decline of (total) live coral cover at the community level was driven by reductions in cover of a highly dominant species, Boulder Star Coral, *Montastrea annularis* (complex). However, other coral species from the south coast reef systems examined during this survey exhibited proportionally similar or even higher reductions of substrate cover than *M. annularis*, suggesting that the observed pattern of declining live coral cover is not a species specific phenomenon. Rather, it appears to be a response to factor(s) that have operated at the (coral reef) ecosystem level. Interestingly, two out of the three reef systems studied in the south coast are located off the coast (Derrumbadero Reef and West Reef of Caja de Muerto), and therefore not expected to be directly effected by coastal processes, or anthropogenic perturbations other than overfishing.

The declining pattern of live coral cover exhibited by south coast reefs was measured over a much longer period than most of the west coast reefs. The elapsed time between baseline characterizations and the present monitoring survey allows comparisons only against the Puerto Botes Reef at 20 m (Isla Desecheo) and Tourmaline Reef at 10 m (Mayaguez Bay). Live coral cover at Puerto Botes has been remarkably constant since 1999. Isla Desecheo is an island surrounded by oceanic depths of not less than 500 m, therefore, processes associated with sediment resuspension and land runoff are expected to be minimal compared to south coast shelf reefs, particularly Cayo Coral, which is located at the inner shelf of an estuarine system. Tourmaline Reef at 10 m in outer Mayaguez Bay presented a trend of declining live coral cover, driven by *M. annularis*, but extensive to other coral species as well. The difference was not statistically significant at $p < 0.05$, due to the inconsistency in magnitude (not direction) of the differences in live coral cover (between surveys) within replicate transects. Given this data, it is reasonable to suggest that a declining trend of live coral cover is the prevailing pattern of mainland coral reefs in Puerto Rico under the Coral Reef Monitoring Program.

Fish populations from the reefs surveyed presented stable richness and taxonomic composition of species in most cases, but variable abundances within belt-transects. The variation of abundance between surveys was generally associated with numerically dominant populations that exhibit highly aggregated distributions, such as the Masked Goby (*Coryphopterus personatus*), Blue Chromis (*Chromis cyanea*), Creole Wrasse (*Clepticus parrae*) and Bluehead Wrasse (*Thalassoma bifasciatum*). Although in low abundance, large demersal fishes that have been overfished during the last decades have been detected during ASCE surveys in several reefs. These include Yellowfin, Tiger and Nassau Groupers (*Mycteroperca venenosa*, *M. tigris*, *Epinephelus striatus*), and the Cubera, Dog and Mutton Snappers (*Lutjanus cyanopterus*, *L. jocu*, *L. analis*).

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I INTRODUCTION

This work is part of the US National Coral Reef Monitoring Program sponsored by NOAA and administered by the Department of Natural and Environmental Resources (DNER) in Puerto Rico. It includes the third annual monitoring cycle of Puerto Botes Reef (Isla Desecheo) at 20 m, and the second monitoring of Tourmaline Reef (Mayaguez Bay) at 10 m, after the initial (baseline) characterizations of 1999 (García-Sais et al., 2001 a, b). The report also presents the first monitoring observations of Cayo Coral Reef (Guánica), Derrumbadero Reef (Ponce), West Reef of Isla Caja de Muertos (Ponce), Puerto Botes Reef at 15 and 30 m, Tourmaline Reef at 20 and 30 m, and Tres Palmas Reef (Rincon) at 5, 10, and 20 m. The initial (baseline) characterizations of Cayo Coral Reef and West Reef of Isla Caja de Muertos were performed during the summer of 1999 (García-Sais et al., 2001 a). Baseline characterizations of the Tres Palmas Reef at 5, 10, and 20 m, Tourmaline Reef at 20 and 30 m, and Puerto Botes/Puerto Canoas Reefs at 15 and 30 m were performed during the summer of 2004 (García-Sais et al., 2004 a).

The Tres Palmas Reef in Rincón designated in 2003 as a Marine Reserve with a “no-take zone”, or Marine Protected Area due to the presence of perhaps the most extensive and “healthy” biotope of Elkhorn Coral (*Acropora palmata*) in the island. El Tourmaline Reef in outer Mayaguez Bay is a shelf-edge “spur-and-groove” formation which extends across a depth range of 10 – 30 m and presents one of the most diverse coral communities in the Island. Puerto Canoas and Puerto Botes of Isla Desecheo represent reef systems with the highest live coral cover, fish density and fish species richness of Puerto Rico. The Cayo Coral and West Reef of Caja de Muertos have been included in the Puerto Rico National Coral Reef Monitoring Program because of their location within Natural Reserves where present and/or potentially high recreational impact may be expected. These are Natural Reserves where the DNER of the Puerto Rican government has constructed public recreational facilities and receive visitors on a daily basis. Derrumbadero Reef in Ponce has been included in the coral monitoring program because it is one of the best developed coral reef systems in Puerto Rico (García et al, 2005) and is located just offshore of a large scale coastal maritime development project in Ponce, Las Americas Megaport.

The first monitoring cycle of coral reef communities under the US National Coral Reef Monitoring Program in Puerto Rico was prepared by DNER in 2001 DNER (Nemeth,

2002). It included 18 reefs from seven Natural Reserve sites. In general, the variation of sessile-benthic community structure among the reefs monitored one year after the baseline characterization by García et al (2001 a, b, c) was very small, within the sampling error margin estimated at approximately 3 %. A similar assessment holds for the six reefs more recently surveyed at Isla de Vieques (García et al., 2004 b), and for the reefs at Puerto Botes-20 m (Isla Desecheo) and Tourmaline-10 m (Mayaguez Bay) where in most cases live coral cover has remained virtually constant three (Vieques reefs) to four (Puerto Botes-20 m, Tourmaline -10 m) years after the initial baseline characterizations (García et al., 2001 d, 2004 a). The inference from the monitoring program so far is that coral reef systems associated with Natural Reserves in Puerto Rico have been stable (within 3 % sampling error) with respect to their live coral cover along the set of five permanent transects monitored at each reef.

The field work corresponding to the present monitoring cycle of 2005 was completed in late August (2005), about one month prior to the onset of a massive coral bleaching event observed to affect corals of several species throughout the island of Puerto Rico and elsewhere in the northern Caribbean within a depth range of one (1) to (at least) 40 m. Therefore, the report from this monitoring cycle does not include an assessment of the bleaching impact upon coral reefs surveyed.

II Methods

The general location of coral reef monitoring sites in the west and south coasts of Puerto Rico are shown in Figures 1 and 2. A total of five permanent 10-m long transects were established at depths of 5, 10 and 20 m in Tres Palmas Reef (Rincón). This sampling scheme includes reef zones at depths of 3-5 m (reef crest), 10-12 m (hard ground platform) and 18-20 m (shelf-edge). An initial exploratory scan of the area was performed by echo-sounding runs and towed divers to select the best representative sections of the reef system to be characterized. Tourmaline Reef in Mayaguez Bay was monitored at depths of 10, 20 and 30 m from existing sets of five permanent transects at each depth. Puerto Canoas Reef in Isla Desecheo was monitored at an existing set of five permanent transects at 30 m. The Puerto Botes Reef (Isla Desecheo) was monitored from the existing sets of permanent transects at depths of 15 and 20 m. The DGPS referenced station coordinates are presented in Table 1.

Table 1. Geographic coordinates and depths of coral reefs surveyed. 2005

Reef site	Depth (m)	Latitude	Longitude
Rincon			
Rincon elkhorn reef	3	18° 21.023' N	067° 15.959' W
Rincon outer shelf	10	18° 20.832' N	067° 16.206' W
Rincon shelf edge	20	18° 20.790' N	067° 16.248' W
Isla Desecheo			
Desecheo inner shelf - Puerto Botes	15	18° 22.920' N	067° 29.300' W
Desecheo mid shelf - Puerto Botes	20	18°22.900' N	067° 29.315' W
Desecheo shelf edge - Puerto Canoas	30	18°22.706' N	067° 29.199' W
Tourmaline (Mayaguez Bay)			
Tourmaline 10m	10	18° 09.788' N	067° 16.424' W
Tourmaline 20m	20	18° 09.910' N	067° 16.512' W
Tourmaline 30m	30	18° 09.985' N	067° 16.581' W
Ponce			
West Reef of Caja de Muerto	7.6	17° 53.701' N	066° 31.703' W
Derrumbadero	20	17° 54.2371' N	066° 36.5161' W
Guánica			
Cayo Coral	7.6	17° 56.173' N	066° 53.303' W

A. Sessile-benthic reef communities

Sessile-benthic reef communities were characterized by the continuous intercept chain-link method, as modified from Porter (1972) by CARICOMP (1984). This method provides information on the percent linear cover by sessile-benthic biota and other substrate categories. It allows construction of reef community profiles by assignment of metric units to each substrate transition, which serves as a high precision baseline for monitoring. The chain has links of 1.42 cm long, marked every 10 links for facilitation of counting underwater. The positioning of the chain was guided by a series of steel nails hammered into available hard (abiotic) substrates at approximately 0.5 m intervals in the reef. Also, a thin nylon reference line was stretched from rod to rod in order to identify the location of transects and guide the divers over the linear transect paths. Individual measurements of substrate categories, as recorded from the number of chain links were sorted, added and divided by the total distance (in chain links) on each transect to calculate the cumulative percent linear cover by each substrate category.

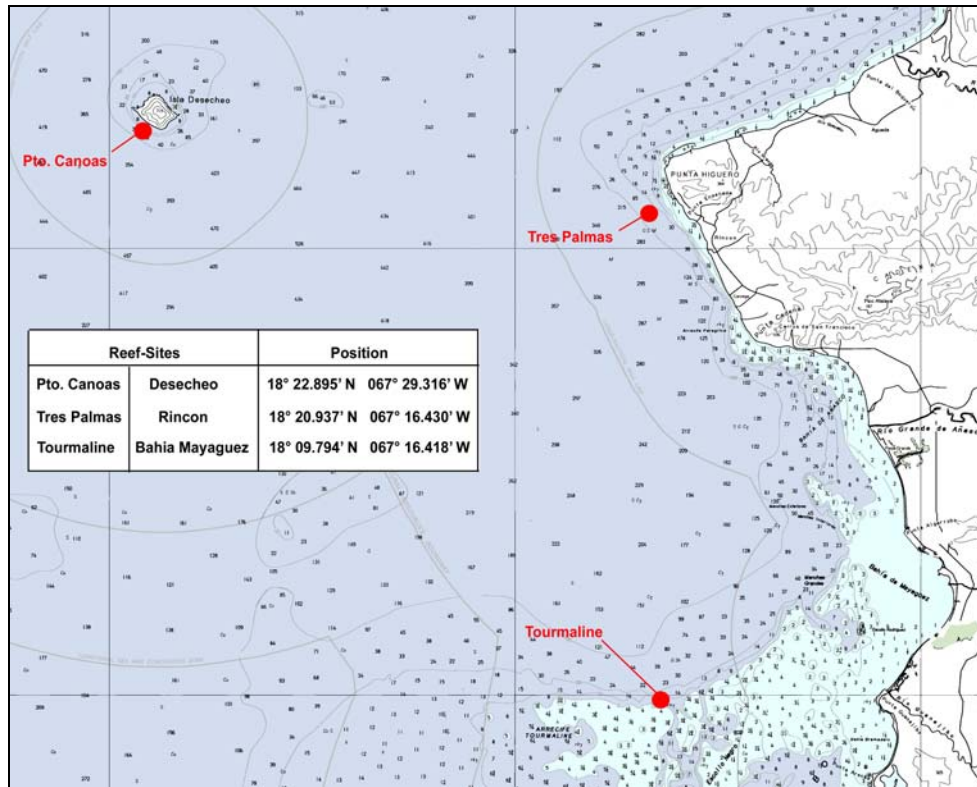


Figure 1. Location of west coast reef sites, Isla Desecheo, Mayaguez Bay and Rincón.

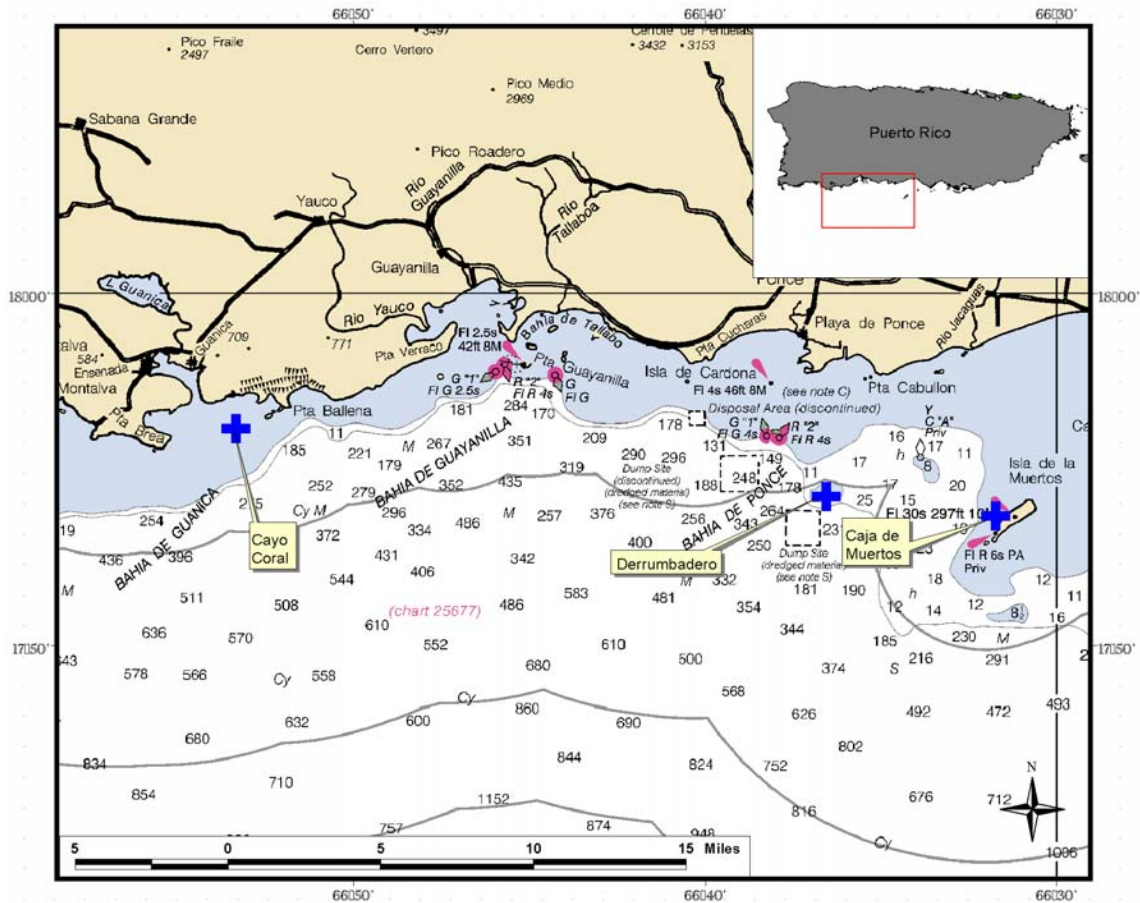


Figure 2. Location of south coast reef sites, Cayo Coral (Guánica), Derrumbadero and West Reef of Isla Caja de Muerto (Ponce)

Soft corals, with the exception of encrusting forms (e.g. *Erythropodium caribaeorum*) were counted as number of colonies intercepted per transect, whenever any of their branches crossed the transect reference line. The vertical relief of the reef, or rugosity, was calculated by subtracting 10 m from the total length (links) recorded with the chain at the 10 m marker of the reference line. Underwater videos of each transect were recorded for archival records on Digital-8 format using a Sony TR camcorder and an Ikelite underwater housing. Distance from the bottom was maintained constant using a metal rod fixed to the housing.

B. Reef Fishes and Motile Megabenthic Invertebrates

Demersal and territorial reef fish populations and motile megabenthic invertebrates were surveyed by five 10-m long by 3-m wide (30 m²) belt-transects centered along the reference line of transects used for sessile-benthic reef community characterizations. Transect width was marked with flagging tape stretched and tied to weights on both ends. Each transect was surveyed during 12 minutes. Fish species observed outside transect areas were reported to supplement taxonomic assessments, but were not included in density determinations. This approach yields a taxonomic account of the diurnal, non-cryptic fish and motile megabenthic (> 3 cm) invertebrate species present and provides estimates of their densities at each reef physiographic zones or depths. A set of five belt-transects for fish and motile megabenthic invertebrates were performed at each reef surveyed.

Large, elusive fish populations, which includes most of the commercially important and many recreationally valuable populations were surveyed using an Active Search Census (ASEC). This is a non-random, fixed-time method designed to optimize information of the numbers of fish individuals present at each of the main reef habitats, providing simultaneous information on size frequency data. At each reef physiographic zone (or depth strata) the total number of individuals of each particular species observed within a fixed time frame of 20 minutes was registered. Individuals were actively searched for in the water column and within crevices, ledges and potentially important hiding places. For each individual sighted, a length estimate was recorded. Length (in cms) was visually estimated and aided by a measuring rod with adjustable width. Precision of length estimates allows discrimination between small juveniles, juveniles, adult and large adult size classes. One ASEC survey was performed at the same depths in which belt-transects were surveyed from each reef. All data was recorded in plastic paper.

Statistical Analyses

Monitoring data on the percent cover by corals was analyzed using a Student T-test based on the differences between baseline survey values (percent cover) and the current 2005 survey results. The Student T-test statistic (T) was calculated as :

$T = \text{expected } \% \Delta - \text{observed } \% \Delta / \text{standard deviation } \% \Delta$, where the expected $\% \Delta = 0$.

III Baseline Characterization and Monitoring of Coral Reef Communities

A. Tres Palmas Reef System – Rincon

1. Fringing *Acropora palmata* (Elkhorn Coral) Reef

1.1 Sessile-benthic Reef Community

The rocky shoreline of the Tres Palmas Marine Reserve leads to a narrow backreef lagoon with coarse sandy sediments. The lagoon is a semi-protected environment associated with an extensive *Acropora palmata* (Elkhorn Coral) reef formation that has developed along a hard ground platform fringing the shoreline. The top of the platform is found at depths between 2 - 4 m. The branching Elkhorn Coral colonies are large, rising more than one meter from the hard ground platform almost to the surface and wide, extending more than two m horizontally in many cases. Where the hard ground platform is continuous, coral colonies grow close together forming a dense and intertwined Elkhorn Coral biotope. Sand pools and channels separate the reef where the hard ground platform breaks up. Interspersed within the *A. palmata* biotope are abundant colonies of encrusting corals, mostly *Diploria clivosa*, *D. strigosa* and *Porites astreoides*. These encrusting and mound shaped corals are more abundant on the seaward slope of the hard ground platform which ends in a sandy bottom at a depth of about six meters.

During our previous survey (García et al., 2004 a), rainfall runoff with heavy loads of terrestrial sediments was observed to reach the fringing coral reef following the prevailing northerly alongshore current. Many coral colonies were entangled with clothing and towels, apparently lost from immigrants trying to reach the Rincon coastline. Also, there were considerable amounts of garbage (cans, bottles, tires, etc.) in the reef. The backreef lagoon is a popular place for bathers and divers, some of which were observed fishing with spear guns within the no-take area. During the 2005 monitoring cycle, the field work at this reef had to be postponed several times due to strong wave action. The work was finally completed in December (2005) under considerable surge from waves. Figure 3 shows the location of monitoring stations at the Tres Palmas Reef system in Rincón. Panoramic photos of the Tres Palmas fringing Elkhorn Coral reef are presented as Photo Album 1.

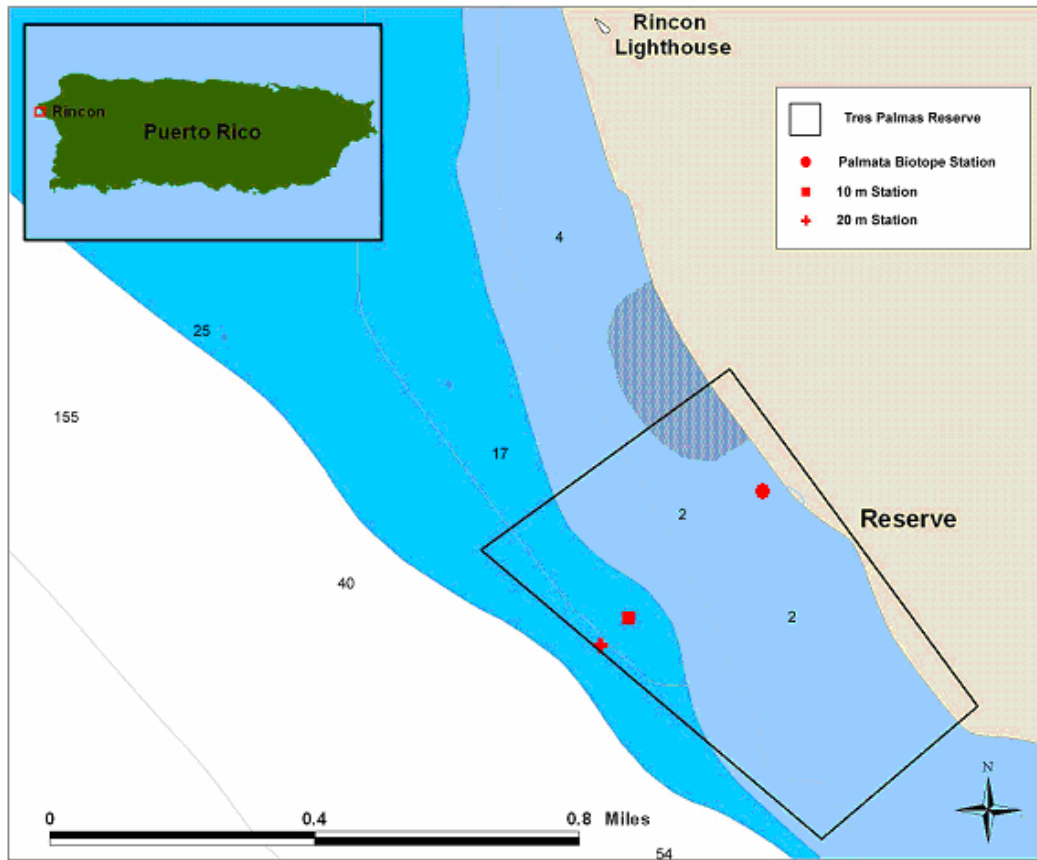


Figure 3. Location of coral reef survey stations off Tres Palmas, Rincon.

A set of five permanent transects were established along one continuous hard ground section of the fringing *Acropora palmata* reef at depths between 2 – 5 m (Figure 3). The percent of reef substrate cover by sessile-benthic categories along permanent transects surveyed are presented in Table 2. Live coral cover averaged 35.55% (range: 24.78 – 46.12 %). Elkhorn Coral, *A. palmata* was the dominant species with a mean substrate cover of 27.61 % (range: 9.19 – 44.95 %), representing 72.3 % of the total live coral cover. Five additional coral species, mostly encrusting types (e.g. *Diploria clivosa*, *D. strigosa*, *P. astreoides*) were intersected by linear transects during our survey. A total of 13 species of stony corals were identified from the fringing reef. Hard ground substrate, including dead coral sections not colonized by corals was mostly covered by turf algae (mean cover: 43.73 %). Fleshy macroalgae (*Valonia sp.*, *Styopodium sp.*) and red coralline algae were observed outside transect areas. The encrusting zoanthid,

Table 2. Percent substrate cover by sessile-benthic categories at at the fringing Elkhorn Coral Reef off Tres Palmas Reef 5m, Rincón. June, 2005

	TRANSECTS					MEAN
	1	2	3	4	5	
Rugosity (m)	5.01	4.55	3.89	3.10	3.48	4.48
SUBSTRATE CATEGORIES						
TURF ALGAE	44.64	41.92	35.21	37.83	59.03	43.73
ZOANTHIDS	1.88		6.19			1.61
ABIOTIC						
Reef Overhangs	28.51	22.34	10.37	16.05	15.31	18.52
Sand	0.19					0.04
Gaps			2.74			
Total Abiotic	28.7	22.34	13.11	16.05	15.31	18.55
CORAL SPECIES						
<i>Acropora palmata</i>	12.66	34.3	36.93	44.95	9.19	27.61
<i>Diploria strigosa</i>	8.99	0.58	0.61		12.04	4.44
<i>Diploria clivosa</i>			8.01			1.60
<i>Montastrea annularis</i>	2.00				4.31	1.26
<i>Porites astreoides</i>	1.13	0.87		1.17		0.63
TOTAL STONY CORAL	24.78	35.75	45.55	46.12	25.54	35.55
GORGONIANS (# col.)	1	0	0	0	0	0.2

Coral Species Outside Transects: *Colpophyllia natans*, *Millepora alcicornis*, *Siderastrea radians*, *Mycetophyllia lamarkiana*, *Isophyllia rigida*, *Agaricia agaricites*, *Porites porites*, *Diploria labyrinthiformis*

Palythoa caribdea and the encrusting gorgonian *Erythropodium caribaeorum* were present but with relatively low cover (< 2 %). Abiotic categories, associated with reef overhangs, gaps or holes and sand represented 18.6 % of the reef substrate cover. Vertically projected soft corals (gorgonians) were found in very low abundance (mean 0.2 colonies/transect). This was expected in an environment seasonally affected by strong wave action. The most common species observed out of transects included *Pseudopterogorgia americana*, *Plexaura homomalla*, *Gorgonia ventalina*, *Muricea spp.* and *Eunicea spp.*

Monitoring trends of the sessile-benthic community at the Tres Palmas fringing reef are presented in Figure 4. Live coral cover averaged 38.62 % in 2004 and declined to 35.55 % in 2005. Turf algae averaged 40.07 % in 2004 and increased to 43.73 % in 2005. The difference between the two surveys was not statistically significant (T= 0.57 p < 0.05), probably due to the inconsistency of the variation trend within replicate transects.

For example, relative to the 2004 baseline survey, live coral cover declined markedly in transects two and five, but remained essentially unchanged in transects one and four (varied < 1%), and increased slightly (1.8 %) in transect three during 2005. The difference in total live coral cover was largely driven by the variation of substrate cover by the dominant species, *Acropora palmata* (Figure 5). It is possible that the sampling variability for this reef may be comparatively higher than for others in the monitoring program due to the high morphological complexity (irregularity) of the Elkhorn coral colonies and the constraints in marking the chain path over such long stretches of live coral. Also, the extremely shallow nature of this coral reef (reef crest zone) and its frequent exposure to strong wave action makes it difficult to provide repeated measurements of the reef profile using the chain technique for monitoring evaluations.

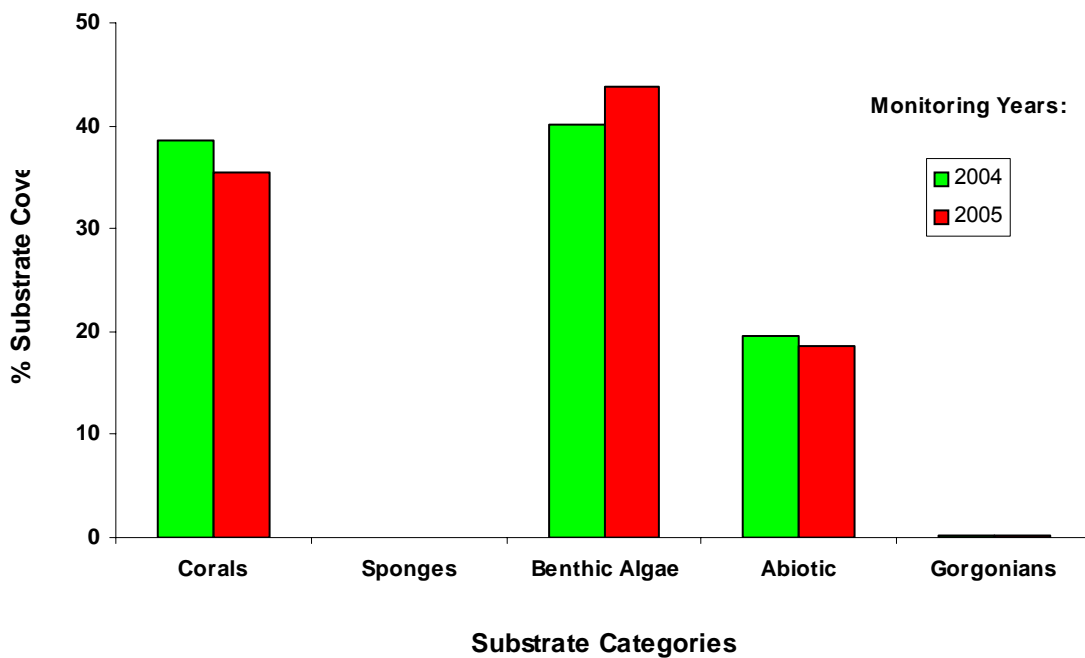


Figure 4. Monitoring trends of mean substrate cover by sessile-benthic categories at Tres Palmas Reef – 5 m.

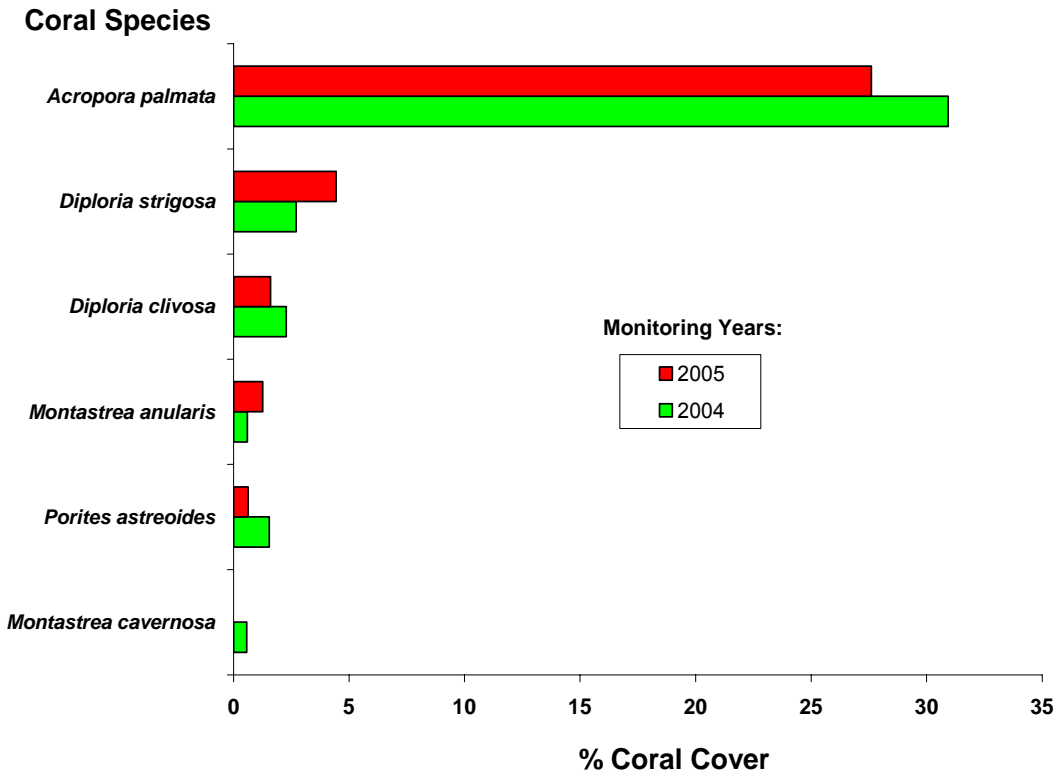


Figure 5. Monitoring trends of mean substrate cover by stony coral species at Tres Palmas Reef – 5 m.

1.2 Reef Fishes and Motile Megabenthic Invertebrates

A total of 43 fish species, including 22 present within belt-transects were identified from the fringing reef formation at the Tres Palmas Reef system of Rincon (depth: 2-5 m). The mean abundance of individuals was 63.2 Ind/30 m² (range: 37 - 96 Ind/30 m²). The mean number of species per transect was 10 (range: 7-14). Fish species richness decreased by 13.8 % and mean abundance decreased by 13.8 % compared to the 2004 baseline survey (Table 3). The combined abundance of five species represented 85 % of the mean abundance within belt-transects (Table 4). The most abundant species was the Bluehead Wrasse (*Thalassoma bifasciatum*) with a mean of 20 Ind/30 m², followed by the Redlip Blenny (*Ophioblennius atlanticus*) with 12.4 Ind/30 m², and the Dusky Damsel fish (*Stegastes dorsopunicans*) with 10 Ind/30 m². The Glassy Sweeper (*Pempheris schomburgki*) maintains since the previous survey in 2004 a large aggregation within a crevice in Transect 1. The Dusky Damsel fish, Redlip Blenny and the Yellowtail Damsel fish (*Microspathodon chrysurus*) were present within all transects surveyed and appear to be the main resident fish assemblage of the reef. The latter

Table 3. Summary of monitoring observations on fish species richness and mean abundance within belt-transects during baseline survey and the present 2005 survey.

Reef - Site	Baseline Survey			2005 Survey		% Change	
	Year	Spp/Transect	Mean Abundance (Ind/30m2)	Spp/Transect	Mean Abundance (Ind/30m2)	Spp/Transect	Abundance
Tres Palmas 5m - Rincon	2004	11.6	73.4	10	63.2	13.8 (-)	13.8 (-)
Tres Palmas 10m - Rincon	2004	17.8	111.4	18.4	106.4	3.2 (+)	4.4 (-)
Tres Palmas 20m - Rincon	2004	26	531.4	23	329.8	11.5 (+)	37.9 (-)
Tourmaline 30m - Mayaguez	2004	23	111.8	19.4	174.6	15.6 (-)	36.0 (+)
Tourmaline 20m - Mayaguez	2004	25.4	116.8	24.8	313.8	2.4 (-)	62.8 (+)
Tourmaline 10m - Mayaguez	1999	22	96.8	25	101.4	12.0 (+)	4.5 (+)
Puerto Canoas 30m - Isla Desecheo	2004	33.7	557.8	32.2	443.2	4.4 (-)	20.5 (-)
Puerto Botes 20m - Isla Desecheo	2000	25	241.4	25.8	236.8	3.2 (+)	1.9 (-)
Puerto Botes 15m - Isla Desecheo	2004	23.6	133.8	24.6	247.6	4.1 (+)	46.0 (+)
Cayo Coral - Guanica	1999	14	26.8	26.4	84.6	43.1 (+)	68.3 (+)
West Reef of Caja de Muerto - Ponce	1999	21	61.8	27.8	397.6	24.5 (+)	84.4 (+)
Derrumbadero - Ponce	2001	25	161.4	23.8	195.6	4.8 (-)	17.5 (+)

species (Yellowtail Damselfish) was mostly present as early juveniles. Large schools of Blue Tangs and Yellowtail Goatfishes were observed moving in and out of transect areas. Smaller schools of juvenile grunts and Sergeant Majors were also common.

The shallow, high energy environment of the fringing reef appears to be an ideal habitat for opportunistic carnivores, such as Wrasses (*Thalassoma bifasciatum*, *Halichoeres radiatus*, *H. maculipinna*, *H. bivittatus*) and Blennies (*Ophioblennius atlanticus*) which feed on small benthic (infaunal) invertebrates that become exposed upon disturbances of the substrate due to wave action. Also, herbivores (e.g. parrotfishes, doctorfishes, damselfishes) that feed on the turf algae were common. Large pelagic piscivorous species (Cero Mackerel, Bar Jacks, Blue Runners) were observed in the sand pools of the backreef feeding upon dense aggregations of zooplanktivorous anchovies (*Anchoa spp.*) near the surface. Large (adult) commercially important demersal fishes (snappers, groupers, hogfishes) were not observed. Juvenile stages of snappers (*Lutjanus analis*, *L. apodus*, *L. synagris*) were observed during our ASEC survey (Table 5). One Hawksbill Turtle (*Eretmochelys imbricata*) was reported during the 2004 baseline survey (García-Sais et al., 2004).

Among motile megabenthic invertebrates, White and Long-spined Sea Urchins (*Tripneustes esculentus*, *Diadema antillarum*), and one Channel Clinging Crab (*Mithrax spinosissimus*) were present within belt-transects (Table 5). One juvenile Spiny Lobster (*Panulirus argus*) were present outside transect areas in the reef.

