

FINAL REPORT

**BASELINE CHARACTERIZATION AND MONITORING OF CORAL REEF
COMMUNITIES AT ISLA DESECHEO, RINCON AND MAYAGUEZ BAY,
PUERTO RICO, 2004**

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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 monitoring cycle of marine communities associated with the coral reef systems at Puerto Canoas/Puerto Botes in Isla Desecheo at a depth of 20 meters, and at El Tourmaline Reef in Mayaguez Bay at depth of 10 meters. The report also contains the initial baseline characterizations of marine communities at the Tres Palmas Reef system in Rincón, and at two additional depths (physiographic zones) in the reef systems from Isla Desecheo (15 & 30m) and El Tourmaline (20 & 30 m).

The Tres Palmas Reef in Rincón is a newly designated 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 meters 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. Baseline characterizations of the Isla Desecheo and Mayaguez Bay reefs are available in García et al. (2001 a, b).

The first monitoring cycle of coral reef communities under the US National Coral Reef Monitoring Program in Puerto Rico was held during 2001-02 and included 18 reefs from seven Natural Reserve sites (DNER, 2003). The most notable difference of reef community structure from the baseline characterization by García et al. (2001a) was an increment of approximately 10 % in live coral cover at El Tourmaline Reef from permanent transects at a depth of 10 meters. Smaller declines of live coral cover were measured at the Ventana and Coral reefs from Guánica (DNER, 2003). In general, the variation of sessile-benthic community structure among the reefs monitored one year after the baseline characterization was very small, mostly within the sampling error margin estimated at approximately 3 %. A similar assessment holds for the six reefs monitored at Isla de Vieques (García et al., 2004 b), where in most cases live coral cover remained virtually constant three years after the initial baseline characterization in 2000 (García et al., 2001 c). The inference from the monitoring program so far is that coral reef systems associated with Natural Reserves in Puerto Rico are stable.

Methods

The location of coral reef monitoring sites in the west coast of Puerto Rico is presented in Figure 1. A total of five permanent 10-meter long transects were established at the three main reef physiographic zones of the Tres Palmas Reef System in Rincon. 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 echosounding runs and towed divers to select the best representative sections of the reef system to be characterized. The Tourmaline Reef community in Mayaguez Bay was monitored at a depth of 10 m from an existing set of five permanent transects. Additional sets of five permanent transects were constructed and surveyed at depths of 20 m and 30 m down the shelf-edge reef system. Puerto Botes Reef in Isla Desecheo was monitored at a depth of 20 m on the set of existing permanent transects. Additional series of five permanent transects were constructed and surveyed at depths of 15 m on Puerto Botes and at 30 m on the Puerto Canoas shelf-edge reef. The location of all transects was DGPS referenced for continued monitoring (Table 1).

Table 1. Geographic coordinates and depths of coral reefs surveyed during 2004

Reef Sites	Depth (m)	Latitude	Longitude
Tres Palmas Reef System - Rincon			
Rincon Elkhorn Coral reef	3	18° 21.023' N	067° 15.959' W
Rincon Outer Shelf Reef	10	18° 20.832' N	067° 16.206' W
Rincon Shelf-edge Reef	20	18° 20.790' N	067° 16.248' W
Puerto Canoas/Botes Ref. System - 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 Reef System - Mayaguez			
Tourmaline Outer Shelf Reef - 10m	10	18° 09.788' N	067° 16.424' W
Tourmaline Outer Shelf Reef - 20m	20	18° 09.910' N	067° 16.512' W
Tourmaline Shelf-edge Reef - 30m	30	18° 09.985' N	067° 16.581' W

Sessile-benthic Reef communities

Sessile-benthic reef communities were characterized and monitored by the continuous intercept chain-link method, as modified from Porter (1972) by CARICOMP (1994). 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.

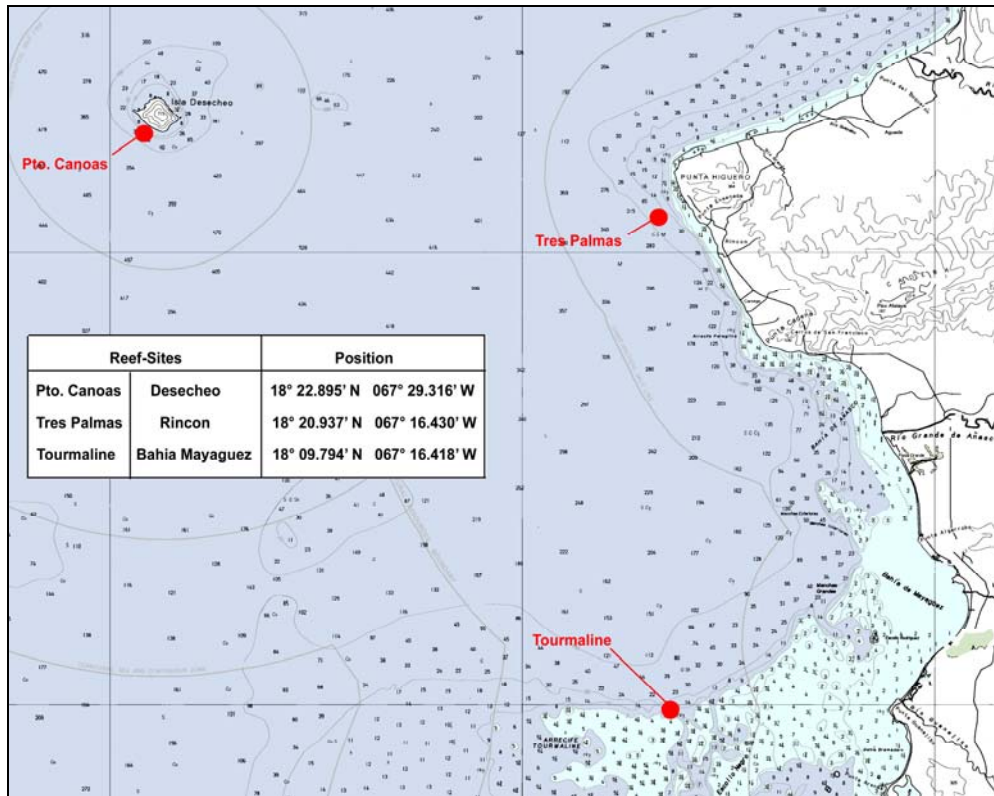


Figure 1. Location of reef survey sites at Isla Desecheo, Mayaguez and Rincón.

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 meters from the total length (links) recorded with the chain at the 10 meter 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.

Reef Fishes and Motile Megabenthic Invertebrates

Demersal reef fish populations and motile megabenthic invertebrates were surveyed by five 10-meter long by 3-meter wide (30 m²) belt-transects centered along the reference line of transects used for sessile-benthic reef 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 (> 1 cm) invertebrate species present and provides estimates of their densities at each reef physiographic zone or depth strata. A total of 15 belt-transects for fish and motile megabenthic invertebrates were performed at each of the three reef systems included in this report (e.g. Tres Palmas, Puerto Canoas/Botes, Tourmaline).

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 each reef physiographic zone, or depth strata, for a total of three ASEC surveys per site. All data will be recorded in plastic paper.

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. Essentially, the entire fringing Elkhorn Coral formation is contained within the Marine Reserve boundaries (Figure 2). The top of the platform is found at depths between 2 - 5 meters. 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 meters 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 *Acropora 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 survey, 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

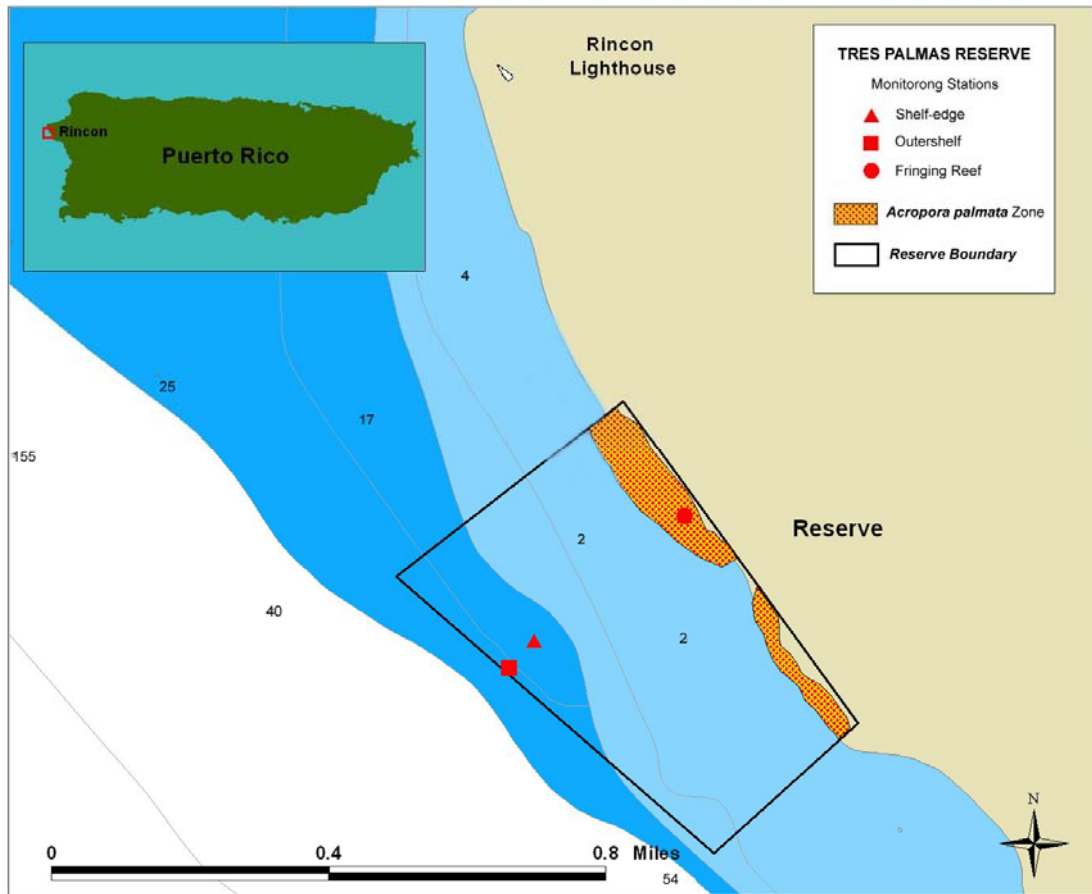


Figure 2. Location of coral reef survey stations off Tres Palmas, Rincon.

for bathers and divers, some of which were fishing with spearguns within the no-take area during our survey. Panoramic views of the Tres Palmas fringing Elkhorn Coral reef are presented in Photo Album 1.

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 meters. The percent of reef substrate cover by sessile-benthic categories along the permanent transects surveyed are presented in Table 2. Live coral cover averaged 38.6 % (range: 24.1 – 46.5 %). Elkhorn Coral, *A. palmata* was the dominant species with a mean

Table 2. Percent substrate cover by sessile-benthic categories from the fringing *Acropora palmata* formation at the Tres Palmas Reef system in Rincon, July, 2004

	TRANSECTS					MEAN
	1	2	3	4	5	
Rugosity (m)	4.17	4.31	3.94	3.13	3.41	3.79
SUBSTRATE CATEGORIES						
<i>CORAL SPECIES</i>						
<i>Acropora palmata</i>	10.66	41.84	37.04	42.88	22.24	30.93
<i>Diploria strigosa</i>	9.74				3.80	2.71
<i>Diploria clivosa</i>			4.02		7.37	2.28
<i>Porites astreoides</i>	1.20	0.59	2.30	3.66		1.55
<i>Montastrea annularis</i>	2.61		0.41			0.60
<i>Montastrea cavernosa</i>					2.83	0.57
STONY CORALS	24.14	42.42	43.76	46.53	36.25	38.62
TURF ALGAE	51.52	37.81	32.93	40.37	37.73	40.07
ZOANTHIDS	4.66		2.32			1.40
ENCRUSTING GORG.			0.51	0.43	0.42	0.27
ABIOTIC						
Reef Overhangs	18.00	18.59	19.87	10.97	21.92	17.87
Gaps/Holes	1.69	1.18	0.65	1.72		1.05
Sand					3.68	0.74
GORGONIANS (# col.)	1	0	0	2	2	1
Coral Species Outside Transects: <i>Colpophyllia natans</i> , <i>Millepora alvicornis</i> , <i>Siderastrea radians</i> , <i>Mycetophyllia lamarkiana</i> , <i>Isophyllia rigida</i> , <i>Agaricia agaricites</i> , <i>Porites porites</i> , <i>Diploria labyrinthiformis</i>						

substrate cover of 30.9 % (range: 10.7 - 42.9 %), representing 80 % 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 14 species of stony corals were identified from the fringing reef during our survey. Hard ground substrate, including dead coral sections not colonized by corals was mostly covered by turf algae (mean cover: 40.1 %). Fleshy macroalgae (*Valonia sp.*, *Stytopodium sp.*) and red coralline algae were observed outside transect areas. The encrusting zoanthid, *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 almost 20 % of the reef substrate cover. Vertically projected soft corals (gorgonians) were found in very low abundance (mean: 1 colony/transect). This was expected in an environment seasonally affected by strong wave action. The most common species included *Pseudopterogorgia americana*, *Plexaura homomalla*, *Gorgonia ventalina*, *Muricea spp.* and *Eunicea spp.*

1.2 Fishes and Motile Megabenthic Invertebrates

A total of 54 fish species, including 26 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 73.4 Ind/30 m² (range: 51-136 Ind/30 m²). The mean number of species per transect was 11.6 (range: 10-13). The combined abundance of four species represented 74 % of the mean abundance within belt-transects (Table 3). The most abundant species was the Glassy Sweeper (*Pempheris schomburgki*) which was found in one large aggregation within a crevice in Transect 1. The Dusky Damselfish, Redlip Blenny and the Bluehead Wrasse were present within all five transects surveyed and along with the Night Sergeant, Stoplight Parrotfish and the Yellowtail Damselfish comprised the most common fish assemblage of the reef. The two latter species were mostly present as early juvenile stages. 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 Blennies (*Ophioblennius*) and Wrasses (*Thalassoma bifasciatum*, *Halichoeres radiatus*, *H. maculipinna*, *H. bivittatus*) which feed on small benthic 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 piscivores (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*) and one Hawksbill Turtle (*Eretmochelys imbricata*) were observed during our ASEC survey (Table 4). Gobies and blennies were the most prominent assemblage at the tide pool habitats of the rocky shoreline.