Table 4. Taxonomic composition and abundance of fishes within belt-transects at the fringing Elkhorn Coral Reef off Tres Palmas, Rincón. June, 2005

SPECIES	COMMON NAME	Transects					MEAN
		1	2	3	4	5	
		Individuals/30m ²					
<i>Thalassoma bifasciatum</i>	Bluehead wrasse	5	11	35	45	6	20.4
<i>Ophioblennius atlanticus</i>	Redlip blenny	10	8	25	10	9	12.4
<i>Stegastes dorsopunicans</i>	Dusky damselfish		15	20	11	4	10.0
<i>Pempheris sp.</i>	Sweeper	29	5				6.8
<i>Microspathodon chrysurus</i>	Yellowtail damselfish	3	6	6	6	1	4.4
<i>Halichoeres maculipinna</i>	Clown wrasse			3	2	3	1.6
<i>Acanthurus coeruleus</i>	Blue tang	1	1		2	1	1.0
<i>Halichoeres radiatus</i>	Pudding wife	1	1	2		1	1.0
<i>Acanthurus bahianus</i>	Ocean surgeon	1				3	0.8
<i>Sparisoma viride</i>	Stoplight parrotfish	2				2	0.8
<i>Acanthurus chirurgus</i>	Doctorfish	1				2	0.6
<i>Kyphosus bermudensis</i>	Bermuda chub			3			0.6
<i>Bodianus rufus</i>	Spanish hogfish	1			1		0.4
<i>Caranx ruber</i>	Bar jack					2	0.4
<i>Halichoeres bivittatus</i>	Slippery dick	2					0.4
<i>Sparisoma rubripinne</i>	Yellowtail parrotfish			1	1		0.4
<i>Canthigaster rostrata</i>	Caribbean puffer	1					0.2
<i>Diodon hystrix</i>	Porcupinefish				1		0.2
<i>Gobiosoma sp.</i>	Goby			1			0.2
<i>Holocentrus ascensionis</i>	Longjaw squirrelfish					1	0.2
<i>Malacoctenus triangulatus</i>	Saddled blenny					1	0.2
<i>Sparisoma radians</i>	Bucktooth parrotfish					1	0.2
	TOTAL INDIVIDUALS	57	47	96	79	37	63.2
	TOTAL SPECIES	12	7	9	9	14	10

Outside Transects:

<i>Abudefduf sexatilis</i>	Sergeant major
<i>Anisotremus virginicus</i>	Porgy
<i>Calamus pennatula</i>	Pluma
<i>Cantherhines macrocerus</i>	Whitespotted filefish
<i>Caranx latus</i>	Horse eye jack
<i>Dasyatis americana</i>	Southern stingray
<i>Gerres cinereus</i>	Yellowfin mojarra
<i>Haemulon chrysargyreum</i>	Smallmouth grunt
<i>Haemulon flavolineatum</i>	French grunt
<i>Haemulon plumieri</i>	White grunt
<i>Haemulon sciurus</i>	Bluestripped grunt
<i>Halichoeres pictus</i>	Painted wrasse
<i>Labrisomus nuchipinnis</i>	Hairy blenny
<i>Lutjanus analis</i>	Mutton snapper
<i>Lutjanus apodus</i>	Schoolmaster

Table 4. (continued)

<i>Melichthys niger</i>	Black durgon
<i>Mulloidichthys martinicus</i>	Yellow goatfish
<i>Pomacanthus paru</i>	French angelfish
<i>Scarus vetula</i>	Queen parrotfish
<i>Sphyræna barracuda</i>	Great barracuda
<i>Stegastes variabilis</i>	Cocoa damselfish

Table 5. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at the fringing Elkhorn Coral Reef off Tres Palmas Reef, Rincon, June, 2005

Depth range : 3 – 5 m
Duration – 30 min.

SPECIES	COMMON NAME	# - (cm)	
<i>Carangoides crysos</i>	Blue Runner	1 – (25)	2 – (30)
<i>Caranx latus</i>	Horse-eye Jack	1 – (10)	1 – (15)
<i>Dasyatis americana</i>	Southern Stingray	1 – (50)	
<i>Gramma loreto</i>	Fairy Basslet	2 – (3)	6 – (4)
<i>Lutjanus apodus</i>	Schoolmaster	1 – (20)	3 – (25)
<i>Scomberomorus regalis</i>	Cero Mackerel	1 – (45)	
<i>Sphyræna barracuda</i>	Great barracuda	1 – (60)	
Invertebrates			
		1 –	
<i>Panulirus argus</i>	Spiny Lobster	(5.0)	

Table 6. Taxonomic composition and abundance of motile megabenthic invertebrates within belt-transects at the fringing Elkhorn Coral Reef off Tres Palmas Reef, Rincon, June, 2005

Depth: 5.0 m

SPECIES	COMMON NAME	TRANSECTS					MEAN ABUNDANCE (IND/30 m²)
		1	2	3	4	5	
<i>Diadema antillarum</i>	Long-spined Sea Urchin	1					0.2
<i>Tripneustes esculentus</i>	White Sea Urchin	1				2	0.6
<i>Mithrax spinosissimus</i>	Channel Clinging Crab					1	0.2
<i>Echinometra lucunter</i>	Rock boring urchin			1			0.2
TOTALS		2	0	1	0	3	1.2

Photo Album Rincon 5 m



Plate 1



Plate 2



Plate 3



Plate 4



Plate 5



Plate 6

2. Outer Shelf Patch Coral Reefs

2.1 Sessile-benthic Community

A series of submerged patch reefs are located in the Tres Palmas outer shelf, at about 0.5 kilometers east from the shelf-edge. Patch reefs are associated with an irregular and discontinuous line of hard ground promontories that rise from a sandy bottom at depths of 12 -15 m. Our permanent transects were installed within one of these patch reef promontories at a depth of 10 m running east to west on the top of the reef. The reef surveyed rose from the bottom as a vertical wall on the eastern end forming a sloping terrace toward the west. The east wall was about 5 m high and exhibited deep crevices and overhangs. At the top, the reef platform was mostly flat, with some depressions, but without any prominent pattern of spurs and/or grooves. Large sand channels separated the reef promontories. Vertically projected soft corals (gorgonians) and encrusting corals were the most prominent benthic assemblage of the community on the reef top. Panoramic views of the outer shelf patch reefs are presented as Photo Album 2.

A diverse and abundant assemblage of soft corals (gorgonians) was the most prominent feature of the sessile-benthic patch reef community. Soft corals were present at all transects surveyed with a mean of 18 col./transect (range: 11 – 23 col./transect) (Table 7). Some of the most common species included the Sea Fans, *Gorgonia flabellum*, *G. ventalina* and *G. mariae*; Sea Plumes, *Pseudopterogorgia americana*, *P. bipinnata*, *Muriceopsis* sp. And Sea Rods, *Plexaura homomalla*, *Pseudoplexaura* sp., *Eunicea* spp., *Muricea* spp.

Stony corals occurred mostly as encrusting colonies of typically small size and low vertical relief. A total of 19 species of stony corals were identified from the patch reef community during our survey. Stony coral cover averaged 20.26 % (range: 12.26 – 25.97 %). Great Star Coral, *Montastrea cavernosa* was the dominant species in terms of substrate cover with a mean of 4.78 % (range: 2.56 – 9.48 %), representing 23.6 % of the total live coral cover from this reef. Fourteen additional coral species were intersected by linear transects, but seven of them with less than 1 % mean cover.

Table 7. Percent substrate cover by sessile-benthic categories at Tres Palmas Reef 10m, Rincon. June, 2005.

	TRANSECTS					MEAN
	1	2	3	4	5	
Rugosity (m)	2.49	2.25	2.01	1.82	1.86	2.09
SUBSTRATE CATEGORIES						
TURF ALGAE	65.89	75.29	67.89	62.69	69.65	68.28
SPONGES	13.05	6.12	5.82	3.81	4.89	6.74
ABIOTIC						
Reef Overhangs	5.76	1.39	1.41	4.31	3.20	3.21
Sand				1.19		0.24
TOTAL ABIOTIC	8.76	1.39	1.41	7.76	4.7	4.80
CALCAREOUS ALGAE	2.00			1.07		0.61
ENCRUSTING GORGONIAN	0.32			0.95	1.26	0.51
FLESHY ALGAE	0.68					0.14
CORAL SPECIES						
<i>Agaricia agaricites</i>	0.34	1.35	2.00		0.48	0.83
<i>Colpophyllia natans</i>			1.66	6.55		1.64
<i>Dendrogyra cylindrus</i>				6.68		1.34
<i>Diploria labyrinthiformis</i>			5.66		3.88	1.91
<i>Diploria strigosa</i>	1.44	4.57		1.78	1.35	1.83
<i>Isophyllia sinuosa</i>				0.48		0.10
<i>Madracis decactis</i>	1.12					0.22
<i>Meandrina meandrites</i>		2.04	1.05			0.62
<i>Montastrea annularis</i>	6.57	3.02				1.92
<i>Montastrea cavernosa</i>	2.56	3.75	9.48	4.31	3.80	4.78
<i>Porites astreoides</i>	0.23	2.28	3.24	1.78	7.93	3.09
<i>Porites porites</i>					0.24	0.05
<i>Siderastrea siderea</i>		0.23	1.75	2.96	2.7	1.53
<i>Stephanocoenia michelini</i>				1.19	0.36	0.31
<i>Millepora sp.</i>				0.24	0.24	0.10
TOTAL STONY CORAL	12.26	17.24	24.84	25.97	20.98	20.26
GORGONIANS (# col.)	20	20	15	11	23	18
Coral Species Outside Transects: <i>Acropora cervicornis</i> , <i>Favia fragum</i> , <i>Isophyllastrea rigida</i> , <i>Manicina areolata</i>						

Turf algae, a mixed assemblage of short filamentous red and brown macroalgae presented the highest percent of reef substrate cover by sessile-benthic components with a mean of 68.28 % (range: 62.69 – 75.29 %). Fleshy brown (*Dyctiota sp.*), red (*Galaxaura sp.*) and calcareous (*Halimeda discoidea*) macroalgae were present in small amounts within transects. Encrusting sponges were intersected by all five transects with a mean substrate cover of 6.74 % (range: 3.81 – 13.05 %). The encrusting gorgonian *Erythropodium caribaeorum* was present in three out of the five transects, but with relatively low mean cover (< 1 %). *Palythoa caribdea*, an encrusting zoanthid was observed outside transects. Abiotic categories, associated with reef overhangs comprised only 4.80 % of the reef substrate cover, influenced in part by the essentially flat bathymetry and the prevailing encrusting growth pattern of corals and sponges. Reef rugosity, which is a measure of underwater topographic relief, was only 2.09 m.

The sessile-benthic community at the patch reef surveyed is typical of high wave energy environments, dominated by encrusting stony corals and sponges and flexible soft corals. The high abundance of small coral colonies may be an indication of active recruitment. Mortality of coral colonies induced by mechanical detachment during heavy wave action is most likely to be prevailing process in this reef which has probably led to the high species richness evidenced by this survey. The reef hard ground was mostly colonized by turf algae, which is the dominant assemblage and a quasi-permanent feature of high energy reef systems in the north coast of Puerto Rico (García-Sais et al., 2003).

The monitoring time series for sessile-benthic communities at the Tres Palmas outer-shelf patch reefs consists of the baseline characterization of 2004 (García-Sais et al., 2004 a) and the present survey of 2005. The largest variation of percent substrate cover by sessile-benthic categories between both years was an increment of 2.3 % in abiotic cover (Figure 6). Total live cover by stony corals, sponges and benthic algae varied by less than 1 %. The apparent decline of substrate cover by great star coral, *Montastrea cavernosa* of 1.8 % (Figure 7) is still below the sampling variability error (3 %). All other coral species intersected by transects maintained substrate cover differences within 1% of baseline measurements in 2004.

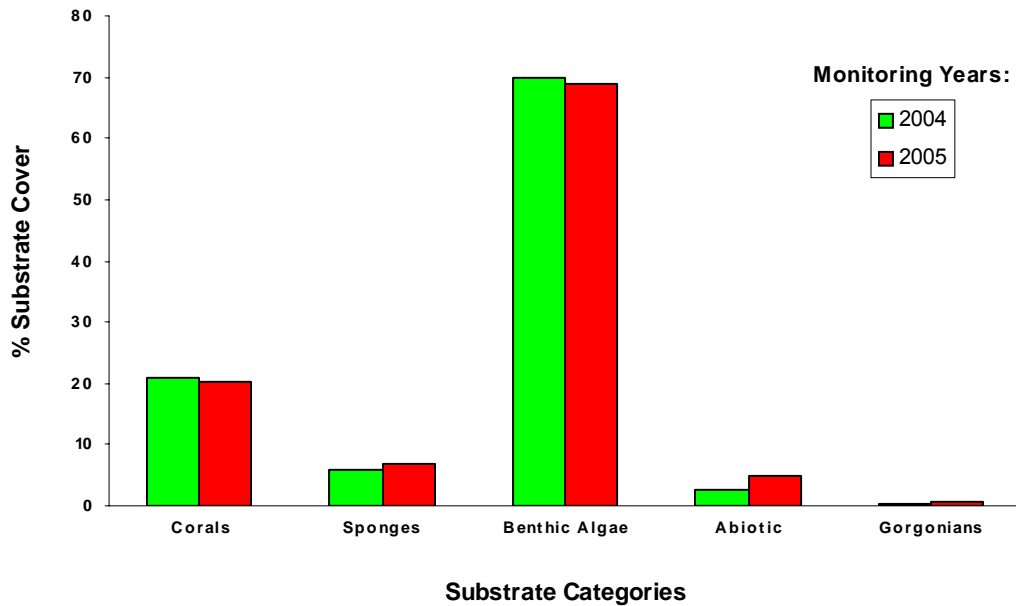


Figure 6. Monitoring trends of mean substrate cover by sessile-benthic categories at Tres Palmas Reef – 5 m.

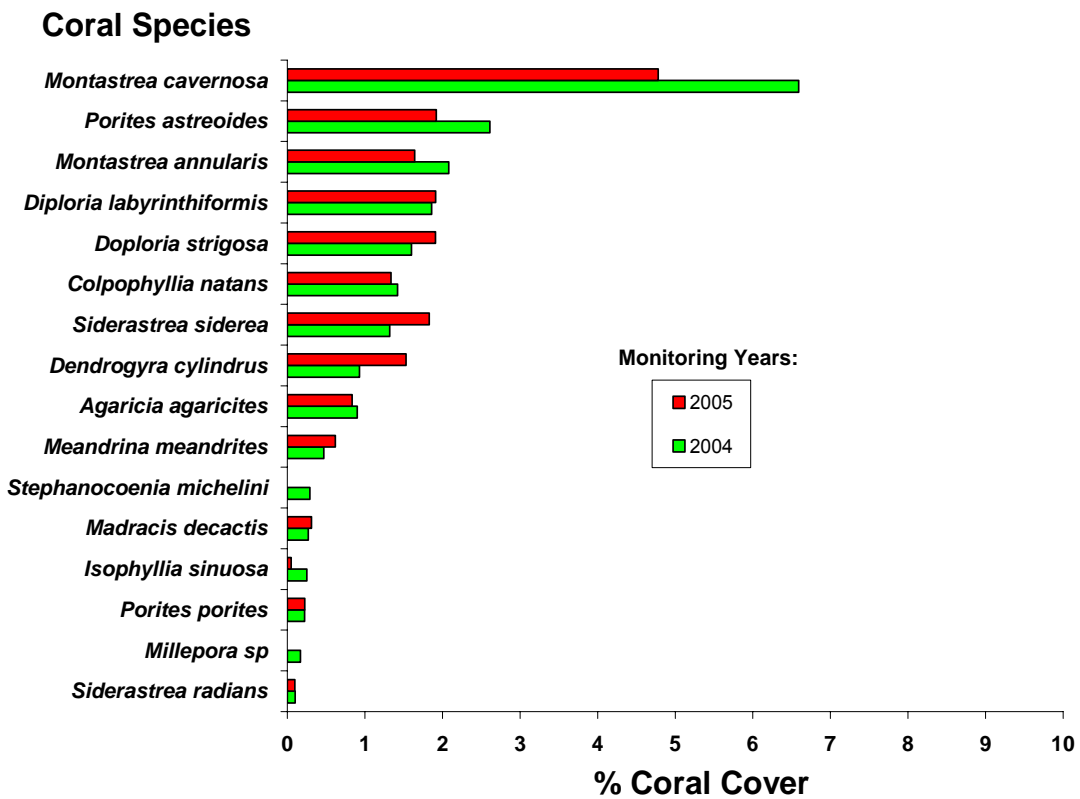


Figure 7. Monitoring trends of mean substrate cover by stony coral species at Tres Palmas Reef – 10 m.

2.2 Fishes and Motile Megabenthic Invertebrates

A total of 95 fish species, including 35 present within belt-transects were identified from the patch reef formation at the Tres Palmas Reef system of Rincon (depth: 10.0 m). The mean abundance of individuals was 106.4 Ind/30 m² (range: 77-135 Ind/30 m²). The mean number of species per transect was 18.4 (range: 16-21). Fish species richness increased by 3.2 % and mean abundance decreased by 4.4 % compared to the 2004 baseline survey (Table 3). Two species, the Bluehead Wrasse (*Thalassoma bifasciatum*) and the Bicolor Damselfish (*Stegastes partitus*) were numerically dominant within belt-transects with mean abundances of 36.2 and 34.6 Ind/30 m², respectively (Table 8). The combined abundance of these two species represented 66.5 % of the community mean abundance within belt-transects. In addition to the two aforementioned species, the Sharknose Goby, Bucktooth and Redband Parrotfishes, and the Coney were present within all five transects surveyed and appear to be part of the resident fish assemblage at this reef. Other fish species, such as the Fairy Basslet, Queen Angelfish, Rock Beauty, Lane and Schoolmaster Snappers, Glasseye and White and Spanish Grunts were observed at the vertical wall habitat during the ASEC survey (Table 9). Only juveniles snappers were present. Angelfishes and grunts included both juveniles and adults.

The high energy environment at the top of the patch reef is an appropriate habitat for opportunistic carnivores, such as Wrasses (*Thalassoma bifasciatum*, *Halichoeres garnoti*, *H. maculipinna*) which feed on small benthic (infaunal) invertebrates that become exposed upon disturbances of the substrate due to wave action. Also, herbivores (e.g. parrotfishes, doctorfishes, damselfishes) that feed on the turf algae were common. Pelagic piscivores (Cero Mackerel, Bar Jacks) were observed on top of the reef. Large (adult) commercially important demersal fishes (snappers, groupers, hogfishes) were not observed.

Among motile megabenthic invertebrates, several slate-pencil and Long-spined Sea Urchins (*Eucidaris tribuloides*, *Diadema antillarum*), Cleaner Shrimps (*Periclimenes sp.*), Arrow and Clinging Crabs (*Stenorhynchus seticornis*, *Mithrax sp.*), Flamingo Tongue

Table 8. Taxonomic composition and abundance of fishes within belt-transects at Tres Palmas Reef 10m Rincon, June 2005

SPECIES	COMMON NAME	TRANSECTS					MEAN
		1	2	3	4	5	
		(individuals/30 m ²)					
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	45	31	23	63	19	36.2
<i>Stegastes partitus</i>	Bicolor Damselfish	28	36	40	39	30	34.6
<i>Chromis cyanea</i>	Blue Chromis	2	32				6.8
<i>Gobiosoma evelynae</i>	Sharknose Goby	4	5	1	5	2	3.4
<i>Sparisoma radians</i>	Bucktooth Parrotfish	1	4	6	1	5	3.4
<i>Cephalopholis fulva</i>	Coney	2	1	3	2	1	1.8
<i>Coryphopterus glaucofraenum</i>	Bridled Goby	1	6	1	1		1.8
<i>Scarus iserti</i>	Striped Parrotfish	6		1	1		1.6
<i>Acanthurus bahianus</i>	Ocean Surgeon	2	2	2		1	1.4
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	5	2				1.4
<i>Halichoeres maculipinna</i>	Clown Wrasse		3	1	1	2	1.4
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	2	1	1	2	1	1.4
<i>Malacoctenus triangulatus</i>	Saddled Blenny		1	1	1	3	1.2
<i>Serranus tigrinus</i>	Harlequin Bass	2	1		2	1	1.2
<i>Sparisoma viride</i>	Stoplight Parrotfish	1	1	2		1	1.0
<i>Acanthurus chirurgus</i>	Doctorfish		2		2		0.8
<i>Microspathodon chrysurus</i>	Yellowtail Damselfish				1	3	0.8
<i>Pseudupeneus maculatus</i>	Spotted Goatfish	1	1	1	1		0.8
<i>Amblycirrhitus pinos</i>	Redspotted Hawkfish		1			2	0.6
<i>Aulostomus maculatus</i>	Trumpetfish	1		1	1		0.6
<i>Scarus taeniopterus</i>	Princess Parrotfish		2	1			0.6
<i>Acanthurus coeruleus</i>	Blue Tang		1			1	0.4
<i>Chaetodon capistratus</i>	Four eye Butterflyfish			2			0.4
<i>Chaetodon striatus</i>	Banded Butterflyfish	2					0.4
<i>Holocentrus rufus</i>	Squirrelfish		1			1	0.4
<i>Bodianus rufus</i>	Spanish Hogfish					1	0.2
<i>Canthigaster rostrata</i>	Caribbean Puffer				1		0.2
<i>Coryphopterus sp1.</i>	Goby	1					0.2
<i>Equetus lanceolatus</i>	Jackknife Fish			1			0.2
<i>Halichoeres radiatus</i>	Puddinwife					1	0.2
Table 8. (continued)							
<i>Muraena sp.</i>	Moray		1				0.2
<i>Ophioblennius atlanticus</i>	Redlip Blenny					1	0.2
<i>Priacanthus arenatus</i>	Glasseye					1	0.2
<i>Serranus sp.</i>	Bass	1					0.2
<i>Stegastes leucostictus</i>	Beau Gregory	1					0.2
	TOTAL INDIVIDUALS	108	135	88	124	77	106.4
	TOTAL SPECIES	19	21	17	16	19	18.4

Table 8. (continued)**Outside Transects:**

<i>Abudefduf sexatilis</i>	Sergeant Major
<i>Aluterus sp.</i>	Filefish
<i>Anisotremus virginicus</i>	Porkfish
<i>Cantherhines pullus</i>	Orange-spotted Filefish
<i>Canthidermis sufflamen</i>	Ocean Triggerfish
<i>Carangoides ruber</i>	Bar Jack
<i>Caranx crysos</i>	Blue Runner
<i>Caranx lugubris</i>	Black Jack
<i>Cephalopholis cruentatus</i>	Graysby
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish
<i>Chromis multilineata</i>	Brown Chromis
<i>Clepticus parrae</i>	Creole Wrasse
<i>Coryphopterus lipernes</i>	Peppermint Goby
<i>Coryphopterus personatus</i>	Masked Goby
<i>Diodon hystrix</i>	Porcupinefish
<i>Epinephelus adscensionis</i>	Rock Hind
<i>Epinephelus guttatus</i>	Red Hind
<i>Equetus acuminatus</i>	Highhat
<i>Flameo marianus</i>	Longspine Squirrelfish
<i>Gerres cinereus</i>	Yellowfin Mojarra
<i>Grama loreto</i>	Fairy Basslet
<i>Gymnothorax moringa</i>	Spotted Moray
<i>Haemulon aurolineatum</i>	Tomtate
<i>Haemulon chrysargyreum</i>	Smallmouth Grunt
<i>Haemulon flavolineatum</i>	French Grunt
<i>Haemulon macrostomum</i>	Spanish Grunt
<i>Haemulon melanurum</i>	Cottonwick
<i>Haemulon sciurus</i>	Bluestriped Grunt
<i>Halichoeres bivittatus</i>	Slippery Dick
<i>Holacanthus ciliaris</i>	Queen Angelfish
<i>Holacanthus tricolor</i>	Rock Beauty
<i>Holocentrus adscensionis</i>	Longjaw Squirrelfish
<i>Holocentrus coruscus</i>	Reef Squirrelfish
<i>Hypoplectrus chlorurus</i>	Yellowtail Hamlet
<i>Hypoplectrus guttavarius</i>	Shy Hamlet
<i>Hypoplectrus nigricans</i>	Black Hamlet
<i>Hypoplectrus puella</i>	Barred Hamlet
Table 8. (continued)	
<i>Hypoplectrus unicolor</i>	Butter Hamlet
<i>Kyphosus sectatrix</i>	Bermuda Chub
<i>Lactophrys polygonia</i>	Honeycomb Cowfish
<i>Lactophrys triqueter</i>	Smooth Trunkfish
<i>Liopropoma rubre</i>	Peppermint Bass
<i>Lutjanus apodus</i>	Schoolmaster
<i>Lutjanus mahogani</i>	Mahogani Snapper
<i>Melichthys niger</i>	Black Durgon

Table 8. (continued)

<i>Mulloides martinicus</i>	Yellowtail Goatfish
<i>Myripristis jacobus</i>	Blackbar Soldierfish
<i>Ocyurus chrysurus</i>	Yellowtail Snapper
<i>Odontoscion dentex</i>	Reef Croaker
<i>Paranthias furcifer</i>	Creole Fish
<i>Pempheris sp.</i>	Sweepers
<i>Scarus coeruleus</i>	Blue Parrotfish
<i>Scarus vetula</i>	Queen Parrotfish
<i>Scarus sp.</i>	Parrotfish
<i>Scomberomorus regalis</i>	Cero Mackerel
<i>Sparisoma rubripinne</i>	Yellowtail Parrotfish
<i>Sphoeroides testudineus</i>	Checkered Puffer
<i>Sphyaena barracuda</i>	Great Barracuda
<i>Stegastes planifrons</i>	Yellow-eye Damselfish
<i>Synodus intermedius</i>	Sand Diver

Table 9. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at the Tres Palmas outer patch reef system. June, 2005.

Depth range : 9 – 12 m
Duration – 30 min.

SPECIES	COMMON NAME	# - (cm)		
<i>Epinephelus guttatus</i>	Red Hind	1 – (25)		
<i>Lutjanus apodus</i>	Schoolmaster	1 – (25)		
<i>Lutjanus synagris</i>	Lane Snapper	1 – (15)	1 – (25)	
<i>Scomberomorus regalis</i>	Cero Mackerel	1 – (40)		
<i>Holacanthus ciliaris</i>	Queen Angel	1 – (30)		
<i>Gramma loreto</i>	Fairy Basslet	33 – (3)	7 – (4)	4 – (5)
<i>Holacanthus tricolor</i>	Rock Beauty	1 – (15)		
Invertebrates				
<i>Panulirus argus</i>	Spiny Lobster	1 – (20)*	2 – (25)*	
<i>Panulirus guttatus</i>	Spotted Spiny Lobster	1 – (15)		

(*Cyphoma gibbosum*), and the Giant Basket Star (*Astrophyton muricatum*) were present within belt-transects (Table 10). One juvenile Spiny Lobster (*Panulirus argus*) was observed outside transect areas during the ASEC survey. During the 2004 survey, one Spanish Lobster (*Scyllarides aequinoctialis*) and the squid (*Sephioteuthis sp.*) were reported during the ASEC survey (García-Sais et al., 2004).

Table 10. Taxonomic composition and abundance of motile megabenthic invertebrates from belt-transects at Tres Palmas Reef 10m. Rincon. June 2005

		TRANSECTS					MEAN ABUNDANCE (IND/30 m ²)
		1	2	3	4	5	
DATE: June 2005							
Depth: 10.0 m							
TAXA	COMMON NAME						
<i>Eucidaris tribuloides</i>	Slate-pencil urchin	1					0.8
<i>Periclimenes pedersoni</i>	Cleaner shrimp	1	1	1		1	0.6
<i>Cyphoma gibbosum</i>	Flamingo tongue		2	1	1		0.2
<i>Stenorhynchus seticornis</i>	Arrow crab		1	1	1		0.2
<i>Astrophytum muricatum</i>	Giant basket star		1				0.2
<i>Mithrax sp.</i>	Clinging crab			1			0.0
<i>Diadema antillarum</i>	Long-spined urchin					1	3.0
TOTALS		2	5	4	2	2	3.0

Photo Album Rincon 10 m



Plate 7



Plate 8



Plate 9



Plate 10



Plate 11



Plate 12

3.0 Tres Palmas Shelf-edge Reef

3.1 Sessile-benthic Community

A “spur-and-groove” coral reef formation is found associated with the shelf-edge off Tres Palmas within a depth range of 18 – 23 m. Spurs are oriented perpendicular to the shelf-edge. The shelf breaks in a series of irregular steps, forming narrow terraces at variable depths from 23 – 40 m. Coral growth below 20-23 m was mostly observed as few isolated massive and encrusting colonies, not forming any prominent reef buildup. There was substantial sediment transport down the shelf-edge and most of the rocky substrate was covered by fine sand and silt. Such heavy sedimentation may limit coral reef formation down the slope off Tres Palmas. The reef is not a continuous system along the shelf-edge, as there are wide sections of mostly uncolonized pavement covered by sandy-silt sediments with interspersed sponges and macroalgae. Panoramic views of the shelf-edge reef formation off Tres Palmas are presented in Photo Album 3.

A total of 22 stony coral species (including two hydrocorals) were identified from the shelf-edge reef off Tres Palmas, 14 of which were intercepted by line transects during our survey (Table 11). Stony corals occurred mostly as encrusting and mound shaped colonies. Substrate cover by stony corals along transects averaged 21.09 % (range: 12.66 – 29.07 %). Boulder Star Coral, *Montastrea annularis* was the dominant species in terms of substrate cover with a mean of 8.51 % (range: 1.6 – 16.03 %), representing 40.4 % of the total cover by stony corals (Table 11). Colonies of *Montastrea annularis*, *M. cavernosa*, *Meandrina meandrites*, and *Porites astreoides* were present in all five transects. Small colonies of Maze coral, *Madracis decactis*, and Lettuce Coral, *Agaricia* s pp. were also very common. Soft corals (gorgonians) were moderately abundant, with an average of 11 colonies/transect. The deep water Sea Fan, *Iciligorgia schrammi* was common at the shelf-edge, particularly at the edge of rock walls and crevices.

Encrusting and erect sponges, including several large Basket Sponges, *Xestospongia muta* were present in all transects with an average cover of 5.04 %. Reef overhangs averaged 7.47 % and contributed to a topographic rugosity of 2.80 m. Turf algae, comprised by an assemblage of short filamentous red and brown macroalgae was the dominant sessile-benthic component in terms of substrate cover with an average of

Table 11. Percent substrate cover by sessile-benthic categories at Tres Palmas Shelf-Edge Reef 20m Rincon. June 2005.

Depth: 20 m	TRANSECTS						
		1	2	3	4	5	MEAN
Rugosity (m)		2.31	3.10	4.01	1.93	2.66	2.80
SUBSTRATE CATEGORIES							
TURF ALGAE		77.35	63.74	44.22	71.08	57.42	62.76
ABIOTIC							
	Reef Overhangs	6.90	7.94	10.98	5.45	6.08	7.47
SPONGES		1.87	2.60	10.56	5.20	4.98	5.04
FLESHY ALGAE		0.46	1.53	5.71	3.10	2.23	2.61
ENCRUSTING GORGORGONIANS		0.57		2.92			0.70
MILLEPORA						0.22	0.04
CALCAREOUS ALGAE		0.57		0.40	0.94		0.38
CORAL SPECIES							
	<i>Montastrea annularis</i>	1.62	5.04	14.06	5.78	16.03	8.51
	<i>Montastrea cavernosa</i>	3.00	3.36	1.41	1.42	1.58	2.15
	<i>Meandrina meandrites</i>	1.14	0.65	2.00	2.68	2.69	1.83
	<i>Colpophyllia natans</i>		5.04	2.31		1.56	1.78
	<i>Porites astreoides</i>	0.57	2.90	0.80	2.35	1.58	1.64
	<i>Diploria strigosa</i>	0.80	2.44	0.90		2.69	1.37
	<i>Agaricia agaricites</i>	1.62	0.54		1.26	0.45	0.77
	<i>Siderastrea radians</i>		3.36				0.67
	<i>Madracis decactis</i>	1.87		0.40		0.67	0.59
	<i>Leptoseris cucullata</i>	0.80		2.01			0.56
	<i>Agaricia lamarcki</i>	0.91	0.86		0.71		0.50
	<i>Siderastrea siderea</i>					1.9	0.38
	<i>Dichocoenia stokesii</i>			0.70			0.14
	<i>Agaricia grahamae</i>			0.60			0.12
TOTAL STONY CORAL		12.66	24.20	25.25	14.25	29.07	21.09
GORGONIANS (# col.)		12	6	6	17	12	11

Coral Species Outside Transects: *Acropora cervicornis*, *Favia fragum*, *Porites porites*, *Isophyllastrea rigida*, *Manicina areolata*, *Siderastrea siderea*, *Millepora alcicornis*, *Stylaster roseus*

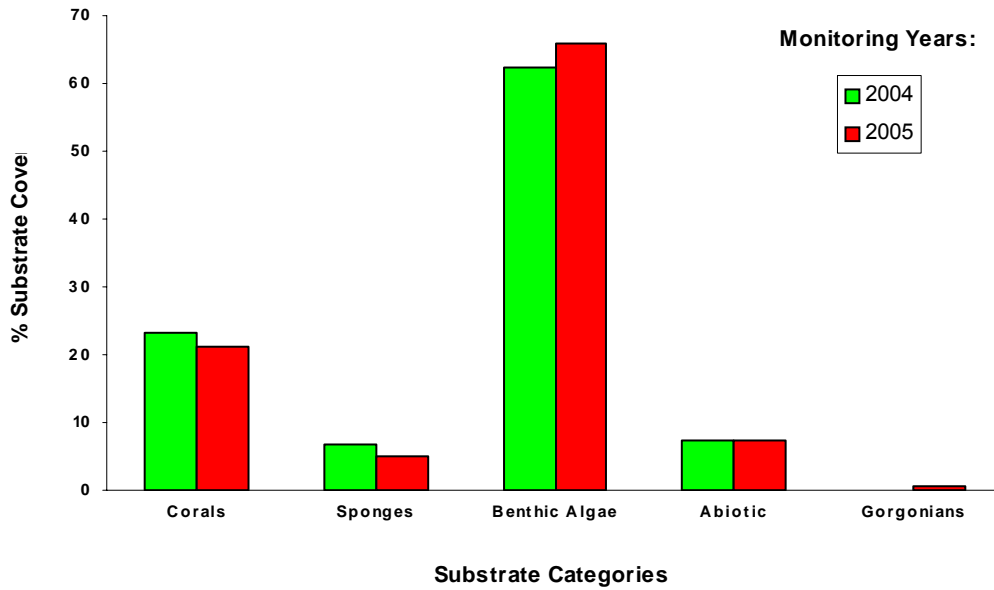


Figure 8. Monitoring trends of mean substrate cover by sessile-benthic categories at Tres Palmas Reef – 20 m.

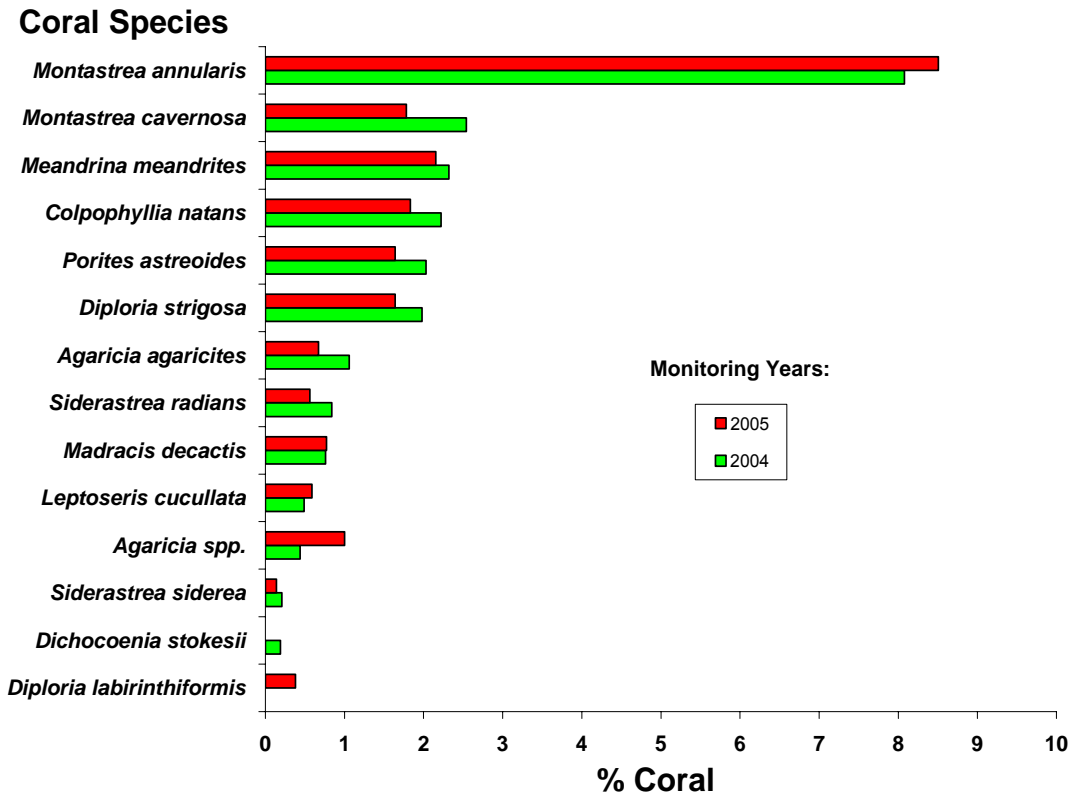


Figure 9. Monitoring trends of mean substrate cover by stony coral species at Tres Palmas Reef – 20 m.

62.76 % (range : 44.22 – 77.35 %). Turf algae was found overgrowing rocky substrates, as well as dead coral sections and other hard ground. Fleshy brown and red macroalgae, particularly *Lobophora sp.* And *Amphiroa sp.* Were also common in the reef.

Figure 8 presents the variation in percent cover by sessile-benthic components at the Tres Palmas shelf-edge reef in Rincón between the baseline characterization in 2004 and the present survey of 2005.. Slight reductions of mean substrate cover by (total) live corals (2.06 %) and sponges (1.77 %) were compensated by a corresponding increment in benthic algae. Differences were not statistically significant because of the high within replicate transect variability relative to the measured differences in substrate cover between monitoring years. Individual coral species did not present any pronounced variation in its mean percent substrate cover between 2004 and 2005 at the Tres Palmas shelf-edge reef (Figure 9).