Table 3. Taxonomic composition and abundance of fishes within belt-transects at the fringing *Acropora palmata* formation in the Tres Palmas Reef system, Rincon, July, 2004

		TRANSECTS					MEAN ABUNDANCE (Ind/30 m ²)
		1	2	3	4	5	
SPECIES	COMMON NAME						
<i>Pempheris schomburgki</i>	Glassy Sweeper	100					20.0
<i>Stegastes dorsopunicans</i>	Dusky Damselfish	1	12	22	15	19	13.8
<i>Ophioblennius atlanticus</i>	Redlip Blenny	15	12	16	9	6	11.6
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	8	14	7	10	7	9.2
<i>Abudefduf sexatilis</i>	Sergeant Major			11			2.2
<i>Mulloides martinicus</i>	Yellowtail Goatfish					11	2.2
<i>Haemulon sp</i>	Juvenile Grunts		9		1		2.0
<i>Acanthurus coeruleus</i>	BlueTang	2	2		3	2	1.8
<i>Microspathodon chrysurus</i>	Yellowtail Damselfish		2	3	1	3	1.8
<i>Acanthurus bahianus</i>	Ocean Surgeon				3	4	1.4
<i>Abudefduf taurus</i>	Night Sergeant	2	2	1	1		1.2
<i>Sparisoma viride</i>	Stoplight Parrotfish	1		1	2	2	1.2
<i>Sparisoma rubripinne</i>	Yellowtail Parrotfish		2	1	1		0.8
<i>Bodianus rufus</i>	Spanish Hogfish	2				1	0.6
<i>Aulostomus maculatus</i>	Trumpetfish			1		1	0.4
<i>Chaetodon capistratus</i>	Four-eye Butterflyfish				2		0.4
<i>Halichoeres radiatus</i>	Pudding Wife				1	1	0.4
<i>Halichoeres maculipinna</i>	Clown Wrasse			1		1	0.4
<i>Odontoscion dentex</i>	Reef Croaker	2					0.4
<i>Sparisoma radians</i>	Bucktooth Parrotfish				2		0.4
<i>Cantherhines pullus</i>	Tail-light Filefish	1					0.2
<i>Chromis multilineata</i>	Brown Chromis		1				0.2
<i>Haemulon chrysargyreum</i>	Smallmouth Grunt	1					0.2
<i>Halichoeres bivittatus</i>	Slippery Dick	1					0.2
<i>Holocentrus rufus</i>	Squirrelfish		1				0.2
<i>Myripristis jacobus</i>	Black-bar Soldierfish		1				0.2
TOTAL INDIVIDUALS		136	58	64	51	58	73.4
TOTAL SPECIES		12	11	10	13	12	11.6

Table 4. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at the fringing *Acropora palmata* formation in the Tres Palmas Reef, Rincon, July, 2004

Depth range : 3 - 5 m
Duration - 20 min.

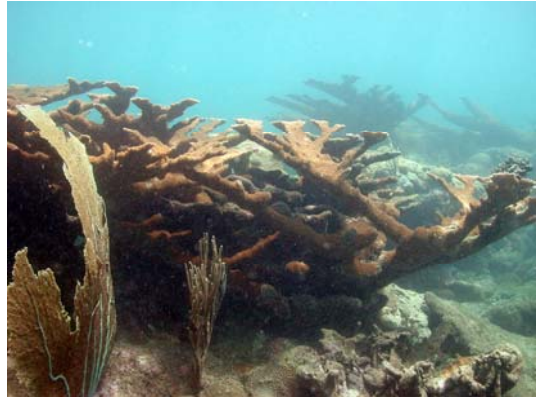
SPECIES	COMMON NAME	# - (cm)	
<i>Carangoides crysos</i>	Blue Runner	1 - (35)	
<i>Caranx lugubris</i>	Black Jack	1 - (10)	
<i>Caranx latus</i>	Horse-eye Jack	1 - (15)	
<i>Cephalopholis fulva</i>	Coney	1 - (20)	
<i>Gramma loreto</i>	Fairy Basslet	1 - (3)	2 - (4)
<i>Lutjanus analis</i>	Mutton Snapper	1 - (5)	2 - (25)
<i>Lutjanus apodus</i>	Schoolmaster	1 - (20)	
<i>Scarus coelestinus</i>	Midnight Parrotfish	1 - (30)	
<i>Scomberomorus regalis</i>	Cero Mackerel	2 - (35)	3 - (50)
Sea Turtles			
<i>Eretmochelys imbricata</i>	Hawksbill Turtle		
Other Fishes Present :			
<i>Acanthurus bahianus</i>	Ocean Surgeon		
<i>Acanthurus chirurgus</i>	Doctorfish		
<i>Anchoa sp.</i>	Anchovy		
<i>Anisotremus virginicus</i>	Porkfish		
<i>Cantherhines pullus</i>	Tail-light Filefish		
<i>Chaetodon capistratus</i>	Four-eye Butterflyfish		
<i>Gerres cinereus</i>	Yellowfin Mojarra		
<i>Haemulon carbonarium</i>	Caesar's Grunt		
<i>Haemulon plumieri</i>	White Grunt		
<i>Holocentrus adsensionis</i>	Longjaw Squirrelfish		
<i>Holocentrus rufus</i>	Squirrelfish		
<i>Kyphosus sectatrix</i>	Bermuda Chub		
<i>Mulloidis martinicus</i>	Yellowtail Goatfish		
<i>Pseudupeneus maculatus</i>	Striped Goatfish		
<i>Scarus iserti</i>	Striped Parrotfish		
<i>Scarus vetula</i>	Queen Parrotfish		
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish		
<i>Stegastes partitus</i>	Bicolor Damselfish		
<i>Synodus intermedius</i>	Lizardfish		

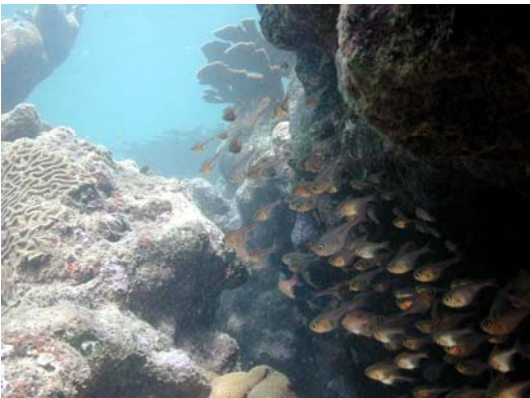
Among motile megabenthic invertebrates, Rock-boring Urchins (*Echinometra lucunter*) and Fire Worms (*Hermodice carunculata*) were present within belt-transects (Table 5). The White and Long-Spined Sea Urchins (*Tripneustes esculentus*, *Diadema antillarum*) were also present outside transect areas in the reef.

Table 5. Taxonomic composition and abundance of motile megabenthic invertebrates within belt-transects at the fringing *Acropora palmata* formation in Tres Palmas Reef, Rincon, July, 2004

		TRANSECTS					MEAN ABUNDANCE (IND/30 m ²)
		1	2	3	4	5	
Depth: 5.0 m							
<i>SPECIES</i>	COMMON NAME						
<i>Hermodice carunculata</i>	Fire worm		2				0.4
<i>Echinometra lucunter</i>	Rock boring urchin		6	14	9		5.8
TOTALS			8	14	9		6.2

1.3 Photo Album 1







2. Outer Shelf Patch Coral Reefs

2.1 Sessile-benthic Reef Community

A series of submerged patch reefs were found on the Tres Palmas outer shelf, at about 200 meters 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 meters. Our permanent transects were installed within one of these patch reef promontories at a depth of 10 meters 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 meters 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 in 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 21 col./transect (range: 14 – 30 col./transect) (Table 6). 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 20 species of stony corals were identified from the patch reef community during our survey. Stony coral cover averaged 20.9 % (range: 14.5 – 27.0 %). Great Star Coral, *Montastrea cavernosa* was the dominant species in terms of substrate cover with a mean of 6.6 % (range: 2.6 – 10.0 %), representing 31.5 % of the total live coral cover from this reef. Fourteen additional coral species were intersected by linear transects, but eight of them with less than 1 % mean cover (Table 6). Only *M. cavernosa* and the Mustard Hill Coral, *Porites astreoides* were intersected by all five transects.

Table 6. Percent substrate cover by sessile-benthic categories from the Tres Palmas Outer Shelf patch reef formation at a depth of 10 meters, July, 2004.

	TRANSECTS					MEAN
	1	2	3	4	5	
Rugosity (m)	1.59	1.52	1.51	1.32	1.38	1.46
SUBSTRATE CATEGORIES						
<i>CORAL SPECIES</i>						
<i>Montastrea cavernosa</i>	2.58	8.44	10.04	5.84	6.04	6.59
<i>Montastrea annularis</i>	8.27	4.77				2.61
<i>Colpophyllia natans</i>			2.82	7.59		2.08
<i>Porites astreoides</i>	0.36	2.45	3.30	1.15	2.02	1.86
<i>Diploria labyrinthiformis</i>			3.43	0.63	3.95	1.60
<i>Dendrogyra cylindrus</i>				7.10		1.42
<i>Diploria strigosa</i>	2.06	4.52				1.32
<i>Siderastrea siderea</i>			2.57		2.10	0.93
<i>Agaricia agaricites</i>		0.74	1.47	1.33	0.97	0.90
<i>Meandrina meandrites</i>			0.86	1.50		0.47
<i>Siderastrea radians</i>					1.47	0.29
<i>Stephanocoenia michilini</i>	0.36			1.00		0.27
<i>Porites porites</i>				0.38	0.88	0.25
<i>Madracis decactis</i>	0.86				0.25	0.22
<i>Millepora sp.</i>		0.37		0.25	0.25	0.17
<i>Isophyllia sinuosa</i>				0.50		0.10
STONY CORALS	14.49	20.91	24.48	27.03	17.67	20.92
TURF ALGAE	74.97	67.60	65.98	65.54	73.99	69.62
FLESHY ALGAE		1.10	0.49			0.32
CALCAREOUS ALGAE	0.24					0.05
SPONGES	8.36	6.73	6.49	3.09	4.31	5.80
ENCRUSTING GORG		0.37		0.49	1.15	0.40
ASCIDIANS			1.35			0.27
ABIOTIC						
Reef Overhangs	1.98	2.93	1.23	3.61	2.64	2.48
GORGONIANS (# col.)	30	19	18	14	25	21

Coral Species Outside Transects: *Acropora cervicornis*, *Favia fragum*, *Isophyllastrea rigida*, *Manicina areolata*

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 69.6 % (range: 65.5 – 75.0 %). 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 5.8 % (range: 3.1 – 8.4 %). 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 2.5 % 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 1.46 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 a 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).

2.2 Fishes and Motile Megabenthic Invertebrates

A total of 54 fish species, including 29 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 111.4 Ind/30 m² (range: 76-135 Ind/30 m²). The mean number of species per transect was 17.8 (range: 12-20). Two species, the Bluehead Wrasse (*Thalassoma bifasciatum*) and the Bicolor Damselfish (*Stegastes partitus*) were numerically dominant within belt-transects with mean abundances of 38.4 and 38.2 Ind/30 m², respectively (Table 7). The combined abundance of these two species represented 69 % of the community mean abundance within belt-transects. In addition to the two aforementioned species, the Sharknose Goby, Striped and Bucktooth Parrotfishes, Doctorfish, Ocean Surgeon, Coney, Caribbean Puffer and Four-eye Butterflyfish were present within all five transects surveyed and can be considered prominent components of the resident fish assemblage from 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 8). Only juvenile 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 Arrow Crabs (*Stenorhynchus seticornis*) and Cleaner Shrimps (*Stenopus hispidus*, *Periclimenes sp.*) were present within belt-transects (Table 9). Three juvenile Spiny Lobsters (*Panulirus argus*), one Rock Lobster (*Scyllarides sp.*) and one squid (*Sephioteuthis sp.*) were observed outside transect areas during the ASEC survey.

Table 7. Taxonomic composition and abundance of fishes within belt-transects at the Tres Palmas patch reef formation at a depth of 10 meters. July, 2004.

SPECIES	COMMON NAME	TRANSECTS					MEAN ABUNDANCE (Ind/30 m²)
		1	2	3	4	5	
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	44	20	35	56	37	38.4
<i>Stegastes partitus</i>	Bicolor Damselfish	52	53	1	42	43	38.2
<i>Gobiosoma evelynae</i>	Sharknose Goby	6	4	10	2	4	5.2
<i>Scarus iserti</i>	Stripped Parrotfish	4	6	4	8	1	4.6
<i>Sparisoma radians</i>	Bucktooth Parrotfish	1	5	2	3	3	2.8
<i>Acanthurus chirurgus</i>	Doctorfish	1	4	4	2	2	2.6
<i>Halichoeres maculipinna</i>	Clown Wrasse	2	1	2		5	2.0
<i>Acanthurus bahianus</i>	Ocean Surgeon	2	2	1	2	2	1.8
<i>Cephalopholis fulva</i>	Coney	2	2	3	1	1	1.8
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	3	3			3	1.8
<i>Chaetodon capistratus</i>	Foureye Butterflyfish	2	1	2	1	2	1.6
<i>Serranus tigrinus</i>	Harlequin Bass	1	4	2		1	1.6
<i>Chromis cyanea</i>	Blue Chromis	4		3			1.4
<i>Coryphopterus lipernes</i>	Peppermint Goby	5	2				1.4
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	1	3	1		1	1.2
<i>Canthigaster rostrata</i>	Caribbean Puffer	1	1	1	1	1	1.0
<i>Holacanthus tricolor</i>	Rock Beauty		1		1	1	0.6
<i>Acanthurus coeruleus</i>	BlueTang	1	1				0.4
<i>Amblycirrhitus pinnos</i>	Redspotted Hawkfish	1				1	0.4
<i>Holocentrus rufus</i>	Squirrelfish			1		1	0.4
<i>Microspathodon chrysurus</i>	Yellowtail Damselfish	1				1	0.4
<i>Sparisoma viride</i>	Stoplight Parrotfish		1	1			0.4
<i>Aulostomus maculatus</i>	Trumpetfish			1			0.2
<i>Epinephelus guttatus</i>	Red Hind					1	0.2
<i>Malacoctenus triangulatus</i>	Saddled Blenny			1			0.2
<i>Ophioblennius atlanticus</i>	Redlip Blenny		1				0.2
<i>Scarus taeniopterus</i>	Princess Parrotfish				1		0.2
<i>Scomberomorus regalis</i>	Cero Mackerel	1					0.2
<i>Synodus intermedius</i>	Galliwasp			1			0.2
	TOTAL INDIVIDUALS	135	115	76	120	111	111.4
	TOTAL SPECIES	20	19	19	12	19	17.8

Table 8. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at the Tres Palmas patch reef formation. July, 2004.

Depth range : 9 - 12 m
Duration - 20 min.

SPECIES	COMMON NAME	# - (cm)		
<i>Epinephelus guttatus</i>	Red Hind	1 - (30)		
<i>Lutjanus apodus</i>	Schoolmaster	1 - (25)		
<i>Lutjanus mahogany</i>	Mahogany Snapper	3 - (20)	2 - (25)	
<i>Lutjanus synagris</i>	Lane Snapper	1 - (15)	2 - (20)	1 - (30)
<i>Scomberomorus regalis</i>	Cero Mackerel	2 - (60)	1 - (90)	
<i>Holacanthus ciliaris</i>	Queen Angel	1 - (30)		
<i>Gramma loreto</i>	Fairy Basslet	16 - (3)	10 - (4)	3 - (5)
<i>Holacanthus tricolor</i>	Rock Beauty	2 - (15)	1 - (20)	2 - (25)
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish	3 - (6-7)		
<i>Chaetodon sedentarius</i>	Reef Butterflyfish	2 - (7)		
Invertebrates				
<i>Panulirus argus</i>	Spiny Lobster	1 - (20)*	2 - (25)*	
<i>Scyllarides sp.</i>	Rock Lobster	1 - (20)*		
<i>Sepioteuthis sp.</i>	Squid	1 - (25)		
Other Fishes Present :				
<i>Abudefduf sexatilis</i>	Sergeant Major			
<i>Abudefduf taurus</i>	Night Sergeant			
<i>Apogon sp.</i>	Cardinalfish			
<i>Aulostomus maculatus</i>	Trumpetfish			
<i>Bodianus rufus</i>	Spanish Hogfish			
<i>Cantherhines pullus</i>	Tail-light Filefish			
<i>Cephalopholis cruentatus</i>	Graysbe			
<i>Coryphopterus personatus</i>	Masked Goby			
<i>Flammeo marianus</i>	Longspine Squirrelfish			
<i>Diodon holacanthus</i>	Porcupinefish			
<i>Equetus acuminatus</i>	Spotted Drum			
<i>Haemulon flavolineatum</i>	French Grunt			
<i>Haemulon plumieri</i>	White Grunt			
<i>Haemulon macrostomum</i>	Spanish Grunt			
<i>Hemiramphus ballyhoo</i>	Ballyhoo			
<i>Holocentrus rufus</i>	Squirrelfish			
<i>Mulloides martinicus</i>	Yellowtail Goatfish			
<i>Malacanthus plumieri</i>	Sand Tilefish			
<i>Melichthys niger</i>	Black Durgon			
<i>Myripristis jacobus</i>	Black-bar Soldierfish			
<i>Pomacanthus arcuatus</i>	Gray Angelfish			
<i>Priacanthus arenatus</i>	Glasseye			
<i>Sparisoma viride</i>	Stoplight Parrotfish			
<i>Stegastes variabilis</i>	Cocoa Damselfish			

* Carapace length (cm)

Table 9. Taxonomic composition and abundance of motile megabenthic invertebrates within belt-transects at the Tres Palmas Outer Shelf patch reef formation. July, 2004.