3.2 Fishes and Motile Megabenthic Invertebrates

A total of 68 fish species, including 46 within belt-transect areas were identified from the shelf-edge reef off Tres Palmas during June, 2005. Mean abundance within belt-transects was 329.8 Ind/30 m² (range: 224 – 533 Ind/30 m²). The mean number of species per transect was 23 (range: 18 – 32). Fish species richness increased by 11.5 % and mean abundance decreased by 37.9 % compared to the 2004 baseline survey (Table 3). The Masked Goby, *Coryphopterus personatus* was the numerically dominant species with a mean abundance of 112.4 Ind/30 m² (range: 35 – 190 Ind/30 m²), representing 34.1 % of the total abundance within belt-transects (Table 12). The Masked Goby is a small carnivorous fish (< 2.0 cm) that forms swarms of up to 100 individuals below large coral ledges and near the sand-coral interface of the spur and groove reef formation. In many instances, swarms of Masked Goby coincided with swarms of mysid shrimps in the reef, for which it is possible that gobies were feeding from the shrimps. The Bicolor Damselfish, Masked, Peppermint and Sharknose Gobies, Bluehead Wrasse, and Black-bar Soldierfish were present within all five transects surveyed.

Table 12. Taxonomic composition and abundance of fishes within belt-transects at the shelf-edge reef off Tres Palmas, Rincón. June, 2005

SPECIES	COMMON NAME	TRANSECTS					MEAN
		1	2	3	4	5	
		(individuals/30 m ²)					
<i>Coryphopterus personatus</i>	Masked Goby	120	190	107	110	35	112.4
<i>Chromis cyanea</i>	Blue Chromis	125	20		25	68	47.6
<i>Stegastes partitus</i>	Bicolor Damselfish	52	31	37	45	47	42.4
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	48	35	12	20	70	37.0
<i>Coryphopterus lipernes</i>	Peppermint goby	54	38	1	39	17	29.8
<i>Gramma loreto</i>	Royal gramma	79					15.8
<i>Chromis multilineata</i>	Brown chromis	5	2	21		5	6.6
<i>Clepticus parrae</i>	Creole wrasse	1		6	15	4	5.2
<i>Sparisoma radians</i>	Bucktooth Parrotfish	4		5	4	5	3.6
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	1	7	3	5		3.2
<i>Myripristis jacobus</i>	Blackbar Soldierfish	5	2	2	2	1	2.4
<i>Gobiosoma evelynae</i>	Sharknose Goby	2	3	1	1	3	2.0
<i>Stegastes leucostictus</i>	Beau Gregory	3	4	2		1	2.0
<i>Amblycirrhitus pinos</i>	Redspotted Hawkfish	2	2		3	2	1.8
<i>Haemulon flavolineatum</i>	French grunt	4		3	1		1.6
<i>Serranus tigrinus</i>	Harlequin Bass	4	2			2	1.6
<i>Mulloides martinicus</i>	Yellowtail goatfish	7					1.4
<i>Flammeo marianus</i>	Longspine squirrelfish	1		1	2	2	1.2
<i>Canthigaster rostrata</i>	Caribbean Puffer	2		1	2		1.0
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	2	1	2			1.0
<i>Acanthurus chirurgus</i>	Doctorfish		1	2		1	0.8
<i>Cephalopholis cruentatus</i>	Graysby	1		1	1	1	0.8
<i>Chaetodon capistratus</i>	Four-eye Butterflyfish	1	2		1		0.8
<i>Melichthys niger</i>	Black durgon	1		2		1	0.8
<i>Scarus taeniopterus</i>	Princess Parrotfish		3	1			0.8
<i>Hypoplectrus puella</i>	Barred hamlet	1	2				0.6
<i>Scarus iserti</i>	Stripped Parrotfish	1		2			0.6
<i>Paranthias furcifer</i>	Creole fish			3			0.6
<i>Acanthurus bahianus</i>	Ocean Surgeon			1	1		0.4
<i>Apogon sp.</i>	Cardinalfish	1				1	0.4
<i>Bodianus rufus</i>	Spanish Hogfish	1				1	0.4
<i>Holacanthus tricolor</i>	Rock beauty			2			0.4
<i>Acanthurus coeruleus</i>	Blue Tang			1			0.2
<i>Aulostomus maculatus</i>	Trumpetfish	1					0.2
<i>Cephalopholis fulva</i>	Coney		1				0.2
<i>Chaetodon striatus</i>	Banded Butterflyfish			1			0.2
<i>Haemulon melanurum</i>	Cottonwick	1					0.2
<i>Holocentrus rufus</i>	Squirrelfish			1			0.2
<i>Hypoplectrus chlorurus</i>	Yellowtail hamlet			1			0.2
<i>Hypoplectrus unicolor</i>	Butter hamlet	1					0.2
<i>Lioproma sp.</i>	Bass			1			0.2
<i>Muraena sp.</i>	Moray					1	0.2

Table 12. (continued)

<i>Serranus sp.</i>	Bass	1					0.2
<i>Synodus intermedius</i>	Sand diver	1					0.2
	Longsnout						
<i>Chaetodon aculeatus</i>	Butterflyfish		1				0.2
<i>Caranx crysos</i>	Blue runner				1		0.2
TOTAL		<hr/>					
	INDIVIDUALS	533	346	224	277	269	329.8
	TOTAL SPECIES	32	18	29	17	21	23

Outside Transects:

<i>Abudefduf sexatilis</i>	Sergeant Major
<i>Anisotremus virginicus</i>	Porkfish
<i>Bothus lunatus</i>	Peacock flounder
<i>Decapterus macarellus</i>	Mackerel Scad
<i>Epinephelus guttatus</i>	Red Hind
<i>Lutjanus analis</i>	Mutton snapper
<i>Malacanthus plumieri</i>	Sand tilefish
<i>Opistognathus aurifrons</i>	Yellowhead jawfish
<i>Pomacanthus arcuatus</i>	Gray angelfish
<i>Scomberomorus regalis</i>	Cero Mackerel
<i>Seriola sp.</i>	Jack
<i>Sphyrnaena barracuda</i>	Great Barracuda
<i>Holacanthus ciliaris</i>	Queen angelfish
<i>Cantherhines macrocerus</i>	Whitespotted filefish
<i>Lutjanus mahogany</i>	Mahogany snapper

The fish community associated with the Tres Palmas shelf-edge reef appears to be well balanced in terms of trophic structure, except for the absence of large demersal predators, such as large snappers and groupers. However, this is the present condition for most insular coral reefs. Large schools of Creole Wrasse, *Clepticus parrae* and Mackerel Scad, *Decapterus macarellus* were present in mid-water over the reef. These are zooplanktivores that serve as forage for pelagic predators, such as Cero Mackerels, Blue Runners and Barracudas observed during an ASEC survey in this reef (Table 13). The Blue and Brown Chromis are also important zooplanktivores that were common over coral heads closer to the reef. A large variety of small invertebrate feeders were present, including wrasses (3 spp), hamlets (3 spp), gobies (3 spp), and squirrelfishes (3 spp), among others. Larger invertebrate and small fish predators included the Schoolmaster and Mahogany snappers, Coney, Graysbe and Red Hind groupers, Spanish Hogfish, lizardfishes and grunts. Parrotfishes (4 spp), doctorfishes (3 spp) and damselfishes (3 spp) comprised the main herbivorous assemblage.

The shelf-edge reef is an ideal habitat for adult reef fishes, as evidenced by the presence of adult Lane and Schoolmaster snappers, Red Hinds, Great Barracuda, Cero Mackerels and Blue Runners. The absence of the larger demersal predators appears to be related to the high fishing pressure, since the physical habitat and potential food (fish forage) are available. Nevertheless, large snappers and groupers may be using deeper sections of the upper insular slope as residential habitat or refuge and the shelf-edge reef as foraging ground at night. One giant Hawksbill Turtle (*Eretmochelys imbricata*) was present at the shelf-edge reef during the 2005 monitoring survey. Commercially important species included aquarium trade targets, such as the Fairy Basslet (*Gramma loreto*), Queen Angelfish (*Holacanthus ciliaris*), Rock Beauty (*Holacanthus tricolor*), Blue Chromis (*Chromis cyanea*) and Peppermint Bass (*Liopropoma rubre*).

Table 13. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at the shelf-edge reef off Tres Palmas, Rincón. June, 2005

Depth range : 18 - 22 m
Duration - 30 min.

SPECIES	COMMON NAME	# - (cm)		
<i>Carangoides crysos</i>	Blue Runner	2 – (25)	1 – (30)	
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish	1 - (7)		
<i>Chaetodon sedentarius</i>	Reef Butterflyfish	1 - (8)		
<i>Decapterus macarellus</i>	Mackerel Scad	300 - (20)		
<i>Epinephelus guttatus</i>	Red Hind	1 - (30)	1 – (40)	
<i>Gramma loreto</i>	Fairy Basslet	16 - (3)	10 - (4)	3 - (5)
<i>Holacanthus ciliaris</i>	Queen Angel	1 - (30)		
<i>Holacanthus tricolor</i>	Rock Beauty	2 - (15)	1 - (20)	2 - (25)
<i>Liopropoma rubre</i>	Peppermint Bass	1 - (6)		
<i>Lutjanus analis</i>	Mutton Snapper	1 – (40)	1 - (50)	
<i>Lutjanus apodus</i>	Schoolmaster	1 - (20)		
<i>Lutjanus mahogany</i>	Mahogany Snapper	1 - (35)		
<i>Lutjanus synagris</i>	Lane Snapper	2 - (20)		
<i>Opistognathus aurifrons</i>	Yellowhead Jawfish	4 – (12)		
<i>Scomberomorus regalis</i>	Cero Mackerel	2 - (60)	2 - (75)	
<i>Seriola sp.</i>	Amberjack	3 – (60)		
<i>Sphyræna barracuda</i>	Great Barracuda	1 - (122)		
Invertebrates				
<i>Panulirus argus</i>	Spiny Lobster	1 - (20)*		
Sea Turtles				
<i>Eretmochelys imbricata</i>	Hawksbill Turtle			

The Arrow Crab, *Stenorhynchus seticornis* and the cleaner shrimps, *Periclimenes sp.* and *Stenopus hispidus* were the motile megabenthic invertebrates observed within belt-transects (Table 14). One juvenile Spiny Lobster, *Panulirus argus* was observed outside transects during the ASEC survey.

Table 14. Taxonomic composition and abundance of motile megabenthic invertebrates within belt-transects at the shelf-edge reef off Tres Palmas, Rincon. June, 2005

SPECIES	COMMON NAME	TRANSECTS					MEAN ABUNDANCE (IND/30 m ²)
		1	2	3	4	5	
<i>Stenopus hispidus</i>	Banded coral shrimp	1			2		0.6
<i>Periclimenes sp.</i>	Cleaner shrimp			3	1	1	1.0
	TOTALS	1		3	3	1	1.6

Photo Album Rincon 20 m



Plate 13



Plate 14



Plate 15



Plate 16



Plate 17



Plate 18

B. Puerto Canoas /Puerto Botes Reefs - Isla Desecheo

Isla Desecheo is an oceanic island in the Mona Passage, located approximately nine nautical miles off Rincón, northwest coast of Puerto Rico. The island, which used to be a U. S. Navy shooting range during the Second World War was designated as a Natural Reserve in 1999. Marine communities at Isla Desecheo are influenced by clear waters, strong currents and seasonally high wave action from North Atlantic winter swells (cold fronts). Coral reefs are established off the west coast at depths between 15 and (at least) 50 m (García-Sais et al., 2005). Coral monitoring surveys were performed at depths of 15 and 20 m off Puerto Botes, and at 30 m off Puerto Canoas, on the west coast of Isla Desecheo. The baseline monitoring survey for the Puerto Botes Reef at a depth of 20 m was performed during 1999 by García-Sais et al. (2001 b). For Puerto Botes Reef at 15 m and for Puerto Canoas Reef at 30 m, the baseline survey was performed during 2004 by García-Sais et al. (2004 a). Figure 10 presents the location of coral reef monitoring stations at Isla Desecheo.

1. Shelf-edge Reef Puerto Canoas

1.1 Sessile-benthic Reef Community

The shelf-edge off Puerto Canoas is at the southwest end of a massive and impressive coral buildup that has developed as a series of patch reef promontories separated by coralline sand deposits. Coral promontories are typically comprised of several very large colonies of Boulder Star Coral (*Montastrea annularis*). There are colonies that rise from the bottom at least four m and extend horizontally more than 5 m, in some instances merging with other large colonies to form continuous laminar coral formations that are unique in Puerto Rico. Within the depth range of 22 – 25 m there are many sections in this reef where coral cover along 10 meter long transects is between 80 – 100 %.

Towards the northern end, the shelf-edge reef platform leads to an almost vertical wall with sparse coral growth down to a depth of 40 m. At the southern end, the reef platform ends in an extensive sand deposit that slopes down gently to a depth of about 70 m.

Our survey was performed right at the end of the reef on the southern section.

Transects were installed at a depth of 27 – 30 m, bordering the edge of one of the larger coral promontories.

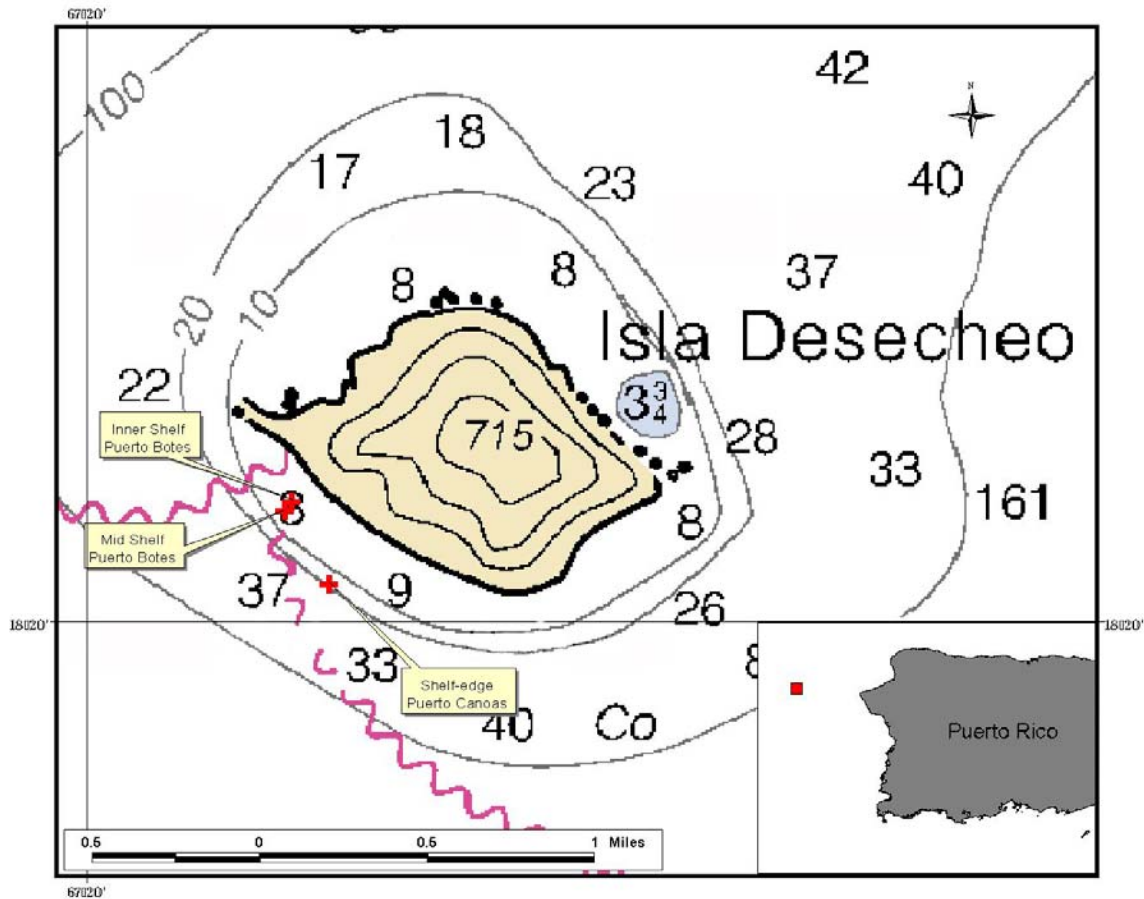


Figure 10. Location of coral reef survey stations at Puerto Canoas/Botes, Isla Desecheo.

Stony corals dominated reef substrate cover along surveyed transects with a mean of 48.07 % (range: 39.89 – 56.26 %). Boulder Star Coral (*Montastrea annularis*), with a mean cover of 32.77 % represented 68.17 % of the total stony coral cover. In addition to *M. annularis*, Lettuce Coral (*Agaricia agaricites*) and Mustard-Hill Coral (*Porites astreoides*) were present in all five transects and comprised part of the main stony coral assemblage of the shelf-edge reef at Puerto Canoas (Table 15). A total of 17 species of stony corals were identified, including 10 intersected by line transects. Several colonies of the Bushy Black Coral, *Anthipathes* sp. were observed near the base of the reef and within crevices. Soft corals (gorgonians) were not intercepted by transects and were not common at the shelf-edge reef. Abiotic cover, associated with reef overhangs averaged 17.6 % and contributed to a mean reef substrate rugosity of 3.66 m. Encrusting sponges were common, but in relatively low cover in the reef (mean: 2.54 %).

Table 15. Percent substrate cover by sessile-benthic categories at Pto. Canoas Reef, Isla Desecheo 30m., June 2005

	TRANSECTS					MEAN
	1	2	3	4	5	
Rugosity (m)	2.92	3.31	4.78	3.73	3.58	3.66
SUBSTRATE CATEGORIES						
TURF ALGAE	28.12	38.92	17.33	38.14	29.55	30.41
ABIOTIC						
Reef Overhangs	20.60	13.75	19.43	15.28	15.77	16.97
Sand					1.76	0.35
SPONGES		2.85	4.60	3.93	1.33	2.54
FLESHY ALGAE		4.06	2.38		1.84	1.66
CORAL SPECIES						
<i>Montastrea annularis</i>	26.16	27.80	46.62	23.31	39.94	32.77
<i>Colpophyllia natans</i>	16.72	4.66		5.75		5.43
<i>Agaricia agaricites</i>	2.71	0.90	9.07	5.32	2.73	4.15
<i>Porites astreoides</i>	0.33	1.35	0.57	5.03	2.58	1.97
<i>Eusmilia fastigiata</i>	5.34	0.63		1.24	0.21	1.48
<i>Diploria strigosa</i>					4.27	0.85
<i>Agaricia lamarcki</i>		2.78		0.51		0.66
<i>Meandrina meandrites</i>		0.53		1.53		0.41
<i>Mycetophyllia ferox</i>		1.27				0.25
<i>Millepora sp.</i>		0.53				0.11
TOTAL STONY CORAL	51.28	39.89	56.26	42.65	49.74	48.07
GORGONIANS (# col.)	0	0	0	0	0	0

Coral Species Outside Transects: *Agaricia sp.*, *Diploria labyrinthiformis*, *Isophyllastrea rigida*, *Montastrea cavernosa*, *Mycetophyllia lamarki*, *Eusmilia fastigiata*, *Stylaster roseus*

Benthic macroalgae, comprised by an assemblage of turf and fleshy macroalgae presented a combined substrate cover of 32.06 % along permanent transects. *Lobophora variegata*, *Padina sp.* and *Ventricaria ventricosa* were some of the most common fleshy macroalgae present. Turf algae included an unidentified variety of short filamentous red and brown macroalgae.

Figure 11 presents the variations of mean percent cover by the main sessile-benthic categories from the shelf-edge reef at Puerto Canoas. Differences of mean total percent cover by stony corals, sponges and benthic algae during the current 2005 monitoring survey were all within 1 % of the baseline characterization values. Such small

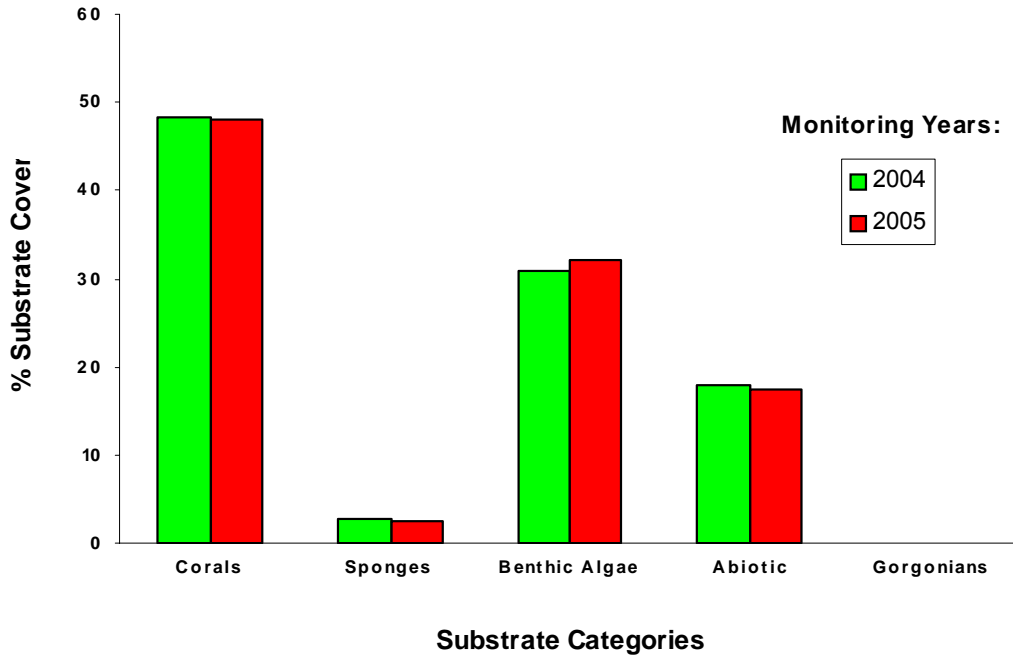


Figure 11. Monitoring trends of substrate cover by sessile-benthic categories a Puerto Canoas Reef – 30 m.

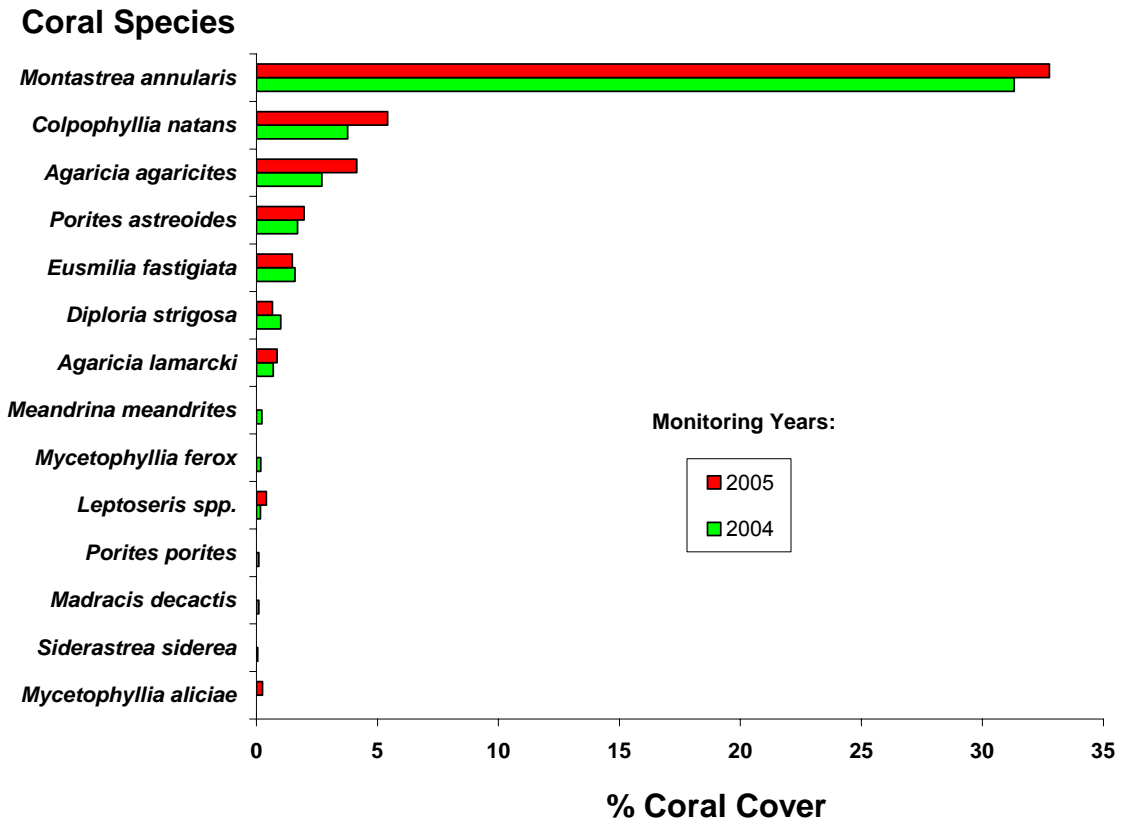


Figure 12. Monitoring trends of mean substrate cover by stony coral species at Perto Canoas Reef – 30 m.

differences at the community level were not statistically significant (ANOVA, $p > 0.05$). The variations of the mean substrate cover by coral species between the current 2005 survey and the previous 2004 baseline survey (Figure 12) were also very small ($< 2\%$), and within the sampling error of the method, estimated at approximately 3% .

1.2 Fishes and Motile Megabenthic Invertebrates

A total of 118 fish species, including 63 within belt-transect areas were identified from the shelf-edge reef off Puerto Canoas, Isla Desecheo during June, 2005 (Table 16). Mean abundance of fishes within belt-transects was 443.2 Ind/30 m² (range: 390 – 578 Ind/30 m²). The mean number of species per transect was 33.7 (range: 29 - 38). Both fish mean abundance and species richness from this reef stand as the highest ever reported for coral reef systems in Puerto Rico. Fish species richness decreased by 4.4 % and mean abundance decreased by 20.5 % compared to the 2004 baseline survey (Table 3). The Creole Wrasse, *Clepticus parrae* was the numerically dominant species with a mean abundance of 215.7 Ind/30 m² (range: 68 – 326 Ind/30 m²), representing 38.7 % of the total abundance within belt-transects (Table 16). The Masked Goby, Blue Chromis, Peppermint Goby, Fairy Basslet, Sharknose Goby and Bicolor Damselfish were also present in high abundances at the shelf-edge reef. Large streaming schools of Creole Wrasse were observed throughout the water column, making frequent incursions over the reef. These are zooplanktivores that serve as forage for pelagic predators, such as Cero Mackerels, Blue Runners and Barracudas observed during an ASEC survey in this reef (Table 17). The Blue and Brown Chromis, Masked Goby and Bicolor Damselfish are also important zooplanktivores that were common over coral heads closer to the reef. Dense swarms of mysid shrimps were present below ledges and on crevices in the reef. These small shrimps appear to be important forage for zooplanktivorous fishes in the reef.

The shelf-edge reef off Puerto Canoas presented an unusually well balanced fish community in terms of trophic structure, including the presence of large demersal and pelagic predators, such as Dog Snappers, Nassau and Yellowfin Groupers, Barracudas, Cero Mackerels, Blue Runners, Rainbow Runners and Black Jacks (Table 17).

Table 16. Taxonomic composition and abundance of fishes within belt-transects at Puerto Canoas Reef, Isla Desecheo, June 2005.

SPECIES	COMMON NAME	TRANSECTS					MEAN
		1	2	3	4	5	
		(individuals/30 m ²)					
<i>Coryphopterus personatus</i>	Masked Goby	107	115	50	60	180	102.4
<i>Gramma loreto</i>	Fairy Basslet	103	152	143	42	54	98.8
<i>Coryphopterus lipernes</i>	Peppermint Goby	49	87	44	72	28	56.0
<i>Chromis cyanea</i>	Blue Chromis	53	66	43		25	37.4
<i>Chromis multilineata</i>	Brown Chromis		16	76	47		27.8
<i>Clepticus parrae</i>	Creole Wrasse		40	20	22	37	23.8
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	9	12	18	25	10	14.8
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	11	9	24	14	8	13.2
<i>Gobiosoma evelynae</i>	Sharknose Goby	11	13	9	15	16	12.8
<i>Stegastes partitus</i>	Bicolor Damselfish		16		15	15	9.2
<i>Mulloides martinicus</i>	Yellowtail Goatfish	3			23		5.2
<i>Kyphosus bermudensis</i>	Sea Chub	5	16		2	1	4.8
<i>Sparisoma radians</i>	Bucktooth Parrotfish	6	7	5	1		3.8
<i>Halichoeres maculipinna</i>	Clown Wrasse	3		5	2	3	2.6
<i>Cephalopholis cruentatus</i>	Graysby	1	2	3	5		2.2
<i>Amblycirrhitus pinos</i>	Redspotted Hawkfish		1	4	5		2.0
<i>Bodianus rufus</i>	Spanish Hogfish	3		1	2	1	1.4
<i>Flammeo marianus</i>	Longspine Squirrelfish	2	3			2	1.4
<i>Paranthias furcifer</i>	Creole Fish		3		3	1	1.4
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	2			2	3	1.4
<i>Chaetodon capistratus</i>	Four-eye Butterflyfish	2	1		2	1	1.2
<i>Lutjanus apodus</i>	Schoolmaster	1	3	1		1	1.2
<i>Acanthurus coeruleus</i>	Blue Tang	1	1	1	1	1	1.0
<i>Holocentrus rufus</i>	Squirrelfish	1	1	1	1	1	1.0
<i>Melichthys niger</i>	Black Durgon		1	2	2		1.0
<i>Caranx lugubris</i>	Black Jack			1	2	1	0.8
<i>Coryphopterus glaucofraenum</i>	Bridled Goby	1	1	1		1	0.8
<i>Holacanthus tricolor</i>	Rock Beauty		1	1	1	1	0.8
<i>Microspathodon chrysurus</i>	Yellowtail Damselfish	2			1	1	0.8
<i>Myripristis jacobus</i>	Blackbar Soldierfish	2	1	1			0.8
<i>Calamus sp.</i>	Porgy			4			0.8
<i>Balistes vetula</i>	Queen Triggerfish	1	1			1	0.6
<i>Carangoides ruber</i>	Bar Jack			3			0.6
<i>Caranx hippos</i>	Crevalle Jack	1	2				0.6
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish	1	1			1	0.6
<i>Lactophrys triqueter</i>	Smooth Trunkfish	1			1	1	0.6
<i>Malacoctenus triangulatus</i>	Saddled Blenny	1		1		1	0.6
<i>Stegastes leucostictus</i>	Beau Gregory					3	0.6
<i>Acanthurus bahianus</i>	Ocean Surgeon			2			0.4
<i>Cephalopholis fulva</i>	Coney			2			0.4

Table 16. (continued)

<i>Liopropoma</i> sp.	Bass/basslet			1	1		0.4
<i>Scarus taeniopterus</i>	Princess Parrotfish		2				0.4
<i>Sparisoma chrysopterus</i>	Redtail Parrotfish	1	1				0.4
<i>Sparisoma viride</i>	Stoplight Parrotfish	1			1		0.4
<i>Stegastes planifrons</i>	Yellow-eye Damselfish	2					0.4
<i>Acanthurus chirurgus</i>	Doctorfish					1	0.2
<i>Canthidermis sufflamen</i>	Ocean Triggerfish	1					0.2
<i>Canthigaster rostrata</i>	Caribbean Puffer					1	0.2
<i>Coryphopterus</i> sp1.	Goby			1			0.2
<i>Epinephelus guttatus</i>	Red Hind					1	0.2
<i>Equetus acuminatus</i>	Highhat				1		0.2
<i>Gobiosoma</i> sp. (<i>saucrum</i>)	(Leopard) Goby				1		0.2
<i>Hypoplectrus nigricans</i>	Black Hamlet				1		0.2
<i>Hypoplectrus unicolor</i>	Butter Hamlet	1					0.2
<i>Lactophrys polygonia</i>	Honeycomb Cowfish					1	0.2
<i>Lutjanus mahogani</i>	Mahogani Snapper					1	0.2
<i>Ocyurus chrysurus</i>	Yellowtail Snapper		1				0.2
<i>Scarus iserti</i>	Stripped Parrotfish				1		0.2
<i>Scarus vetula</i>	Queen Parrotfish		1				0.2
<i>Serranus baldwini</i>	Lantern Bass	1					0.2
<i>Serranus tigrinus</i>	Harlequin Bass				1		0.2
<i>Serranus</i> sp.	Bass		1				0.2
<i>Chromis insolata</i>	Sunshine Chromis					1	0.2
	TOTAL INDIVIDUALS	390	578	468	376	404	443.2
	TOTAL SPECIES	33	32	29	34	33	32.2

Outside Transects:

<i>Abudefduf sexatilis</i>	Sergeant Major
<i>Aluterus schoepfi</i>	Orange Filefish
<i>Anisotremus surinamensis</i>	Black Margate
<i>Anisotremus virginicus</i>	Porkfish
<i>Aulostomus maculatus</i>	Trumpetfish
<i>Cantherhines macrocerus</i>	Whitespotted Filefish
<i>Cantherhines pullus</i>	Tail-light Filefish
<i>Caranx crysos</i>	Blue Runner
<i>Chaetodon striatus</i>	Banded Butterflyfish
<i>Dasyatis americana</i>	Southern Stingray
<i>Diodon hystrix</i>	Porcupinefish
<i>Epinephelus adscensionis</i>	Rock Hind
<i>Epinephelus striatus</i>	Nassau Grouper
<i>Equetus lanceolatus</i>	Jackknife Fish
<i>Gerres cinereus</i>	Yellowfin Mojarra
<i>Gymnothorax moringa</i>	Spotted Moray
<i>Haemulon aurolineatum</i>	Tomtate
<i>Haemulon chrysargyreum</i>	Smallmouth Grunt
<i>Haemulon flavolineatum</i>	French Grunt

Table 16. (continued)

<i>Haemulon macrostomum</i>	Spanish Grunt
<i>Haemulon melanurum</i>	Cottonwick
<i>Haemulon plumieri</i>	White Grunt
<i>Haemulon sciurus</i>	Bluestriped Grunt
<i>Halichoeres bivittatus</i>	Slippery Dick
<i>Halichoeres radiatus</i>	Puddinwife
<i>Holacanthus ciliaris</i>	Queen Angelfish
<i>Holocentrus adscensionis</i>	Longjaw Squirrelfish
<i>Holocentrus coruscus</i>	Reef Squirrelfish
<i>Hypoplectrus chlorurus</i>	Yellowtail Hamlet
<i>Hypoplectrus guttavarius</i>	Shy Hamlet
<i>Hypoplectrus puella</i>	Barred Hamlet
<i>Kyphosus sectatrix</i>	Bermuda Chub
<i>Liopropoma rubre</i>	Peppermint Bass
<i>Lutjanus jocu</i>	Dog Snapper
<i>Lutjanus apodus</i>	Schoolmaster Snapper
<i>Lutjanus mahogany</i>	Mahogany Snapper
<i>Malacoctenus sp.</i>	Blenny
<i>Malacoctenus sp.</i>	Blenny
<i>Mulloides martinicus</i>	Yellow Goatfish
<i>Muraena sp.</i>	Moray
<i>Ocyurus chrysurus</i>	Yellowtail Snapper
<i>Odontoscion dentex</i>	Reef Croaker
<i>Ophioblennius atlanticus</i>	Redlip Blenny
<i>Opistognathus aurifrons</i>	Yellow-head Jawfish
<i>Pempheris sp.</i>	Sweepers
<i>Priacanthus arenatus</i>	Glasseye

Table 16. (continued)

<i>Pseudupeneus maculatus</i>	Spotted Goatfish
<i>Scarus coeruleus</i>	Blue Parrotfish
<i>Scarus sp.</i>	Parrotfish
<i>Scomberomorus regalis</i>	Cero Mackerel
<i>Serranus tabacarius</i>	Tobacco Fish
<i>Sparisoma rubripinne</i>	Yellowtail Parrotfish
<i>Sphoeroides testudineus</i>	Checkered Puffer
<i>Sphyraena barracuda</i>	Great Barracuda
<i>Synodus intermedius</i>	Sand Diver

Yellowtail, Mahogany and Schoolmaster Snappers, Red Hind, Coney and Queen Triggerfish were observed in full adult sizes. The Caribbean Reef Shark (*Carcharhinus perezii*) was reported in the previous survey of this reef (García-Sais et al., 2004). Other mid-size carnivores that are commercially exploited, such as A large variety of small invertebrate feeders were present, including wrasses, gobies, goatfishes and

Table 17. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at the shelf-edge reef, Puerto Canoas, Isla Desecheo. June, 2005

Depth range : 25 - 30 m

Duration - 30 min.

SPECIES	COMMON NAME	# - (cm)		
<i>Balistes vetula</i>	Queen Triggerfish	1 - (35)		
<i>Carangoides crysos</i>	Blue Runner	2 - (30)	2 - (40)	1 - (50)
<i>Caranx hippos</i>	Horse-eye Jack	6 - (40)	3 - (50)	
<i>Caranx lugubris</i>	Black Jack	2 - (30)	3 - (40)	1 - (50)
	Longsnout			
<i>Chaetodon aculeatus</i>	Butterflyfish	3 - (5)	5 - (7)	
<i>Dasyatis americana</i>	Southern Stingray	1 - (120)		
<i>Epinephelus guttatus</i>	Red Hind	2 - (30)	1 - (35)	
<i>Epinephelus striatus</i>	Nassau Grouper	1 - (45)	1 - (60)	1 - (75)
<i>Gramma loreto</i>	Fairy Basslet	80 - (3)	46 - (6)	10 - (8)
<i>Holacanthus ciliaris</i>	Queen Angel	1 - (30)		
<i>Holacanthus tricolor</i>	Rock Beauty	2 - (5)	4 - (12)	1 - (15)
<i>Lactophrys trigonus</i>	Buffalo Trunkfish	1 - (35)		
<i>Lutjanus apodus</i>	Schoolmaster	3 - (20)	60 - (25)	2 - (35)
<i>Lutjanus jocu</i>	Dog Snapper	1 - (38)		
Table 17. (continued)				
<i>Lutjanus mahogany</i>	Mahogany Snapper	1 - (20)	2 - (25)	
<i>Mycteroperca venenosa</i>	Yellowfin Grouper	1 - (45)	1 - (55)	
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	1 - (40)		
<i>Scomberomorus regalis</i>	Cero Mackerel	1 - (50)	2 - (60)	
<i>Sphyrnaena barracuda</i>	Great Barracuda	1 - (120)		

Invertebrates

<i>Panulirus argus</i>	Spiny Lobster	1 - (20)
<i>Strombus gigas</i>	Queen Conch	2 - (25)

squirrelfishes, among others. Parrotfishes, doctorfishes and damselfishes comprised the main herbivorous assemblage. Commercially important species for the aquarium trade market, such as the Fairy Basslet (*Gramma loreto*), Queen Angelfish (*Holacanthus ciliaris*), Rock Beauty (*Holacanthus tricolor*), Blue Chromis (*Chromis cyanea*), Yellow-head Jawfish (*Opistognathus aurifrons*) and Peppermint Bass (*Liopropoma rubre*) were common. The Arrow Crab, *Stenorhynchus seticornis* and the cleaner shrimps, *Periclimenes sp.* and *Stenopus hispidus* were the motile megabenthic invertebrates observed within belt-transects (Table 18). One juvenile Spiny Lobster, *Panulirus argus* and the Queen Conch were observed outside transects during the ASEC survey.