SPECIES	COMMON NAME	TRANSECTS					MEAN ABUNDANCE (IND/30 m2)
		1	2	3	4	5	
<i>Stenopus hispidus</i>	Banded coral shrimp			1	1		0.4
<i>Stenorhynchus seticornis</i>	Arrow crab	1	1	3			1.0
<i>Periclimenes sp.</i>	Cleaner shrimp		1		1		0.4
TOTALS		1	2	4	2	0	1.8

2.3 Photo Album 2





3.0 Shelf-edge Coral 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 meters. 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 meters 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 structure 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 off Tres Palmas are presented in Photo Album 3.

A total of 21 stony coral species were identified from the shelf-edge reef off Tres Palmas, 13 of which were intercepted by line transects during our survey (Table 10). Stony corals occurred mostly as encrusting and mound shaped colonies. Substrate cover by stony corals along transects averaged 23.2 % (range: 15.9 – 31.8 %). Boulder Star Coral, *Montastrea annularis* was the dominant species in terms of substrate cover with a mean of 8.1 % (range: 1.9 – 19.2 %), representing 35 % of the total cover by stony corals (Table 10). Colonies of *Montastrea annularis*, *M. cavernosa*, *Meandrina meandrites*, and *Madracis decactis* were present in all five transects. Small colonies of Mustard-Hill Coral, *Porites astreoides* and Lettuce Coral, *Agaricia agaricites* were also very common. Soft corals (gorgonians) were moderately abundant, with an average of 11 colonies/transect. Encrusting and erect sponges, including several large Basket Sponges, *Xestospongia muta* were present in all transects with an average cover of 6.8 %. Reef overhangs averaged 7.5 % and contributed to a topographic rugosity of 2.58 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 57.7 % (range : 44.4 – 68.3 %). 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.

Table 10. Percent substrate cover by sessile-benthic categories at the Tres Palmas Shelf-edge reef formation at a depth of 20 meters, July, 2004.

	TRANSECTS					MEAN
	1	2	3	4	5	
Rugosity (m)	1.80	3.39	2.37	2.51	2.85	2.58
SUBSTRATE CATEGORIES						
<i>CORAL SPECIES</i>						
<i>Montastrea annularis</i>	1.91	6.41	19.17	3.73	9.19	8.08
<i>Colpophyllia natans</i>		5.26	3.16		4.29	2.54
<i>Montastrea cavernosa</i>	2.51	3.26	2.05	1.68	2.11	2.32
<i>Meandrina meandrites</i>	0.95	1.37	2.83	4.53	1.40	2.22
<i>Agaricia sp.</i>	6.2	1.37	0.57	2.00		2.03
<i>Porites astreoides</i>	1.07	2.83		2.97	3.04	1.98
<i>Siderastrea radians</i>	1.31	3.68			0.33	1.06
<i>Leptoseris cucullata</i>	2.15		1.37		0.66	0.84
<i>Agaricia agaricites</i>	0.48	1.16		0.34	1.80	0.76
<i>Madracis decactis</i>	0.24	0.32	0.46	0.68	0.77	0.49
<i>Diploria strigosa</i>	0.24	0.84	1.14			0.44
<i>Dichocoenia stokesii</i>			1.03			0.21
<i>Diploria labyrinthiformis</i>		0.95				0.19
STONY CORALS	17.06	27.45	31.77	15.91	23.58	23.15
SPONGE	8.35	5.05	4.93	5.84	9.88	6.81
ENCRUSTING GORG			0.68			0.14
ABIOTIC						
Reef Overhangs	6.33	7.78	9.70	6.39	7.24	7.49
TURF ALGAE	68.26	52.37	44.38	67.15	56.26	57.68
FLESHY ALGAE		7.36	8.57	4.72	3.04	4.74
GORGONIANS (# col.)	16	6	7	17	11	11
Coral Species Outside Transects: <i>Acropora cervicornis</i> , <i>Favia fragum</i> , <i>Porites porites</i> , <i>Isophyllastrea rigida</i> , <i>Manicina areolata</i> , <i>Siderastrea sidereal</i> , <i>Millepora alcicornis</i> , <i>Stylaster roseus</i>						

3.2 Fishes and Motile Megabenthic Invertebrates

A total of 54 fish species were identified from the shelf-edge reef off Tres Palmas during our baseline characterization survey in July, 2004. Mean abundance within belt-transects was 531.4 Ind/30 m² (range: 377 – 927 Ind/30 m²), which is the second highest ever reported for coral reef systems in Puerto Rico (after Puerto Canoas Reef at 30 meters, this volume). The mean number of species per transect was 26 (range: 21-29). The Masked Goby, *Coryphopterus personatus* was the numerically dominant species with a mean abundance of 341 Ind/30 m² (range: 180 – 787 Ind/30 m²), representing 64 % of the total abundance within belt-transects (Table 11). The Masked Goby is a small carnivorous fish (< 2.0 cm) that formed 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, Blue Chromis, Bluehead and Yellowhead Wrasses, Longspine Squirrelfish, Caribbean Puffer and the Coney were present within all five transects surveyed.

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* 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 12). 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 (4 spp), gobies (4 spp), goatfishes (2 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 (6 spp), doctorfishes (3 spp) and damselfishes (3 spp) comprised the main herbivorous assemblage.

Table 11. Taxonomic composition and abundance of fishes within belt-transects at the Shelf-edge Reef off Tres Palmas, Rincon Marine Reserve. July, 2004

DEPTH: 20 m		TRANSECTS					MEAN
		1	2	3	4	5	
		(Individuals/30 m ²)					
SPECIES	COMMON NAME						
<i>Coryphopterus personatus</i>	Masked Goby	270	787	180	300	170	341.4
<i>Stegastes partitus</i>	Bicolor Damselfish	66	33	45	58	56	51.6
<i>Coryphopterus lipernes</i>	Peppermint Goby	73	67	56	36	19	50.2
<i>Chromis cyanea</i>	Blue Chromis	85	2	26	27	31	34.2
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	15	5	16	12	2	10.0
<i>Clepticus parrae</i>	Creole Wrasse	7		14	15	4	8.0
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	8	4	5	3	2	4.4
<i>Gobiosoma evelynae</i>	Sharknose Goby	8	5		2	2	3.4
<i>Flameo marianus</i>	Longspine Squirrelfish	3	3	5	1		2.4
<i>Scarus iserti</i>	Stripped Parrotfish	3	6		1		2.0
<i>Chromis multilineata</i>	Brown Chromis	5		3		1	1.8
<i>Haemulon flavolineatum</i>	French Grunt	4	1	2	1	1	1.8
<i>Stegastes leucostictus</i>	Beaugregory	3	2	3		1	1.8
<i>Canthigaster rostrata</i>	Caribbean Puffer	1	1	3	2	1	1.6
<i>Cephalopholis cruentatus</i>	Graysby	1	2	1	2	1	1.4
<i>Sparisoma radians</i>	Bucktooth Parrotfish			2		4	1.2
<i>Chaetodon capistratus</i>	Foureye Butterflyfish	2		1	1	1	1.0
<i>Mulloidides martinicus</i>	Yellowtail Goatfish	5					1.0
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	2	1	1	1		1.0
<i>Acanthurus bahianus</i>	Ocean Surgeon	2	1		1		0.8
<i>Acanthurus chirurgus</i>	Doctorfish		2		1	1	0.8
<i>Amblycirrhitus pinos</i>	Redspotted Hawkfish	2		1		1	0.8
<i>Acanthurus coeruleus</i>	BlueTang	1		1	1		0.6
<i>Carangoides ruber</i>	Bar Jack			2		1	0.6
<i>Coryphopterus sp.</i>	Goby		1	1	1		0.6
<i>Holocentrus rufus</i>	Squirrelfish	1			1	1	0.6
<i>Myripristis jacobus</i>	Blackbar Soldierfish	1			1	1	0.6
<i>Scarus taeniopterus</i>	Princess Parrotfish		1	1	1		0.6
<i>Bodianus rufus</i>	Spanish Hogfish	1			1		0.4
<i>Hypoplectrus puella</i>	Barred Hamlet			1	1		0.4
<i>Hypoplectrus unicolor</i>	Butter Hamlet	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>Abudefduf sexatilis</i>	Sergeant Major			1			0.2
<i>Cephalopholis fulva</i>	Coney					1	0.2
<i>Chaetodon striatus</i>	Banded Butterflyfish		1				0.2
<i>Equetus lanceolatus</i>	Jackknife Fish			1			0.2
<i>Haemulon macrostomum</i>	Spanish Grunt					1	0.2
<i>Holacanthus tricolor</i>	Rock Beauty			1			0.2
<i>Holacanthus ciliaris</i>	Queen Angelfish			1			0.2
<i>Hypoplectrus chlorurus</i>	Yellowtail Hamlet	1					0.2
<i>Hypoplectrus nigricans</i>	Black Hamlet	1					0.2
<i>Lutjanus mahogani</i>	Mahogani Snapper				1		0.2

Table 11. Continued

<i>Melichthys niger</i>	Black Durgon					1			0.2
<i>Microspathodon chrysurus</i>	Yellowtail Damselfish						1		0.2
<i>Sparisoma chrysopterum</i>	Redtail Parrotfish			1					0.2
<i>Scarus vetula</i>	Queen Parrotfish						1		0.2
<i>Scomberomorus regalis</i>	Cero Mackerel					1			0.2
<i>Synodus intermedius</i>	Galliwasp			1					0.2
TOTAL INDIVIDUALS		574	927	377	474	305			531.4
TOTAL SPECIES		29	21	29	27	24			26

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. 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*).

The Arrow Crab, *Stenorhynchus seticornis* and the cleaner shrimps, *Periclimenes sp.* and *Stenopus hispidus* were the motile megabenthic invertebrates observed within belt-transects (Table 13). One juvenile Spiny Lobster, *Panulirus argus* was observed outside transects during the ASEC survey.

Table 12. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at the shelf-edge, Tres Palmas Reef. July, 2004

Depth range : 18 - 22 m
Duration - 20 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>Epinephelus guttatus</i>	Red Hind	1 - (30)		
<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 apodus</i>	Schoolmaster	1 - (25)		
<i>Lutjanus mahogany</i>	Mahogani Snapper	3 - (20)	2 - (25)	
<i>Lutjanus synagris</i>	Lane Snapper	1 - (20)	1 - (30)	
<i>Scomberomorus regalis</i>	Cero Mackerel	2 - (60)	1 - (90)	
<i>Sphyaena barracuda</i>	Great Barracuda	1 - (70)		
Invertebrates				
<i>Panulirus argus</i>	Spiny Lobster	1 - (20)*		
Other Fishes Present :				
<i>Equetus acuminatus</i>	Spotted Drum			
<i>Hemiramphus ballyhoo</i>	Ballyhoo			
<i>Sparisoma viride</i>	Stoplight Parrotfish			

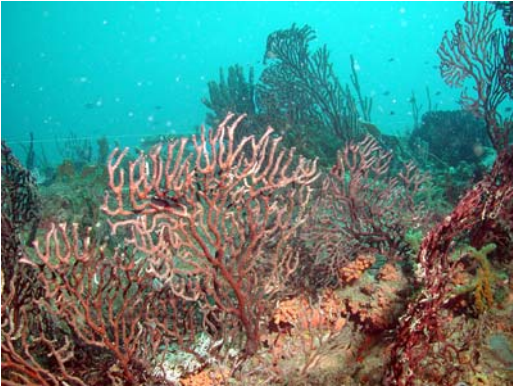
* Carapace length (cm)

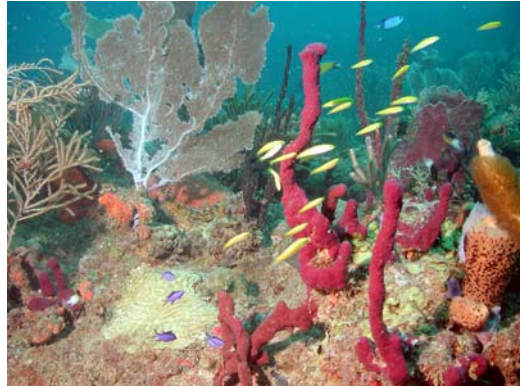
Table 13. Taxonomic composition and abundance of motile megabenthic invertebrates within belt-transects at the shelf-edge reef formation off Tres Palmas, Rincon. July, 2004

SPECIES	COMMON NAME	TRANSECTS					MEAN ABUNDANCE (IND/30 m2)
		1	2	3	4	5	
<i>Stenorhynchus seticornis</i>	Arrow crab	1			1		0.4
	Banded coral shrimp	1					0.2
<i>Periclimenes sp.</i>	Cleaner shrimp				1	1	0.4
TOTALS		2	0	0	2	1	1.0

3.3 Photo Album 3







B. Puerto Canoas /Puerto Reefs - Isla Desecheo

1.0 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 (Figure 3). 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 meters and extend horizontally more than 5 meters, 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 meters 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 meters. At the southern end, the reef platform ends in an extensive sand deposit that slopes down gently to a depth of about 50 meters. Our survey was performed right at the end of the reef on the southern section. Transects were installed at a depth of 27 – 30 meters, bordering the edge of one of the larger coral promontories. Panoramic views of the shelf-edge reef at Puerto Canoas are presented in Photo Album 4.

Stony corals dominated reef substrate cover along surveyed transects with a mean of 48.4 % (range: 35.0 – 64.9 %). Boulder Star Coral (*Montastrea annularis*), with a mean cover of 36.1 % represented almost 75 % of the total stony coral cover and was the only species present in all five transects (Table 14). A total of 22 species of stony corals were identified, including 13 intersected by line transects. Lettuce Coral (*Agaricia agaricites*), Mustard-Hill Coral (*Porites astreoides*) and Flower Coral (*Eusmilia fastigiata*) were present in four transects and along with Boulder Star Coral and Boulder Brain Coral (*Colpophyllia natans*) ranked among the species with highest percent substrate cover. 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 in the shelf-edge reef. Abiotic cover, associated with reef overhangs averaged 17.6 % and contributed to a mean reef substrate rugosity of 3.77 meters. Encrusting sponges were common, but in relatively low cover in the reef (mean: 2.6 %).