Table 18. Taxonomic composition and abundance of motile megabenthic invertebrates within belt-transects at the shelf-edge of Puerto Canoas Reef, Isla Desecheo, August, 2004

Depth: 27 - 30 m

<i>SPECIES</i>	<i>COMMON NAME</i>	<i>TRANSECTS</i>					<i>MEAN ABUNDANCE (IND/30 m²)</i>
		<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	
<i>Stenorhynchus seticornis</i>	Arrow crab		2	1	1	1	1.0
<i>Periclimenes sp.</i>	Cleaner Shrimp	1	1		1		0.6
<i>Stenopus hispidus</i>	Banded Coral Shrimp					1	0.2
TOTALS		1	3	1	2	2	1.8

Photo Album Desecheo 30 m



Plate 19



Plate 20



Plate 21



Plate 22



Plate 23



Plate 24

2.0 Mid-shelf Patch Reefs - Puerto Botes

2.1 Sessile-benthic Reef Community

A series of large submerged reef patches of massive, branching and encrusting coral buildup occupy most of the mid-shelf section off Puerto Botes at depths between 17 -23 m on the northwest coast of Isla Desecheo. The coral reef system is exuberant, with large stony corals growing close together and forming large promontories that provide very high topographic relief. At some points, sand channels cut through the sloping terrace of the reef towards the shelf-edge. Permanent transects were installed over two adjacent patch reef promontories separated by a narrow sand channel. The five transects lie close to the border of each patch reef at depths between 17 -19 m. The initial baseline characterization was performed in June, 2000 (García-Sais et al., 2001). This is the third monitoring survey of the mid-shelf patch reefs at Puerto Botes.

Stony corals, with a mean substrate cover of 47.24 % (range: 44.66 – 51.62 %) represented the most prominent sessile-benthic component of the mid-shelf reef at Puerto Botes (Table 19). A total of 22 stony corals, including 14 intersected by line transects were identified during this survey. As in previous surveys, Boulder Star Coral, *Montastrea annularis* (complex) was the dominant species in terms of reef substrate cover with a mean of 25.15 % (range: 4.21 – 42.84 %). It was present in all five transects surveyed, along with Lettuce Coral, *Agaricia agaricites*. Finger Coral, *Porites porites*, Boulder Brain Coral, *Colpophyllia natans* and Lettuce Coral followed Boulder Star Coral in terms of substrate cover, and comprised the main stony coral assemblage of the reef. Mustard Hill Coral, *Porites astreoides* and Maze Coral, *Meandrina meandrites* contributed slightly to the percent linear cover by stony corals, but were common in the reef, with small encrusting colonies present in four out of the five transects surveyed. Reef overhangs, largely associated with growth of *M. annularis* averaged 9.70 % of substrate cover and contributed substantially to the reef rugosity of 4.13 m. Erect and encrusting sponges were present with a mean substrate cover of 2.35 %. Reef hard-ground substrates not colonized by stony corals or sponges were overgrown by a dense algal turf (mean cover: 36.78 %), comprised of a mixed assemblage of red coralline and brown macroalgae. Fleshy brown (*Lobophora sp.*,

Table 19. Percent substrate cover by sessile-benthic categories at Puerto Botes Mid-shelf Reef, Isla Desecheo. June 2005

Depth: 17 – 20 m	TRANSECTS					
	1	2	3	4	5	MEAN
Rugosity (m)	4.01	4.79	3.54	2.37	5.92	4.13
SUBSTRATE CATEGORIES						
TURF ALGAE	46.93	37.43	32.80	31.88	34.86	36.78
ABIOTIC						
Reef Overhangs	7.63	7.70	12.41	8.01	12.75	9.70
Gap					0.53	0.11
Sand					0.44	0.09
Total Abiotic	7.63	7.7	12.41	8.01	13.72	9.89
FLESHY ALGAE		8.31	6.43	2.28	0.71	3.55
SPONGES		1.55	0.59	6.23	3.39	2.35
CALCAREOUS ALGAE					0.44	0.09
ANEMONES		0.38				0.08
CORAL SPECIES						
<i>Montastrea annularis</i>	33.98	20.84	42.84	4.21	23.87	25.15
<i>Porites porites</i>				31.47	1.06	6.51
<i>Colpophyllia natans</i>	8.24	19.89		3.53		6.33
<i>Agaricia agaricites</i>	1.07	0.38	1.70	2.18	13.25	3.72
<i>Porites astreoides</i>	0.79	0.48		3.32	3.64	1.65
<i>Meandrina meandrites</i>		1.69	1.04	2.02	1.32	1.21
<i>Diploria labyrinthiformis</i>		0.48		4.13		0.92
<i>Eusmilia fastigiata</i>		0.57	1.46		1.26	0.66
<i>Montastrea cavernosa</i>			0.52		2.14	0.53
<i>Agaricia lamarcki</i>	0.40			0.80	0.35	0.31
<i>Leptoseris cucullata</i>	0.50					0.10
<i>Scolymia cubensis</i>	0.40					0.08
<i>Diploria strigosa</i>		0.29				0.06
<i>Millepora alcicornis</i>			0.21			0.04
TOTAL STONY CORAL	45.44	44.66	47.57	51.62	46.92	47.24
GORGONIANS (# col.)	0	0	0	0	0	0
Coral Species Outside Transects: <i>Millepora complanata</i> , <i>Diploria strigosa</i> , <i>Mycetophyllia ferox</i> , <i>M. aliciae</i> , <i>Dendrogyra cylindrus</i> , <i>Siderastrea siderea</i> , <i>Scolymia cubensis</i> , <i>Stylaster roseus</i>						

Padina sp.) and calcareous macroalgae contributed an additional 3.64 % to the total benthic algal cover at Puerto Botes (Table 19).

Compared to previous assessments, the sessile-benthic community at Puerto Botes did not show any major shifts in taxonomic structure and/or statistically significant (ANOVA; $p > 0.05$) differences in live coral cover (Figure 13). García-Sais et al. (2001) reported a mean stony coral cover of 48.01 % along permanent transects during the initial 2000 survey. Five years later, reef substrate cover by stony corals was measured as 47.24 %. The difference of 0.77 % is well within the sampling error margin. Figure 14 shows the variations of percent cover by coral species since the baseline survey of 2000. Differences are small, exhibiting increasing trends for some species (e.g. *Agaricia agaricites*, *Colpophyllia natans*) and decreasing trends in others (e.g. *Porites porites*, *P. astreoides*), but still within the sampling variability error in all cases. The dominant species in terms of substrate cover, *Montastrea annularis* (complex) shows inconsistent fluctuations in time that appear to be associated with sampling variability. The variation between the previous (2004) and the current survey was an increment of 1.6 %.

2.2 Fishes and Motile Megabenthic Invertebrates

A total of 106 fish species, including 45 within belt-transects were identified from the mid-shelf patch reefs off Puerto Botes, Isla Desecheo during June, 2005 (Table 21). Mean abundance of fishes within belt-transects was 236.8 Ind/30 m² (range: 200 - 273 Ind/30 m²). The mean number of species per transect was 25.8 (range: 24 - 29). Fish species richness increased by 3.2 % and mean abundance decreased by 1.9% compared to the 2000 baseline survey (Table 3). The Blue Chromis (*Chromis cyanea*) and the Bluehead Wrasse (*Thalassoma bifasciatum*) were the numerically dominant species within belt-transects with mean abundances of 74 and 44 Ind/30 m², respectively. The combined abundance of eight species, including the Blue and Brown Chromis, Bluehead and Yellowhead Wrasses, Sharknose, Peppermint and Masked Gobies and Bicolor Damselfish represented 87 % of the total fish abundance within belt-transects. A total of 10 species were present in all five transects and other seven species were present in four transects surveyed. Compared to our baseline characterization in 2000 (García-Sais et al., 2001b), the fish community in 2005

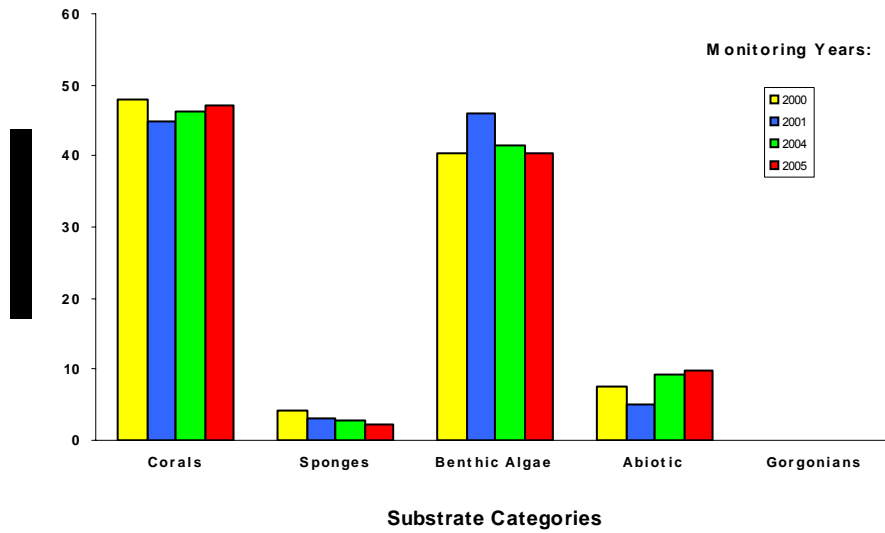


Figure 13. Monitoring trends of mean substrate sessile-benthic categories at Puerto Botes Reef – 20 m.

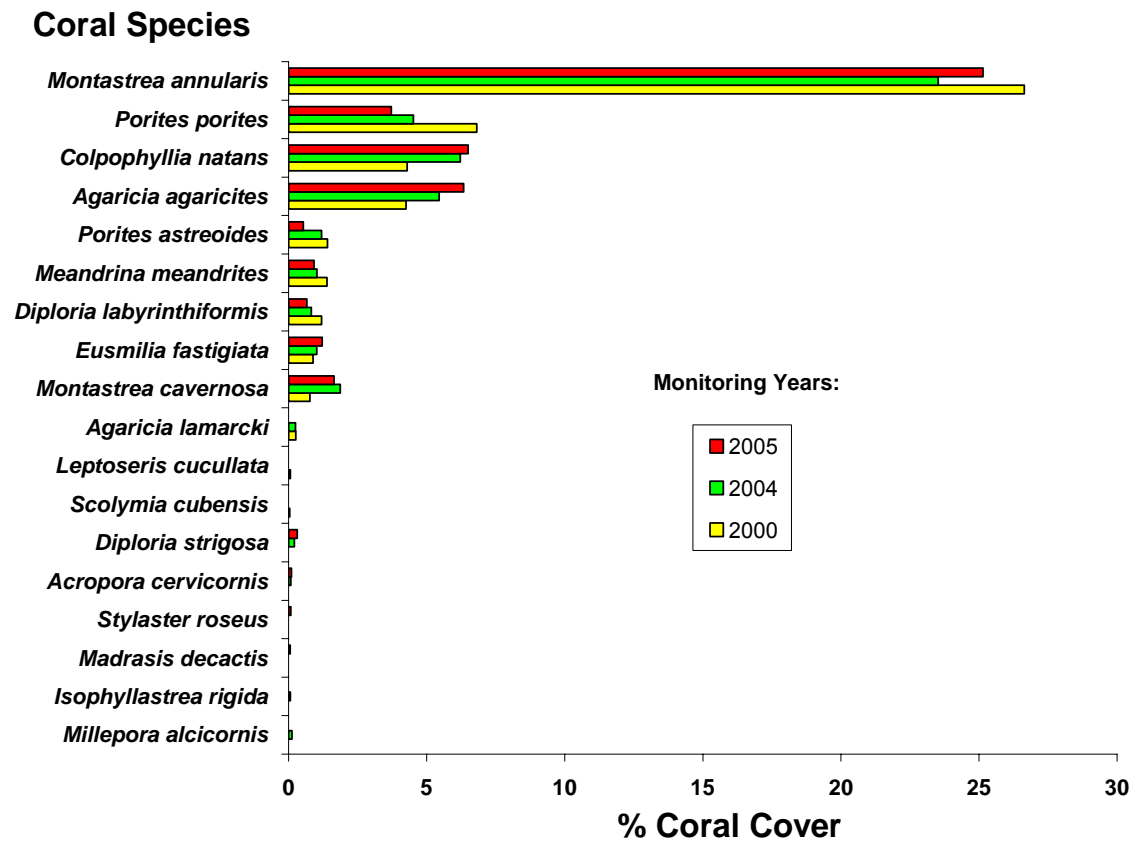


Figure 14. Monitoring trends of mean substrate cover by stony coral species at Puerto Botes Reef – 20 m.

presented an almost identical structure in terms of number of species per transects (+ 0.8) and abundance within belt-transects (- 1.9 %).

The mid-shelf reef off Puerto Botes presented a well balanced fish community in terms of trophic structure, except for the absence of large demersal predators, which were observed to be present in deeper sections of the shelf-edge off Puerto Canoas Reef, adjacent to Puerto Botes. Pelagic schools of Creole Wrasse (15 – 25 individuals) were observed throughout the water column, making frequent incursions over the reef. These are zooplanktivores that serve as forage for large pelagic predators, such as Cero Mackerels, Black Jacks and Barracudas observed during an ASEC survey in this reef (Table 22). The Blue and Brown Chromis, Masked Goby and Bicolor Damselfish are also important zooplanktivores that were common over coral heads closer to the reef. Dense swarms of mysid shrimps were present below ledges and on crevices. These small shrimps appear to be important forage for the demersal zooplanktivorous fishes. Mid-size carnivores that are commercially exploited, such as the Yellowtail, Mahogany and Schoolmaster Snappers, Red Hind, Coney and Queen Triggerfish were observed as full adult sizes. A large variety of small invertebrate feeders were present, including wrasses, gobies, goatfishes and squirrelfishes, among others. Parrotfishes, doctorfishes and damselfishes comprised the main herbivorous assemblage. Commercially important species for the aquarium trade market, such as the Fairy Basslet (*Gramma loreto*), Queen Angelfish (*Holacanthus ciliaris*), Rock Beauty (*Holacanthus tricolor*), Blue Chromis (*Chromis cyanea*), Yellow-head Jawfish (*Opistognathus aurifrons*) and Peppermint Bass (*Liopropoma rubre*) were common.

Motile megabenthic invertebrates within belt-transects included the Arrow Crab (*Stenorhynchus seticornis*), the Banded and Pederson Coral Shrimps (*Stenopus hispidus*, *Periclimenes sp*) and the Long-Spined Urchin (*Diadema antillarum*) (Table 23). A large Spiny Lobster (*Panulirus argus*) was present outside transect areas.

Table 21. Taxonomic composition and abundance of fishes within belt-transects at the Puerto Botes Mid-shelf Reef, Isla Desecheo, August, 2004

Depth: 19 - 21 m		TRANSECTS					MEAN
		1	2	3	4	5	
		(Individuals/30 m ²)					
<i>SPECIES</i>	<i>COMMON NAME</i>						
<i>Stegastes partitus</i>	Bicolor Damselfish	40	45	33	49	48	43.0
<i>Chromis cyanea</i>	Blue Chromis	28	60	20	21	29	31.6
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	14	7	12	22	5	12.0
<i>Chromis multilineata</i>	Brown Chromis		5			50	11.0
<i>Gobiosoma evelynae</i>	Sharknose Goby	16	14	4	5	3	8.4
<i>Clepticus parrae</i>	Creole Wrasse		25			15	8.0
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	7	3	4	5	3	4.4
<i>Scarus iserti</i>	Stripped Parrotfish	7	5	4	3		3.8
<i>Cephalopholis fulva</i>	Coney	5	4	3	3	3	3.6
<i>Coryphopterus lipernes</i>	Peppermint Goby	6	6	3	2	1	3.6
<i>Gramma loreto</i>	Fairy Basslet	1	6		3	5	3.0
<i>Acanthurus coeruleus</i>	BlueTang	2	3	4	3	1	2.6
<i>Amblycirrhitus pinos</i>	Redspotted Hawkfish	4	3		4	2	2.6
<i>Myripristis jacobus</i>	Blackbar Soldierfish		3	6		3	2.4
<i>Holacanthus tricolor</i>	Rock Beauty	4	2	1	2	2	2.2
<i>Microspathodon chrysurus</i>	Yellowtail Damselfil	2	5	2	1	1	2.2
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	4	2	1	2		1.8
<i>Cephalopholis cruentatus</i>	Graysby		2	1	1	3	1.4
<i>Chaetodon capistratus</i>	Foureye Butterflyfish	2		3	2		1.4
<i>Melichthys nigrer</i>	Black Durgon	1	3		1	2	1.4
<i>Carangoides ruber</i>	Bar Jack	1		3		2	1.2
<i>Haemulon flavolineatum</i>	French Grunt		3			3	1.2
<i>Sparisoma radians</i>	Bucktooth Parrotfish	1				4	1.0
<i>Acanthurus bahianus</i>	Ocean Surgeon	1	1	1		1	0.8
<i>Flameo marianus</i>	Longspine Squirrelfish		1	1	1	1	0.8
<i>Holocentrus rufus</i>	Squirrelfish		2	2			0.8
<i>Paranthias furcifer</i>	Creole Fish			3		1	0.8
<i>Sparisoma viride</i>	Stoplight Parrotfish		4				0.8
<i>Bodianus rufus</i>	Spanish Hogfish		2		1		0.6
<i>Canthigaster rostrata</i>	Caribbean Puffer			2		1	0.6
<i>Halichoeres maculipinna</i>	Clown Wrasse	1				2	0.6
<i>Lutjanus apodus</i>	Schoolmaster	2				1	0.6
<i>Scomberomorus regalis</i>	Cero Mackerel		1	1		1	0.6
<i>Lactophrys polygonia</i>	Honeycomb Cowfish		1		1		0.4
<i>Lactophrys triqueter</i>	Smooth Trunkfish		1		1		0.4
<i>Acanthurus chirurgus</i>	Doctorfish			1	1		0.4
<i>Lutjanus mahogani</i>	Mahogani Snapper			2			0.4
<i>Scarus taeniopterus</i>	Princess Parrotfish				2		0.4
<i>Scarus vetula</i>	Queen Parrotfish				1	1	0.4
<i>Serranus tigrinus</i>	Harlequin Bass	1		1			0.4
<i>Stegastes planifons</i>	Yellow-eye Damselfish	1	1				0.4
<i>Aulostomus maculatus</i>	Trumpetfish			1			0.2
<i>Canthidermis sufflamen</i>	Ocean Triggerfish					1	0.2

Table 21. (continued).

<i>Caranx lugubris</i>	Black Jack			1			0.2
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish			1			0.2
<i>Chaetodon striatus</i>	Banded Butterflyfish			1			0.2
<i>Coryphopterus sp1.</i>	Goby				1		0.2
<i>Equetus acuminatus</i>	Highhat					1	0.2
<i>Gymnothorax moringa</i>	Spotted Moray			1			0.2
<i>Halichoeres radiatus</i>	Puddinwife	1					0.2
<i>Kyphosus sectatrix</i>	Bermuda Chub	1					0.2
<i>Lactophrys triqueter</i>	Smooth Trunkfish			1			0.2
<i>Liopropoma rubre</i>	Peppermint Bass				1		0.2
<i>Mulloidides martinicus</i>	Yellowtail Goatfish					1	0.2
<i>Priacanthus arenatus</i>	Glasseye			1			0.2
TOTAL INDIVIDUALS		151	223	124	139	197	166.8
TOTAL SPECIES		23	32	31	26	31	28.6

Table 22. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at the Puerto Botes Mid-shelf Reef, Isla Desecheo. June, 2005

Depth range : 26 - 30 m

Duration - 30 min.

SPECIES	COMMON NAME	# - (cm)		
<i>Carangoides crysos</i>	Blue Runner	3 - (40)		
<i>Caranx lugubris</i>	Black Jack	1 - (30)	2 - (50)	
<i>Dasyatis americana</i>	Southern Stingray	1 - (80)		
<i>Epinephelus striatus</i>	Nassau Grouper	1 - (70)		
<i>Epinephelus guttatus</i>	Red Hind	1 - (30)		
<i>Gramma loreto</i>	Fairy Basslet	12 - (3)	15 - (5)	6 -(7)
<i>Holacanthus ciliaris</i>	Queen Angel	2 - (30)		
<i>Holacanthus tricolor</i>	Rock Beauty	1 - (15)	2 - (25)	
<i>Lutjanus apodus</i>	Schoolmaster	2 - (30)	2 - (40)	
<i>Lutjanus mahogany</i>	Mahogani Snapper	1 - (25)	2 - (30)	
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	2 - (30)	7 - (35)	1 - (40)
<i>Scomberomorus regalis</i>	Cero Mackerel	1 - (40)		
<i>Sphyrnaena barracuda</i>	Great Barracuda	2 - (70)		
Invertebrates				
<i>Panulirus argus</i>	Spiny Lobster	1 - (30)*		

Table 23. Taxonomic composition and abundance of motile megabenthic invertebrates from belt-transects at the Puerto Botes Mid-shelf Reef, Isla Desecheo. June 2005

Depth: 20 m

		TRANSECTS					MEAN ABUNDANCE (IND/30 m ²)
		1	2	3	4	5	
TAXA	COMMON NAME						
<i>Periclimenes pedersoni</i>	Cleaner shrimp	1					0.2
<i>Stenorhynchus seticornis</i>	Arrow crab		1			1	0.4
<i>Stenopus hispidus</i>	Banded coral shrimp			1		1	0.4
TOTALS		1	1	1	0	2	1.0

Photo Album Desecheo 20 m



Plate 25



Plate 26



Plate 27



Plate 28



Plate 29



Plate 30

2.0 Inner Shelf Reefs – Puerto Botes

3.1 Sessile-benthic Reef Community

The rocky shoreline off Puerto Botes leads to a gently sloping hard ground terrace which is colonized by corals and other encrusting biota. With increasing depth, the hard ground terrace breaks into several large promontories with a marked increment of stony coral buildup. The southern section of the terrace presents a more abrupt slope from the shoreline towards deeper waters and is heavily colonized by soft corals (gorgonians). Our survey was performed along the northern section. Five permanent transects were installed almost parallel to each other oriented north-south.

A total of 19 stony corals, including 11 intersected by line transects were identified during this baseline survey at Puerto Botes Inner Reef. Stony corals presented a mean substrate cover of 19.66 % (range: 10.65 – 30.62 %) (Table 24). Boulder Star Coral, *Montastrea annularis* was the dominant species in terms of reef substrate cover with a mean of 11.50 % (range: 4.77 - 22.5 %), representing 58.5 % of the total stony coral cover. Colonies of Boulder Star Coral were present in all five transects surveyed, along with those of Mustard-Hill Coral, *Porites astreoides*. Corals typically exhibited encrusting growth and small to moderate colony sizes, perhaps as adaptations to the strong wave and surge action seasonally acting at the shallower reef zone. Soft corals were present, but in low abundance and out of transects. Reef overhangs, largely associated with growth of *M. annularis* averaged 8.87 % of substrate cover and contributed substantially to the reef rugosity of 4.03 m. Total abiotic cover also included sections of sand and averaged 2.02 %. Erect and encrusting sponges were present at all transects with a mean substrate cover of 4.73 %.

Reef hard-ground substrates not colonized by stony corals or sponges were overgrown by benthic algae. A dense algal turf (mean cover: 45.37 %), comprised of a mixed assemblage of red coralline (*Amphiroa* sp.) and brown macroalgae was the principal component of the benthic algae. Fleshy brown (*Lobophora* sp., *Dictyota* sp., *Padina* sp.) and calcareous macroalgae (*Halimeda* sp) contributed an additional 19.5 % to the total substrate cover at Puerto Botes Inner Reef (Table 24).

Table 24. Percent substrate cover by sessile-benthic categories at Puerto Botes Inner-shelf Reef, Isla Desecheo, June, 2005

	Transects					MEAN
	1	2	3	4	5	
Rugosity	3.39	3.56	4.69	4.28	4.24	4.03
Substrate Categories						
Benthic Algae						
Turf Algae	52.5	38.91	44.94	42.12	48.38	45.37
Fleshy Algae	21.58	29.4	18.22	22.99	5.27	19.49
Total Benthic Algae	74.08	68.31	63.16	65.11	53.65	64.86
Abiotic						
Reef Overhangs	7.24	9.58	12.37	10.79	4.35	8.87
Sand	0	3.76	0.96	5.4	0	2.02
Total Abiotic	7.24	13.34	13.33	16.19	4.35	10.89
Sponges						
	3.66	1.03	3.67	8.06	7.23	4.73
Coral Species						
<i>Montastrea annularis</i>	7.17	9.06	14.0	4.77	22.5	11.50
<i>Porites astreoides</i>	2.39	6.56	1.9	1.26	1.62	2.75
<i>Montastrea cavernosa</i>	3.06		1.63	2.17	2.46	1.86
<i>Agaricia agaricites</i>	0.42	1.33			5.83	1.52
<i>Eusmilia fastigiata</i>				1.89		0.38
<i>Diploria strigosa</i>	0.42				1.29	0.34
<i>Madracis decactis</i>			0.96	0.3		0.25
<i>Meandrina meandrites</i>					0.99	0.20
<i>Diploria labyrinthiformis</i>	0.42	0.42				0.17
<i>Siderastrea siderea</i>	0.63					0.13
<i>Mycetophyllia lamarckiana</i>	0.53					0.11
<i>Agaricia lamarcki</i>					0.4	0.08
<i>Stephanocoenia michelini</i>				0.3		0.06
<i>Millepora alcicornis</i>	0	0	1.36	0	0.2	0.31
Total Stony Corals	15.01	17.32	19.85	10.65	34.62	19.66

Coral Species Outside Transects: *Porites porites*, *Diploria clivosa*, *Stylaster roseus*, *Siderastrea siderea*, *Madracis decactis*, *Leptoseris cucullata*, *Acropora cervicornis*, *Millepora alcicornis*

Figure 15 presents the variations of mean percent cover by the main sessile-benthic categories from the inner shelf reef off Puerto Botes at 15 m depth. Differences of mean total percent cover by stony corals, sponges and benthic algae during the current 2005 monitoring survey were all within 1 % of the baseline characterization values of 2004 (García-Sais et al., 2004). Such small differences at the community level were not statistically significant (ANOVA, $p > 0.05$). Variations of the mean substrate cover by coral species between the current 2005 survey and the previous 2004 baseline survey (Figure 16) were also very small ($< 1\%$), and within the sampling error of the method.

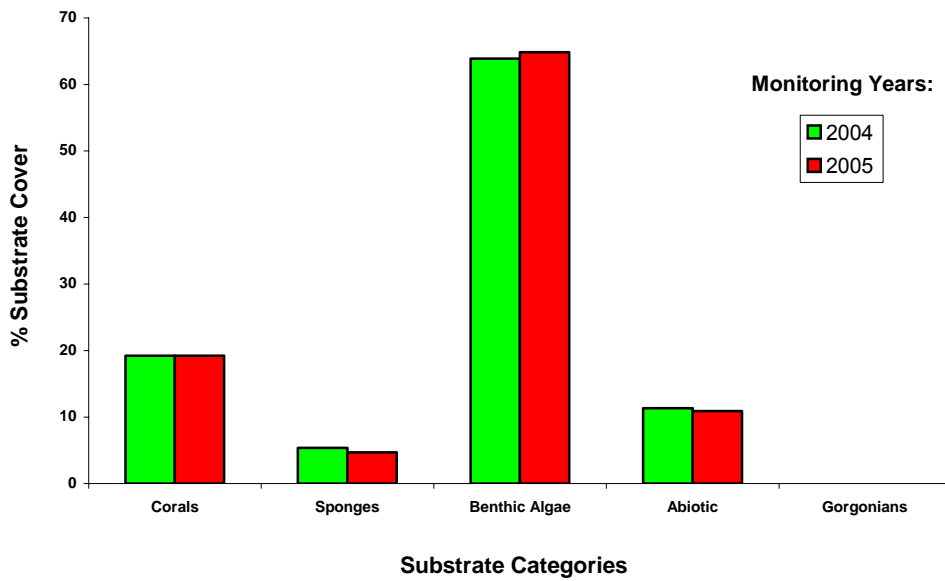


Figure 15. Monitoring trends of mean substrate sessile-benthic categories at Puerto Botes Reef – 15 m.

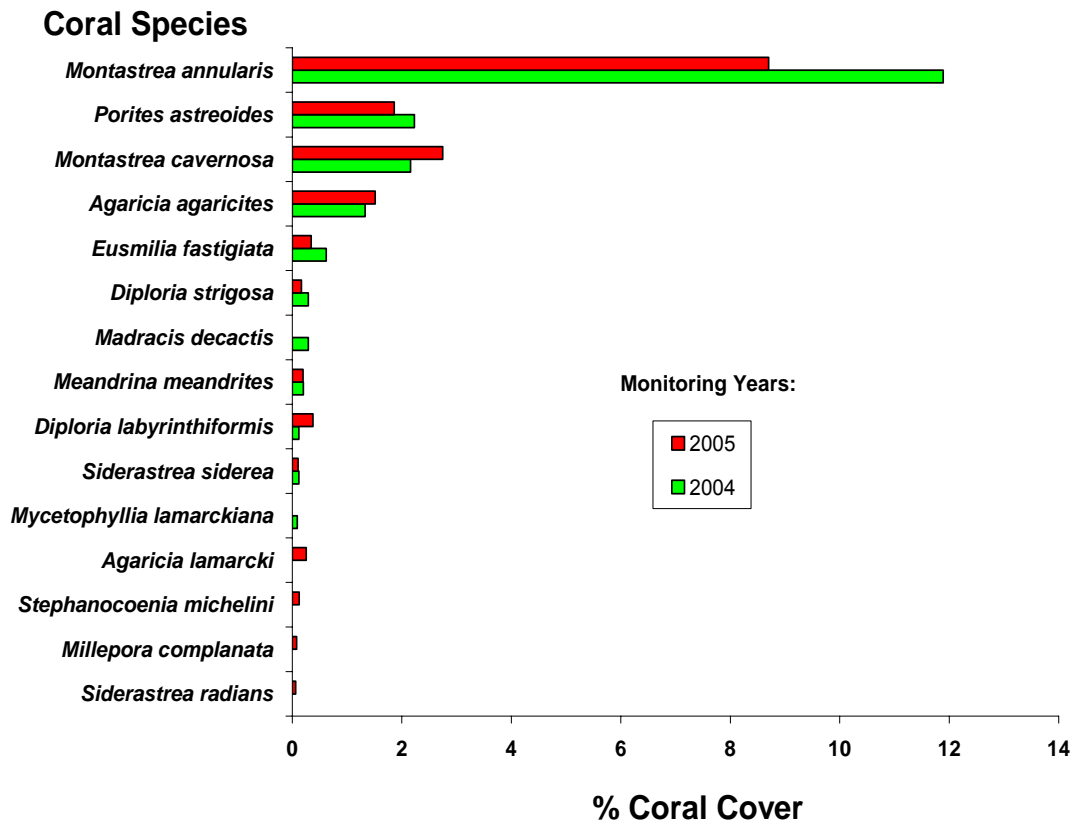


Figure 16. Monitoring trends of mean substrate cover by stony coral species at Puerto Botes Reef – 15 m.

3.2 Fishes and Motile Megabenthic Invertebrates

A total of 57 fish species, including 43 within belt-transects were identified from the Inner-Shelf Reef off Puerto Botes, Isla Desecheo during July, 2005. Mean abundance of fishes within belt-transects was 247.6 Ind/30 m² (range: 155 - 293 Ind/30 m²). The mean number of species per transect was 24.6 (range: 23 - 27). Fish species richness increased by 4.1 % and mean abundance increased by 46.0 % compared to the 2004 baseline survey (Table 3). The Blue Chromis was the numerically dominant species with a mean abundance of 80.6 Ind/30 m² (range: 7 - 120 Ind/30 m²), representing 32.5 % of the total abundance within belt-transects (Table 25). The combined abundance of five species, including the Blue and Brown Chromis (*C. cyanea*, *C. multilineata*), Bicolor Damselfish (*Stegastes partitus*), Bluehead and Yellowhead Wrasses, and the Bicolor Damselfish represented 79.6 % of the total abundance within belt-transects. A total of 10 species were present in all five transects surveyed and other six species were present in four transects (Table 25).

Demersal zooplankton feeders, such as Bicolor Damselfish, Blue and Brown Chromis comprised the most prominent fish assemblage of this inshore reef, both in terms of abundance and biomass. Also, open water zooplanktivores, such as the Creole Wrasse (*Clepticus parrae*) and Mackerel Scad (*Decapterus macarellus*) were present outside transects in large aggregations. This is consistent with fish surveys from the mid-shelf and shelf-edge reefs of Isla Desecheo (see previous sections). The relatively high abundance of zooplanktivorous fish populations is quite interesting because Rodriguez (2004) sampled the macrozooplankton of Puerto Botes/Puerto Desecheo Reefs six times during a year and found that zooplankton populations are depauperate and unproductive with exception of fish eggs. At least three preliminary hypothesis, or an interplay of these can be advanced to explain such scenario: 1) zooplankton production is high, but is continuously being consumed as it grows to an optimal size for fish consumption; 2) fishes produce a very high abundance of pelagic eggs that support the large zooplanktivorous fish populations; 3) micronekton assemblages, such as mysid shrimps supplement, or sustain to a significant extent the diets of the markedly abundant zooplanktivorous fish populations at the Puerto Botes/Puerto Canoas Reef system of Isla Desecheo.

A specious assemblage of small invertebrate feeders were also present, including wrasses, gobies, goatfishes and squirrelfishes, among others. Mid-size carnivores that are commercially exploited, such as the Yellowtail and Schoolmaster Snappers, Red Hind and Coney were observed in low abundance and small sizes (Table 26). Parrotfishes, doctorfishes and damselfishes comprised the main herbivorous assemblage. Commercially important species for the aquarium trade market were mostly represented by the populations of Blue Chromis, which was found in much higher abundance at deeper sections of this and adjacent reefs. Likewise, the Fairy Basslet (*Gramma loreto*) or Royal Gramma, as it is known in the aquarium trade, was present at the Inner Reef, but in much lower abundance than in deeper sections of the reef. A few specimens of the Queen Angelfish (*Holacanthus ciliaris*) and Rock Beauty (*Holacanthus tricolor*) were also present. One large Cero Mackerel and one Great Barracuda were present observed during our ASEC survey (Table 26). Motile megabenthic invertebrates were represented within belt-transects by Coral Crabs, Arrow Crabs, Spotted and Spiny Lobsters, Long-spined Sea Urchins and Brittle Stars (Table 27).