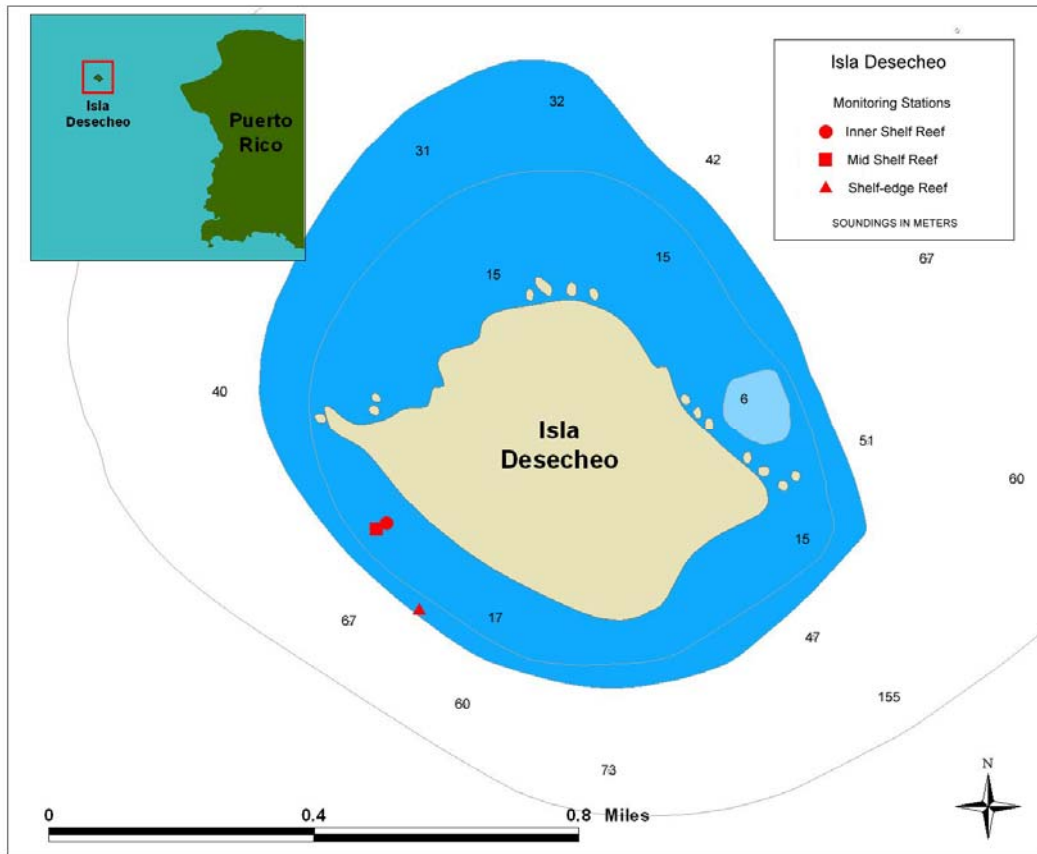


Figure 3. Location of coral reef survey stations at Puerto Canoas/Botes, Isla Desecheo.

Turf algae was comprised by a mixed assemblage of short red filamentous and brown macroalgae. Its mean substrate cover along transects surveyed was 24.1 % (range: 13.2 – 35.9 %). Fleshy brown and red macroalgae presented a combined substrate cover of 6.9 %. *Lobophora sp.*, *Padina sp.* and *Ventricaria ventricosa* were some of the most common fleshy macroalgae present.

Table 14. Percent substrate cover by sessile-benthic categories at Puerto Canoas Shelf-edge Reef, Isla Desecheo, August, 2004

	TRANSECTS						MEAN %
	1	2	3	4	5	6	
Rugosity (m)	3.78	3.92	3.89	3.83	3.79	3.39	3.77
SUBSTRATE CATEGORIES							
<i>CORAL SPECIES</i>							
<i>Montastrea annularis</i>	26.18	19.74	52.53	22.2	35.96	60.15	36.13
<i>Colpophyllia natans</i>	13.19	3.44		6.01			3.77
<i>Agaricia agaricites</i>	1.84	3.04	3.15	3.87	4.29		2.70
<i>Porites astreoides</i>		3.24	0.41	3.46	1.84	1.26	1.70
<i>Eusmilia fastigiata</i>	6.54	1.72	0.3	1.02			1.60
<i>Agaricia lamarcki</i>	1.12	2.53				2.42	1.01
<i>Diploria strigosa</i>					4.18		0.70
<i>Mycetophyllia aliciae</i>		1.32					0.22
<i>Siderastrea siderea</i>						1.05	0.18
<i>Meandrina meandrites</i>				1.02			0.17
<i>Madracis decactis</i>				0.61			0.10
<i>Porites porites</i>	0.61						0.10
<i>Leptoseris cucullata</i>				0.31			0.05
STONY CORALS	49.49	35.02	56.39	38.49	46.28	64.87	48.42
SPONGES	3.58	3.04	4.36	2.14	1.63	1.16	2.65
ENCRUSTING GORG		0.30					0.05
ABIOTIC							
Reef Overhangs	21.47	14.47	19.78	16.60	14.81	18.19	17.55
Sand						0.95	0.16
Gaps		0.20		1.02			0.20
TURF ALGAE	21.68	30.37	18.15	35.94	25.23	13.25	24.10
FLESHY ALGAE	3.78	16.60	1.32	5.81	12.05	1.58	6.86
Stony Coral Species Outside Transects: <i>Agaricia sp.</i> , <i>Diploria labyrinthiformis</i> , <i>Isophyllastrea rigida</i> , <i>Stylaster roseus</i> , <i>Montastrea cavernosa</i> , <i>Mycetophyllia lamarki</i> , <i>Eusmilia fastigiata</i>							

1.2 Fishes and Motile Megabenthic Invertebrates

A total of 69 fish species were identified from the shelf-edge reef off Puerto Canoas, Isla Desecheo during August, 2004. Mean abundance of fishes within belt-transects was 557.8 Ind/30 m² (range: 314 – 870 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. 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 15). 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 16). 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, Caribbean Reef Sharks, Barracudas, Cero Mackerels, Blue Runners, Rainbow Runners and Black Jacks (Table 16). Other mid-size carnivores that are commercially exploited, such as the Yellowtail, Mahogany and Schoolmaster Snappers, Red Hind, Coney and Queen Triggerfish were observed in 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*) and Peppermint Bass (*Liopropoma rubre*) were common.

Table 15. Taxonomic composition and abundance of fishes within belt-transects at the Puerto Canoas Shelf-edge Reef, Isla Desecheo, August, 2004

SPECIES	COMMON NAME	TRANSECTS						MEAN
		1	2	3	4	5	6	
		Individuals/30 m ²						
<i>Clepticus parrae</i>	Creole Wrasse	150	300	68	250	200	326	215.7
<i>Coryphopterus personatus</i>	Masked Goby	60	129	25	18	160	250	107.0
<i>Chromis cyanea</i>	Blue Chromis	11	15	12	59	40	156	48.8
<i>Coryphopterus lipernes</i>	Peppermint Goby	43	31	25	52	49	38	39.7
<i>Gramma loreto</i>	Fairy Basslet	15	27	60	46	28	31	34.5
<i>Chromis multilineata</i>	Brown Chromis	56	16	12		8	4	16.0
<i>Unidentified 1</i>	Silvery Fishes		40	50				15.0
<i>Gobiosoma evelynae</i>	Sharknose Goby	12	5	5	9	11	6	8.0
<i>Stegastes partitus</i>	Bicolor Damsel	7	2	9	12	10	8	8.0
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	3	10	7	6	7		5.5
<i>Coryphopterus sp1.</i>	Goby	5	8	4	6	4	4	5.2
<i>Kyphosus sectatrix</i>	Bermuda Chub	15	8		2		1	4.3
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	1	6	4	5	3	3	3.7
<i>Sparisoma radians</i>	Bucktooth Parrotfish	3	5	2	4	4	3	3.5
<i>Caranx hippos</i>	Horse-eye Jack	10	7				3	3.3
<i>Cephalopholis cruentatus</i>	Graysby	3	4	3	3	2	3	3.0
<i>Paranthias furcifer</i>	Creole Fish	3	3	2	4	5	1	3.0
<i>Chaetodon capistratus</i>	Foureye Butterflyfish	8		2	2	2	2	2.7
<i>Mulloides martinicus</i>	Yellowtail Goatfish	14			1	1		2.7
<i>Halichoeres maculipinna</i>	Clown Wrasse	1	5	3	1	2		2.0
<i>Lutjanus apodus</i>	Schoolmaster	3	3	1	1	4		2.0
<i>Flammeo marianus</i>	Longspine Squirrelfish	1	1	1	2	3	2	1.7
<i>Chromis insulatus</i>	Sunshine Chromis						9	1.5
<i>Caranx lugubris</i>	Black Jack	1	1	3		2	1	1.3
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish	2			1	2	3	1.3
<i>Canthidermis sufflamen</i>	Ocean Triggerfish	4		2			1	1.2
<i>Myripristis jacobus</i>	Blackbar Soldierfish	4	2			1		1.2
<i>Acanthurus coeruleus</i>	BlueTang	2	1		1	1	1	1.0
<i>Canthigaster rostrata</i>	Caribbean Puffer	1	1		1	2	1	1.0
<i>Carangoides ruber</i>	Bar Jack		3		1		2	1.0
<i>Liopropoma rubre</i>	Peppermint Bass	1	1	1	1	1	1	1.0
<i>Melichthys nigrer</i>	Black Durgon			2	1		3	1.0
<i>Scarus iserti</i>	Stripped Parrotfish	2			3	1		1.0
<i>Sparisoma rubripinne</i>	Yellowtail Parrotfish				4	2		1.0
<i>Amblycirrhitus pinos</i>	Redspotted Hawkfish		1	2	1	1		0.8
<i>Microspathodon chrysurus</i>	Yellowtail Damselfil	1			2	1	1	0.8
<i>Sparisoma chrysopterygum</i>	Redtail Parrotfish				2	3		0.8
<i>Bodianus rufus</i>	Spanish Hogfish		1	2	1			0.7
<i>Scomberomorus regalis</i>	Cero Mackerel	1					3	0.7
<i>Cantherhines macrocerus</i>	Whitespotted Filefish					2	1	0.5
<i>Holacanthus tricolor</i>	Rock Beauty		1	1	1			0.5
<i>Holocanthus ciliaris</i>	Queen Angelfish	2		1				0.5

Table 15. Continued

<i>Holocentrus rufus</i>	Squirrelfish			1	2			0.5
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	1		1	1			0.5
<i>Scarus vetula</i>	Queen Parrotfish			1		1		0.3
<i>Serranus tigrinus</i>	Harlequin Bass					1	1	0.3
<i>Stegastes planifrons</i>	Yellow-eye Damselfish	1		1				0.3
<i>Alutherus scriptus</i>	Scrawled Filefish				1			0.2
<i>Apogon sp.</i>	Cardinalfish			1				0.2
<i>Diodon hystrix</i>	Porcupinefish					1		0.2
<i>Epinephelus guttatus</i>	Red Hind				1			0.2
<i>Equetus acuminatus</i>	Highhat					1		0.2
<i>Haemulon flavolineatum</i>	French Grunt				1			0.2
<i>Haemulon sciurus</i>	Bluestripped Grunt	1						0.2
<i>Lactophrys triqueter</i>	Smooth Trunkfish					1		0.2
<i>Pomacanthus arcuatus</i>	Gray Angelfish						1	0.2
<i>Serranus tabacarius</i>	Tobacco Fish	1						0.2
<i>Sparisoma viride</i>	Stoplight Parrotfish					1		0.2
TOTAL INDIVIDUALS		449	637	314	510	567	870	557.8
TOTAL SPECIES		36	29	32	38	36	31	33.7

Table 16. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at the shelf-edge, Puerto Canoas Reef. August, 2004.

Depth range : 26 - 30 m

Duration - 20 min.

SPECIES	COMMON NAME	# - (cm)				
<i>Carangoides crysos</i>	Blue Runner	2 - (30)	1 - (35)	1 - (40)		
<i>Caranx hippos</i>	Horse-eye Jack	20 - (45)	1 - (60)	1 - (70)		
<i>Caranx lugubris</i>	Black Jack	1 - (30)	2 - (40)			
	Caribbean Reef					
<i>Carcharhinus limbatus</i>	Shark	1 - (90)				
	Longsnout					
<i>Chaetodon aculeatus</i>	Butterflyfish	1 - (5)	5 - (7)	2 - (9)		
<i>Dasyatis americana</i>	Southern Stingray	1 - (120)				
<i>Elagatis bipinnulatus</i>	Rainbow Runner	3 - (60)				
<i>Epinephelus guttatus</i>	Red Hind	1 - (30)	1 - (35)			
<i>Epinephelus striatus</i>	Nassau Grouper	1 - (50)	1 - (75)	1 - (90)		
<i>Gramma loreto</i>	Fairy Basslet	20 - (4)	56 - (5)	7 - (6-7)		
<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>Liopropoma rubre</i>	Peppermint Bass	5 - (6-7)				
<i>Lutjanus apodus</i>	Schoolmaster	2 - (12)	6 - (15)	1 - (17)	2 - (20)	1 - (28)
<i>Lutjanus jocu</i>	Dog Snapper	1 - (38)				

Table 16. Continued

<i>Lutjanus mahogany</i>	Mahogani Snapper	3 - (20)	2 - (25)
<i>Mycteroperca venenosa</i>	Yellowfin Grouper	1 - (60)	1 - (80)
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	2 - (25)	1 - (30)
<i>Scomberomorus regalis</i>	Cero Mackerel	1 - (60)	2 - (90)
<i>Sphyræna barracuda</i>	Great Barracuda	1 - (120)	

Invertebrates

<i>Panulirus argus</i>	Spiny Lobster	1 - (20)*
<i>Strombus gigas</i>	Queen Conch	7 - (22-25)**

Other Fishes Present :

<i>Anisotremus surinamensis</i>	Black Margate
<i>Decapterus macarellus</i>	Mackerel Scad
<i>Hemiramphus ballyhoo</i>	Ballyhoo

* Carapace length (cm)

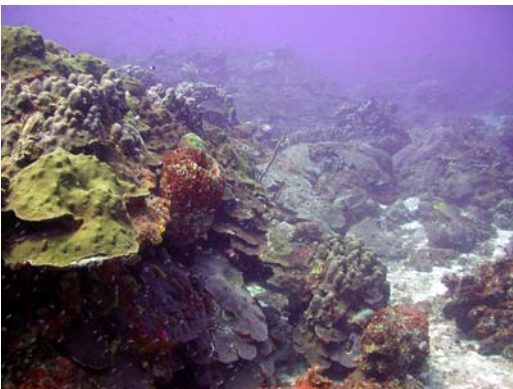
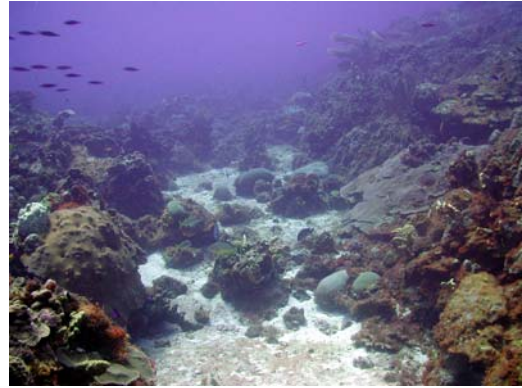
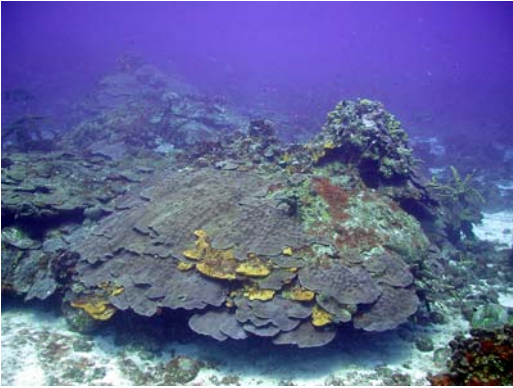
** Conch Length (cm)

The Arrow Crab, *Stenorhynchus seticornis* and the cleaner shrimps, *Periclimenes sp.* and *Stenopus hispidus* were the motile megabenthic invertebrates observed within belt-transects (Table 17). One juvenile Spiny Lobster, *Panulirus argus* and a group of Queen Conch were observed outside transects during the ASEC survey. The Queen Conch were found in full adult sizes half-buried in the sand. Several Sea Cucumbers, *Holothuria mexicana* were also present in the sand habitat.

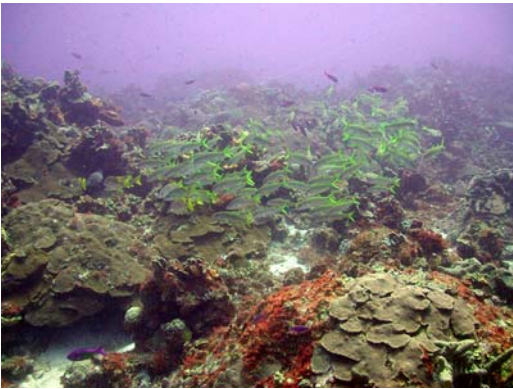
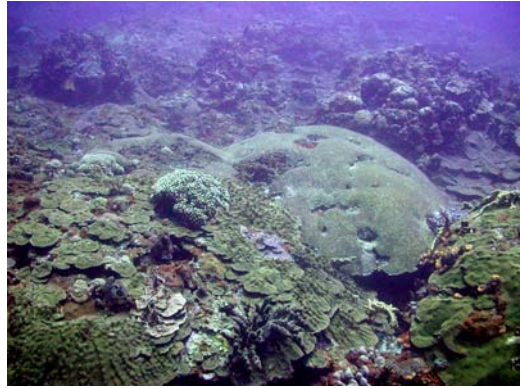
Table 17. Taxonomic composition and abundance of motile megabenthic invertebrates within belt-transects at the Puerto Canoas shelf-edge of Reef, Isla Desecheo, August, 2004

		TRANSECTS						MEAN ABUNDANCE (IND/30 m ²)
		1	2	3	4	5	6	
SPECIES	COMMON NAME							
<i>Stenorhynchus seticornis</i>	Arrow crab	5		2	1	2	2	2.0
<i>Periclimenes sp.</i>	Cleaner Shrimp		1		1	2	1	0.8
<i>Stenopus hispidus</i>	Banded Coral Shrimp	1		1	1	2		0.8
<i>Strombus gigas</i>	Queen Conch			1				0.2
<i>Diadema antillarum</i>	Long-Spined Urchin						1	0.2
TOTALS		6	1	4	3	6	4	4.0

1.3 Photo Album 4







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 meters 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 -20 meters. The initial baseline characterization was performed in June, 2000 (García-Sais et al., 2001a) and the first monitoring event by DNER took place in July, 2001 (see García-Sais et al., 2004). This is the second monitoring survey of the mid-shelf patch reefs at Puerto Botes. Panoramic views of the mid-shelf patch reef are presented in Photo Album 5.

Stony corals, with a mean substrate cover of 46.4 % (range: 43.5 – 51.7 %) represented the most prominent sessile-benthic component of the mid-shelf reef at Puerto Botes (Table 18). A total of 21 stony corals, including 14 intersected by line transects were identified during this survey. As in previous surveys, Boulder Star Coral, *Montastrea annularis* was the dominant species in terms of reef substrate cover with a mean of 23.5 % (range: 5.2 – 36.3 %). It was the only species present in all five transects surveyed. Finger Coral, *Porites porites*, Boulder Brain Coral, *Colpophyllia natans* and Lettuce Coral, *Agaricia agaricites* 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 9.4 % of substrate cover and contributed substantially to the reef rugosity of 3.86 meters. Erect and encrusting sponges were present with a mean substrate cover of 2.7 %. Reef hard-ground substrates not colonized by stony corals or sponges were overgrown by a dense algal turf (mean cover: 35.4 %), comprised of a mixed assemblage of red coralline and brown macroalgae.

Table 18. Percent substrate cover by sessile-benthic categories at Puerto Botes Mid-shelf Reef, Isla Desecheo, August, 2004

Depth: 17-20 meters	TRANSECTS					MEAN
	1	2	3	4	5	%
Rugosity	3.54	4.16	3.87	2.08	5.65	3.86
SUBSTRATE CATEGORIES						
<i>CORAL SPECIES</i>						
<i>Montastrea annularis</i>	35.82	16.33	36.27	5.22	23.98	23.52
<i>Porites porites</i>				30.22	0.9	6.22
<i>Colpophyllia natans</i>	7.07	16.55		3.61		5.45
<i>Agaricia agaricites</i>		3.6	2.74	2.81	13.43	4.52
<i>Porites astreoides</i>		2.76	0.51	2.32	3.77	1.87
<i>Montastrea cavernosa</i>		0.4	2.44	0.7	2.43	1.19
<i>Diploria labyrinthiformis</i>				5.13		1.03
<i>Meandrina meandrites</i>	1.25	1.49	0.61	1.75		1.02
<i>Eusmilia fastigiata</i>		1.79	1.02		1.28	0.82
<i>Millepora alcicornis</i>	0.31		0.94			0.25
<i>Agaricia sp.</i>	1.04					0.21
<i>Isophyllastrea rigida</i>		0.6				0.12
<i>Leptoseris cucullata</i>	0.42					0.08
<i>Madracis decactis</i>			0.3			0.06
STONY CORALS	45.91	43.52	44.83	51.76	45.79	46.36
SPONGES		2.47	3.24	4.88	2.94	2.71
ABIOTIC						
Reef Overhangs	8.94	6.64	8.22	10.26	12.85	9.38
TURF ALGAE	41.21	36.33	38.72	27.73	33.12	35.42
FLESHY ALGAE	3.99	11.02	4.83	4.72	4.14	5.74
CALCAREOUS ALGAE			0.22	0.66	1.17	0.41
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>						

Fleshy brown (*Lobophora sp.*, *Padina sp.*) and calcareous macroalgae contributed an additional 3.1 % to the total benthic algal cover at Puerto Botes (Table 18).

Compared to previous assessments, the sessile-benthic community at Puerto Botes does not show any major shifts in taxonomic structure and/or differences in live coral cover (Figure 4). García-Sais et al. (2001a) reported a mean stony coral cover of 48.01 % along permanent transects during the initial 2000 survey. Four years later, reef substrate cover by stony corals was measured as 46.36 %. The difference of 1.6 % is within the sampling error margin. In terms of taxonomic structure, the present survey

includes three small coral colonies of species not previously intersected by transects, one each of Sunrise Lettuce Coral, *Leptoseis cucullata*, Rough Star Coral, *Isophyllastrea rigida* and Ten-Ray Star Coral, *Madracis decactis*. These may either be new coral recruits or colonies that have grown into the transect line. Conversely, small colonies or branches of Staghorn Coral, *Acropora cervicornis* and Rose Lace Coral, *Stylaster roseus* were missing from the present survey. These may have died and removed by mechanical detachment and/or overgrown by benthic algae or encrusting biota. Aside from such minor changes, the taxonomic assemblage and substrate cover by stony corals along permanent transects remained stable (Figure 5). Minor differences in cover by corals, sponges and benthic algae appear to be within an estimated sampling variability error of 3%.

Figure 4. Mean substrate cover by sessile-benthic categories at Puerto Botes Reef from monitoring surveys 2000 - 2004

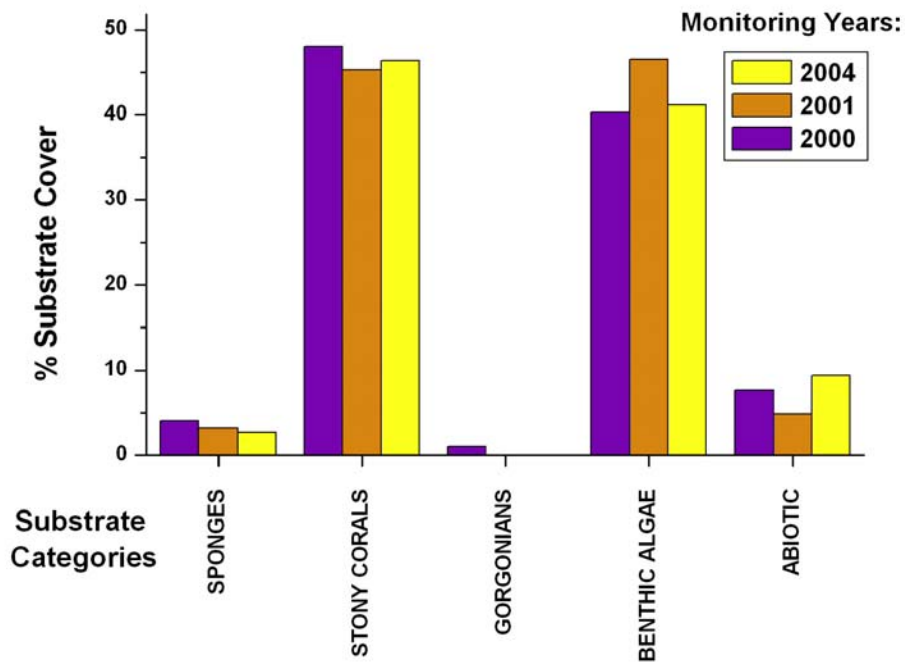
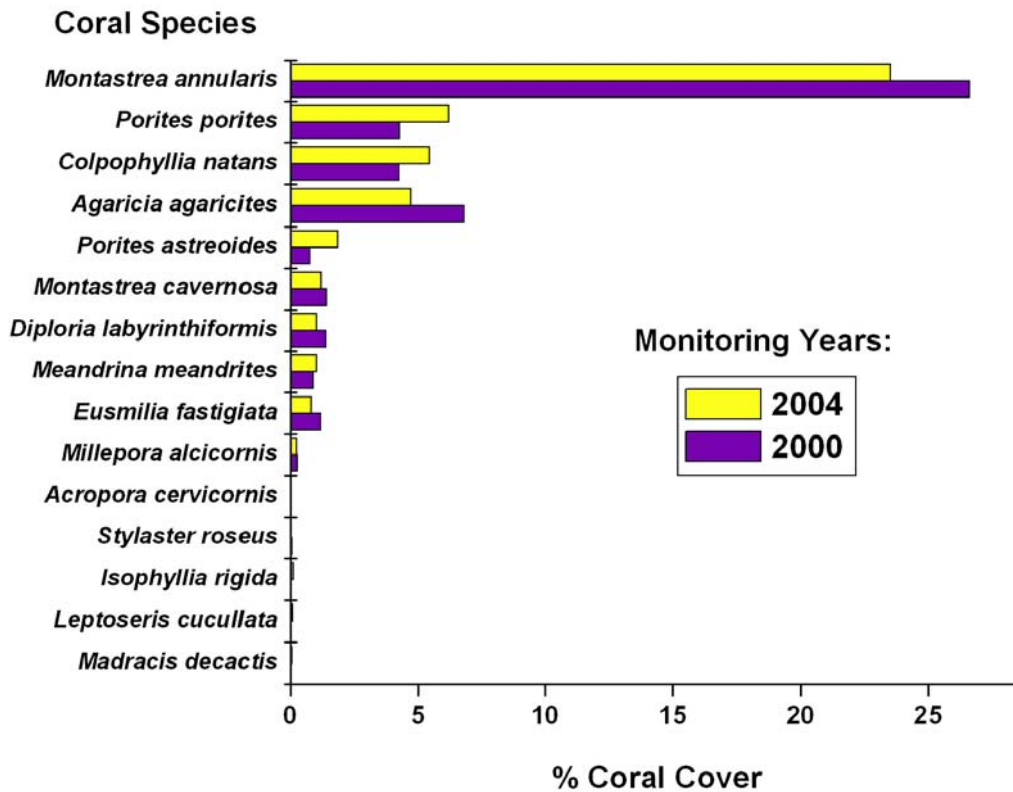


Figure 5. Mean substrate cover by stony coral species at Puerto Botes Reef from monitoring surveys 2000 and 2004.



2.2 Fishes and Motile Megabenthic Invertebrates

A total of 64 fish species, including 55 within belt-transects were identified from the mid-shelf patch reefs off Puerto Botes, Isla Desecheo during August, 2004. Mean abundance of fishes within belt-transects was 166.8 Ind/30 m² (range: 69 – 120 Ind/30 m²). The mean number of species per transect was 28.6 (range: 23 - 32). The Bicolor Damselfish, *Stegastes partitus* was the numerically dominant species with a mean abundance of 43.0 Ind/30 m² (range: 33 – 49 Ind/30 m²), representing 25.8 % of the total abundance within belt-transects (Table 19). The combined abundance of six species, including the Blue and Brown Chromis, Bluehead and Creole Wrasses, Sharknose Goby and Bicolor Damselfish represented 68 % of the total abundance within belt-transects. A total of ten species were present in all five transects and other seven species were present in four transects surveyed.

Table 19. Taxonomic composition and abundance of fishes within belt-transects at the Puerto Botes Mid-shelf Reef, Isla Desecheo, August, 2004

Depth: 17 - 20 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>	Blue Tang	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 Damselfish	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 niger</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>Flammeo 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

Table 19. Continued

<i>Canthidermis sufflamen</i>	Ocean Triggerfish					1	0.2
<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

Compared to our baseline characterization in 2000, the fish community structure in 2004 presented a slight increment in number of species per transects (+ 2.6) and a decline of abundance of approximately 30 %. The increment of species, in part, is a sampling artifact due to the inclusion in 2004 of several criptic species, such as the Peppermint and Bridled Goby (*Coryphopterus lipernes*, *C. glaucofraenum*). Both of these species were probably present during our baseline survey, but not included due to their criptic behavior. In fact, the reported abundances within belt-transects in this present survey (2004) are undoubtedly underestimates of their real abundance. The present survey also includes the Mahogany and Schoolmaster snappers (*Lutjanus mahogany*, *L. apodus*), which were present outside transects in previous surveys. The decline of fish community abundance was mostly related to reductions in the numbers of Bluehead Wrasse (*Thalassoma bifasciatum*) and Blue Chromis (*Chromis cyanea*), both of which were numerically dominant species within belt-transects. Nevertheless, both species were present within all five transects surveyed and ranked second and third in abundance during the present survey. These are schooling species with transitional (non-territorial) behavior. Their reduction within transects may be fortuitous and does not have any implication of shifts in community structure.

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 20). 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*) and Peppermint Bass (*Liopropoma rubre*) were common. One small Hawksbill Turtle, *Eretmochelys imbricata* was observed during the ASEC survey.

Motile megabenthic invertebrates within belt-transects included the Arrow Crab (*Stenorhynchus seticornis*), the Banded Coral Shrimp (*Stenopus hispidus*) and the Long-Spined Urchin (*Diadema antillarum*) (Table 21). A large Spiny Lobster (*Panulirus argus*) was present outside transect areas.

Table 20. 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. August, 2004

Depth range : 26 - 30 m

Duration - 20 min.