Table 25. Taxonomic composition and abundance of fishes within belt-transects at the Inner Shelf Reef off Puerto Botes, Isla Desecheo, July, 2005

Depth: 15m

SPECIES	COMMON NAME	Transects					MEAN
		1	2	3	4	5	
		(Individuals/30 m2)					
<i>Chromis cyanea</i>	Blue Chromis	51	120	135	7	90	80.6
<i>Stegastes partitus</i>	Bicolor Damselfish	61	51	49	43	37	48.2
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	73	46	31	35	36	44.2
<i>Chromis multilineata</i>	Brown Chromis	1	14	12	8	34	13.8
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	5	8	16	15	8	10.4
<i>Gobiosoma evelynae</i>	Sharknose Goby	11	22	5	2	6	9.2
<i>Coryphopterus lipernes</i>	Peppermint Goby	5	3	7	3	9	5.4
<i>Cephalopholis fulva</i>	Coney	4	1	2	8	4	3.8
<i>Halichoeres maculipinna</i>	Clown Wrasse	3	5	3	5		3.2
<i>Amblycirrhitus pinnos</i>	Redspotted Hawkfish	1		1	6	5	2.6
<i>Malacoctenus sp.</i>	Blenny	3		3	5	2	2.6
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	3	2	3	2	2	2.4
<i>Microspathodon chrysurus</i>	Yellowtail Damselfish	3	3		2	3	2.2
<i>Coryphopterus sp1.</i>	Goby	2	2	1	1	1	1.4
<i>Gramma loreto</i>	Fairy Basslet			2	1	4	1.4
<i>Scarus iserti</i>	Stripped Parrotfish	1	2	2	2		1.4
<i>Acanthurus coeruleus</i>	Blue Tang	2	1		1	2	1.2
<i>Lutjanus apodus</i>	Schoolmaster			4	1	1	1.2
<i>Holocentrus rufus</i>	Squirrelfish	1		1		3	1.0
<i>Sparisoma radians</i>	Bucktooth Parrotfish				1	4	1.0
<i>Sparisoma viride</i>	Stoplight Parrotfish			2		3	1.0
<i>Chaetodon capistratus</i>	Four-eye Butterflyfish	2		2			0.8
<i>Haemulon macrostomum</i>	Spanish Grunt					4	0.8
<i>Holacanthus tricolor</i>	Rock Beauty		2	1		1	0.8
<i>Malacoctenus triangulatus</i>	Saddled Blenny	1	1			2	0.8
<i>Mulloides martinicus</i>	Yellowtail Goatfish			1	3		0.8
<i>Acanthurus chirurgus</i>	Doctorfish	1	1	1			0.6
<i>Bodianus rufus</i>	Spanish Hogfish	1	1		1		0.6
<i>Chaetodon striatus</i>	Banded Butterflyfish		2		1		0.6
<i>Myripristis jacobus</i>	Blackbar Soldierfish		1	1		1	0.6
<i>Cephalopholis cruentatus</i>	Graysby		2				0.4
<i>Lactophrys triqueter</i>	Smooth Trunkfish		1			1	0.4
<i>Cantherhines macrocerus</i>	Whitespotted Filefish		1				0.2
<i>Caranx crysos</i>	Blue Runner				1		0.2
<i>Diodon hystrix</i>	Porcupinefish	1					0.2
<i>Flammeo marianus</i>	Longspine Squirrelfish			1			0.2
<i>Kyphosus bermudensis</i>	Sea Chub					1	0.2
Table 25. (continued)							
<i>Melichthys niger</i>	Black Durgon			1			0.2
<i>Muraena sp.</i>	Moray sp.			1			0.2
<i>Sargocentrum coruscus</i>	Reef Squirrelfish		1				0.2

Table 25. (continued)

<i>Scarus taeniopterus</i>	Princess Parrotfish	1					0.2
<i>Scarus vetula</i>	Queen Parrotfish			1			0.2
<i>Serranus tigrinus</i>	Harlequin Bass				1		0.2
TOTAL INDIVIDUALS		237	293	289	155	264	247.6
TOTAL SPECIES		23	24	27	24	25	24.6

Fishes Outside Transects

SPECIES	COMMON NAME
<i>Lutjanus apodus</i>	Schoolmaster
<i>Sphyraena barracuda</i>	Great Barracuda
<i>Clepticus parrae</i>	Creole Wrasse
<i>Ocyurus chrysurus</i>	Yellowtail Snapper
<i>Echidna catenata</i>	Chain Moray
<i>Epinephelus guttatus</i>	Red Hind
<i>Gramma loreto</i>	Fairy Basslet
<i>Decapterus macarellus</i>	Mackerel Scad
<i>Xanthichthys ringens</i>	Sargassum Triggerfish
<i>Halichoeres maculipinna</i>	Clown Wrasse
<i>Carangoides ruber</i>	Bar Jack
<i>Ginglymostoma cirratum</i>	Nurse Shark
<i>Opistognathus aurifrons</i>	Yellowhead Jawfish

Table 26. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at the Puerto Botes Inner-shelf Reef, Isla Desecheo. July, 2005

Depth range : 14 - 16 m
Duration - 30 min.

SPECIES	COMMON NAME	# - (cm)		
<i>Decapterus macarellus</i>	Mackerel Scad	40 - (12)		
<i>Epinephelus guttatus</i>	Red Hind	1 - (30)		
<i>Gramma loreto</i>	Fairy Basslet	12 - (3)	15 - (5)	6 -(7)
<i>Ginglymostoma cirratum</i>	Nurse Shark	1 - (90)		
<i>Holacanthus ciliaris</i>	Queen Angel	1 - (35)		
<i>Holacanthus tricolor</i>	Rock Beauty	1 - (10)	2 - (15)	1 - (20)
<i>Lutjanus apodus</i>	Schoolmaster	2 - (25)	2 - (30)	
<i>Lutjanus mahogany</i>	Mahogani Snapper	1 - (25)	2 - (30)	
<i>Scomberomorus regalis</i>	Cero Mackerel	1 - (50)		
<i>Sphyraena barracuda</i>	Great Barracuda	1 - (70)		
Invertebrates				
<i>Panulirus guttatus</i>	Spotted Spiny Lobster	1 - (25)		
<i>Panulirus argus</i>	Spiny Lobster	1 - (40)*		

Table 27. Taxonomic composition and abundance of motile megabenthic invertebrates from belt-transects at the Puerto Botes Inner-Shelf Reef, Isla Desecheo. July, 2005

		TRANSECTS					MEAN ABUNDANCE (IND/30 m ²)
		1	2	3	4	5	
TAXA	COMMON NAME						
<i>Panulirus argus</i>	Spiny Lobster					1	0.2
<i>Ophiothrix suensoni</i>	Sponge Brittle Star	40		30		1	14.2
<i>Panulirus guttatus</i>	Spotted Spiny Lobster		1				0.2
<i>Carpilius corallinus</i>	Coral Crab		1				0.2
<i>Stenorhynchus seticornis</i>	Arrow crab		1		2	1	0.8
<i>Diadema antillarum</i>	Long-Spined Sea Urchin			1		1	0.4
TOTALS		41	3	31	2	4	16.0

Photo Album Desecheo 15 m



Plate 31



Plate 32



Plate 33

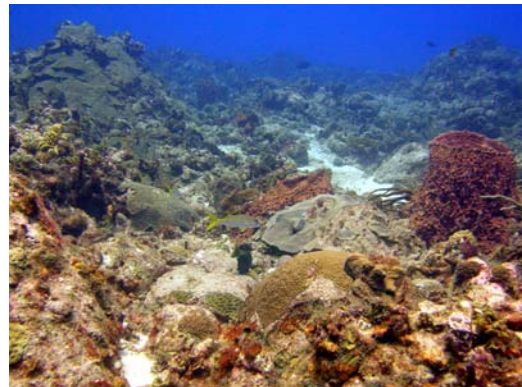


Plate 34



Plate 36



Plate 37

C. Tourmaline Reef System – Mayaguez Bay

Tourmaline Reef, located due west of Bahía Bramadero, Cabo Rojo was designated as a Natural Reserve in 1996 in recognition of its ecological value as the most important coral reef system of the west coast of Puerto Rico. The total extension of the Natural Reserve is 19.43 square nautical miles. The reef sits at the northern section of the Cabo Rojo platform, approximately five miles away from the coastline (Figure 17).

Tourmaline Reef is a submerged coral reef system comprised by a series of narrow hard ground terraces, or steps fringing the edge of the Mayaguez Bay shelf along a depth range of 10 - 32 m. The reef starts at a depth of 10 m with a well defined "spur-and-groove" formation that follows a gentle slope towards the north, ending in a coralline sand pool at a depth of 13.3 m. A more diffuse "spur-and-groove" reef formation of massive coral buildup is found at a depth of 17 m, extending due north to a depth of 21 m. This second terrace also ends in a fine silt-sand interface. The third and last hard ground terrace is very scarped and narrow, breaking abruptly from 22 m down to 32 m along an irregular slope with high topographic relief given by large massive corals. Below 25 m, the slope rises somewhat and stony coral growth is more scattered and less massive than above. This last hard ground terrace leads to an extensive fine silt-sand bottom that drops gradually towards the insular slope (>50 m).

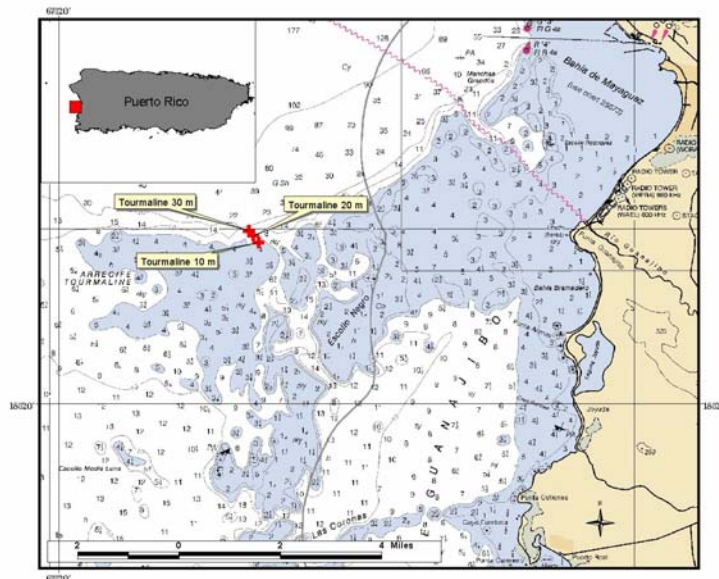


Figure 17. Location of coral reef survey stations at Tourmaline Reef, Mayaguez.

1.0 Shelf-edge Reef – 30 meter

1.1 Sessile-Benthic Reef Community

Permanent transects were oriented south - north, perpendicular to the shelf-edge and on top of the spurs at a depth of 28 - 30 m. Panoramic views of Tourmaline shelf-edge reef are presented in Photo Album 7.

A total of 24 stony corals and two black coral species were identified from the shelf-edge off of El Tourmaline Reef, 14 of which were intercepted by line transects during our survey (Table 28). Stony corals occurred mostly as isolated encrusting and mound shaped colonies. Substrate cover by stony corals along transects averaged 14.99 % (range: 5.41 – 24.85 %). Boulder Star Coral, *Montastrea annularis* (complex) was the dominant species in terms of substrate cover with a mean of 5.91 % (range: 2.18 - 9.86 %), representing 39.4 % of the total cover by stony corals. Isolated colonies of Lamark's Sheet Coral, *Agaricia lamarcki* and Great Star Coral, *Montastrea cavernosa* were also prominent at the shelf-edge. Small colonies of Mustard-Hill Coral, *Porites astreoides* and Lettuce Coral, *Agaricia spp.* were also common. Soft corals (gorgonians) were moderately abundant, with an average of 7.0 colonies/transect. Colonies of Bushy Black Coral (*Antipathes sp.*) and Wire Coral (*Stichopathes lutkeni*) were present close to the deepest end of the reef at 32 m.

Encrusting and erect sponges, including several large Basket Sponges, *Xestospongia muta* were present in all transects with an average cover of 1.43 %. The Blue Bell Tunicate, *Clavelina puertosecensis* was very common throughout the shelf-edge reef. Reef overhangs, associated with substrate depressions and coral ledges averaged 28.02 % and contributed substantially to a topographic rugosity of 5.34 m.

Turf algae, comprised by an assemblage of short filamentous red and brown macroalgae was the dominant sessile-benthic component in terms of substrate cover at the shelf-edge reef with an average of 52.21 % (range : 41.39 - 66.29 %). Turf algae was found overgrowing rocky substrates, as well as dead coral sections and other hard ground. Fleshy macroalgae were not prominent at 30 m.

Table 28. Percent substrate cover by sessile-benthic categories at Tourmaline Shelf-Edge Reef, Mayaguez. July 2005.

Depth: 30 m

		Transects					
		1	2	3	4	5	MEAN
	Rugosity (m)	6.65	4.80	6.44	4.24	4.55	5.34
SUBSTRATE CATEGORIES							
	TURF ALGAE	47.48	41.39	54.26	66.29	51.62	52.21
	ABIOTIC						
	Reef Overhangs	31.07	26.54	33.33	25.70	23.44	28.02
	Silt		4.85	1.82			1.33
	Total Abiotic	31.07	31.39	35.15	25.7	23.44	29.35
	ENCRUSTING GORGONIAN	5.23	0.48	0.60	2.11	1.74	2.03
	SPONGES	1.86	1.89	0.85	0.49	2.06	1.43
	CORAL SPECIES						
	<i>Montastrea annularis</i>	5.11	9.86	3.59	2.18	8.8	5.91
	<i>Agaricia lamarcki</i>	3.67	6.08	1.11	0.30	2.89	2.81
	<i>Montastrea cavernosa</i>		0.86	3.35	1.05	3.71	1.79
	<i>Agaricia agaricites</i>	1.14	1.15	0.77	1.47	1.37	1.18
	<i>Agaricia grahame</i>	1.50	2.16		0.40	1.55	1.12
	<i>Stephanocoenia michelini</i>	1.27	1.15			1.37	0.76
	<i>Madracis formosa</i>		3.33				0.67
	<i>Mycetophyllia aliciae</i>	1.27					0.25
	<i>Meandrina meandrites</i>					0.68	0.14
	<i>Madracis sp.</i>		0.19	0.34			0.11
	<i>Siderastrea siderea</i>					0.48	0.10
	<i>Siderastrea radians</i>					0.39	0.08
	<i>Madracis decactis</i>	0.25					0.05
	<i>Scolymia cubensis</i>	0.17					0.03
	TOTAL STONY CORAL	14.36	24.85	9.18	5.41	21.17	14.99
	GORGONIANS (# col.)	5	9	3	7	11	7

Coral Species Outside Transects : *Stephanocoenia michelini*, *Siderastrea siderea*, *Diploria strigosa*, *Antipathes sp.*, *Stichopathes lutkeni*, *Scolymia cubensis*, *Millepora alcicornis*, *Meandrina meandrites*, *Mycetophyllia lamarkiana*, *M. aliciae*, *Porites porites*, *Madracis decactis*

Figure 18 presents the variations of mean percent cover by sessile-benthic categories from the shelf-edge reef off Tourmaline at 30 m depth. Differences of mean total percent cover by stony corals (+ 1.4 %), sponges (- 1.7 %) and benthic algae (-2.6 %) during the current 2005 monitoring survey were all within 3 % of the baseline characterization values of 2004 (García-Sais et al., 2004). Such small differences at the community level were not statistically significant (ANOVA, $p > 0.05$). Variations of the mean substrate

cover by coral species between the current 2005 survey and the previous 2004 baseline survey (Figure 19) were also very small (< 1 %), and within the sampling error of the method.

1.2 Fishes and Motile Megabenthic Invertebrates

A total of 97 fish species, including 39 within belt-transects were identified from Tourmaline shelf-edge reef during our baseline characterization survey in July, 2005. Mean abundance within belt-transects was 174.6 Ind/30 m² (range: 96 - 253 Ind/30 m²). The mean number of species per transect was 19.4 (range: 18 - 21). Fish species richness decreased by 15.6 % and mean abundance increased by 36.0 % compared to the 2004 baseline survey (Table 3). The Masked Goby, *Coryphopterus personatus* was the numerically dominant species with a mean abundance of 120.0 Ind/30 m² (range: 50 - 200 Ind/30 m²), representing 68.7 % of the total abundance within belt-transects (Table 29). The Masked Goby is a small carnivorous fish (< 2.0 cm) that aggregates in swarms below coral ledges and crevices near the sand-coral interface. The Bicolor Damselfish, Masked and Peppermint Gobies, Blue Chromis, Fairy Basslet, Yellowhead Wrasse, Black-bar Soldierfish, Caribbean Puffer, Creole Wrasse, and the Beaugregory were present on at least four out of the five transects surveyed and comprised the most abundant fish assemblage at the shelf-edge reef.

The fish community associated with Tourmaline shelf-edge reef was characterized by rather low abundance of individuals and species, compared to other well developed shelf-edge reef systems, such as Puerto Canoas in Isla Desecheo (443 Ind/30 m² with 32 spp/transect) and Tres Palmas (329.8 Ind/30 m², with 23 spp/transect). Top demersal predators, such as large snappers and groupers are not common. One large Yellowfin Grouper (*Mycteroperca venenosa*) and one Cero Mackerel (*Scomberomorus regalis*) were observed during the 2005 ASEC survey (Table 30). During the previous 2004 baseline survey, one juvenile Nassau Grouper and juveniles of Mutton, Schoolmaster and Yellowtail Snappers were reported. Also, adult Hogfish and several Queen Triggerfishes were observed at the reef - sand interface. Several Ocean Triggerfishes and one large Spotted Eagle-Ray were observed higher in the water column in 2004 (García-Sais et al., 2004). Schools of Mackerel Scad, *Decapterus macarellus* were present at mid-water over the reef. These are zooplanktivores that

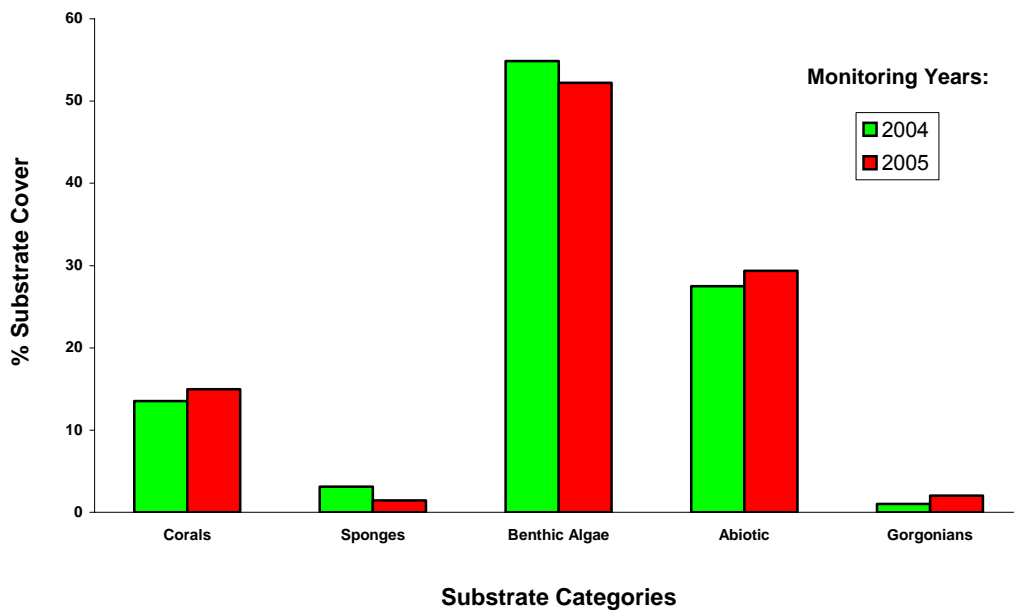


Figure 18. Monitoring trends of mean substrate sessile-benthic categories at Tourmaline Reef – 30 m, Mayaguez.

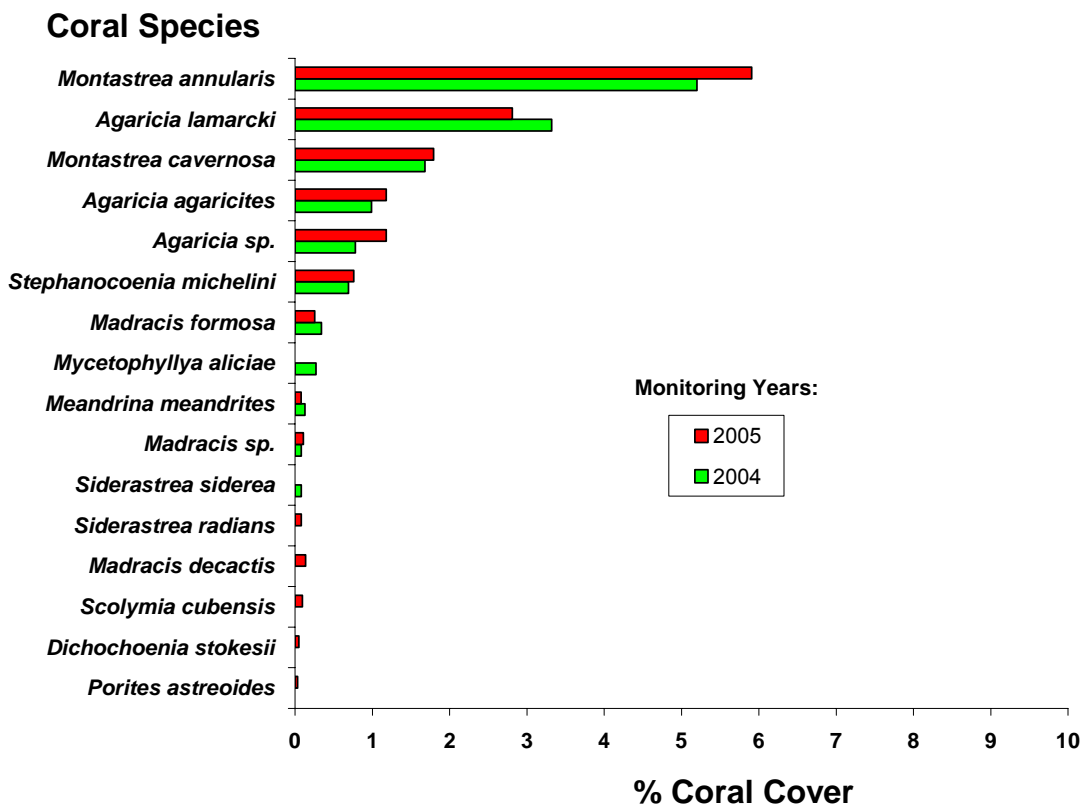


Figure 19. Monitoring trends of mean substrate cover by stony coral species at Tourmaline Reef – 30 m, Mayaguez.

serve as forage for pelagic predators, such as Cero Mackerels and Barracudas. The Blue Chromis is also an important zooplanktivore that was common over coral heads closer to the reef. A large variety of small invertebrate feeders were present, including wrasses, gobies, goatfishes and squirrelfishes among others.

Motile megabenthic invertebrates were not observed within belt-transects at the Tourmaline shelf-edge reef during this survey. One Spiny Lobster (*Panulirus argus*) was observed during the ASEC survey (Table 30). In the previous survey, the Cleaner Shrimp, *Periclimenes pedersoni* and one Sea Cucumber, *Holothuria sp.* were present within belt-transects.

Table 29. Taxonomic composition and abundance of fishes within belt-transects at the Tourmaline Shelf-Edge Reef, Mayaguez, July, 2005

		Transects					MEAN
		1	2	3	4	5	
Depth: 30m		(Individuals/30 m ²)					
<i>SPECIES</i>	COMMON NAME						
<i>Coryphopterus personatus</i>	Masked Goby	150	200	100	100	50	120.0
<i>Chromis cyanea</i>	Blue Chromis	7	1	30	3	3	8.8
<i>Stegastes partitus</i>	Bicolor Damselfish	9	7	13	7	5	8.2
<i>Gramma loreto</i>	Fairy Basslet		8	9	7	5	5.8
<i>Coryphopterus lipernes</i>	Peppermint Goby	5	3	3	6	8	5.0
<i>Myripristis jacobus</i>	Blackbar Soldierfish	3	5	3	5	3	3.8
<i>Clepticus parrae</i>	Creole Wrasse	6	3		5	3	3.4
<i>Stegastes leucostictus</i>	Beau Gregory		5	2	3	4	2.8
<i>Haemulon aurolineatum</i>	Tomtate	3	4		3		2.0
<i>Canthigaster rostrata</i>	Caribbean Puffer	1	1	1	2		1.0
<i>Gobiosoma evelynae</i>	Sharknose Goby		1	2		2	1.0
<i>Scarus iserti</i>	Striped Parrotfish	1		1	1	2	1.0
<i>Sparisoma radians</i>	Bucktooth Parrotfish	1			2	2	1.0
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	1	4				1.0
	Longspine						
<i>Flammeo marianus</i>	Squirrelfish	2	1		1		0.8
<i>Halichoeres garnoti</i>	Yellow-head Wrasse		2		1	1	0.8
<i>Scarus taeniopterus</i>	Princess Parrotfish		1	1		2	0.8
<i>Cephalopholis cruentatus</i>	Graysby	2	1				0.6
<i>Cephalopholis fulva</i>	Coney	1				2	0.6
<i>Chaetodon capistratus</i>	Four-eye Butterflyfish		2		1		0.6
<i>Chaetodon ocellatus</i>	Spotfin Butterflyfish			2			0.6
<i>Haemulon flavolineatum</i>	French Grunt	1		1		1	0.6
<i>Bodianus rufus</i>	Spanish Hogfish		2				0.4
<i>Holacanthus tricolor</i>	Rock Beauty	1		1			0.4
<i>Holocentrus rufus</i>	Squirrelfish		1	1			0.4
<i>Hypoplectrus chlorurus</i>	Yellowtail Hamlet	1		1			0.4
<i>Hypoplectrus puella</i>	Barred Hamlet				1	1	0.4
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish				1	1	0.4
<i>Acanthurus chirurgus</i>	Doctorfish					1	0.2
<i>Anisotremus virginicus</i>	Porkfish				1		0.2
<i>Carangoides ruber</i>	Bar Jack	1					0.2
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish				1		0.2
<i>Equetus lanceolatus</i>	Jackknife Fish				1		0.2
<i>Hypoplectrus unicolor</i>	Butter Hamlet	1					0.2
<i>Lactophrys polygonia</i>	Honeycomb Cowfish			1			0.2
<i>Malacoctenus sp.</i>	Blenny		1				0.2
<i>Priacanthus arenatus</i>	Glasseye			1			0.2
<i>Pseudupeneus maculatus</i>	Spotted Goatfish				1		0.2
<i>Sparisoma viride</i>	Stoplight Parrotfish	1					0.2
TOTAL INDIVIDUALS		198	253	173	153	96	174.6

Table 29. (continued)

	TOTAL SPECIES	20	20	18	21	18	19.4
Outside Transects:							
<i>Abudefduf sexatilis</i>	Sergeant Major						
<i>Acanthurus bahianus</i>	Ocean Surgeon						
<i>Acanthurus coeruleus</i>	Blue Tang						
<i>Aluterus sp.</i>	Filefish						
<i>Amblycirrhitus pinos</i>	Redspotted Hawkfish						
<i>Aulostomus maculatus</i>	Trumpetfish						
<i>Cantherhines pullus</i>	Tail-light Filefish						
<i>Canthidermis sufflamen</i>	Ocean Triggerfish						
<i>Caranx crysos</i>	Blue Runner						
<i>Caranx lugubris</i>	Black Jack						
<i>Chaetodon striatus</i>	Banded Butterflyfish						
<i>Chromis multilineata</i>	Brown Chromis						
<i>Coryphopterus glaucofraenum</i>	Bridled Goby						
<i>Coryphopterus sp1.</i>	Goby						
<i>Epinephelus adscensionis</i>	Rock Hind						
<i>Epinephelus guttatus</i>	Red Hind						
<i>Epinephelus sp.</i>	Coney						
<i>Equetus acuminatus</i>	Highhat						
<i>Gerres cinereus</i>	Yellowfin Mojarra						
<i>Gobiosoma saucrum</i>	Leopard Goby						
<i>Gymnothorax moringa</i>	Spotted Moray						
<i>Haemulon chrysargyreum</i>	Smallmouth Grunt						
<i>Haemulon macrostomum</i>	Spanish Grunt						
<i>Haemulon melanurum</i>	Cottonwick						
<i>Haemulon sciurus</i>	Bluestriped Grunt						
<i>Halichoeres maculipinna</i>	Clown Wrasse						
<i>Halichoeres radiatus</i>	Puddinwife						
<i>Holacanthus ciliaris</i>	Queen Angelfish						
<i>Holocentrus coruscus</i>	Reef Squirrelfish						
<i>Hypoplectrus guttavarius</i>	Shy Hamlet						
<i>Hypoplectrus nigricans</i>	Black Hamlet						
<i>Kyphosus sectatrix</i>	Bermuda Chub						
<i>Lactophrys triqueter</i>	Smooth Trunkfish						
<i>Liopropoma rubre</i>	Peppermint Bass						
<i>Lutjanus apodus</i>	Schoolmaster						
<i>Lutjanus mahogani</i>	Mahogani Snapper						
<i>Melichthys niger</i>	Black Durgon						
<i>Microspathodon chrysurus</i>	Yellowtail Damselfish						
<i>Mulloidides martinicus</i>	Yellowtail Goatfish						
<i>Ocyurus chrysurus</i>	Yellowtail Snapper						
<i>Odontoscion dentex</i>	Reef Croaker						
<i>Ophioblennius atlanticus</i>	Redlip Blenny						
<i>Paranthias furcifer</i>	Creole Fish						
<i>Scarus coeruleus</i>	Blue Parrotfish						
<i>Scarus vetula</i>	Queen Parrotfish						
<i>Scarus sp.</i>	Parrotfish						

Table 29. (continued)

<i>Scomberomorus regalis</i>	Cero Mackerel
<i>Serranus tigrinus</i>	Harlequin Bass
<i>Sphoeroides sp.</i>	Puffer
<i>Sphoeroides testudineus</i>	Checkered Puffer
<i>Sphyraena barracuda</i>	Great Barracuda
<i>Stegastes planifrons</i>	Yellow-eye Damselfish
<i>Synodus intermedius</i>	Sand Diver

Table 30. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at Tourmaline Shelf-edge Reef. July, 2005

Depth range : 25 - 32 m

Duration - 30 min.

SPECIES	COMMON NAME	# - (cm)	
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	2 - (25)	1 - (30)
<i>Mycteroperca venenosa</i>	Yellowfin Grouper	1 - (50)	
<i>Epinephelus guttatus</i>	Red Hind	1 - (30)	
<i>Scomberomorus regalis</i>	Cero Mackerel	1 - (60)	
Invertebrates			
<i>Panulirus argus</i>	Spiny Lobster	1 - (30)*	

Photo Album Tourmaline 30 m



Plate 38



Plate 39



Plate 40



Plate 41



Plate 42



Plate 43

2.0 Tourmaline Outer Shelf Reef – 20 m

2.1 Sessile-Benthic Reef Community

The Tourmaline outer shelf reef is separated from the shelf-edge by an irregular fringe of sandy-silt bottom. Submerged at a depth of 16 m, the reef extends down a narrow and abrupt slope to a depth of 21 m. A rugged and diffuse "spur-and-groove" formation of massive coral buildup is the main structural feature of the reef. The spurs are rather narrow (< 2 m) and rise from the sandy channels or grooves about 2 – 3 m. At the deeper edge of the reef, where the interface with the sandy bottom is reached, massive coral colonies have grown close together forming large coral promontories that partially mask the spur and groove pattern. Permanent transects were installed on top of consecutive spurs at a depth of 20 m. Panoramic views of Tourmaline outer shelf reef are presented in Photo Album 8.

A total of 20 stony corals and two black coral species (*Stichopathes lutkeni*, *Antipathes* sp.) were identified from the outer shelf reef, 15 of which were intercepted by line transects during our survey (Table 31). Stony corals occurred as massive (*Montastrea annularis* (complex), *Colpophyllia natans*, *Diploria labyrinthiformis*), branching (*Madracis* spp., *Porites porites*), encrusting (*Mycetophyllia* spp., *M. cavernosa*) and mound shaped colonies (*P. astreoides*, *M. cavernosa*, *Dichocoenia stokesii*). Substrate cover by stony corals along transects averaged 28.74 % (range: 19.64 – 39.4 %). Large and massive colonies of Boulder Star Coral (complex), *M. annularis* were the most prominent feature of the reef benthos. Boulder Star Coral was the dominant species in terms of substrate cover with a mean of 21.57 % (range: 12.84 - 34.5 %), representing 75 % of the total cover by stony corals. Colonies of Boulder Star Coral, Great Star Coral (*M. cavernosa*) and Mustard Hill Coral were intercepted by all five transects and along with Massive Starlet Coral (*Siderastrea siderea*) comprised the main stony coral assemblage.

Soft corals (gorgonians) were moderately abundant, with an average of 9.0 colonies/transect. Colonies of Bushy Black Coral (*Antipathes caribbeana*) were present at the reef base. Encrusting sponges and gorgonians (*Erythropodium caribaeorum*) were present, but represented minor components of the reef benthos (substrate cover < 2 %). Reef overhangs, associated with coral ledges of Boulder Star Coral averaged 25.68 % and contributed markedly to the topographic rugosity of 5.76 m.

Table 31. Percent substrate cover by sessile-benthic categories at 20m Tourmaline Reef, Mayaguez. July, 2005.

TRANSECTS						
	1	2	3	4	5	MEAN
Rugosity (m)	4.04	6.31	4.87	6.38	7.21	5.76
SUBSTRATE CATEGORIES						
TURF ALGAE	53.21	39.20	38.26	33.29	36.43	40.08
ABIOTIC						
Reef Overhangs	13.82	29.63	27.44	20.89	36.61	25.68
Sand				1.55		0.31
Gap			0.47		0.49	0.19
Total Abiotic	13.82	29.63	27.91	22.44	37.1	26.18
SPONGES	0.50	0.35	0.87	3.10	0.87	1.14
ENCRUSTING GORGONIAN	1.00	1.72	1.14	0.86	0.41	1.03
CORAL SPECIES						
<i>Montastrea annularis</i>	21.95	22.58	15.94	34.53	12.84	21.57
<i>Montastrea cavernosa</i>	3.49	0.60	4.17	1.04	2.86	2.43
<i>Siderastrea siderea</i>	1.20		0.94	1.72	1.55	1.08
<i>Porites astreoides</i>	0.20	0.95	2.62	0.34	1.06	1.03
<i>Madracis formosa</i>	2.91					0.58
<i>Colpophyllia natans</i>		1.81			0.82	0.53
<i>Diploria labyrinthiformis</i>			2.27			0.45
<i>Madracis decactis</i>		1.10		0.86		0.39
<i>Stephanocoenia michelini</i>	0.60					0.12
<i>Mycetophyllia lamarckiana</i>			0.57			0.11
<i>Meandrina meandrites</i>				0.52		0.10
<i>Agaricia lamarcki</i>					0.49	0.10
<i>Dichocoenia stokesii</i>			0.38			0.08
<i>Siderastrea radians</i>				0.34		0.07
<i>Agaricia agaricites</i>	0.30					0.06
TOTAL STONY CORAL	30.70	27.06	26.90	39.40	19.64	28.74
GORGONIANS (# col.)	9	16	9	4	6	9

Coral Species Outside Transects : *Eusmilia fastigiata*, *Acropora cervicornis*, *Diploria strigosa*, *Antipathes* sp, *Leptoseris cucullata*, *Stephanocoenia michelini*, *Scolymia cubensis*,

Turf algae, comprised by a mixed assemblage of short filamentous red and brown macroalgae was the dominant sessile-benthic component in terms of substrate cover at the outer shelf reef with an average of 40.08 % (range: 33.29 – 53.21 %). Turf algae was found overgrowing rocky substrates, as well as dead coral sections and other hard ground.

Figure 20 presents the variations of mean percent cover by sessile-benthic categories from the outer shelf reef off Tourmaline at 20 m depth. Differences of mean percent cover by sponges (+0.2 %) and benthic algae (-2.48 %) during the current 2005 monitoring survey were within 3 % of the baseline characterization values of 2004 (García-Sais et al., 2004). Such small differences at the community level were not statistically significant (ANOVA, $p > 0.05$). However, there was a decline of substrate cover by stony corals of 3.05 % which may be real. The decline was not statistically significant (ANOVA; $p > 0.05$), probably because the trend was not consistent in every transect. For example, coral cover at transects one and four remained virtually unchanged from 2004 baseline levels, but marked reductions were evidenced from transects two, three and five. Variations of the mean substrate cover by coral species between the current 2005 survey and the previous 2004 baseline survey (Figure 21) reveal that the decline of live coral cover was mostly driven by the dominant species, *Montastrea annularis* (complex).

3.2 Fishes and Motile Megabenthic Invertebrates-

A total of 93 fish species, including 41 within belt-transects were identified from Tourmaline outer shelf reef during our baseline characterization survey in June, 2005. Mean abundance within belt-transects was 313.8 Ind/30 m² (range: 198 - 444 Ind/30 m²). The mean number of species per transect was 24.8 (range: 20 - 29). Fish species richness decreased by 2.4 % and mean abundance increased by 62.8 % compared to the 2004 baseline survey (Table 3). The Masked Goby, *Coryphopterus personatus* was the numerically dominant species with a mean abundance of 182.2 Ind/30 m² (range: 86 – 300 Ind/30 m²), representing 62.0 % of the total abundance within belt-transects (Table 32). The Masked Goby is a small zooplanktivorous fish (< 2.0 cm) that was observed hovering in small to moderate aggregations below coral ledges and crevices near the sand-coral interface. The Masked, Sharpnose and Peppermint Gobies, Fairy Basslet, Bicolor Damselfish, Bluehead, Creole and Yellowhead Wrasses, Blue Chromis, Beaugregory, Black-bar Soldierfish, Caribbean Puffer and the Stoplight, Striped and Redband Parrotfishes were present in at least four of the five transects surveyed, and comprised the most abundant fish assemblage at the outer shelf reef.

The high reef rugosity with sand channels, crevices, large coral ledges and holes makes Tourmaline outer shelf reef an ideal habitat for large demersal fishes, such as snappers, groupers, hogfishes and others. It is almost surprising not to see them in the reef and the apparent cause for their absence is probably, that the reef was severely overfished during the last decades. Tourmaline outer reef has been identified as a Red Hind spawning aggregation site and since 1993 has been seasonally closed to fishing (December – February). The intense fishing effort over the last 20-30 years, however, has decimated the populations of commercially important fishes, conch and lobster. Clear signs of recuperation of the Red Hind population are not yet evident.

Small zooplanktivorous fishes, such as the Masked Goby, Blue Chromis, Bicolor Damselfish and micro-invertebrate predators, including wrasses, gobies, basslets, hamlets, and squirrelfishes numerically dominate the reef fish community. Parrotfishes (*Scarus spp.*, *Sparisoma spp.*), represented by seven species and doctorfishes (*Acanthurus spp.*), represented by three species comprised the main herbivorous fish assemblage. Among large invertebrate and small demersal fish predators, adult Nassau Grouper, Hogfish, Red Hinds, Cubera and Dog Snappers, Great Barracuda and Cero Mackerels were observed during an ASEC survey (Table 33). Also, several juvenile and adult Schoolmaster, Mahogany and Yellowtail Snappers were observed close to the reef-sand interface. Schools of Mackerel Scad, *Decapterus macarellus* were present in mid-water over the reef. These are zooplanktivores that serve as forage for pelagic predators, such as Cero Mackerels and Barracudas. One juvenile Spiny Lobster was observed within belt-transects (Table 34).