SPECIES	COMMON NAME	# - (cm)		
<i>Balistes vetula</i>	Queen Triggerfish	1 - (30)		
<i>Carangoides crysos</i>	Blue Runner	2 - (30)		
<i>Caranx lugubris</i>	Black Jack	1 - (30)		
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish	1 - (7)	2 - (9)	
<i>Epinephelus guttatus</i>	Red Hind	1 - (30)		
<i>Gramma loreto</i>	Fairy Basslet	15 - (4)	32 - (5)	3 - (6-7)
<i>Holacanthus ciliaris</i>	Queen Angel	1 - (25)		
<i>Holacanthus tricolor</i>	Rock Beauty	1 - (5)	3 - (10)	1 - (15)
<i>Liopropoma rubre</i>	Peppermint Bass	1 - (6-7)		
<i>Lutjanus apodus</i>	Schoolmaster	2 - (15)	3 - (20)	1 - (30)
<i>Lutjanus mahogany</i>	Mahogani Snapper	3 - (25)	1 - (30)	
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	2 - (25)	1 - (30)	1 - (40)
<i>Scomberomorus regalis</i>	Cero Mackerel	3 - (35)	1 - (50)	
<i>Sphyræna barracuda</i>	Great Barracuda	1 - (60)		
Invertebrates				
<i>Panulirus argus</i>	Spiny Lobster	1 - (30)*		
Other Fishes Present :				
<i>Ophioblennius atlanticus</i>	Redlip Blenny			
<i>Hemiramphus ballyhoo</i>	Ballyhoo			

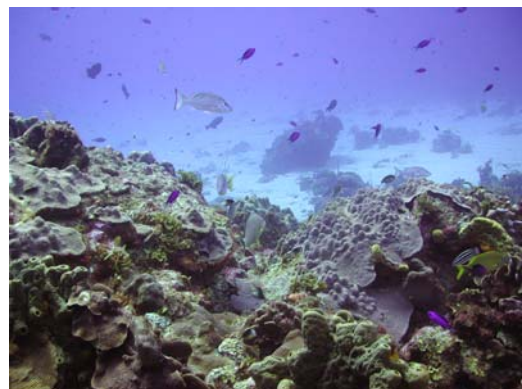
* Carapace length (cm)

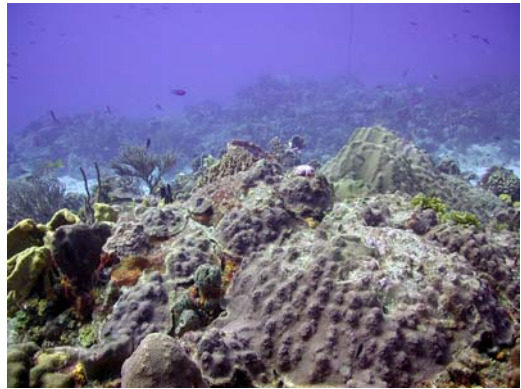
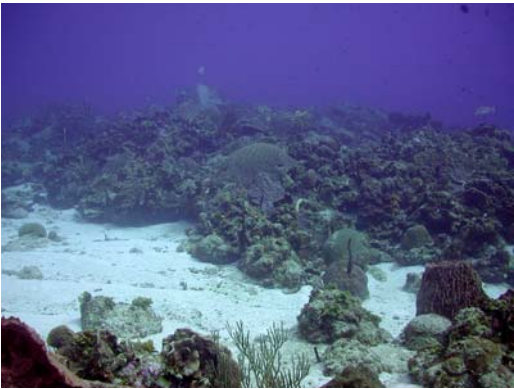
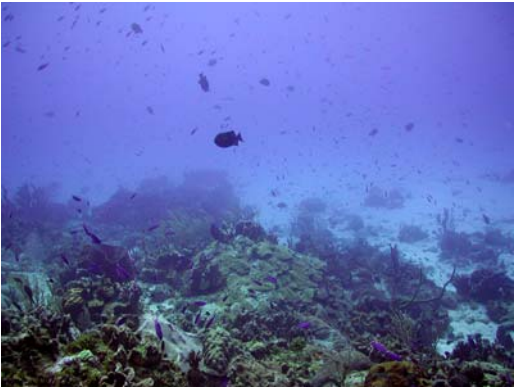
Table 21. Taxonomic composition and abundance of motile megabenthic invertebrates within belt-transects at the Puerto Canoas mid-shelf of Reef, Isla Desecheo, August, 2004

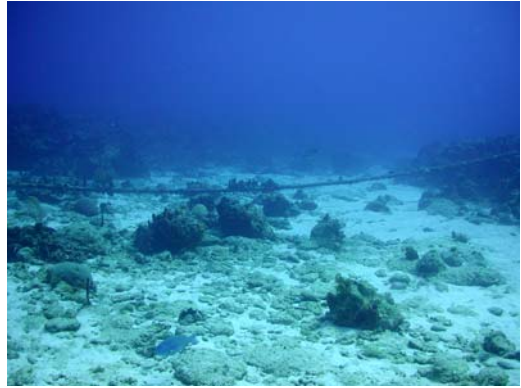
Depth: 30.0 m

SPECIES	COMMON NAME	TRANSECTS						MEAN ABUNDANCE (IND/30 m²)
		1	2	3	4	5	6	
<i>Stenorhynchus seticornis</i>	Arrow crab			1		2		0.6
<i>Periclimenes sp.</i>	Cleaner Shrimp					2		0.4
<i>Stenopus hispidus</i>	Banded Coral Shrimp					2	2	0.8
<i>Diadema antillarum</i>	Long-Spined Urchin			1				0.2
TOTALS		0	0	2	0	6	2	2.0

2.3 Photo Album 5







3.0 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 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. Panoramic views of the Inner Shelf Reef off Puerto Botes are presented in Photo Album 6.

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 19.3 % (range: 10.1 – 30.9 %) (Table 22). Boulder Star Coral, *Montastrea annularis* was the dominant species in terms of reef substrate cover with a mean of 11.9 % (range: 5.8 – 20.0 %), representing 61.8 % of the total stony coral cover. Colonies of Boulder Star Coral were present in all five transects surveyed, along with those of Great Star Coral, *M. cavernosa*, Mustard-Hill Coral, *Porites astreoides* and Lettuce Coral, *Agaricia agaricites*. The aforementioned species also comprised the main coral assemblage in terms of reef substrate cover. Corals typically exhibited encrusting growth patterns and small to moderate colony sizes, perhaps as adaptations to the strong wave and surge action seasonally active 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 7.9 % of substrate cover and contributed substantially to the reef rugosity of 4.11 meters. Total abiotic cover also included sections of sand and averaged 11.4 %. Erect and encrusting sponges were present at all transects with a mean substrate cover of 5.4 %. Reef hard-ground substrates not colonized by stony corals or sponges were overgrown by benthic algae. A dense algal turf (mean cover: 56.2 %), 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

Table 22. Percent substrate cover by sessile-benthic categories at Puerto Botes Inner-shelf Reef, Isla Desecheo, August, 2004

Depth : 14 – 17 m	TRANSECTS					MEAN
	1	2	3	4	5	
Rugosity (m)	3.69	3.8	5	4.3	3.78	4.11
SUBSTRATE CATEGORIES						
<i>STONY CORAL SPECIES</i>						
<i>Montastrea annularis</i>	8.55	6.52	18.59	5.8	19.99	11.89
<i>Montastrea cavernosa</i>	2.7	0.8	3.6	1.89	2.18	2.23
<i>Porites astreoides</i>	2.05	3.33	2.07	1.4	1.96	2.16
<i>Agaricia agaricites</i>	0.8	0.61	0.28	0.39	4.58	1.33
<i>Diploria strigosa</i>	1.03	0.82			1.23	0.62
<i>Siderastrea radians</i>	0.93	0.51				0.29
<i>Diploria labyrinthiformis</i>	0.31	1.12				0.29
<i>Meandrina meandrites</i>					1.02	0.20
<i>Mycetophyllia lamarckiana</i>	0.62					0.12
<i>Eusmilia fastigiata</i>				0.59		0.12
<i>Millepora complanata</i>			0.47			0.09
STONY CORALS	16.95	13.77	24.51	10.06	30.88	19.32
SPONGES	1.97	6.67	2.93	9.85	5.6	5.40
ABIOTIC						
Reef Overhangs	8.11	8.7	10.13	6.91	5.81	7.93
Sand		5.29	3.6	7.68	0.61	3.44
TURF ALGAE	70.27	60	55.36	47.77	47.6	56.20
FLESHY ALGAE	2.7	5.58	2.53	17.74	8.93	7.50
CALCAREOUS ALGAE			0.47		0.58	0.21
Coral Species Outside Transects: <i>Porites porites</i> , <i>Diploria clivosa</i> , <i>Stylaster roseus</i> , <i>Siderastrea siderea</i> , <i>Madracis decactis</i> , <i>Leptoseris cucullata</i> , <i>Acropora cervicornis</i> , <i>Millepora alcicornis</i>						

macroalgae (*Halimeda sp*) contributed an additional 7.7 % to the total substrate cover at Puerto Botes Inner Reef (Table 22).

3.2 Fishes and Motile Megabenthic Invertebrates

A total of 53 fish species, including 45 within belt-transects were identified from the Inner-Shelf Reef off Puerto Botes, Isla Desecheo during August, 2004. Mean abundance of fishes within belt-transects was 133.8 Ind/30 m² (range: 98 – 159 Ind/30

m²). The mean number of species per transect was 23.6 (range: 21 - 25). The Bicolor Damselfish, *Stegastes partitus* was the numerically dominant species with a mean abundance of 38.4 Ind/30 m² (range: 22 – 75 Ind/30 m²), representing 28.7 % of the total abundance within belt-transects (Table 23). The combined abundance of five species, including the Blue and Brown Chromis, Bluehead and Creole Wrasses, and Bicolor Damselfish represented 71.7 % of the total abundance within belt-transects. Seven species were present in all five transects and other four species were present in four transects surveyed.

Demersal zooplankton feeders, such as Bicolor Damselfish, Blue and Brown Chromis and the more open water zooplanktivore Creole Wrasse comprised the most prominent fish assemblage of this inshore reef, both in terms of abundance and biomass. 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 one year and found that zooplankton populations were 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 zooplanktivore fish populations at the Puerto Botes/Puerto Desecheo Reef system.

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 were observed in both juvenile and full adult size classes. Red Hinds and Coneys were observed in low abundance and small sizes (Table 24). 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

Table 23. Taxonomic composition and abundance of fishes within belt-transects at the Puerto Canoas Inner-shelf Reef, Isla Desecheo, August, 2004

Depth: 14 - 17 m

SPECIES	COMMON NAME	TRANSECTS					MEAN
		1	2	3	4	5	
		Individuals/30 m ²					
<i>Stegastes partitus</i>	Bicolor Damselfish	22	75	38	33	24	38.4
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	18	20	26	26	28	23.6
<i>Chromis cyanea</i>	Blue Chromis	14	11	25	21	17	17.6
<i>Clepticus parrae</i>	Creole Wrasse	12		18	16		9.2
<i>Chromis multilineata</i>	Brown Chromis		15	9		12	7.2
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	5	6	4	3	5	4.6
<i>Cephalopholis fulva</i>	Coney	1	4	2	4	3	2.8
<i>Halichoeres maculipinna</i>	Clown Wrasse	1	6		7		2.8
<i>Scarus iserti</i>	Stripped Parrotfish			4	9		2.6
<i>Malacoctenus triangulatus</i>	Saddled Blenny	4	3	4	2		2.6
<i>Microspathodon chrysurus</i>	Yellowtail Damselfish		4	2	3	1	2.0
<i>Myripristis jacobus</i>	Blackbar Soldierfish	2	2	3	1	2	2.0
<i>Melichthys niger</i>	Black Durgon	2	2	1	1	1	1.4
<i>Mulloides martinicus</i>	Yellowtail Goatfish		1	2	1	3	1.4
<i>Sparisoma radians</i>	Bucktooth Parrotfish				3	4	1.4
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	1		3	1	2	1.4
<i>Holacanthus tricolor</i>	Rock Beauty		1	2	2	1	1.2
<i>Lutjanus apodus</i>	Schoolmaster	1		1	3		1.0
<i>Amblycirrhitis pinos</i>	Redspotted Hawkfish	1		2	1		0.8
<i>Chaetodon capistratus</i>	Foureye Butterflyfish	1		2		1	0.8
<i>Gobiosoma evelynae</i>	Sharknose Goby	2	1			1	0.8
<i>Holocentrus rufus</i>	Squirrelfish	2			1	1	0.8
<i>Acanthurus bahianus</i>	Ocean Surgeon	1	1			1	0.6
<i>Acanthurus coeruleus</i>	Blue Tang	1			1	1	0.6
<i>Chaetodon striatus</i>	Banded Butterflyfish	1	2				0.6
<i>Flammeo marianus</i>	Longspine Squirrelfish	1	1			1	0.6
<i>Bodianus rufus</i>	Spanish Hogfish	1			1		0.4
<i>Cantherhines macrocerus</i>	Whitespotted Filefish	1				1	0.4
<i>Cephalopholis cruentatus</i>	Graysby			2			0.4
<i>Halichoeres radiatus</i>	Puddinwife	1	1				0.4
<i>Scomberomorus regalis</i>	Cero Mackerel		1			1	0.4
<i>Xanthichthys ringens</i>	Sargassum Triggerfish		1		1		0.4
<i>Lactophrys triqueter</i>	Smooth Trunkfish			1			0.2
<i>Acanthurus chirurgus</i>	Doctorfish			1			0.2
<i>Aulostomus maculatus</i>	Trumpetfish				1		0.2
<i>Coryphopterus lipernes</i>	Peppermint Goby				1		0.2
<i>Gymnothorax moringa</i>	Spotted Moray					1	0.2
<i>Kyphosus sectatrix</i>	Bermuda Chub				1		0.2
<i>Serranus tigrinus</i>	Harlequin Bass		1				0.2
<i>Sparisoma chrysopterum</i>	Redtail Parrotfish					1	0.2
<i>Sparisoma viride</i>	Stoplight Parrotfish					1	0.2
<i>Synodus intermedius</i>	Galliwasp	1					0.2

Table 23. Continued

		TRANSECTS					
		1	2	3	4	5	
<i>Lactophrys bicaudalis</i>	Spotted Trunkfish	1					0.2
<i>Pomacanthus paru</i>	French Angelfish					1	0.2
<i>Pseudupeneus maculaus</i>	Spotted Goatfish			1			0.2
TOTAL INDIVIDUALS		98	159	153	144	115	133.8
TOTAL SPECIES		25	21	22	25	25	23.6

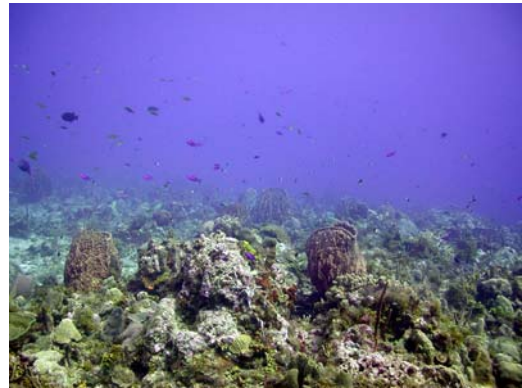
Table 24. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at the Puerto Botes Inner-shelf Reef, Isla Desecheo. August, 2004

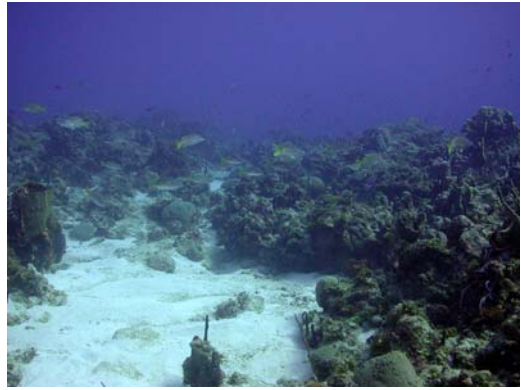
Depth range : 14 - 17 m
Duration - 20 min.

SPECIES	COMMON NAME	# - (cm)			
<i>Balistes vetula</i>	Queen Triggerfish	1 - (40)			
<i>Epinephelus guttatus</i>	Red Hind	1 - (25)			
<i>Gramma loreto</i>	Fairy Basslet	6 - (4)	13 - (5)		
<i>Holacanthus ciliaris</i>	Queen Angel	1 - (15)			
<i>Holacanthus tricolor</i>	Rock Beauty	1 - (7)			
<i>Lutjanus apodus</i>	Schoolmaster	9 - (15)	10 - (20)	13 - (30)	4 - (40)
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	2 - (25)	4 - (30)	4 - (50)	
<i>Ophioblennius atlanticus</i>	Redlip Blenny	3 - (6)	4 - (8)		
<i>Scomberomorus regalis</i>	Cero Mackerel	1 - (80)			
<i>Sphyaena barracuda</i>	Great Barracuda	1 - (60)			
Other Fishes Present :					
<i>Hemiramphus ballyhoo</i>	Ballyhoo				

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 observed during our ASEC survey (Table 24). No motile megabenthic invertebrates were observed within belt-transects.