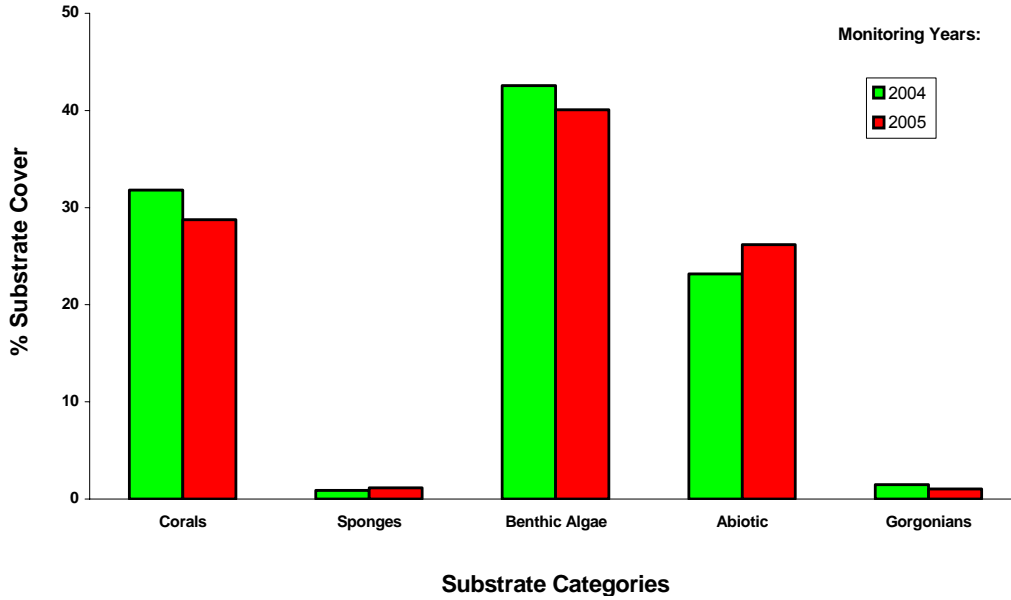


Figure 20. Monitoring trends of mean substrate sessile-benthic categories at Tourmaline Reef – 20 m, Mayaguez.

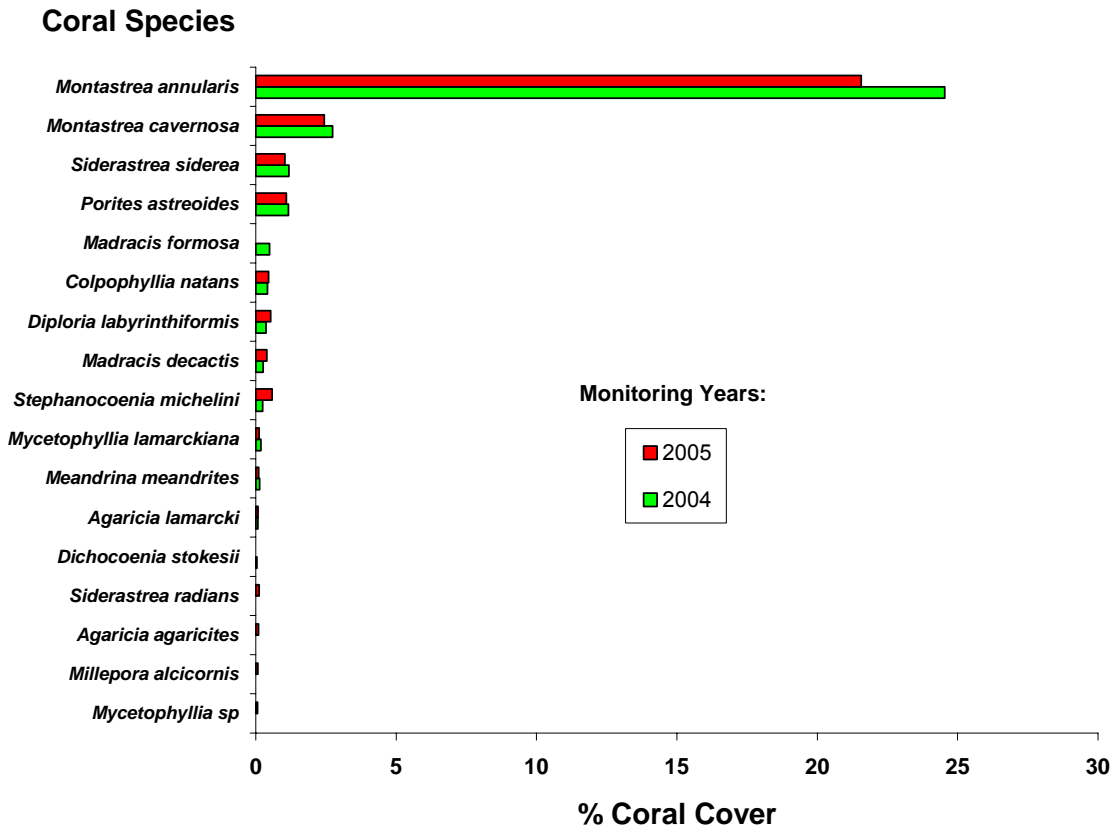


Figure 21. Monitoring trends of mean substrate cover by stony coral species at Tourmaline Reef – 20 m, Mayaguez.

Table 32. Taxonomic composition and abundance of fishes within belt-transects at Tourmaline Outer Shelf Reef , Mayaguez, June, 2005

Depth: 20m		TRANSECTS					MEAN
		1	2	3	4	5	
<i>SPECIES</i>	<i>COMMON NAME</i>	(individuals/30 m ²)					
<i>Coryphopterus personatus</i>	Masked Goby	140	86	300	125	260	182.2
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	31	11	34	50	12	27.6
<i>Coryphopterus lipernes</i>	Peppermint Goby	23	27	35	21	19	25.0
<i>Gramma loreto</i>	Fairy Basslet	13	18	15	14	18	15.6
<i>Stegastes partitus</i>	Bicolor Damsel	4	10	8	16	11	9.8
<i>Chromis cyanea</i>	Blue Chromis	10	3	10	11	10	8.8
<i>Gobiosoma evelynae</i>	Sharknose Goby	6	2	11	14	4	7.4
<i>Clepticus parrae</i>	Creole Wrasse	18	1	7	5	3	6.8
<i>Myripristis jacobus</i>	Blackbar Soldierfish		6	3	5	5	3.8
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	2	7	1	5	3	3.6
<i>Scarus iserti</i>	Stripped Parrotfish	3	6	2		7	3.6
<i>Stegastes leucostictus</i>	Beau Gregory	3	6	1	2	1	2.6
<i>Canthigaster rostrata</i>	Caribbean Puffer	3	2	3		2	2.0
<i>Sparisoma viride</i>	Stoplight Parrotfish		1	2	2	3	1.6
<i>Chaetodon capistratus</i>	Four-eye Butterflyfish	3	2			2	1.4
<i>Cephalopholis cruentatus</i>	Graysby		1	1	2	2	1.2
<i>Scarus taeniopterus</i>	Princess Parrotfish			3		2	1.0
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish	2		1	1		0.8
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	1	1	1		1	0.8
<i>Acanthurus bahianus</i>	Ocean Surgeon	1	1			1	0.6
<i>Acanthurus chirurgus</i>	Doctorfish			1		2	0.6
<i>Holacanthus tricolor</i>	Rock Beauty	1	1			1	0.6
<i>Hypoplectrus puella</i>	Barred Hamlet	1			1	1	0.6
<i>Mulloides martinicus</i>	Yellowtail Goatfish	1	1			1	0.6
<i>Acanthurus coeruleus</i>	Blue Tang				1	1	0.4
<i>Amblycirrhitus pinos</i>	Redspotted Hawkfish	1			1		0.4
<i>Anisotremus virginicus</i>	Porkfish	1		1			0.4
<i>Haemulon flavolineatum</i>	French Grunt		1			1	0.4
<i>Haemulon sciurus</i>	Bluestriped Grunt	1			1		0.4
<i>Hypoplectrus unicolor</i>	Halfbeak		2				0.4
<i>Lutjanus apodus</i>	Schoolmaster				1	1	0.4
<i>Synodus intermedius</i>	Sand Diver		1			1	0.4
<i>Aulostomus maculatus</i>	Trumpetfish			1			0.2
<i>Epinephelus adscensionis</i>	Rock Hind	1					0.2
<i>Flammeo marianus</i>	Longspine Squirrelfish			1			0.2
<i>Holocentrus rufus</i>	Squirrelfish	1					0.2
<i>Hypoplectrus chlorurus</i>	Yellowtail Hamlet				1		0.2
<i>Hypoplectrus nigricans</i>	Black Hamlet		1				0.2
<i>Lactophrys triqueter</i>	Smooth Trunkfish					1	0.2
<i>Priacanthus arenatus</i>	Glasseye					1	0.2

Table 32 (continued)

<i>Sparisoma radians</i>	Bucktooth Parrotfish	1					0.2
	TOTAL INDIVIDUALS	271	198	444	279	377	313.8
	TOTAL SPECIES	28	24	23	20	29	24.8

Outside Transects:

<i>Abudefduf sexatilis</i>	Sergeant Major
<i>Bodianus rufus</i>	Spanish Hogfish
<i>Cantherhines pullus</i>	Tail-light Filefish
<i>Canthidermis sufflamen</i>	Ocean Triggerfish
<i>Carangoides ruber</i>	Bar Jack
<i>Caranx crysos</i>	Blue Runner
<i>Caranx lugubris</i>	Black Jack
<i>Cephalopholis fulva</i>	Coney
<i>Chaetodon striatus</i>	Banded Butterflyfish
<i>Chromis multilineata</i>	Brown Chromis
<i>Coryphopterus glaucofraenum</i>	Bridled Goby
<i>Coryphopterus sp1.</i>	Goby
<i>Epinephelus guttatus</i>	Red Hind
<i>Equetus acuminatus</i>	Highhat
<i>Gerres cinereus</i>	Yellowfin Mojarra
<i>Gobiosoma saucrum</i>	Leopard Goby
<i>Gymnothorax moringa</i>	Spotted Moray
<i>Haemulon aurolineatum</i>	Tomtate
<i>Haemulon chrysargyreum</i>	Smallmouth Grunt
<i>Haemulon macrostomum</i>	Spanish Grunt
<i>Haemulon melanurum</i>	Cottonwick
<i>Halichoeres maculipinna</i>	Clown Wrasse
<i>Halichoeres radiatus</i>	Puddinwife
<i>Holacanthus ciliaris</i>	Queen Angelfish
<i>Holocentrus coruscus</i>	Reef Squirrelfish
<i>Hypoplectrus guttavarius</i>	Shy Hamlet
<i>Kyphosus sectatrix</i>	Bermuda Chub
<i>Lactophrys polygonia</i>	Honeycomb Cowfish
<i>Liopropoma rubre</i>	Peppermint Bass
<i>Lutjanus mahogani</i>	Mahogani Snapper
<i>Melichthys niger</i>	Black Durgon
<i>Microspathodon chrysurus</i>	Yellowtail Damselfish
<i>Ocyurus chrysurus</i>	Yellowtail Snapper
<i>Odontoscion dentex</i>	Reef Croaker
<i>Ophioblennius atlanticus</i>	Redlip Blenny
<i>Paranthias furcifer</i>	Creole Fish
<i>Pseudupeneus maculatus</i>	Spotted Goatfish
<i>Scarus coeruleus</i>	Blue Parrotfish
<i>Scarus vetula</i>	Queen Parrotfish
<i>Scarus sp.</i>	Parrotfish
<i>Scomberomorus regalis</i>	Cero Mackerel

Table 32. (continued)

<i>Serranus tigrinus</i>	Harlequin Bass
<i>Sphoeroides sp</i>	Marbled Puffer
<i>Sphoeroides testudineus</i>	Checkered Puffer
<i>Sphyraena barracuda</i>	Great Barracuda
<i>Stegastes planifrons</i>	Yellow-eye Damselfish

Table 33. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at Tourmaline Outer Shelf Reef. June, 2005

Depth range : 17 - 21 m

Duration - 30 min.

SPECIES	COMMON NAME	# - (cm)		
<i>Epinephelus guttatus</i>	Red Hind	1 - (25)		
<i>Epinephelus striatus</i>	Nassau Grouper	1 - (55)		
<i>Decapterus macarellus</i>	Mackerel Scad	200 - (15)		
<i>Lutjanus apodus</i>	Schoolmaster	1 - (35)	6 - (40)	
<i>Lutjanus cyanopterus</i>	Cubera Snapper	1 - (76)	1 - (86)	
<i>Lutjanus synagris</i>	Lane Snapper	3 - (20)	1 - (25)	1 - (30)
<i>Lutjanus jocu</i>	Dog Snapper	2 - (40)		
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	5 - (18)	2 - (30)	
<i>Scomberomorus regalis</i>	Cero Mackerel	3 - (40)	1 - (60)	
<i>Holacanthus tricolor</i>	Rock Beauty	1 - (15)	3 - (20)	2 - (25)
Invertebrates				
<i>Panulirus argus</i>	Spiny Lobster	1 - (30)*		

* Carapace length (cm)

Table 34. Taxonomic composition and abundance of motile megabenthic invertebrates from belt-transects at Tourmaline Outer Shelf Reef, Mayaguez. June, 2005

DATE: June, 2005

Depth: 20.0 m

TAXA	COMMON NAME	TRANSECTS					MEAN
							ABUNDANCE
							(IND/30 m2)
<i>Panulirus argus</i>	Spiny lobster			1			0.2
TOTALS		0	0	1	0	0	0.2

Photo Album Tourmaline 20 m



Plate 44



Plate 45



Plate 46



Plate 47



Plate 48



Plate 49

3.0 Tourmaline Outer Shelf Reef – 10 m

3.1 Sessile-benthic Reef Community

Tourmaline Outer Shelf Reef system at a depth of 10 m exhibited a very well defined “spur-and-groove” formation that runs perpendicular to the shelf-edge and ends in a sandy-silt deposit at a depth of 14 m. Spurs are about 2 - 3 m tall, separated by coralline sand and rubble deposited at the grooves. Stony corals grow on top of the spurs and along the walls in massive, branching and encrusting colonies. Soft corals are common and a visually prominent feature of the reef benthos. An existing set of five permanent transects established on top of the spurs during the baseline characterization in 1999 by García et al. (2001) were monitored during July, 2005. Panoramic views of El Tourmaline outer shelf reef at a depth of 10 m are presented in Photo Album 9.

A total of 24 stony coral species were identified from the Outer Shelf Reef at a depth of 10 m, 16 of which were intercepted by line transects during this survey (Table 35). Stony corals occurred as massive (*Montastrea annularis*, *Colpophyllia natans*, *Diploria labyrinthiformis*), branching (*Madracis* spp., *Porites porites*, *Acropora cervicornis*), encrusting (*Mycetophyllia* spp., *M. cavernosa*) and mound shaped colonies (*P. astreoides*, *M. cavernosa*, *Dichocoenia stokesii*). Substrate cover by stony corals along transects averaged 44.14 % (range: 31.77 - 70.33 %). Boulder Star Coral, *Montastrea annularis* (complex) was the dominant coral species in terms of substrate cover with a mean of 13.88 % (range: 8.58 – 18.82 %), representing 31.4 % of the total cover by stony corals. An extraordinarily large colony of Yellow Pencil Coral, *Madracis mirabilis* covered almost four meters along transect two, contributing to a total cover by stony corals of 70.3 %, which is our highest record of live coral cover for a 10 m transect in the 2005 coral reef monitoring survey. Colonies of Boulder and Great Star Corals (*Montastrea annularis*, *M. cavernosa*), Mustard Hill Coral (*Porites astreoides*), Lettuce Coral (*Agaricia agaricites*), and Finger Coral (*Porites porites*) were intercepted by all five transects.

Table 35. Percent substrate cover by sessile-benthic categories from El Tourmaline Outer Shelf Reef at a depth of 10 m. November, 2004

		TRANSECTS					MEAN
Rugosity (m)		1	2	3	4	5	
Rugosity (m)		3.54	3.56	4.59	4.35	3.78	3.96
SUBSTRATE CATEGORIES							
Benthic Algae							
	Turf Algae	41.73	21.67	44.32	52.54	56.1	43.27
	Calcareous Algae	0		0.96	0	0	0.19
	Total Benthic Algae	41.73	21.67	45.28	52.54	56.1	43.46
Abiotic							
	Reef Overhangs	7.16	3.76	8.22	9.69	6.83	7.13
	Coral Rubble	4.37	0	0	0	0	0.87
	Total Abiotic	11.53	3.76	8.22	9.69	6.83	8.01
	Total Zoanthids	0.52	0	0.58	1.39	0.72	0.64
	Total Sponges	0	0	0	0.98	0.8	0.36
Encrusting Gorgonians							
	<i>Erythropodium caribbaeorum</i>	2.73	3.24	1.37	3.62	5.09	3.21
Stony Corals							
	<i>Montastrea annularis</i>	13.44	18.82	17.07	8.58	11.47	13.88
	<i>Madracis mirabilis</i>		38.1				7.62
	<i>Porites porites</i>	14.99	1.77	4.66	4.67	4.93	6.20
	<i>Porites astreoides</i>	3.32	4.64	6.92	1.88	3.77	4.11
	<i>Agaricia agaricites</i>	1.55	1.99	3.5	4.95	4.5	3.30
	<i>Dendrogyra cylindrus</i>	4.99			7.27		2.45
	<i>Colpophyllia natans</i>	1.56	0.21	8.77			2.11
	<i>Montastrea cavernosa</i>	0.73	0.52	2.06	0.98	1.52	1.16
	<i>Meandrina meandrites</i>	1.7	0.96		2.16	0.41	1.05
	<i>Diploria labyrinthiformis</i>		1.87		0.79	1.84	0.90
	<i>Diploria strigosa</i>			1.26		1.02	0.46
	<i>Agaricia lamarcki</i>	0.31	0.62		0.49		0.28
	<i>Madracis decactis</i>	0.31				1.02	0.27
	<i>Acropora cervicornis</i>		0.83				0.17
	<i>Siderastrea radians</i>	0.59					0.12
	<i>Millepora alcicornis</i>	0	0	0.39	0	0	0.08
	Total Stony Corals	43.49	70.33	44.63	31.77	30.48	44.14
	Total Gorgonians (# col/transect)	25	14	15	15	12	16.2

Coral species outside transects: *Siderastrea sidereal*, *Manicina areolata*, *Mycetophyllia lamarkiana*, *Mycetophyllia sp.*, *Millepora squamosa*, *Leptoseria cucullata*, *Stephanocoenia mechelini*, *Diploria strigosa*

Soft corals (gorgonians) were highly abundant, with an average of 16.2 colonies/transect and along with stony corals were the most visually prominent assemblage of the reef benthos. Encrusting sponges, zoanthids (*Palythoa caribdea*) and gorgonians (*Erythropodium caribaeorum*) were present, but represented minor components of the reef benthos (substrate cover < 3 %). Reef overhangs, associated with coral ledges of Boulder Star Coral averaged 7.13 % and contributed markedly to the topographic rugosity of 3.96 m. Turf algae, comprised by a mixed assemblage of short filamentous red and brown macroalgae presented an average substrate cover of 43.27 % (range: 21.67 – 56.1 %). Turf algae was found overgrowing rocky substrates, as well as dead coral sections and other hard ground.

Figure 22 presents the variations of mean percent cover by sessile-benthic categories from the Tourmaline outer shelf reef at 10 m depth. There was a reduction of mean substrate cover by (total) stony corals of 4.96 % between last year's 2004 survey and the present 2005 survey. The difference was not statistically significant ($T= 1.28$, $p> 0.05$). Although the decline of coral cover was measured from all five transects surveyed, there was substantial variability associated with the magnitude of the variations within transects. Several species of stony corals shared the overall decline of live coral cover in the reef (Figure 23). The two dominant coral species Boulder Star Coral (*Montastrea annularis*) and Yellow Pencil Coral (*Madracis mirabilis*) present a consistent pattern of declining substrate cover since the baseline survey in 1999. Three species of corals intercepted by transects during the 2004 survey were not intercepted during the present 2005 survey. Although these were represented by small colonies and/or sections of colonies intercepted by the transect line, their absence suggests that the sampling variability at this reef may have been unusually high due to the prevailing strong surge at the time of the survey. The fact that these colonies were not present in the baseline 1999 survey supports the possibility that the chain path during the present 2005 survey may have been in error. This reef is also one of the most complex reefs in the monitoring program because of the high number of substrate transitions and the presence of large, irregular coral colonies (e.g. *Dendrogyra cylindrus*) and extensive zones of fragile branching corals (*M. mirabilis*), where the chain path can not be properly marked for precise repeated measurements of substrate cover.

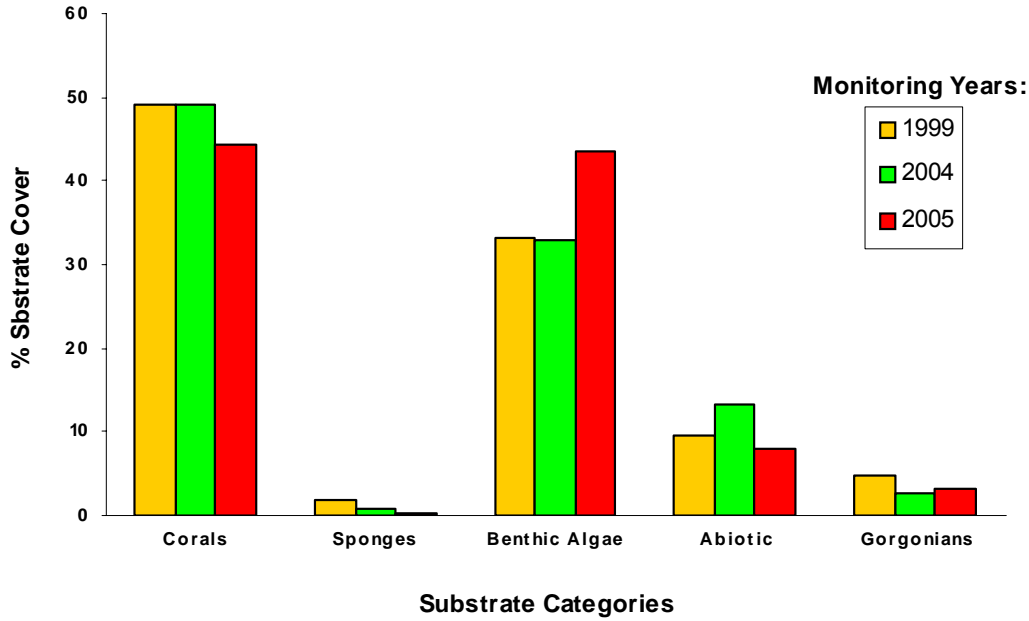


Figure 22. Monitoring trends of mean substrate sessile-benthic categories at Tourmaline Reef – 10 m, Mayaguez.

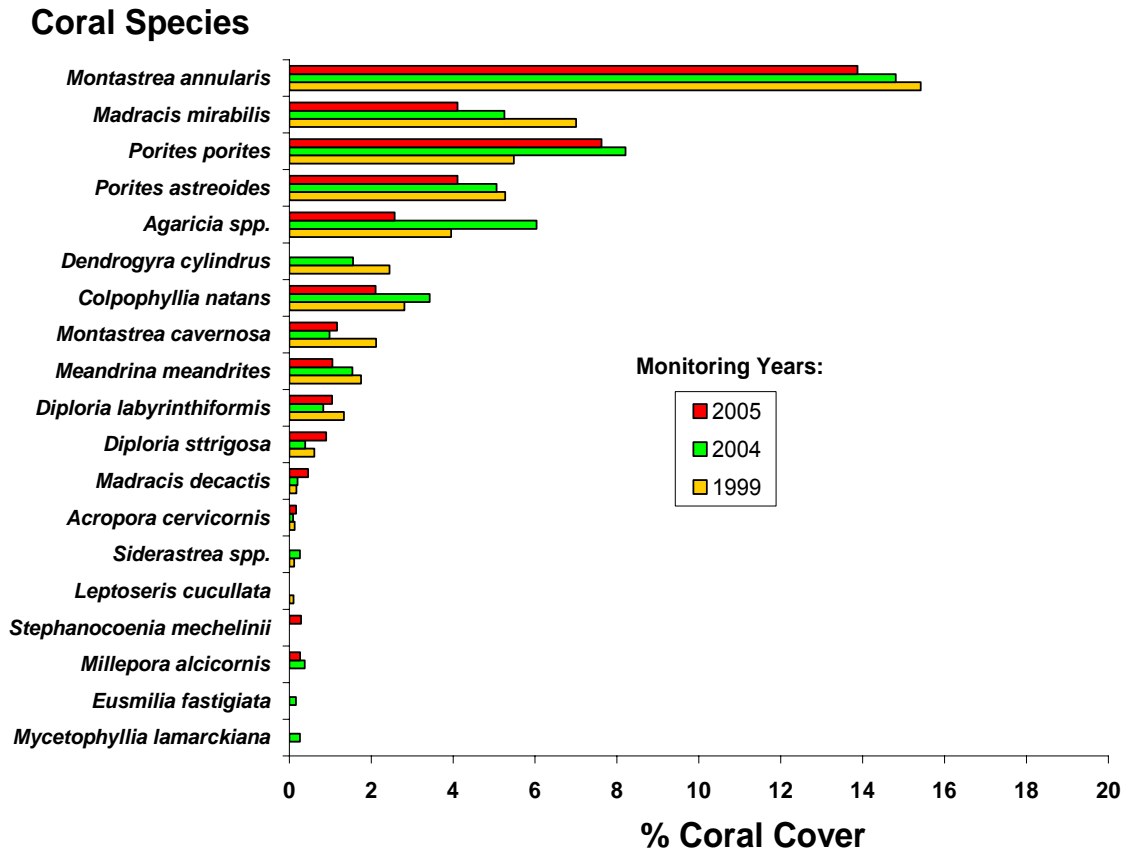


Figure 23. Monitoring trends of mean cover by stony coral species at Tourmaline Reef – 15 m, Mayaguez.

3.2 Fishes and Motile Megabenthic Invertebrates

A total of 89 fish species, including 49 within belt-transects were identified from Tourmaline Outer Shelf Reef at a depth of 10 m during our monitoring survey in July, 2005. Mean abundance within belt-transects was 101.8 Ind/30 m² (range: 73 - 119 Ind/30 m²). The mean number of species per transect was 25 (range: 23 - 28). Fish species richness increased by 12.0 % and mean abundance increased by 4.5 % compared to the 1999 baseline survey (Table 3). The Blue Chromis (*Chromis cyanea*), Bluehead Wrasse (*Thalassoma bifasciatum*) and the Bicolor Damsel fish (*Stegastes partitus*) were the numerically dominant species with a combined mean abundance of 42.4 Ind/30 m², representing 41.6 % of the total abundance within belt-transects (Table 36). The Blue Chromis is a well known zooplanktivores that swims in schools close to the reef benthos. The Bluehead Wrasse is an opportunistic carnivore that feeds upon small benthic invertebrates. The Peppermint Goby, Beaugregory and Bicolor Damsel fishes, Bluehead and Yellowhead Wrasses, Redband Parrotfish, Black-bar Soldierfish and Blue Chromis were present within all five transects surveyed, and along with schooling Creole Wrasse, Sharknose Goby and Striped Parrotfish comprised the most abundant fish assemblage from the outer shelf reef at a depth of 10 m.

Small, opportunistic micro-invertebrate predators (wrasses, gobies, basslets, and squirrelfishes), demersal and pelagic schooling zooplanktivores (Bicolor Damsel fish, Blue Chromis, Creole Wrasse, Mackerel Scad) and herbivores (*Scarus spp.*, *Sparisoma spp.*, *Acanthurus spp.*) numerically dominated the reef fish community. Among large invertebrate and small demersal fish predators, small growing groupers such as Coneys and Graysbys were common. Adult Red Hind, Schoolmaster, Mahogany and Yellowtail Snappers represented top demersal predators observed during an ASEC survey at this reef (Table 37). Schools of Mackerel Scad, *Decapterus macarellus* were present in mid-water over the reef. Pelagic predators included the King and Cero Mackerels, Great Barracuda and Blue Runner.

As in deeper zones of Tourmaline outer shelf reef, the high rugosity with sand channels, crevices, large coral ledges and holes makes this reef an ideal habitat for large demersal fishes, such as snappers, groupers, hogfishes and others. Their occurrence in very low abundance may be related to the intense fishing pressure that this reef has experienced

over the last 20-30 years, since the seasonal spawning aggregations of Red Hind were detected by local fishermen. El Tourmaline outer reef has been seasonally (December – February) closed to fishing since 1993 to protect the declining Red Hind stock, but an intense fishing effort for finfish, lobster and conch with fish traps and SCUBA is still ongoing during the open fishing season. Although our fish surveys have been performed previous to the group spawning aggregation from December to February, the relatively low abundance of Red Hinds evidenced during our surveys in 1999, 2004 and the present survey appear to be an indication that this fish population has not recovered from the intense fishing effort that it received during the previous decade.

No motile megabenthic invertebrates were present within belt-transects. One small Spiny Lobster, *Panulirus argus* was observed outside transects during the ASEC survey.

Table 36. Taxonomic composition and abundance of fishes within belt-transects at the Tourmaline Outer Shelf Reef at 20 m, Mayaguez, July, 2005

Depth: 10m

SPECIES	COMMON NAME						MEAN
		1	2	3	4	5	
<i>Chromis cyanea</i>	Blue Chromis	23	30	10	9	5	15.4
<i>Stegastes partitus</i>	Bicolor Damselfish	12	26	17	11	9	15.0
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	7	10	6	34	3	12.0
<i>Clepticus parrae</i>	Creole Wrasse		13	15	6	11	9.0
<i>Gobiosoma evelynae</i>	Sharknose Goby		2	18	6		5.2
<i>Stegastes leucostictus</i>	Beau Gregory	4	4	5	4	5	4.4
<i>Scarus iserti</i>	Stripped Parrotfish	3		11		6	4.0
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	6	1	3	4	3	3.4
<i>Scarus taeniopterus</i>	Princess Parrotfish		2		8	5	3.0
<i>Sparisoma viride</i>	Stoplight Parrotfish	3		1	6	3	2.6
<i>Gramma loreto</i>	Fairy Basslet	3	3		5		2.2
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	4	1	1	4	1	2.2
<i>Sparisoma radians</i>	Bucktooth Parrotfish	7	1			3	2.2
<i>Coryphopterus lipernes</i>	Peppermint Goby	1	1	2	2	3	1.8
<i>Haemulon flavolineatum</i>	French Grunt	1	3	1	4		1.8
<i>Acanthurus bahianus</i>	Ocean Surgeon	3	1	1		2	1.4
<i>Canthigaster rostrata</i>	Caribbean Puffer	1	2	1	1	2	1.4
<i>Myripristis jacobus</i>	Blackbar Soldierfish		1	2	3	1	1.4
<i>Acanthurus coeruleus</i>	Blue Tang	1	2	1		1	1.0
<i>Chaetodon capistratus</i>	Four-eye Butterflyfish		2	1	2		1.0
<i>Amblycirrhitis pinos</i>	Redspotted Hawkfish			1		3	0.8
<i>Aulostomus maculatus</i>	Trumpetfish	1	2		1		0.8
<i>Cephalopholis cruentatus</i>	Graysby	1	3				0.8
<i>Serranus tigrinus</i>	Harlequin Bass	1	1	1	1		0.8
<i>Stegastes planifrons</i>	Yellow-eye Damselfish	2	2				0.8
<i>Flammeo marianus</i>	Longspine Squirrelfish		2		1		0.6
<i>Gobiosoma saucrum</i>	Leopard Goby	3					0.6
<i>Haemulon chrysargyreum</i>	Smallmouth Grunt			1	2		0.6
<i>Caranx crysos</i>	Blue Runner	2					0.4
<i>Cephalopholis fulva</i>	Coney		1	1			0.4
<i>Hypoplectrus unicolor</i>	Butter Hamlet		1			1	0.4
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	1				1	0.4
<i>Scarus vetula</i>	Queen Parrotfish					2	0.4
<i>Acanthurus chirurgus</i>	Doctorfish	1					0.2
<i>Anisotremus virginicus</i>	Porkfish				1		0.2
<i>Cantherhines pullus</i>	Whitespotted Filefish			1			0.2
<i>Epinephelus guttatus</i>	Red Hind	1					0.2
<i>Equetus acuminatus</i>	Highhat				1		0.2
<i>Haemulon melanurum</i>	Cottonwick				1		0.2
<i>Holacanthus tricolor</i>	Rock Beauty		1				0.2
<i>Holocentrus coruscus</i>	Reef Squirrelfish	1					0.2
<i>Holocentrus rufus</i>	Squirrelfish	1					0.2

Table 36. (continued)

<i>Hypoplectrus puella</i>	Barred Hamlet	1					0.2
<i>Lutjanus apodus</i>	Schoolmaster			1			0.2
<i>Ophioblennius atlanticus</i>	Redlip Blenny				1		0.2
<i>Scarus sp.</i>	Parrotfish	1					0.2
<i>Sphoeroides testudineus</i>	Checked Puffer					1	0.2
<i>Sphyraena barracuda</i>	Great Barracuda		1				0.2
<i>Synodus intermedius</i>	Sand Diver					1	0.2
	TOTAL INDIVIDUALS	97	119	102	118	73	509
	TOTAL SPECIES	28	27	23	24	23	25.0

Outside Transects:

<i>Abudefduf sexatilis</i>	Sergeant Major						
<i>Aluterus sp.</i>	Filefish						
<i>Bodianus rufus</i>	Spanish Hogfish						
<i>Canthidermis sufflamen</i>	Ocean Triggerfish						
<i>Carangoides ruber</i>	Bar Jack						
<i>Caranx lugubris</i>	Black Jack						
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish						
<i>Chaetodon striatus</i>	Banded Butterflyfish						
<i>Chromis multilineata</i>	Brown Chromis						
<i>Coryphopterus glaucofraenum</i>	Bridled Goby						
<i>Coryphopterus personatus</i>	Masked Goby						
<i>Coryphopterus sp1.</i>	Goby						
<i>Epinephelus sp.</i>	Coney						
<i>Gerres cinereus</i>	Yellowfin Mojarra						
<i>Gymnothorax moringa</i>	Spotted Moray						
<i>Haemulon aurolineatum</i>	Tomtate						
<i>Haemulon macrostomum</i>	Spanish Grunt						
<i>Haemulon sciurus</i>	Bluestriped Grunt						
<i>Halichoeres maculipinna</i>	Clown Wrasse						
<i>Halichoeres radiatus</i>	Puddinwife						
<i>Holacanthus ciliaris</i>	Queen Angelfish						
<i>Hypoplectrus chlorurus</i>	Yellowtail Hamlet						
<i>Hypoplectrus guttavarius</i>	Shy Hamlet						
<i>Hypoplectrus nigricans</i>	Black Hamlet						
<i>Kyphosus sectatrix</i>	Bermuda Chub						
<i>Lactophrys polygonia</i>	Honeycomb Cowfish						
<i>Lactophrys triqueter</i>	Smooth Trunkfish						
<i>Liopropoma rubre</i>	Peppermint Bass						
<i>Lutjanus mahogani</i>	Mahogani Snapper						
<i>Melichthys niger</i>	Black Durgon						
<i>Microspathodon chrysurus</i>	Yellowtail Damselfish						
<i>Mulloides martinicus</i>	Yellowtail Goatfish						
<i>Odontoscion dentex</i>	Reef Croaker						
<i>Paranthias furcifer</i>	Creole Fish						
<i>Priacanthus arenatus</i>	Glasseye						
<i>Pseudupeneus maculatus</i>	Spotted Goatfish						
<i>Scarus coeruleus</i>	Blue Parrotfish						
<i>Scomberomorus regalis</i>	Cero Mackerel						

Table 37. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at Tourmaline Outer Shelf Reef - 10 m. July, 2005

Depth range : 10 - 13 m

Duration - 30 min.

SPECIES	COMMON NAME	# - (cm)		
<i>Carangoides crysos</i>	Blue Runner	1 - (30)	1 - (40)	
<i>Epinephelus guttatus</i>	Red Hind	1 - (30)		
<i>Lutjanus apodus</i>	Schoolmaster	2 - (20)	5 - (30)	2 - (40)
<i>Lutjanus synagris</i>	Lane Snapper	2 - (15)	3 - (20)	1 - (25)
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	1 - (15)		
<i>Scomberomorus regalis</i>	Cero Mackerel	1 - (60)		
<i>Sphyaena barracuda</i>	Great Barracuda	1 - (60)		
<i>Holacanthus tricolor</i>	Rock Beauty	1 - (25)	1 - (17)	
Invertebrates				
<i>Panulirus argus</i>	Spiny Lobster	1 - (25)*		

* Carapace length (cm)

Photo Album Tourmaline 10 m



Plate 50



Plate 51



Plate 52



Plate 53



Plate 54



Plate 55

D. Cayo Coral – Guánica Natural Reserve

Guánica is located on the southwest coast of Puerto Rico. The marine section of the Natural Reserve extends 8.9 kilometers along the coastline from the eastern corner of Guánica Bay in the east, almost to Punta Ventana in the west, and approximately 1.6 kilometers offshore from Punta Jacinto. There is a deep submarine canyon associated with Guánica Bay that cuts through the insular shelf and extends easterly towards the shelf-edge.

Cayo Coral is an emergent reef located to the west of Cayos de Caña Gorda, between Punta Ballena and the mouth of Guánica Bay (Figure 24). The reef is about two kilometers long and sits in the same platform as Caña Gorda Reef, 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. Our survey was performed on an existing set of five permanent transects at a depth of 7 - 8 meters close to the base of Cayo Coral's fore reef. Panoramic views of Cayo Coral are presented as Photo Album 10.