3.3 Photo Album 6







C. Tourmaline Reef System – Mayaguez

1.0 Shelf-edge Reef – 30 meter

1.1 Sessile-Benthic Reef Community

El Tourmaline 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 meters (Figure 6). The reef starts at a depth of 10 meters 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 meters, extending due north to a depth of 21 meters. This second terrace also ends in a fine silty-sand interface. The third and last hard ground terrace is very scarped and narrow, breaking abruptly from 22 meters down to 32 meters along an irregular slope with high topographic relief given by large massive corals. Below 25 meters, 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 meters). Permanent transects were oriented south - north, perpendicular to the shelf-edge and on top of the spurs at a depth of 28 - 30 meters. Panoramic views of Tourmaline Shelf-edge Reef are shown in Photo Album 7.

A total of 21 stony corals and two black coral species were identified from the shelf-edge off El Tourmaline Reef, 11 of which were intercepted by line transects during our survey (Table 25). Stony corals occurred mostly as isolated encrusting and mound shaped colonies. Substrate cover by stony corals along transects averaged 13.5 % (range: 5.2 – 21.3 %). Boulder Star Coral, *Montastrea annularis* was the dominant species in terms of substrate cover with a mean of 5.2 % (range: 1.2 – 8.9 %), representing 38.5 % of the total cover by stony corals. Isolated colonies of Fragile Saucer Coral, *Agaricia fragilis* 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 10.2 colonies/transect. Colonies of Bushy Black Coral (*Anthipathes sp.*) and Wire Coral (*Cirrhopathes sp.*) were present close to the deepest end of the reef at 32 meters.

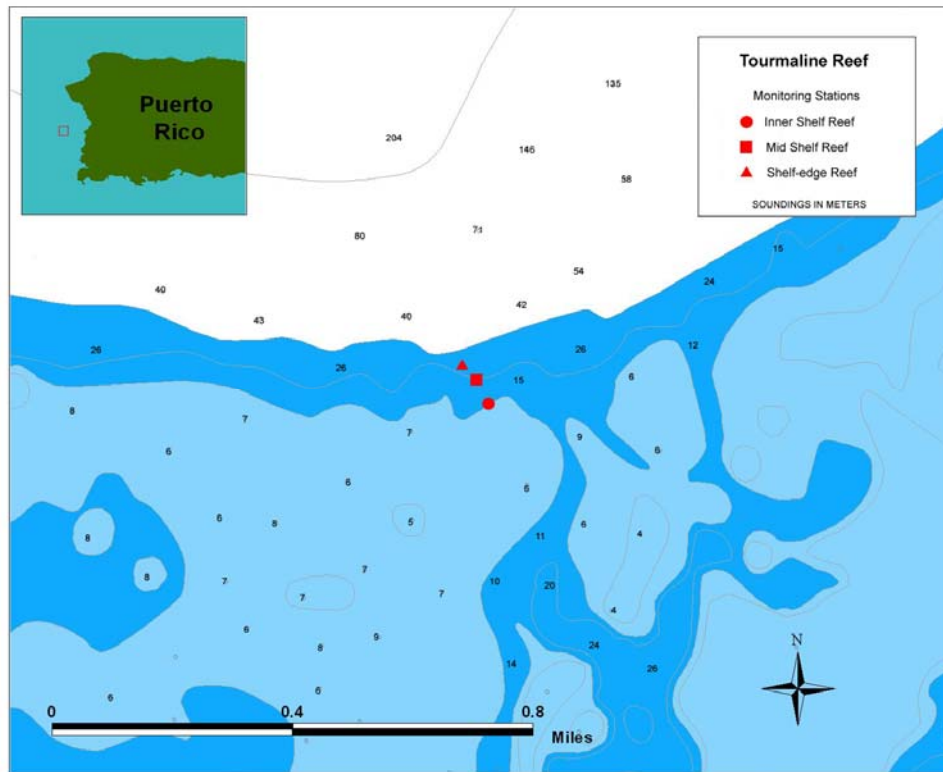


Figure 6. Location of coral reef survey stations at Tourmaline Reef off Mayaguez.

Encrusting and erect sponges, including several large Basket Sponges, *Xestospongia muta* were present in all transects with an average cover of 3.1 %. The Blue Bell Tunicate, *Clavelina puertosecensis* was very common throughout the shelf-edge reef. Reef overhangs, associated with substrate depressions and coral ledges averaged 24.5 % and contributed to a topographic rugosity of 4.6 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 54.8 % (range : 44.6 – 63.0 %). Turf algae was found overgrowing rocky substrates, as well as dead coral sections and other hard ground. Fleishy macroalgae were not prominent at 30 m.

Table 25. Percent substrate cover by sessile-benthic categories at El Tourmaline Shelf-edge Reef, Mayaguez. November, 2004

Reef Rugosity (m)	4.96	4.21	5.11	3.85	4.85	4.60
Depth : 27 - 30 m	TRANSECTS					
	1	2	3	4	5	MEAN
SUBSTRATE CATEGORIES						
<i>CORAL SPECIES</i>						
<i>Montastrea annularis</i>	5.28	8.93	4.03	1.22	6.54	5.20
<i>Agaricia fragilis</i>	3.94	6.47		2.96	3.23	3.32
<i>Montastrea cavernosa</i>		0.77	3.37	0.61	3.64	1.68
<i>Madracis pharensis</i>	1.41	1.20	0.66		1.68	0.99
<i>Madracis formosa</i>	0.94	2.97				0.78
<i>Agaricia sp.</i>	0.56	0.98			1.89	0.69
<i>Mycetophyllia aliciae</i>	1.69					0.34
<i>Porites astreoides</i>	1.34					0.27
<i>Siderastrea radians</i>					0.66	0.13
<i>Agaricia agaricites</i>				0.41		0.08
<i>Dichocoenia stokesii</i>	0.38					0.08
STONY CORALS	15.52	21.32	8.00	5.20	17.65	13.54
SPONGE	2.07	5.07	0.66	4.48	3.30	3.12
GORG	1.34	1.06		0.81	1.80	1.00
ABIOTIC						
Reef Overhangs	24.28	22.03	30.49	23.99	21.63	24.48
Sand/Silt		5.95		2.54	6.64	3.03
TURF ALGAE	56.79	44.62	60.85	63.01	48.99	54.85
Coral Species Outside Transects : <i>Stephanocoenia mechelini</i> , <i>Siderastrea siderea</i> , <i>Diploria strigosa</i> , <i>Anthipathes sp.</i> , <i>Cirrhopathes sp.</i> , <i>Scolymia cubensis</i> , <i>Millepora alcicornis</i> , <i>Meandrina meandrites</i> , <i>Mycetophyllia lamarkiana</i> , <i>M. aliciae</i> , <i>Porites porites</i> , <i>Madracis decactis</i>						

1.2 Fishes and Motile Megabenthic Invertebrates

A total of 58 fish species, including 47 within belt-transects were identified from El Tourmaline Shelf-edge Reef during our baseline characterization survey in November, 2004. Mean abundance within belt-transects was 111.8 Ind/30 m² (range: 59 - 173 Ind/30 m²). The mean number of species per transect was 23 (range: 18 - 31). The Masked Goby, *Coryphopterus personatus* was the numerically dominant species with a mean abundance of 26.0 Ind/30 m² (range: 9 – 60 Ind/30 m²), representing 23 % of the total abundance within belt-transects (Table 26). 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, French Grunt and the Beaugregory were present within all five transects surveyed and comprised the most abundant fish assemblage at the shelf-edge reef.

The fish community associated with El 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 Desecheo and Tres Palmas (this volume). Large demersal predators, such as snappers and groupers were not observed. One juvenile Nassau Grouper was present along with juvenile Mutton, Schoolmaster and Yellowtail Snappers (Table 27). One 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. Schools of Mackerel Scad, *Decapterus macarellus* were present at mid-water over the reef. These are zooplanktivores that 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 rare at the shelf-edge reef. The Cleaner Shrimp, *Periclimenes* sp. and one Sea Cucumber, *Holothuria* sp. were present within belt-transects (Table 28). One small Spiny Lobster, *Panulirus argus* was observed outside transects.

Table 26. Taxonomic composition and abundance of fishes within belt-transects at El Tourmaline Shelf-edge Reef during November 2004.

Depth : 27 - 30 meters

SPECIES	COMMON NAME	TRANSECTS					MEAN
		1	2	3	4	5	
		Individuals/30 m ²					
<i>Coryphopterus personatus</i>	Masked Goby	60	29	20	9	12	26.0
<i>Coryphopterus lipernes</i>	Peppermint Goby	23	16	18	16	15	17.6
<i>Chromis cyanea</i>	Blue Chromis	8	3	34	4	3	10.4
<i>Stegastes partitus</i>	Bicolor Damselfish	15	2	15	10	4	9.2
<i>Myripristis jacobus</i>	Blackbar Soldierfish	4	18	8	8	1	7.8
<i>Gramma loreto</i>	Royal Gramma	3	2	5	20	3	6.6
<i>Haemulon aurolineatum</i>	Tomtate	13		1	6		4.0
<i>Scarus iserti</i>	Stripped Parrotfish	5	3	6	1	4	3.8
<i>Stegastes leucostictus</i>	Beaugregory	1	6	2	5	4	3.6
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	1	2	4	3	3	2.6
<i>Haemulon flavolineatum</i>	French Grunt	3	4	1	1	1	2.0
<i>Canthigaster rostrata</i>	Caribbean Puffer	1	3	1	1	2	1.6
<i>Clepticus parrae</i>	Creole Wrasse	8					1.6
<i>Carangoides ruber</i>	Bar Jack	1	5	1			1.4
<i>Flammeo marianus</i>	Longspine Squirrelfish	3	2			1	1.2
<i>Mulloides martinicus</i>	Yellowtail Goatfish	3	1	2			1.2
<i>Chaetodon capistratus</i>	Foureye Butterflyfish	2	1	1		1	1.0
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish	3	1				0.8
<i>Holocentrus rufus</i>	Squirrelfish			2	1	1	0.8
<i>Pseudupeneus maculatus</i>	Striped Goatfish	3		1			0.8
<i>Aulostomus maculatus</i>	Trumpetfish	1	1	1			0.6
<i>Cephalopholis cruentatus</i>	Graysby	2		1			0.6
<i>Coryphopterus sp1.</i>	Goby	1	1	1			0.6
<i>Hypoplectrus puella</i>	Barred Hamlet			2		1	0.6
<i>Hypoplectrus chlorurus</i>	Yellowtail Hamlet	1		1			0.4
<i>Priacanthus sp.</i>	Glasseye			1		1	0.4
<i>Scarus taeniopterus</i>	Princess Parrotfish		2				0.4
<i>Scarus vetula</i>	Queen Parrotfish	1			1		0.4
<i>Acanthurus bahianus</i>	Ocean Surgeon		1				0.2
<i>Acanthurus coeruleus</i>	Blue Tang			1			0.2
<i>Anisotremus virginicus</i>	Porkfish	1					0.2
<i>Bodianus rufus</i>	Spanish Hogfish	1					0.2
<i>Cephalopholis fulva</i>	Coney	1					0.2
<i>Chromis insolatus</i>	Sunshine Chromis				1		0.2
<i>Gobiosoma evelynae</i>	Sharknose Goby			1			0.2
<i>Holacanthus tricolor</i>	Rock Beauty			1			0.2
<i>Holacanthus ciliaris</i>	Queen Angelfish	1					0.2
<i>Hypoplectrus nigricans</i>	Black Hamlet				1		0.2
<i>Hypoplectrus indico</i>	Indico Hamlet				1		0.2
<i>Hypoplectrus unicolor</i>	Butter Hamlet				1		0.2
<i>Lactophrys bicaudalis</i>	Spotted Trunkfish					1	0.2
<i>Liopropoma sp.</i>	Candy Basslet	1					0.2
<i>Gymnothorax miliaris</i>	Spotted Moray		1				0.2

Table 26. Continued

		TRANSECTS					
		1	2	3	4	5	
<i>Serranus tigrinus</i>	Harlequin Bass					1	0.2
<i>Sparisoma viride</i>	Stoplight Parrotfish			1			0.2
<i>Sphyraena barracuda</i>	Great Barracuda	1					0.2
<i>Stegastes planifrons</i>	Yellow-eye Damselfish	1					0.2
TOTAL INDIVIDUALS		173	104	133	90	59	111.8
TOTAL SPECIES		31	21	27	18	18	23

Table 27. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at El Tourmaline Shelf-edge Reef. November, 2004

Depth range : 27 - 32 m
Duration - 20 min.

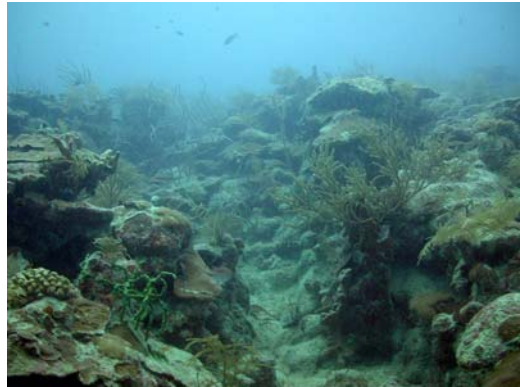
SPECIES	COMMON NAME	# - (cm)		
<i>Aetobatus narinari</i>	Spotted Eagle Ray	1 - (150)		
<i>Balistes vetula</i>	Queen Triggerfish	1 - (40)		
<i>Canthidermis sufflamen</i>	Ocean Triggerfish	3 - (60)		
<i>Epinephelus guttatus</i>	Red Hind	1 - (30)		
<i>Epinephelus striatus</i>	Nassau Grouper	1 - (40)		
<i>Lachnolaimus maximus</i>	Hogfish	1 - (60)		
<i>Lutjanus apodus</i>	Schoolmaster	1 - (20)		
<i>Lutjanus synagris</i>	Lane Snapper	1 - (25)		
<i>Lutjanus analis</i>	Mutton Snapper	1 - (35)	2 - (40)	
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	2 - (20)	1 - (30)	
<i>Scomberomorus regalis</i>	Cero Mackerel	1 - (60)	1 - (70)	
<i>Holacanthus ciliaris</i>	Queen Angel	1 - (25)		
<i>Holacanthus tricolor</i>	Rock Beauty	2 - (10)	1 - (15)	
<i>Gramma loreto</i>	Fairy Basslet	5 - (3)	12 - (4)	2 - (5)
<i>Sphyraena barracuda</i>	Great Barracuda	1 - (120)		
INVERTEBRATES				
<i>Panulirus argus</i>	Spiny Lobster	1 - (20)*		
Other Fishes Present :				
<i>Chaetodon sedentarius</i>	Reef Butterflyfish			
<i>Chaetodon ocellatus</i>	Spotfin Butterflyfish			
<i>Melichthys niger</i>	Black Durgon			
<i>Pomacanthus arcuatus</i>	Gray Angelfish			

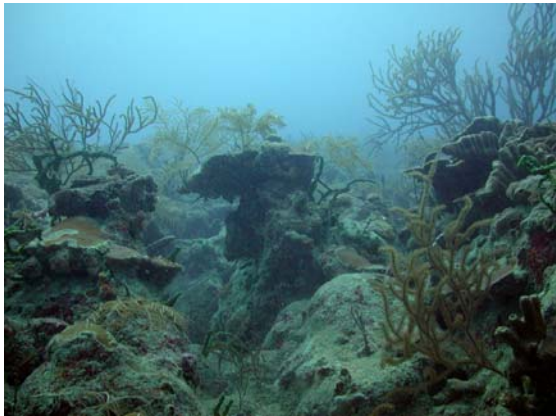
* Carapace length (cm)

Table 28. Taxonomic composition and abundance of motile megabenthic invertebrates observed within belt-transects at El Tourmaline Shelf-edge Reef during November, 2004.