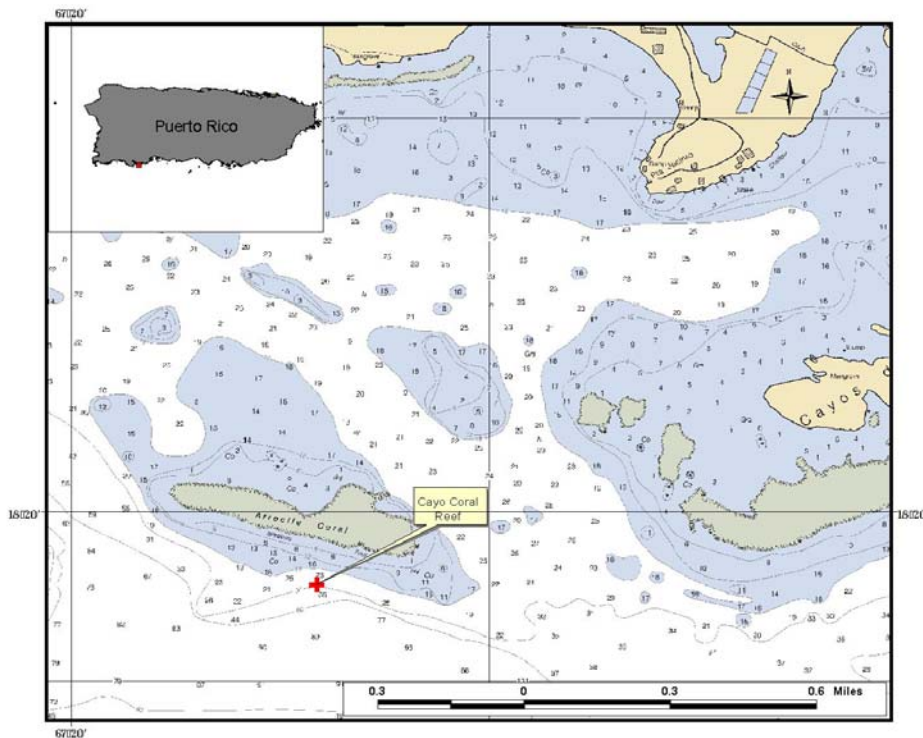


Figure 24. Location of coral reef survey stations at Cayo Coral Reef, Guánica.

1.0 Sessile-benthic Reef Community

A total of 22 stony corals, including 14 intersected by line transects were identified from Cayo Coral Reef. Stony corals occurred as massive, encrusting and mound shaped colonies. Substrate cover by stony corals along transects averaged 14.47 % (range: 9.85 – 20.32 %). Boulder Star Coral, *Montastrea annularis* (complex) was the dominant species in terms of substrate cover with a mean of 6.50% (range: 3.16 - 14.95 %), representing 44.9 % of the total cover by stony corals (Table 38). It was the only species of coral present in the five transects surveyed. Boulder Brain Coral (*Colpophyllia natans*) and Great Star Coral (*M. cavernosa*) were present in four transects and ranked second and third in terms of substrate cover at Cayo Coral. Small colonies of Mustard-Hill Coral, *Porites astreoides* and Lettuce Coral, *Agaricia spp.* were also common. Soft corals (gorgonians) were highly abundant, with an average of 22 colonies/transect, and along with stony corals contributed to the reef high benthic habitat complexity. Small sponges and patches of colonial zoanthids (*Palythoa caribdea*) represented minor components of the reef benthos with a combined substrate cover of 2.47 %. Reef overhangs associated with growth of massive Boulder Star Coral colonies averaged 11.43 m and contributed substantially to the mean rugosity of 2.84 m.

Benthic algae, comprised by turf, calcareous and fleshy macroalgae were the most prominent sessile-benthic category in terms of substrate cover with a mean of 65.65 %. Turf algae was the dominant assemblage, representing almost 95 % of the total cover by benthic algae at Cayo Coral (Table 38).

Figure 25 presents the variations of mean percent cover by sessile-benthic categories from Cayo Coral between the original baseline survey in 1999 and the present 2005 survey. Differences of mean total percent cover by stony corals (-10.03 %) were statistically significant ($T=2.35$; $p < 0.05$), and constitute evidence of a drastic degradation of the coral reef community structure. The reduction of 10 % of mean substrate cover represents a decline of approximately 41 % in total live coral cover at Cayo Coral. The reduction of live coral cover was consistent across the five permanent transects. A corresponding increment of cover by benthic algae was measured. Variations of the mean substrate cover by coral species between 1999 baseline survey and the current 2005 survey are shown in Figure 26. Marked reductions of the mean

Table 38. Percent substrate cover by sessile-benthic categories at Cayo Coral, Guánica
 . May, 2005

	TRANSECTS					MEAN
	1	2	3	4	5	
Rugosity (m)	1.51	4.58	2.48	3.2	2.45	2.84
SUBSTRATE CATEGORIES						
TURF ALGAE	74.80	59.05	77.90	51.30	53.30	63.27
ABIOTIC						
Reef Overhangs	4.78	17.22	4.88	16.70	13.59	11.43
Sand				14.80	10.19	5.00
ZOANTHIDS	0.49	1.03	2.96	2.40	1.45	1.67
CALCAREOUS ALGAE	1.22	1.44	2.96	1.10	3.38	2.02
SPONGES	0.96		1.44	0.80	0.80	0.80
FLESHY ALGAE	1.22			0.60		0.36
ANTHOZOANS		0.77				0.15
CORAL SPECIES						
<i>Montastrea annularis</i>	4.78	6.45	3.16	3.18	14.95	6.50
<i>Colpophyllia natans</i>	3.43	1.17	3.04	4.62		2.45
<i>Montastrea cavernosa</i>	0.61	4.05	2.48	1.07		1.64
<i>Porites astreoides</i>	3.65	2.06				1.14
<i>Eusmilia fastigiata</i>	3.09					0.62
<i>Siderastrea siderea</i>	0.98	1.16				0.43
<i>Agaricia agaricites</i>	1.13		0.56		0.34	0.41
<i>Siderastrea radians</i>	0.86	0.68				0.31
<i>Agaricia grahame</i>				1.28		0.26
<i>Diploria strigosa</i>		0.89				0.18
<i>Dichocoenia stokesii</i>					0.68	0.14
<i>Isophyllia sinuosa</i>					0.68	0.14
<i>Meandrina meandrites</i>			0.56			0.11
<i>Millepora alcicornis</i>					0.23	0.05
TOTAL STONY CORAL	15.38	19.55	9.85	10.2	16.87	14.37
GORGONIANS (# col.)	17	25	29	21	18	22

Coral Species Outside Transects: *Acropora. cervicornis*, *Agaricia. lamarki*, *Diploria. labyrinthiformis*, *Leptoseris. cucullata*, *Madracis. decactis*, *Porites. astreoides*, *P.porites*, *Stephanocoenia. michilini*

percent substrate cover resulted for *Montastrea annularis* (-3.99 %), *M. cavernosa* (-1.56 %), *Meandrina meandrites* (-1.34 %), *Porites astreoides* (- 1.27 %), and *Colpophyllia natans* (-0.88 %). The density of soft coral (gorgonian) colonies remained virtually constant (22/23) between both surveys.

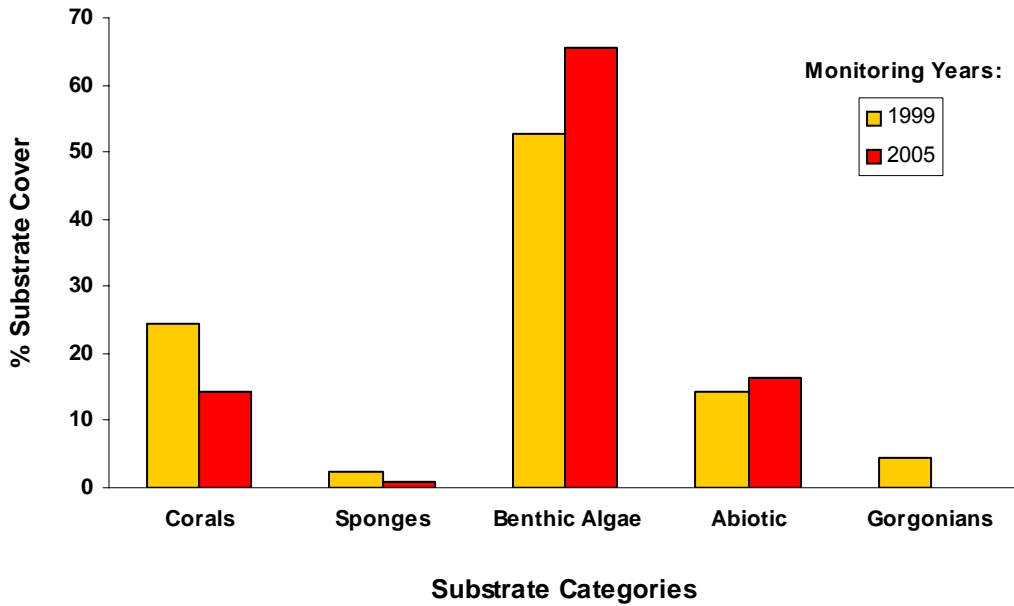


Figure 25. Monitoring trends of mean substrate sessile-benthic categories at Cayo Coral Reef, Guanica.

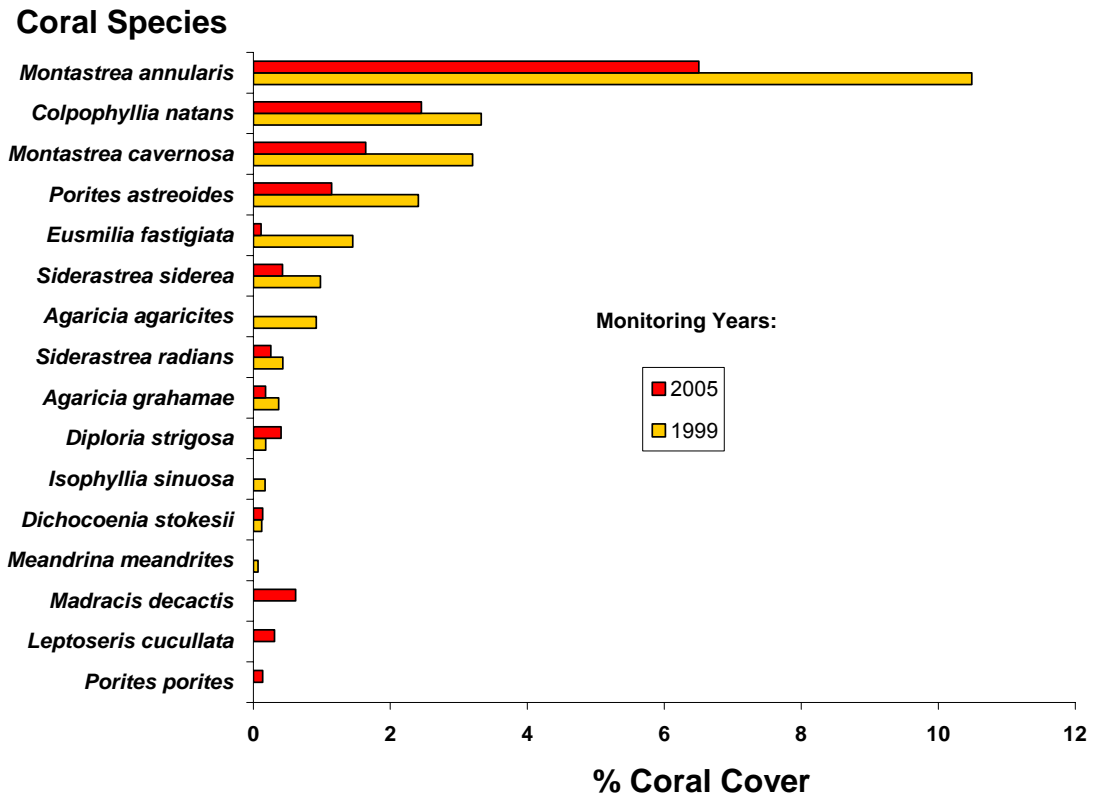


Figure 26. Monitoring trends of mean cover by stony coral species at Tourmaline Reef Cayo Coral Reef, Guanica.

2.0 Fishes and Motile Megabenthic Invertebrates

A total of 79 fish species, including 48 within belt-transects were identified from Cayo Coral at a depth of seven (7) m during our monitoring survey in June, 2005 (Table 39). Mean abundance within belt-transects was 84.6 Ind/30 m² (range: 56 - 167 Ind/30 m²). The mean number of species per transect was 26.4 (range: 23 - 33). Fish species richness increased by 43.1 % and mean abundance increased by 68.3 % compared to the 1999 baseline survey (Table 3). The Bluehead Wrasse (*Thalassoma bifasciatum*), Blue Chromis (*Chromis cyanea*), Sharknose Goby (*Gobiosoma evelynae*), Striped Parrotfish (*Scarus iserti*), and the Bicolor Damsel

Stegastes partitus) were the numerically dominant species with a combined mean abundance of 49.6 Ind/30 m², representing 58.6 % of the total abundance within belt-transects (Table 39). A total of nine species were present in all five transects surveyed, whereas other nine species were present in four transects.

Small, opportunistic micro-invertebrate predators (wrasses, gobies, basslets, and squirrelfishes), demersal and pelagic schooling zooplanktivores (Bicolor Damsel, Blue Chromis, Creole Wrasse) and herbivores (*Scarus spp.*, *Sparisoma spp.*, *Acanthurus spp.*) numerically dominated the reef fish community. Among large invertebrate and small demersal fish predators, small growing groupers such as Coneys and Graysbys were common. Adult Red Hind, Nassau and Yellowfin Groupers, Hogfish, Schoolmaster, Mahogany and Yellowtail Snappers represented top demersal predators observed during an ASEC survey at Cayo Coral (Table 40). Pelagic predators included Cero Mackerels, Great Barracuda and Blue Runner. Cleaner and Banded Coral Shrimps, and the Flamingo Tongue were the motile megabenthic invertebrates observed within belt-transects (Table 41).

Table 39. Taxonomic composition and abundance of fishes within belt-transects at Cayo Coral-Guánica, May, 2005

Depth: 7 m

SPECIES	COMMON NAME	TRANSECTS					MEAN
		1	2	3	4	5	
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	6	5	56	9	17	18.6
<i>Chromis cyanea</i>	Blue Chromis	5		56		3	12.8
<i>Gobiosoma evelynae</i>	Sharknose Goby	10	7	9	2	6	6.8
<i>Scarus iserti</i>	Stripped Parrotfish	7	10		11	5	6.6
<i>Stegastes partitus</i>	Bicolor Damselfish	2	2	2	4	14	4.8
<i>Stegastes dorsopunicans</i>	Dusky Damselfish	5	5	4	3	4	4.2
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	2	1	1	3	4	2.2
<i>Sparisoma radians</i>	Bucktooth Parrotfish		1	6		4	2.2
<i>Sparisoma viride</i>	Stoplight Parrotfish	1	1	3	3	3	2.2
<i>Acanthurus bahianus</i>	Ocean Surgeon	1		1	5		1.4
<i>Canthigaster rostrata</i>	Caribbean Puffer	1	1	2		3	1.4
<i>Cephalopholis cruentatus</i>	Graysby	1	2	1	2		1.2
<i>Chaetodon capistratus</i>	Four-eye Butterflyfish		3	1		2	1.2
<i>Microspathodon chrysurus</i>	Yellowtail Damselfish	1	1	1	2	1	1.2
<i>Stegastes leucostictus</i>	Beau Gregory		2		1	3	1.2
<i>Stegastes planifrons</i>	Yellow-eye Damselfish	1	3	2			1.2
<i>Acanthurus coeruleus</i>	Blue Tang	1	1	1	1	1	1.0
<i>Coryphopterus glaucofraenum</i>	Bridled Goby	1	1	1	1	1	1.0
<i>Coryphopterus lipernes</i>	Peppermint Goby		5				1.0
<i>Coryphopterus sp1.</i>	Goby	1		2	1	1	1.0
<i>Haemulon flavolineatum</i>	French Grunt		1	1	1	2	1.0
<i>Halichoeres garnoti</i>	Yellow-head Wrasse		1	2	1	1	1.0
<i>Holocentrus rufus</i>	Squirrelfish		1	1	1	1	0.8
<i>Serranus tigrinus</i>	Harlequin Bass	1		1	1	1	0.8
<i>Lutjanus apodus</i>	Schoolmaster			1	2		0.6
<i>Scarus vetula</i>	Queen Parrotfish		1	1		1	0.6
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	1		1	1		0.6
<i>Acanthurus chirurgus</i>	Doctorfish			2			0.4
<i>Aulostomus maculatus</i>	Trumpetfish	1				1	0.4
<i>Chaetodon striatus</i>	Banded Butterflyfish	1			1		0.4
<i>Gobiosoma saucrum</i>	Leopard Goby		1	1			0.4
<i>Gymnothorax moringa</i>	Spotted Moray	1		1			0.4
<i>Hypoplectrus unicolor</i>	Butter Hamlet	1	1				0.4
<i>Pseudupeneus maculatus</i>	Spotted Goatfish	1	1				0.4
<i>Scarus coeruleus</i>	Blue Parrotfish	1		1			0.4
<i>Scarus taeniopterus</i>	Princess Parrotfish				2		0.4
<i>Abudefduf sexatilis</i>	Sergeant Major			1			0.2
<i>Amblycirrhitus pinos</i>	Redspotted Hawkfish			1			0.2
<i>Anisotremus virginicus</i>	Porkfish	1					0.2
<i>Cantherhines pullus</i>	Tail-light Filefish			1			0.2
<i>Gramma loreto</i>	Fairy Basslet				1		0.2

Table 39. (continued)

<i>Haemulon sciurus</i>	Bluestriped Grunt					1	0.2
<i>Holacanthus ciliaris</i>	Queen Angelfish					1	0.2
<i>Hypoplectrus nigricans</i>	Black Hamlet		1				0.2
<i>Hypoplectrus puella</i>	Barred Hamlet	1					0.2
<i>Mulloides martinicus</i>	Yellowtail Goatfish					1	0.2
<i>Odontoscion dentex</i>	Reef Croaker			1			0.2
<i>Priacanthus arenatus</i>	Glasseye			1			0.2
TOTAL INDIVIDUALS		56	59	167	59	82	84.6
TOTAL SPECIES		26	25	33	23	25	26.4

Outside transects:

<i>Aluterus sp.</i>	Filefish
<i>Bodianus rufus</i>	Spanish Hogfish
<i>Canthidermis sufflamen</i>	Ocean Triggerfish
<i>Carangoides ruber</i>	Bar Jack
<i>Caranx crysos</i>	Blue Runner
<i>Caranx lugubris</i>	Black Jack
<i>Cephalopholis fulva</i>	Coney
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish
<i>Chromis multilineata</i>	Brown Chromis
<i>Clepticus parrae</i>	Creole Wrasse
<i>Coryphopterus personatus</i>	Masked Goby
<i>Epinephelus sp.</i>	Coney
<i>Equetus acuminatus</i>	Highhat
<i>Flammeo marianus</i>	Longspine Squirrelfish
<i>Gerres cinereus</i>	Yellowfin Mojarra
<i>Haemulon aurolineatum</i>	Tomtate
<i>Haemulon macrostomum</i>	Spanish Grunt
<i>Halichoeres maculipinna</i>	Clown Wrasse
<i>Halichoeres radiatus</i>	Puddinwife
<i>Holacanthus tricolor</i>	Rock Beauty
<i>Hypoplectrus chlorurus</i>	Yellowtail Hamlet
<i>Hypoplectrus guttavarius</i>	Shy Hamlet
<i>Kyphosus sectatrix</i>	Bermuda Chub
<i>Lactophrys polygonia</i>	Honeycomb Cowfish
<i>Lactophrys triqueter</i>	Smooth Trunkfish
<i>Liopropoma rubre</i>	Peppermint Bass
<i>Lutjanus mahogani</i>	Mahogani Snapper
<i>Melichthys niger</i>	Black Durgon
<i>Myripristis jacobus</i>	Blackbar Soldierfish
<i>Paranthias furcifer</i>	Creole Fish
<i>Scomberomorus regalis</i>	Cero Mackerel

Table 40. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at Cayo Coral. Guánica. May, 2005

Depth range : 10 - 13 m
Duration - 30 min.

SPECIES	COMMON NAME	# - (cm)		
<i>Carangoides crysos</i>	Blue Runner	1 - (30)		
<i>Epinephelus guttatus</i>	Red Hind	1 - (25)		
<i>Epinephelus striatus</i>	Nassau Grouper	1 - (40)		
<i>Lutjanus apodus</i>	Schoolmaster	5 - (25)	19 - (30)	2 - (35)
<i>Lutjanus mahogany</i>	Mahogany Snapper	1 - (15)	2 - (20)	2 - (25)
<i>Lutjanus synagris</i>	Lane Snapper	2 - (15)	3 - (20)	1 - (25)
<i>Mycteroperca venenosa</i>	Yellowfin Grouper	1 - (45)		
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	1 - (15)	1 - (25)	
<i>Scomberomorus regalis</i>	Cero Mackerel	2 - (40)		
<i>Sphyaena barracuda</i>	Great Barracuda	1 - (50)		
<i>Holacanthus ciliaris</i>	French Angel	1 - (25)		

Table 41. Taxonomic composition and abundance of motile megabenthic invertebrates from belt-transects at Cayo Coral. Guánica. May, 2005

DATE: May, 2005
Depth: 7.0 m

TAXA	COMMON NAME	TRANSECTS					MEAN ABUNDANCE (IND/30 m2)
		1	2	3	4	5	
Periclimenes pedersoni	Cleaner shrimp	1	3	1			1.0
<i>Stenopus hispidus</i>	Banded coral shrimp		1	1			0.4
<i>Cyphoma gibbosum</i>	Flamingo tongue			1			0.2
	TOTALS	1	4	3	0	0	1.6

Photo Album Cayo Coral



Plate 56



Plate 57



Plate 58



Plate 59



Plate 60



Plate 61

E. West Reef of Isla Caja de Muertos – Ponce

Caja de Muerto is an island located approximately 8.5 km off the south coast of Puerto Rico, between Ponce and Santa Isabel, within the insular shelf (Figure 2). It is the largest emergent reef system of the south coast. The main reef platform includes Cayo Berbería, 5.5 km. to the northeast and Isla Morrillitos, adjacent to the main island, Caja de Muerto. The total surface area of the reserve is approximately 188.36 square kilometers (Villamil et al., 1980).

West Reef is located on the northwest coast of Caja de Muerto (Figure 27). It is a submerged patch coral reef formation that runs essentially parallel to the coastline. The base of the reef is a sandy-silt bottom at a depth of approximately 15 m. The reef rises to a depth of five m from the surface. It consists of a shallow platform at the reef top and a drop-off wall with deep channels that run perpendicular to the wall face down to the base of the reef. Most of the coral development occurs along the wall, with substantial stony coral and soft coral (gorgonians) growth into the channels. Goenaga and Cintrón (1979) described the geomorphology of this reef and provided the first taxonomic description of the benthic communities. Our survey was performed at a depth of 7.6 m on the fore reef slope. Transects were set roughly parallel to the coastline and perpendicular to the slope of the reef, following the seven (7.0) m depth contour. Panoramic views of West Reef are presented in Photo Album 11.

1.0 Sessile-benthic Reef Communities

A dense algal turf, comprised by a mixed assemblage of short filamentous coralline algae and brown macroalgae was the dominant component of the sessile-benthic biota in terms of substrate cover at West Reef. Turf algae averaged 47.5 % along permanent transects and represented more than 99 % of the total benthic algae during the 2005 survey (Table 42).

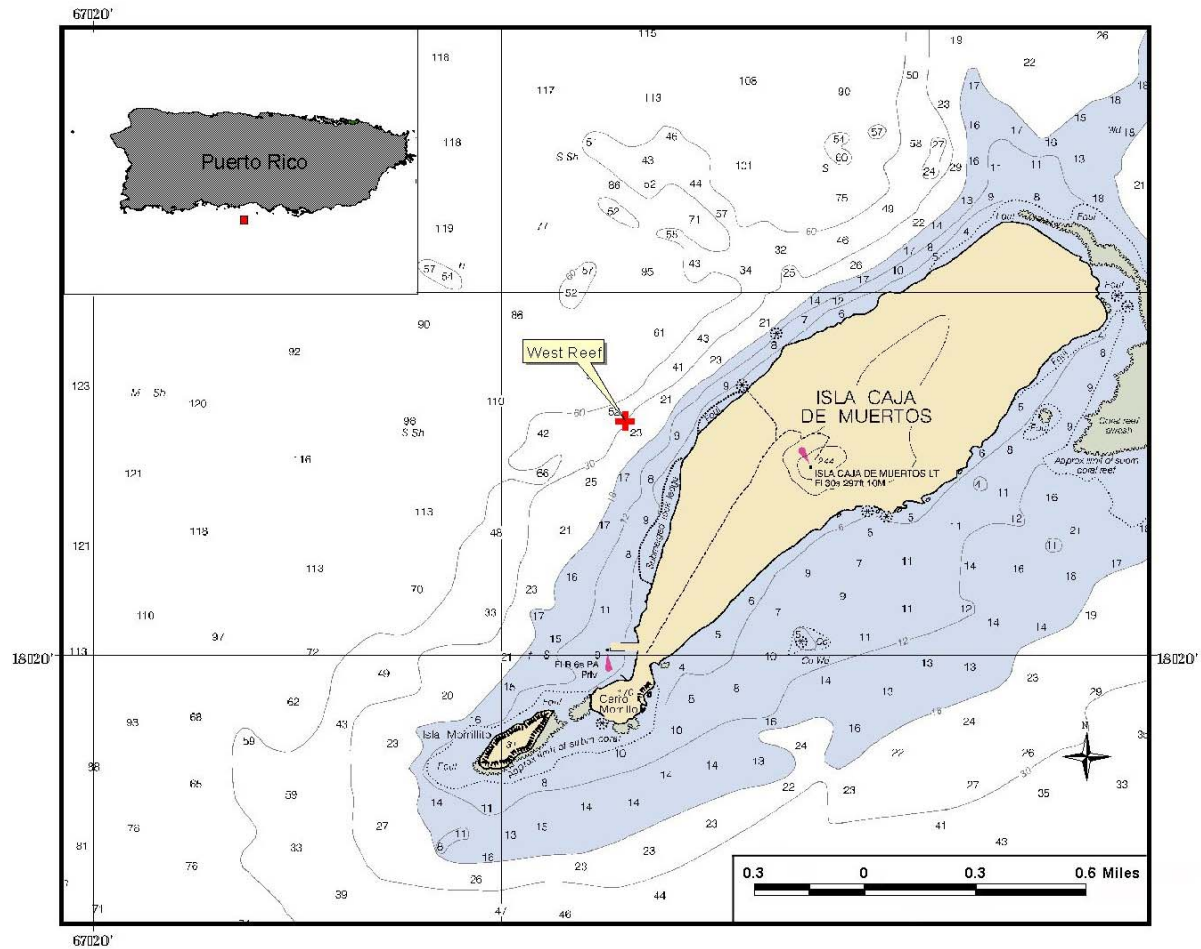


Figure 27. Location of coral reef survey stations at West Reef of Isla Caja de Muertos, Ponce.

Live stony corals averaged 19.32 % (range: 12.39 – 33.69 %) along linear transects surveyed during 2005. The Boulder Star Coral, *Montastrea annularis* (complex) was the dominant coral species with a mean substrate cover of 10.98 % (range 3.65 – 28.23 %), representing 56.8 % of the total substrate cover by live stony corals. A total of 18 species of stony corals were identified from West Reef, including 13 species intersected by linear transects. Great Star Coral (*M. cavernosa*), Lettuce Coral (*Agaricia agaricites*) and Mustard-Hill coral (*Porites astreoides*) were present in at least four out of the five transects surveyed, and along with Boulder Star Coral comprised the main coral assemblage of the West Reef (Table 42).

Soft corals (gorgonians) presented a mean density of 15 colonies/transect and included colonies of very large sizes. Some of the most abundant species included the Common Sea Fan (*Gorgonia ventalina*), Slimy Sea Plumes (*Pseudopterogorgia americana*, *Pseudopterogorgia spp.*), Corky Sea Finger, (*Briareum asbestinum*), Porous Sea Rods (*Pseudoplexaura spp.*), Knobby Sea Rods (*Eunicea spp.*) and the Encrusting Gorgonian (*Erythropodium caribaeorum*). The combined assemblage of soft and stony corals was visually the most prominent component of the sessile-benthic reef community with massive coral colonies providing most of the topographic relief. Sponges were present in four transects with a mean substrate cover of 2.22 %.

Abiotic categories, particularly the reef overhangs (mean: 19.97 %), accounted for substantial substrate cover in West Reef and contributed to a mean rugosity of 6.17 m. Coral rubble and sand accumulated within crevices, holes and gaps of the highly irregular bottom topography. The high rugosity was strongly influenced by growth of *Montastrea annularis*, which formed ledges with its “mushroom type” colonies of large size.

Figure 28 presents the variations of mean percent cover by sessile-benthic categories from West Reef between the original baseline survey in May, 1999 and the present 2005 survey. Differences of mean total percent cover by stony corals (-5.08 %) were statistically significant ($T= 6.13$; $p < 0.01$), and indicative of a degradation trend of the

coral reef community structure. The 5 % reduction of mean substrate cover represents a decline of approximately 21 % in total live coral cover at West Reef. A statistically significant reduction of gorgonian colonies between the 1999 baseline survey (25 col./transect) and the present 2005 survey (16 col./transect) was also detected ($T= 6.13$; $p < 0.05$). The reduction of both live stony coral cover and density of gorgonian colonies was consistent across the five permanent transects. An increment of abiotic cover was measured. Substrate cover by sponges and benthic algae remained virtually constant. Variations of the mean substrate cover by coral species between 1999 baseline survey and the current 2005 survey are shown in Figure 29. Coral species with the largest reductions in mean substrate cover included *Montastrea annularis* (-2.16 %), *Porites astreoides* (- 1.49 %), and *M. cavernosa* (-0.95 %).

Table 42. Percent substrate cover by sessile-benthic categories at West Reef, Caja de Muertos, Ponce. April, 2005.

	TRANSECTS					MEAN
	1	2	3	4	5	
Rugosity (m)	4.2	6.65	6.83	7.8	5.37	6.17
SUBSTRATE CATEGORIES						
TURF ALGAE	46.83	46.97	46.55	47.02	50.23	47.52
ABIOTIC						
Reef Overhangs	18.38	13.21	22.18	22.42	23.68	19.97
Coral Rubble	9.15	4.08	1.93	5.54	5.76	5.29
Sand	9.51		8.44	1.58	3.00	4.51
SPONGES	3.38	1.92	3.63		2.19	2.22
ENCRUSTING GORGONIANS				2.3	0.24	0.51
FLESHY ALGAE			0.48	1.57	0.86	0.58
ANTHOZOANS	0.4				0.16	0.11
CORAL SPECIES						
<i>Montastrea annularis</i>	7.54	28.23	11.06	3.65	4.44	10.98
<i>Montastrea cavernosa</i>		3.24	1.07	4.89	0.57	1.95
<i>Agaricia agaricites</i>	0.5	0.93	1.17	1.12	4.21	1.59
<i>Colpophyllia natans</i>				7.44	0.24	1.54
<i>Porites astreoides</i>	1.29	0.34	2.08	0.96	1.67	1.27
Table 42. (continued)						
<i>Siderastrea radians</i>	1.06	0.34			2.25	0.73
<i>Stephanocoenia michelini</i>	1.19		0.5		0.32	0.40
<i>Porites porites</i>	0.79		0.48			0.25
<i>Siderastrea siderea</i>		0.59		0.47		0.21
<i>Madracis decactis</i>				0.95		0.19
<i>Diploria strigosa</i>			0.42			0.08
<i>Meandrina meandrites</i>				0.16		0.03
<i>Millepora alcicornis</i>		0.17			0.16	0.07
TOTAL STONY CORALS	12.39	33.86	16.83	19.61	13.87	19.32
GORGONIANS (# col.)	13	10	19	13	22	15

Coral Species Outside Transects: *Agaricia lamarki*, *Diploria strigosa*, *D. labyrinthiformis*, *Eusmilia fastigiata*, *Isophyllia sinuosa*, *Dichocoenia stokesii*, *Mycetophyllia lamarckiana*, *Leptoseris cucullata*

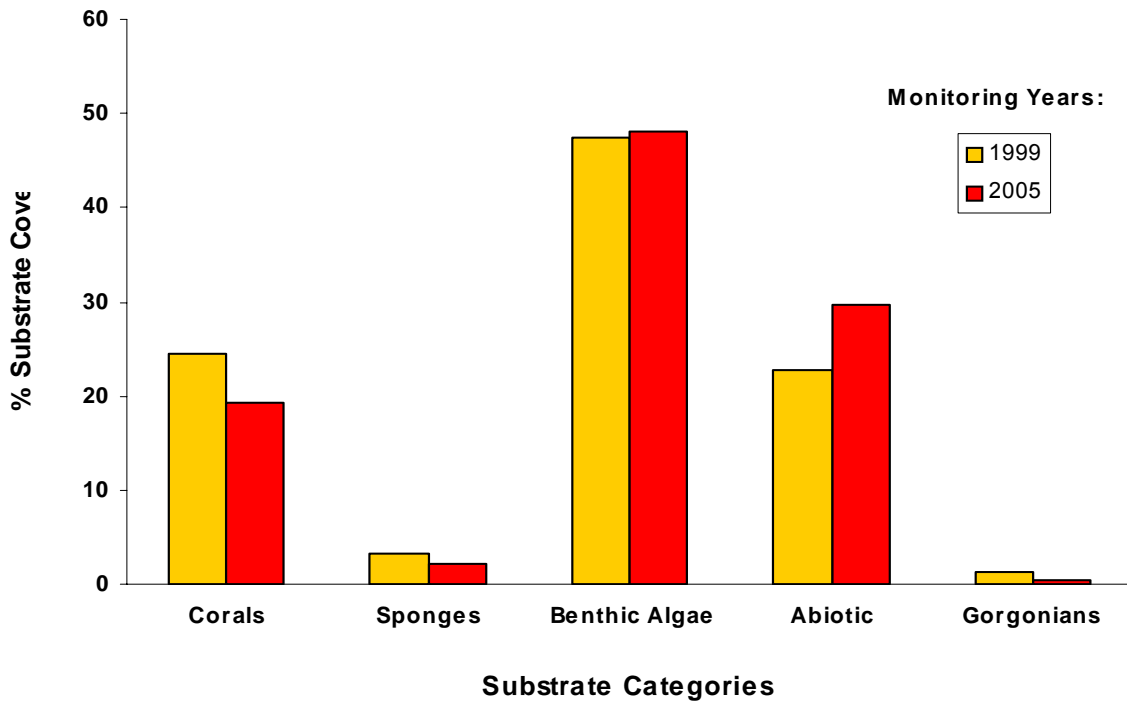


Figure 28. Monitoring trends of mean substrate sessile-benthic categories at West Reef of Isla Caja de Muertos, Ponce.

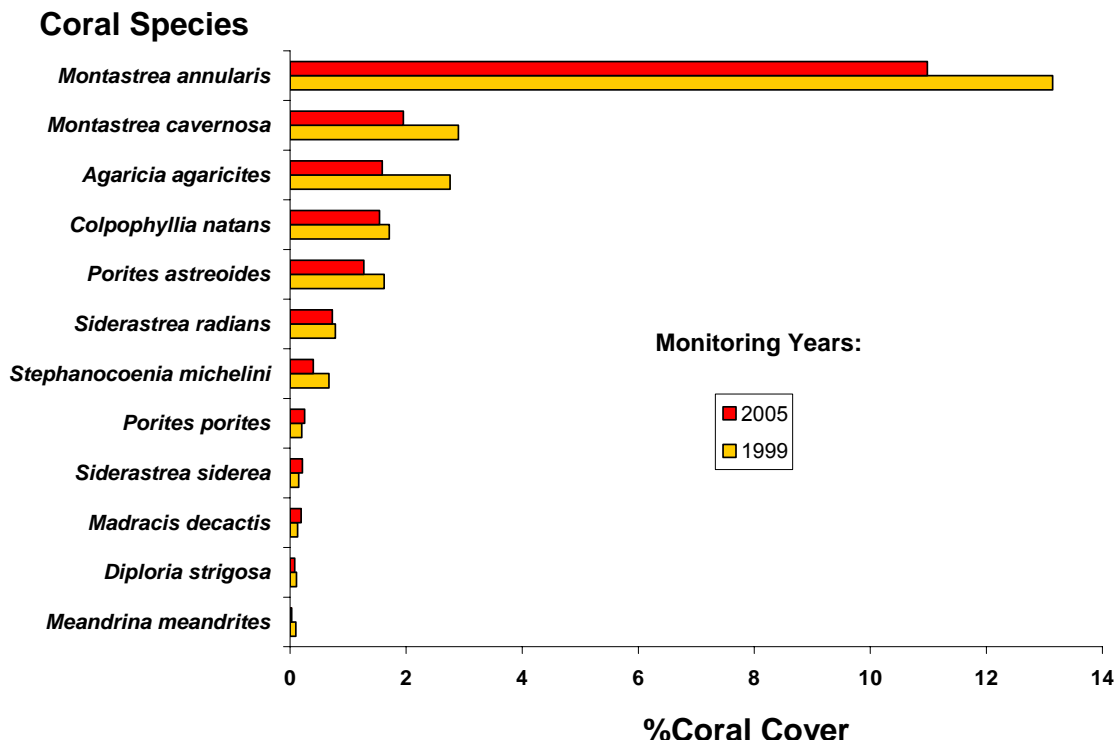


Figure 29. Monitoring trends of mean substrate by stony coral species at West Reef of Isla Caja de Muertos, Ponce.

2.0 Fishes and Motile Megabenthic Invertebrates

A total of 78 fish species, including 43 within belt-transects were identified West Reef, Isla Caja de Muerto during April, 2005. Mean abundance of fishes within belt-transects was 397.6 Ind/30 m² (range: 184 - 559 Ind/30 m²). The mean number of species per transect was 27.8 (range: 23 - 34). Fish species richness increased by 24.5 % and mean abundance increased by 84.4 % compared to the 1999 baseline survey (Table 3). The Masked Goby (*Coryphopterus personatus*) was the numerically dominant species with a mean abundance of 296.4 Ind/30 m² (range: 107 - 450 Ind/30 m²), representing 74.5 % of the total abundance within belt-transects (Table 43). This is the highest density reported for a single fish species in the Puerto Rico coral reef monitoring program. The Masked Goby was present in dense swarms of 50 plus individuals close to the reef substrate, below ledges, in front of crevices and other protective microhabitats of the reef. The Bluehead Wrasse, Striped and Stoplight Parrotfishes, Bicolor, Beaugregory and Dusky Damselfishes, Blue and Brown Chromis, Sharknose Goby, Graysby, French Grunt and Caribbean Puffer were present in at least four out of the five transects surveyed, and represented, along with the Masked Goby the main fish assemblage of West Reef (Table 43).

Demersal zooplankton feeders, including the Masked Goby, Blue and Brown Chromis, Bicolor Damselfish and Caribbean Puffer comprised the most prominent fish assemblage within belt-transects. Also, open water zooplanktivores, such as the Creole Wrasse (*Clepticus parrae*) and Mackerel Scad (*Decapterus macarellus*) were present outside transects in large aggregations. Therefore, zooplanktivorous fishes comprised an important and prominent component of the ichthyofaunal community structure at West Reef. These species are known to serve as forage for a diverse assemblage of top pelagic and demersal predators, including barracudas, jacks, and large groupers and snappers observed during the ASEC survey at this reef (Table 44).

A specious assemblage of small invertebrate feeders was also present, including wrasses, gobies, goatfishes and squirrelfishes, among others. Mid-size carnivores that are commercially exploited, such as the Yellowtail, Mutton, Lane and Schoolmaster Snappers, Red Hind, Coney and juvenile Yellowfin Grouper were observed during the ASEC survey (Table 44). Large aggregations of more than 50 juvenile and adult Lane

Snappers (*Lutjanus synagris*) were observed near the base of the reef, along the reef-sand interface. Juvenile and some adult Yellowtail Snappers (*Ocyurus chrysurus*) were concentrated at the face of the fore-reef slope (wall), with small juveniles (< 5 cm) using the dense soft coral (gorgonian) forest as protective habitat. Schoolmasters (*L. apodus*) were mostly observed as juvenile/adult stages swimming in and out of caves and crevices within the fore-reef slope. One juvenile and four young adult Mutton Snappers (*L. analis*) were observed foraging along with the large Lane Snapper aggregation. One juvenile Yellowfin Grouper (*Mycteroperca venenosa*) was also present at the shallow reef top.

Parrotfishes, doctorfishes and damselfishes comprised the main herbivorous fish assemblage of West Reef. Their combined relative abundance within belt-transects was approximately 5.6 %.

Motile megabenthic invertebrates were represented within belt-transects by Arrow and Hermit Crabs, Spotted Spiny Lobsters, Reef Urchins, Flamingo Tongue and Atlantic wing oyster (Table 45).

Table 43. Taxonomic composition and abundance of fishes within belt-transects at West Reef Caja de Muertos, Ponce. April, 2005

Depth:	TRANSECTS					MEAN	
	1	2	3	4	5		
	(individuals/30 m ²)						
SPECIES	COMMON NAME						
<i>Coryphopterus personatus</i>	Masked Goby	400	450	305	220	107	296.4
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	30	22	35	45	12	28.8
<i>Scarus iserti</i>	Stripped Parrotfish	12		6	14	9	8.2
<i>Chromis multilineata</i>	Brown Chromis		18	15		3	7.2
<i>Stegastes partitus</i>	Bicolor Damselfish	5	14	5	1	4	5.8
<i>Gobiosoma evelynae</i>	Sharknose Goby	1	8	2	4	5	4.0
<i>Chromis cyanea</i>	Blue Chromis	5	6	7		1	3.8
<i>Stegastes planifrons</i>	Yellow-eye Damselfish	4	3	6	3	2	3.6
<i>Myripristis jacobus</i>	Blackbar Soldierfish		6	6	4		3.2
<i>Lutjanus apodus</i>	Schoolmaster	12		1			2.6
<i>Stegastes dorsopunicans</i>	Dusky Damselfish		6	1	5	1	2.6
<i>Sparisoma viride</i>	Stoplight Parrotfish	5		3	1	3	2.4
<i>Scarus taeniopterus</i>	Princess Parrotfish		6			5	2.2
<i>Canthigaster rostrata</i>	Caribbean Puffer	2	1	1	2	3	1.8
<i>Haemulon flavolineatum</i>	French Grunt	2	2	1	3	1	1.8
<i>Stegastes leucostictus</i>	Beau Gregory	2		1	1	5	1.8
<i>Cephalopholis cruentatus</i>	Graysby	1	3	1	2	1	1.6
Table 43. (continued)							
<i>Chaetodon capistratus</i>	Four-eye Butterflyfish	2	2	2	2		1.6
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish			1	4	3	1.6
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	3		1		2	1.2
<i>Hypoplectrus unicolor</i>	Butter Hamlet	3	3				1.2
<i>Acanthurus bahianus</i>	Ocean Surgeon	2	1			2	1.0
<i>Coryphopterus sp1.</i>	Goby	2	1	1		1	1.0
<i>Haemulon sciurus</i>	Bluestriped Grunt	1			4		1.0
<i>Hypoplectrus puella</i>	Barred Hamlet	1	1	1	1	1	1.0
<i>Coryphopterus glaucofraenum</i>	Bridled Goby	1	1	1		1	0.8
<i>Scarus vetula</i>	Queen Parrotfish		1		3		0.8
<i>Acanthurus coeruleus</i>	Blue Tang			1		2	0.6
<i>Aulostomus maculatus</i>	Trumpetfish			1	1	1	0.6
<i>Epinephelus sp.</i>	Coney	0		1	1	1	0.6
<i>Gramma loreto</i>	Fairy Basslet				1	2	0.6
<i>Pseudupeneus maculatus</i>	Spotted Goatfish			3			0.6
<i>Acanthurus chirurgus</i>	Doctorfish				2		0.4
<i>Bodianus rufus</i>	Spanish Hogfish		1	1			0.4
<i>Chaetodon striatus</i>	Banded Butterflyfish		1		1		0.4
<i>Coryphopterus lipernes</i>	Peppermint Goby			1	1		0.4
<i>Lutjanus mahogani</i>	Mahogani Snapper			2			0.4
<i>Aluterus sp.</i>	Filefish	1					0.2
<i>Anisotremus virginicus</i>	Porkfish			1			0.2

Table 43. (continued)

<i>Carangoides ruber</i>	Bar Jack	1				0.2
<i>Caranx crysos</i>	Blue Runner		1			0.2
<i>Gerres cinereus</i>	Yellowfin Mojarra				1	0.2
<i>Gobiosoma saucrum</i>	Leopard Goby	1				0.2
<i>Haemulon aurolineatum</i>	Tomtate		1			0.2
<i>Haemulon macrostomum</i>	Spanish Grunt			1		0.2
<i>Halichoeres radiatus</i>	Puddinwife				1	0.2
<i>Holacanthus tricolor</i>	Rock Beauty				1	0.2
<i>Holocentrus rufus</i>	Squirrelfish				1	0.2
<i>Hypoplectrus chlorurus</i>	Yellowtail Hamlet				1	0.2
<i>Microspathodon chrysurus</i>	Yellowtail Damselfish		1			0.2
<i>Mulloides martinicus</i>	Yellowtail Goatfish		1			0.2
<i>Ocyurus chrysurus</i>	Yellowtail Snapper			1		0.2
<i>Odontoscion dentex</i>	Reef Croaker				1	0.2
<i>Scarus coeruleus</i>	Blue Parrotfish			1		0.2
<i>Serranus tigrinus</i>	Harlequin Bass			1		0.2

TOTAL INDIVIDUALS	498	559	418	329	184	397.6
TOTAL SPECIES	23	24	34	27	31	27.8

Outside transects:

<i>Amblycirrhitis pinos</i>	Redspotted Hawkfish
<i>Canthidermis sufflamen</i>	Ocean Triggerfish
<i>Caranx lugubris</i>	Black Jack
<i>Cephalopholis fulva</i>	Coney
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish
<i>Clepticus parrae</i>	Creole Wrasse
<i>Equetus acuminatus</i>	Highhat
<i>Flammeo marianus</i>	Longspine Squirrelfish
<i>Gymnothorax moringa</i>	Spotted Moray
<i>Halichoeres maculipinna</i>	Clown Wrasse
<i>Holacanthus ciliaris</i>	Queen Angelfish
<i>Hypoplectrus guttavarius</i>	Shy Hamlet
<i>Kyphosus sectatrix</i>	Bermuda Chub
<i>Lactophrys polygonia</i>	Honeycomb Cowfish
<i>Lactophrys triqueter</i>	Smooth Trunkfish
<i>Liopropoma rubre</i>	Peppermint Bass
<i>Melichthys niger</i>	Black Durgon
<i>Paranthias furcifer</i>	Creole Fish
<i>Priacanthus arenatus</i>	Glasseye
<i>Scomberomorus regalis</i>	Cero Mackerel
<i>Sparisoma radians</i>	Bucktooth Parrotfish

Table 44. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at the West Reef of Isla Caja de Muerto, April, 2005. July, 2005

Depth range : 7 – 15 m

Duration - 30 min.

SPECIES	COMMON NAME	# - (cm)		
<i>Decapterus macarellus</i>	Mackerel Scad	30 - (12)		
<i>Epinephelus guttatus</i>	Red Hind	1 - (25)		
<i>Holacanthus ciliaris</i>	Queen Angel	1 - (25)		
<i>Holacanthus tricolor</i>	Rock Beauty	2 - (25)		
<i>Mycteroperca venenosa</i>	Yellowfin Grouper	1 - (30)		
<i>Lutjanus analis</i>	Mutton Snapper	1 - (25)	1 - (30)	2 - (40)
<i>Lutjanus apodus</i>	Schoolmaster	3 - (25)	1 - (30)	
<i>Lutjanus mahogany</i>	Mahogani Snapper	3 - (20)	2 - (25)	
<i>Lutjanus griseus</i>	Grey Snapper	2 - (30)		
<i>Lutjanus synagris</i>	Lane Snapper	12 - (20)	28 - (25)	1 - (30)
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	7 - (15)	6 - (20)	20 - (25)
<i>Scomberomorus regalis</i>	Cero Mackerel	2 - (40)		
<i>Sphyaena barracuda</i>	Great Barracuda	1 - (60)		
Invertebrates				
<i>Panulirus guttatus</i>	Spotted Spiny Lobster	1 - (25)		

Table 45. Taxonomic composition and abundance of motile megabenthic invertebrates from belt-transects at West Reef. Caja de Muertos. April 2005

DATE: April 2005		TRANSECTS					MEAN ABUNDANCE (IND/30 m²)
Depth: 7.0 m		1	2	3	4	5	
TAXA	DEPTH (m) COMMON NAME						
<i>Stenorhynchus seticornis</i>	Arrow crab					1	0.2
<i>Cyphoma gibbosum</i>	Flamingo tongue	3		2	1	1	1.4
<i>Panulirus guttatus</i>	Spotted spiny lobster				1		0.2
<i>Echinometra viridis</i>	Reef urchin				1		0.2
<i>Pteria columbus</i>	Atlantic wing oyster	1			1		0.4
<i>Paguridae</i>	Hermit crab		1		1		0.4
TOTALS		4	1	2	5	2	2.8

Photo Album Caja de Muertos

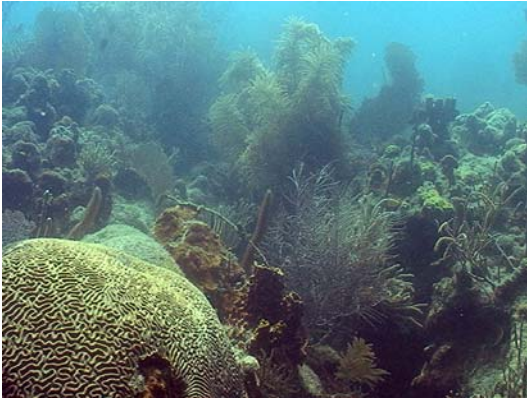


Plate 62



Plate 63



Plate 64



Plate 65



Plate 66



Plate 67

F. Derrumbadero Reef – Ponce

Derrumbadero is a submerged promontory fringing the shelf-edge, 2.2 nautical miles southeast off from the mouth of Ponce Bay (Figure 30). The promontory, or seamount rises from the outer shelf at a depth of about 25 -30 m to a reef top at 15 m, and then drops down the insular slope along the south and west margins. The reef top platform has an irregular spherical shape. It measures approximately 2 kilometers from east to west and about 0.7 kilometers from north to south. Permanent transects were established at the southern edge of the reef, close to the shelf-edge drop-off wall (Figure 30).

Derrumbadero Reef exhibits an impressive spur-and groove coral reef formation that resembles the shelf-edge reef systems of La Parguera and Guánica. Coralline sand channels with coral rubble cut through the reef down to the shelf-edge, separating spurs of approximately 5 meters high. Massive, branching and encrusting live scleractinian corals and gorgonians colonize the spurs and grow towards the channels, creating a highly complex habitat of large coral mounds, ledges and overhangs. Baseline characterization of the reef community was performed during August, 2001 by García-Sais et al. (2001 c). Panoramic views of Derrumbadero Reef are presented as Photo Album 12.

1.0 Sessile-Benthic Reef Community

A total of 23 stony corals, including 16 intersected by line transects were identified from Derrumbadero Reef at a depth of 20 m (Table 46). Stony corals occurred as massive, encrusting and mound shaped colonies. Substrate cover by stony corals along transects averaged 34.69 % (range: 25.35 – 43.91 %). Boulder Star Coral, *Montastrea annularis* (complex) was the dominant species in terms of substrate cover with a mean of 20.41% (range: 14.38 – 29.04 %), representing 58.8 % of the total cover by stony corals. Lettuce Coral (*Agaricia agaricites*) and Mustard-Hill Coral (*Porites astreoides*) ranked second and third in terms of substrate cover by stony corals, and along with *M. annularis* were present in all five transects surveyed. Great Star Coral (*M. cavernosa*) was

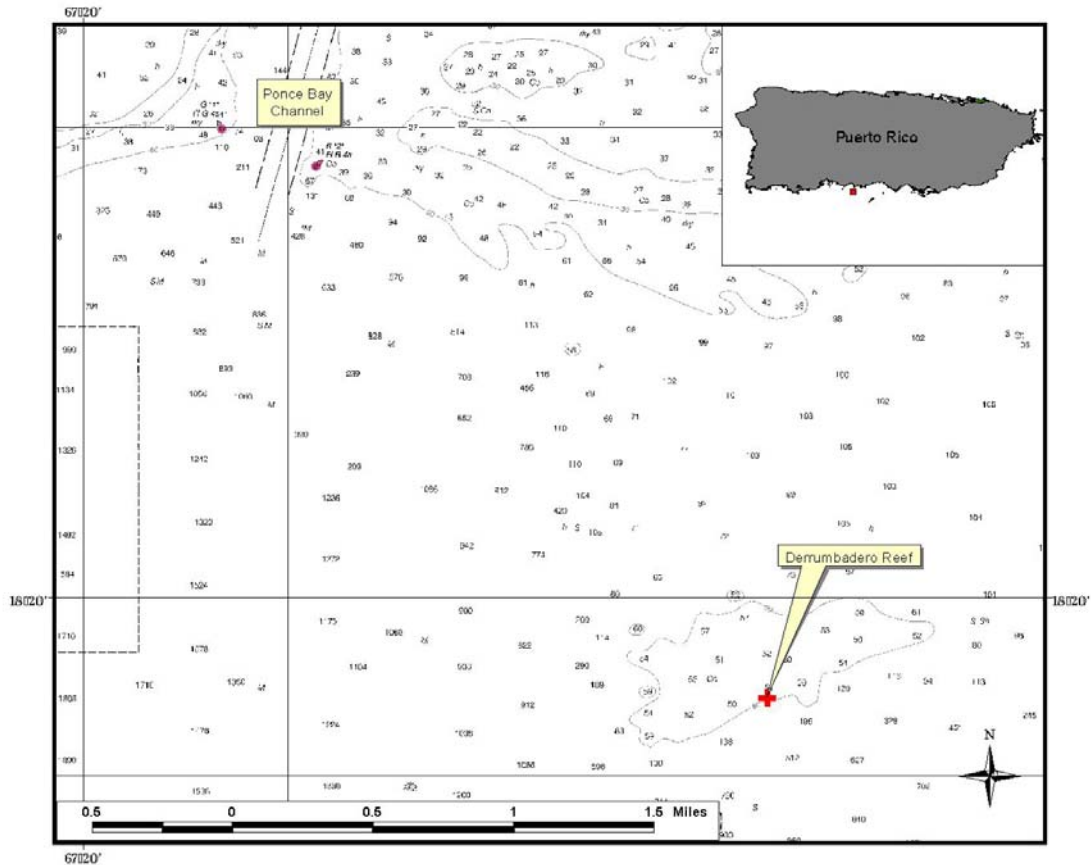


Figure 30. Location of coral reef survey stations at Derrumbadero Reef, Ponce.

present in four transects. The combined substrate cover by these four species represented 86.8 % of the total cover by live stony corals in Derrumbadero Reef during 2005 (Table 46). Black corals (*Antipatharia*) were observed off the shelf-edge at depths of 25 – 30 m. These included the Wire Black Coral (*Stichopathes lutkeni*), and the Bushy Black Coral (*Antipathes caribbeana*). Soft coral colonies were highly abundant at Derrumbadero (mean: 23 col./transect) and because of their large sizes and species richness contributed substantially to the biological diversity and structural complexity of Benthic algae, comprised by turf and fleshy macroalgae were the most prominent sessile-benthic category in terms of substrate cover at Derrumbadero Reef with a mean of 51.37 %. Turf algae was the dominant assemblage, representing 96 % of the total cover by benthic algae (Table 46).

Table 46. Percent substrate cover by sessile-benthic categories at Derrumbadero Reef, Ponce, June 2005

	Transects					MEAN
	1	2	3	4	5	
Rugosity (m)	3.79	2.73	3.73	2.99	3.89	3.43
SUBSTRATE CATEGORIES						
TURF ALGAE	47.72	56.51	51.97	44.45	46.47	49.42
ABIOTIC						
Reef Overhangs	10.30	7.22	7.21	8.55	10.16	8.69
ENCRUSTING GORGONIANS	1.23	6.44	2.26	0.33	2.74	2.60
SPONGES	3.92	0.24	3.20	1.00	1.73	2.02
FLESHY ALGAE	1.52	4.24		1.77	1.73	1.85
MILLEPORA			0.31			0.06
CORAL SPECIES						
<i>Montastrea annularis</i>	19.58	14.38	16.1	29.04	22.94	20.41
<i>Agaricia agaricites</i>	5.08	4.08	2.26	3.39	2.81	3.52
<i>Porites astreoides</i>	2.18	5.50	5.75	0.62	2.25	3.26
<i>Montastrea cavernosa</i>		0.86	1.46	8.24	3.97	2.91
<i>Acropora cervicornis</i>	6.24					1.25
<i>Diploria labyrinthiformis</i>	0.71		2.69		2.81	1.24
<i>Diploria strigosa</i>			2.77	0.65		0.68
<i>Agaricia lamarcki</i>	0.82		0.31	0.43		0.31
<i>Porites porites</i>					1.52	0.30
<i>Leptoseris cucullata</i>				1.09		0.22
<i>Meandrina meandrites</i>					0.91	0.18
<i>Madracis decactis</i>		0.47				0.09
<i>Colpophyllia natans</i>				0.43		0.09
Table 46. (continued)						
<i>Siderastrea siderea</i>	0.41					0.08
<i>Porites colonensis</i>	0.31					0.06
TOTAL STONY CORAL	35.32	25.35	31.30	43.91	37.25	34.63
GORGONIANS (# col.)	23	24	22	26	20	23

Coral Species Outside Transects:

Figure 31 presents the variations of mean percent cover by sessile-benthic categories from Derrumbadero Reef between the original baseline survey in 2001 and the present 2005 survey. Differences of mean total percent cover by stony corals (-6.98 %) were statistically significant ($T=2.39$; $p < 0.05$), and suggest a trend of degradation of the coral reef community structure. The reduction of approximately 7 % of mean substrate cover

represents a decline of 16.7 % in total live coral cover at Derrumbadero Reef. The reduction of live coral cover was consistent across the five permanent transects. A corresponding increment of cover by benthic algae was measured. Variations of the mean substrate cover by coral species between 2001 baseline survey and the current 2005 survey are shown in Figure 32. Marked reductions of the mean percent substrate cover resulted mostly for *Montastrea annularis* (-3.90 %). Minor reductions were measured for *Acropora cervicornis* (-0.85), *Colpophyllia natans* (-0.74 %), *M. cavernosa* (-0.62 %), and others. The density of soft coral (gorgonian) colonies remained constant (23/23) between both surveys.

2.0 Fishes and Motile Megabenthic Invertebrates

A total of 74 fish species, including 40 within belt-transect areas were identified Derrumbadero Reef during April, 2005. Mean abundance within belt-transects was 195.6 Ind/30 m² (range: 165 - 224 Ind/30 m²). The mean number of species per transect was 23.8 (range: 21 - 25). Fish species richness decreased by 4.8 % and mean abundance increased by 17.5 % compared to the 2001 baseline survey (Table 3). The Masked Goby, *Coryphopterus personatus* was the numerically dominant species with a mean abundance of 57.8 Ind/30 m² (range: 28 - 92 Ind/30 m²), representing 29.6 % of the total abundance within belt-transects (Table 47). The Masked Goby is a small carnivorous fish (< 2.0 cm) that forms swarms of up to 100 individuals below large coral ledges and near the sand-coral interface of the spur and groove reef formation. In many instances, swarms of Masked Goby coincided with swarms of mysid shrimps in the reef, for which it is possible that gobies were feeding from the shrimps. The Bicolor Damselfish, Masked, Peppermint and Sharknose Gobies,

Bluehead Wrasse, and Blue Chromis were present within all five transects surveyed. The combined abundance of these six species represented 79.4 % of the total fish individuals within belt-transects.

The fish community associated with Derrumbadero Reef appears to be well balanced in terms of trophic structure, including the presence of large demersal predators, such as large snappers and groupers. There is a strong plankton based food web that serves to transfer energy up to the top predators of the reef system. Numerically dominant

species, such as the Blue and Brown Chromis, Masked Goby, Bicolor Damselfish, Puffers, Creole Wrasse, and juvenile snappers and grunts (which are piscivorous or demersal feeders as adults) comprise the zooplanktivorous assemblage of the reef system. These in turn serve as forage for large pelagic species, such as Cero Mackerels, Blue Runners, Black Jacks and Barracudas observed during an ASEC survey in this reef (Table 47). Large demersal predators, such as Yellowfin and Tiger Groupers, Cubera, Mutton, Schoolmaster and Dog Snappers also feed from the small zooplanktivorous fishes which remain close to the reef benthos.

A large variety of small invertebrate feeders were present, including wrasses (5 spp), hamlets (2 spp), gobies (4 spp), squirrelfishes (3 spp), and others. Larger invertebrate and small fish predators included the hogfishes, Schoolmaster and Mahogany snappers, Coney, Graysby and Red Hind groupers, lizardfishes and grunts. Parrotfishes (7 spp), doctorfishes (3 spp) and damselfishes (2 spp) comprised the main herbivorous assemblage.

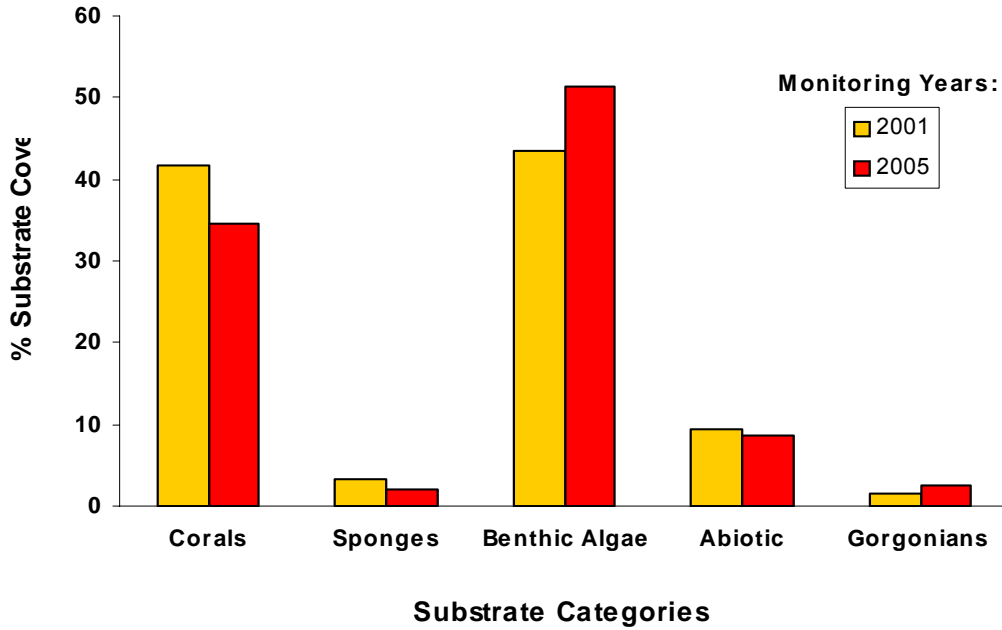


Figure 31. Monitoring trends of mean substrate sessile-benthic categories at Derrumbadero Reef, Ponce.

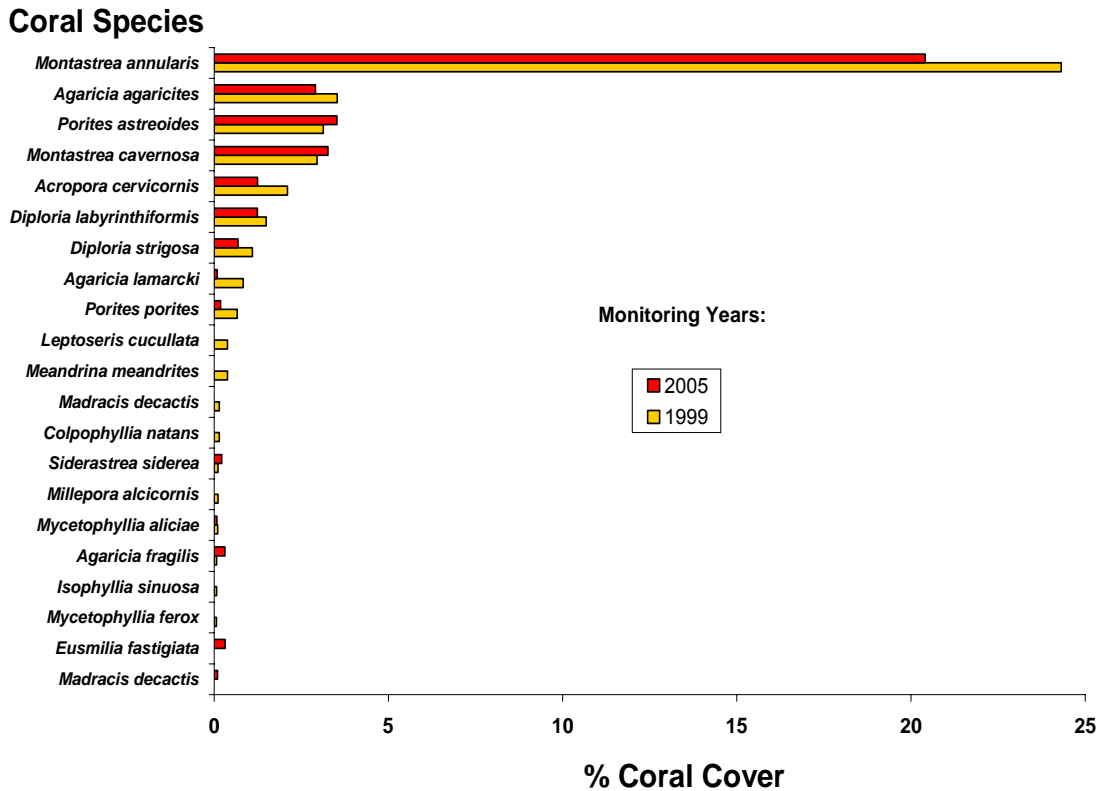


Figure 32. Monitoring trends of mean substrate cover by stony coral species at Derrumbadero Reef, Ponce

Table 47. Taxonomic composition and abundance of fishes within belt-transects at Derrumbadero Reef, Ponce. June, 2005

SPECIES	COMMON NAME	TRANSECTS					MEAN
		1	2	3	4	5	
		(individuals/30 m2)					
<i>Coryphopterus personatus</i>	Masked Goby	28	57	70	42	92	57.8
<i>Chromis cyanea</i>	Blue Chromis	38	4	15	75	33	33.0
<i>Coryphopterus lipernes</i>	Peppermint Goby	19	34	27	23	20	24.6
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	26	16	13	31	18	20.8
<i>Stegastes partitus</i>	Bicolor Damselfish	23	11	7	11	6	11.6
<i>Gobiosoma evelynae</i>	Sharknose Goby	4	5	13	8	8	7.6
<i>Scarus taeniopterus</i>	Princess Parrotfish		4	22	3	8	7.4
<i>Sparisoma radians</i>	Bucktooth Parrotfish	4	4	8	6	4	5.2
<i>Scarus iserti</i>	Stripped Parrotfish	5	11	1	2		3.8
<i>Chromis multilineata</i>	Brown Chromis	3		10		1	2.8
<i>Stegastes leucostictus</i>	Beau Gregory	2	3	3	1	2	2.2
<i>Canthigaster rostrata</i>	Caribbean Puffer	1	1	2	2	3	1.8
<i>Chaetodon capistratus</i>	Four-eye Butterflyfish	2	2	2	1	2	1.8
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	1	2	3	3		1.8
<i>Holocentrus rufus</i>	Squirrelfish		2	1	3	1	1.4
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	1	3	2	1		1.4
<i>Acanthurus chirurgus</i>	Doctorfish	1	1		2	2	1.2
<i>Sparisoma viride</i>	Stoplight Parrotfish	2		1	1	1	1.0
<i>Cephalopholis cruentatus</i>	Graysby			1	1	1	0.6
<i>Coryphopterus glaucofraenum</i>	Bridled Goby	1	1	1			0.6
<i>Haemulon flavolineatum</i>	French Grunt	1			1	1	0.6
<i>Haemulon sciurus</i>	Bluestriped Grunt	1			1	1	0.6
<i>Hypoplectrus puella</i>	Barred Hamlet			1	1	1	0.6
<i>Myripristis jacobus</i>	Blackbar Soldierfish			1		2	0.6
<i>Serranus tigrinus</i>	Harlequin Bass		1			2	0.6
<i>Acanthurus bahianus</i>	Ocean Surgeon		1	1			0.4
<i>Aulostomus maculatus</i>	Trumpetfish		1	1			0.4
<i>Hypoplectrus unicolor</i>	Butter Hamlet	1		1			0.4
<i>Melichthys nigrer</i>	Black Durgon	1				1	0.4
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	1		1			0.4
<i>Scarus vetula</i>	Queen Parrotfish	1				1	0.4
<i>Acanthurus coeruleus</i>	Blue Tang		1				0.2
<i>Aluterus sp.</i>	Filefish				1		0.2
<i>Carangoides ruber</i>	Bar Jack	1					0.2
<i>Flammeo marianus</i>	Longspine Squirrelfish				1		0.2
<i>Holacanthus ciliaris</i>	Queen Angelfish				1		0.2
<i>Hypoplectrus guttavarius</i>	Shy Hamlet	1					0.2
<i>Lactophrys triqueter</i>	Smooth Trunkfish				1		0.2
<i>Priacanthus arenatus</i>	Glasseye					1	0.2
<i>Scarus sp.</i>	Parrotfish				1		0.2

Table 47. (continued)

	TOTAL INDIVIDUALS	169	165	208	224	212	195.6
	TOTAL SPECIES	25	21	25	25	23	23.8
Outside Transects:							
<i>Abudefduf sexatilis</i>	Sergeant Major						
<i>Amblycirrhitus pinos</i>	Redspotted Hawkfish						
<i>Bodianus rufus</i>	Spanish Hogfish						
<i>Canthidermis sufflamen</i>	Ocean Triggerfish						
<i>Carangoides ruber</i>	Crevalle Jack						
<i>Carangoides crysos</i>	Blue Runner						
<i>Caranx lugubris</i>	Black Jack						
<i>Cephalopholis fulva</i>	Coney						
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish						
<i>Chaetodon ocellatus</i>	Spotfin Butterflyfish						
<i>Chaetodon striatus</i>	Banded Butterflyfish						
<i>Clepticus parrae</i>	Creole Wrasse						
<i>Coryphopterus sp1.</i>	Goby						
<i>Equetus acuminatus</i>	Highhat						
<i>Gramma loreto</i>	Fairy Basslet						
<i>Gymnothorax moringa</i>	Spotted Moray						
<i>Halichoeres maculipinna</i>	Clown Wrasse						
<i>Halichoeres radiatus</i>	Puddinwife						
<i>Haemulon plumieri</i>	White Grunt						
<i>Holacanthus tricolor</i>	Rock Beauty						
<i>Kyphosus sectatrix</i>	Bermuda Chub						
<i>Lachnolaimus maximus</i>	Hogfish						
<i>Lactophrys polygonia</i>	Honeycomb Cowfish						
<i>Liopropoma rubre</i>	Peppermint Bass						
<i>Lutjanus analis</i>	Mutton Snapper						
<i>Lutjanus apodus</i>	Schoolmaster						
<i>Lutjanus cyanopterus</i>	Cubera snapper						
<i>Lutjanus jocu</i>	Dog Snapper						
<i>Lutjanus mahogani</i>	Mahogani Snapper						
<i>Microspathodon chrysurus</i>	Yellowtail Damselfish						
<i>Mulloides martinicus</i>	Yellowtail Goatfish						
<i>Mycteroperca tigris</i>	Tiger Grouper						
<i>Mycteroperca venenosa</i>	Yellowfin Grouper						
<i>Opistognathus aurifrons</i>	Yellowhead Jawfish						
<i>Paranthias furcifer</i>	Creole Fish						
<i>Scomberomorus regalis</i>	Cero Mackerel						
<i>Stegastes planifrons</i>	Yellow-eye Damselfish						

Table 48. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at Derrumbadero Reef, Ponce. June, 2005

Depth range : 18 - 22 m

Duration - 30 min.

SPECIES	COMMON NAME	# - (cm)		
<i>Carangoides crysos</i>	Blue Runner	3 - 3)		
<i>Caranx lugubris</i>	Black Jack	2 - (50)		
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish	4 - (7)		
<i>Epinephelus guttatus</i>	Red Hind	2 - (30)	1 - (35)	
<i>Holacanthus ciliaris</i>	Queen Angel	1 - (30)		
<i>Holacanthus tricolor</i>	Rock Beauty	2 - (15)	1 - (20)	2 - (25)
<i>Lachnolaimus maximus</i>	Hogfish	2 - (35)	1 - (45)	
<i>Lutjanus analis</i>	Mutton Snapper	1 - (40)	1 - (50)	
<i>Lutjanus apodus</i>	Schoolmaster	1 - (20)		
<i>Lutjanus cyanopterus</i>	Cubera snapper	1 - (60)	1 - (80)	
<i>Lutjanus jocu</i>	Dog Snapper	2 - (50)		
<i>Lutjanus mahogany</i>	Mahogani Snapper	5 - (25)	2 - (30)	
<i>Lutjanus synagris</i>	Lane Snapper	2 - (20)		
<i>Mycteroperca tigris</i>	Tiger Grouper	1 - (50)		
<i>Mycteroperca venenosa</i>	Yellowfin Grouper	1 - (45)		
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	3 - (20)		
<i>Opistognathus aurifrons</i>	Yellowhead Jawfish	12 - (10)		
<i>Scomberomorus regalis</i>	Cero Mackerel	3 - (40)	2 - (75)	
<i>Sphyraena barracuda</i>	Great Barracuda	1 - (90)		
Invertebrates				
<i>Panulirus argus</i>	Spiny Lobster	1 - (25)*		

Photo Album Derrumbadero

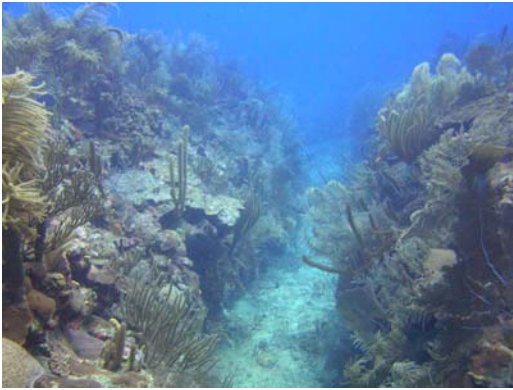


Plate 68



Plate 69



Plate 70



Plate 71



Plate 72



Plate 73

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