		TRANSECTS					MEAN ABUNDANCE (IND/30 m²)
		1	2	3	4	5	
Depth : 27 - 30 m							
SPECIES	COMMON NAME						
<i>Holothuria mexicana</i>	Sea Cucumber					1	0.2
<i>Periclimenes sp.</i>	Cleaner shrimp					2	0.4
TOTALS		0	0	0	0	3	0.6

1.3 Photo Album 7





2.0 El Tourmaline Outer Shelf Reef - 20 m

2.1 Sessile-Benthic Reef Community

El Tourmaline Outer Shelf Reef is separated from the shelf-edge by an irregular fringe of sandy-silt bottom. Submerged at a depth of 16 meters, the reef extends down a narrow and abrupt slope to a depth of 21 meters. 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 meters. 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 18 - 20 meters. Panoramic views of El Tourmaline Outer Shelf Reef are presented in Photo Album 8.

A total of 20 stony corals and one black coral species were identified from the outer shelf reef, 13 of which were intercepted by line transects during our survey (Table 29). Stony corals occurred as massive (*Montastrea annularis*, *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 31.8 % (range: 23.4 - 40.4 %). Large and massive colonies of Boulder Star Coral, *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 24.5 % (range: 16.5 – 34.2 %), representing 77 % 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 comprised the main stony coral assemblage.

Soft corals (gorgonians) were moderately abundant, with an average of 10.2 colonies/transect. Colonies of Bushy Black Coral (*Anthipathes* sp.) 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 22.1 % and contributed markedly to the topographic rugosity of 3.9 m.

Table 29. Percent substrate cover by sessile-benthic categories at El Tourmaline Outer Shelf Reef, Mayaguez Bay. November, 2004

Depth: 18 - 20 m	TRANSECTS					MEAN
	1	2	3	4	5	
Rugosity	3.18	3.37	2.73	5.21	5.01	3.90
SUBSTRATE CATEGORIES						
<i>CORAL SPECIES</i>						
<i>Montastrea annularis</i>	24.91	25.28	21.76	34.25	16.51	24.54
<i>Montastrea cavernosa</i>	2.96	0.84	4.87	1.78	3.19	2.73
<i>Porites astreoides</i>	0.53	0.32	2.91	0.83	1.31	1.18
<i>Siderastrea siderea</i>	0.96		0.66	2.3	1.88	1.16
<i>Mycetophyllia sp.</i>			2.43			0.49
<i>Diploria labyrinthiformis</i>			2.1			0.42
<i>Colpophyllia natans</i>		1.26			0.56	0.36
<i>Madracis decactis</i>		0.75		0.56		0.26
<i>Madracis formosa</i>	1.18					0.24
<i>Mycetophyllia lamarckiana</i>			0.89			0.18
<i>Meandrina meandrites</i>				0.65		0.13
<i>Dichocoenia stokesii</i>			0.33			0.07
<i>Millepora alcicornis</i>		0.21				0.04
STONY CORALS	30.58	28.42	35.98	40.37	23.45	31.79
SPONGES	0.68			3.52	0.28	0.90
ENCRUSTING GORG	2.12	1.80		0.66	2.80	1.48
ABIOTIC						
Reef Overhangs	18.89	20.94	17.83	24.26	28.45	22.07
Gaps		2.11	0.89			0.60
Sand				2.96		0.59
TURF ALGAE	46.13	43.75	39.91	27.66	41.77	39.84
FLESHY ALGAE	1.59	2.77	5.42	0.56	3.26	2.72
Coral Species Outside Transects : <i>Eusmilia fastigiata</i> , <i>Acropora cervicornis</i> , <i>Diploria strigosa</i> , <i>Anthipathes sp.</i> , <i>Leptoseris cucullata</i> , <i>Stephanocoenia mechelinii</i> , <i>Scolymia cubensis</i> ,						

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 39.8 % (range: 27.7 - 46.1 %). Turf algae was found overgrowing rocky substrates, as well as dead coral sections and other hard ground. Fleshy macroalgae (*Dictyota sp.*, *Lobophora sp.*) were present in all transects.

2.2 Fishes and Motile Megabenthic Invertebrates-Tourmaline Outer Reef -20m

A total of 52 fish species, including 45 within belt-transects were identified from El Tourmaline Outer Shelf Reef during our baseline characterization survey in November, 2004. Mean abundance within belt-transects was 116.8 Ind/30 m² (range: 90 - 138 Ind/30 m²). The mean number of species per transect was 25.4 (range: 24 - 27). The Masked Goby, *Coryphopterus personatus* was the numerically dominant species with a mean abundance of 25.8 Ind/30 m² (range: 14 – 32 Ind/30 m²), representing 22.1 % of the total abundance within belt-transects (Table 30). 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 and Peppermint Gobies, Fairy Basslet, Bicolor Damselfish, Bluehead Wrasse, Blue Chromis, Beaugregory, Yellowhead Wrasse, Black-bar Soldierfish, Caribbean Puffer and Redband Parrotfish were present within all 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 El 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 that the reef was severely overfished, now a prevailing feature of most reef systems in Puerto Rico. El 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 apparently decimated the populations of commercially important fishes, conch and lobster. Clear signs of recuperation of the Red Hind population are not yet evident. The fish community was characterized by rather low abundance of individuals and species, compared to other well developed outer shelf reef systems, such as Desecheo and Tres Palmas (this volume). Small zooplanktivorous fishes, such as the Masked Goby, Blue Chromis, Bicolor Damselfish and micro-invertebrate predators, such as wrasses, gobies, basslets, hamlets, and squirrelfishes numerically dominated the reef fish community. Parrotfishes (*Scarus spp.*, *Sparisoma spp.*), represented by six species and doctorfishes (*Acanthurus spp.*), represented by three species comprised the main herbivorous fish assemblage.

Table 30. Taxonomic composition and abundance of fishes within belt-transects at El Tourmaline Outer Shelf Reef - 20 m during November, 2004.

		TRANSECTS					
Depth: 18 - 20 m		1	2	3	4	5	
		(Individuals/30 m ²)					
SPECIES	COMMON NAME						MEAN
<i>Coryphopterus personatus</i>	Masked Goby	32	27	26	14	30	25.8
<i>Coryphopterus lipernes</i>	Peppermint Goby	19	16	12	16	11	14.8
<i>Gramma loreto</i>	Fairy Basslet	17	7	12	6	14	11.2
<i>Stegastes partitus</i>	Bicolor Damselfish	10	10	12	11	12	11.0
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	10	5	9	6	18	9.6
<i>Chromis cyanea</i>	Blue Chromis	4	7	22	4	9	9.2
<i>Stegastes leucostictus</i>	Beaugregory	5	4	6	3	2	4.0
<i>Myripristis jacobus</i>	Blackbar Soldierfish	2	5	3	4	3	3.4
<i>Canthigaster rostrata</i>	Caribbean Puffer	4	4	2	3	1	2.8
<i>Halichoeres garnoti</i>	Yellowhead Wrasse	4	2	3	1	2	2.4
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	4	1	1	3	1	2.0
<i>Scarus iserti</i>	Stripped Parrotfish		2	2	3	2	1.8
<i>Sparisoma viride</i>	Stoplight Parrotfish	3	3	2		1	1.8
<i>Sparisoma radians</i>	Bucktooth Parrotfish	3		3		2	1.6
<i>Chaetodon capistratus</i>	Foureye Butterflyfish	2		2		3	1.4
<i>Gobiosoma evelynae</i>	Sharknose Goby	3		1	2	1	1.4
<i>Cephalopholis cruentatus</i>	Graysby	3	2		1		1.2
<i>Acanthurus bahianus</i>	Ocean Surgeon	1	1	1	2		1.0
<i>Holocentrus rufus</i>	Squirrelfish	2	1	1	1		1.0
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish	1	1		1	1	0.8
<i>Hypoplectrus puella</i>	Barred Hamlet		1	1	1	1	0.8
<i>Acanthurus coeruleus</i>	Blue Tang	1	1	1			0.6
<i>Flammeo marianus</i>	Longspine Squirrelfish	2				1	0.6
<i>Haemulon flavolineatum</i>	French Grunt		1		2		0.6
<i>Scarus taeniopterus</i>	Princess Parrotfish			3			0.6
<i>Acanthurus chirurgus</i>	Doctorfish				1	1	0.4
<i>Anisotremus virginicus</i>	Porkfish			1		1	0.4
<i>Carangoides ruber</i>	Bar Jack	1				1	0.4
<i>Haemulon sciurus</i>	Bluestriped Grunt		1		1		0.4
<i>Holacanthus tricolor</i>	Rock Beauty	1				1	0.4
<i>Hypoplectrus chlorurus</i>	Yellowtail Hamlet			1	1		0.4
<i>Mulloides martinicus</i>	Yellowtail Goatfish	1		1			0.4
<i>Amblycirrhitus pinos</i>	Redspotted Hawkfish	1					0.2
<i>Aulostomus maculatus</i>	Trumpetfish				1		0.2
<i>Caranx lugubris</i>	Black Jack	1					0.2
<i>Chaetodon striatus</i>	Banded Butterflyfish		1				0.2
<i>Epinephelus striatus</i>	Nassau Grouper			1			0.2
<i>Equetus acuminatus</i>	Jackknife Fish		1				0.2
<i>Hypoplectrus nigricans</i>	Black Hamlet		1				0.2
<i>Hypoplectrus unicolor</i>	Butter Hamlet				1		0.2
<i>Lutjanus apodus</i>	Schoolmaster		1				0.2
<i>Pomacanthus arcuatus</i>	Gray Angelfish	1					0.2
<i>Priacanthus sp.</i>	Glasseye					1	0.2

		TRANSECTS					
Table 30. Continued		1	2	3	4	5	MEAN
<i>Pseudupeneus maculatus</i>	Striped Goatfish		1				0.2
<i>Scarus vetula</i>	Queen Parrotfish				1		0.2
TOTAL INDIVIDUALS		138	107	129	90	120	116.8
TOTAL SPECIES		27	26	25	25	24	25.4

Among large invertebrate and small demersal fish predators, one juvenile Nassau Grouper and one adult Red Hind were observed during an ASEC survey (Table 31). 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 Blue Runners.

Motile megabenthic invertebrates were rare at the outer shelf reef. Two Banded Coral Shrimps, *Stenopus hispidus* were present within belt-transects (Table 32). One small Spiny Lobster, *Panulirus argus* was observed outside transects.

Table 31. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at El Tourmaline Outer Shelf Reef – 20 m. November, 2004

Depth range : 18 - 21 m
Duration - 20 min.

SPECIES	COMMON NAME	# - (cm)		
<i>Balistes vetula</i>	Queen Triggerfish	1 - (30)		
<i>Carangoides crysos</i>	Blue Runner	1 - (50)		
<i>Epinephelus guttatus</i>	Red Hind	1 - (25)		
<i>Epinephelus striatus</i>	Nassau Grouper	1 - (35)		
<i>Lutjanus apodus</i>	Schoolmaster	2 - (35)		
<i>Lutjanus synagris</i>	Lane Snapper	4 - (20)	3 - (25)	1 - (30)
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	2 - (18)	3 - (30)	
<i>Scomberomorus regalis</i>	Cero Mackerel	1 - (60)		
<i>Holacanthus tricolor</i>	Rock Beauty	1 - (15)	1 - (17)	
<i>Gramma loreto</i>	Fairy Basslet	3 - (3)	17 - (4)	6 - (5)
Other Fish Species				
<i>Decapterus macarellus</i>	Mackerel Scad			
Invertebrates				
<i>Panulirus argus</i>	Spiny Lobster	1 - (25)*		

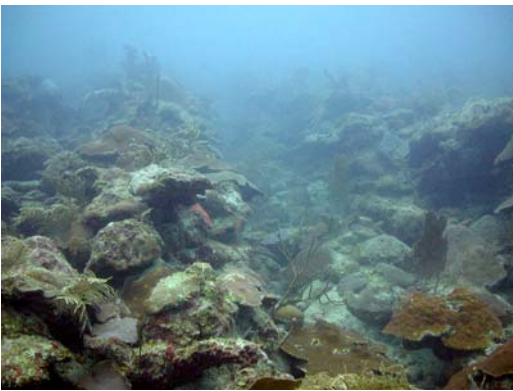
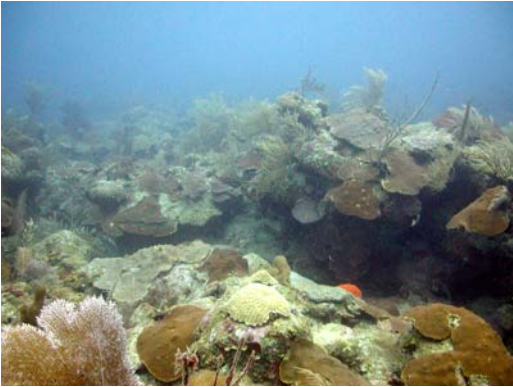
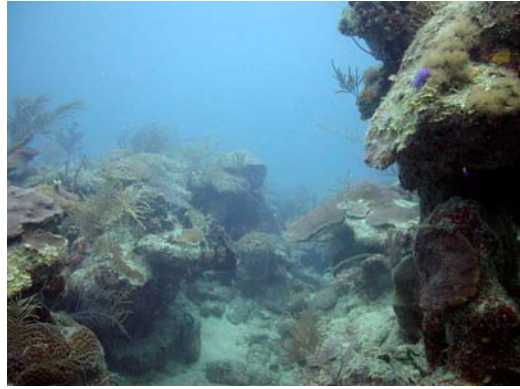
* Carapace length (cm)

Table 32. Taxonomic composition and abundance of motile megabenthic invertebrates observed within belt-transects at El Tourmaline Outer Shelf Reef – 20 m. November, 2004.

SPECIES	COMMON NAME	TRANSECTS					MEAN ABUNDANCE (IND/30 m ²)
		1	2	3	4	5	
<i>Stenopus hispidus</i>	Banded Coral Shrimp	1	1	0	0	0	0.4
	TOTALS	1	1	0	0	0	0.4

2.3 Photo Album 8







3.0 El Tourmaline Outer Shelf Reef – 10 m

3.1 Sessile-benthic Reef Community

El Tourmaline Outer Shelf Reef system at a depth of 10 meters 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 meters. Spurs are about 2 - 3 meters 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 previously established during June, 1999 by García et al. (2001b) during the initial baseline characterization survey was monitored during November, 2004. Panoramic views of El Tourmaline Outer Shelf Reef at a depth of 10 meters 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 meters, 19 of which were intercepted by line transects during this survey (Table 33). 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 49.4 % (range: 33.8 - 72.2 %). Boulder Star Coral, *Montastrea annularis* was the dominant coral species in terms of substrate cover with a mean of 14.8 % (range: 10.9 – 19.3 %), representing 30 % of the total cover by stony corals. An extraordinarily large colony of Yellow Pencil Coral, *Madracis mirabilis* covered more than four meters along transect 2, contributing to a total cover by stony corals of 72.2 % along transect 2, which is the highest ever recorded during reef surveys in Puerto Rico. Colonies of Boulder Star Coral, Mustard Hill Coral (*Porites astreoides*) and Finger Coral (*Porites porites*) were intercepted by all five transects. Other three coral species were present in four out of the five transects. Although in low abundance, a few very large colonies of Pillar Coral, *Dendrogyra cylindrus* and Boulder Brain Coral, *Colpophyllia natans* were present (Table 33).

Table 33. Percent substrate cover by sessile-benthic categories from El Tourmaline Outer Shelf Reef at a depth of 10 meters. November, 2004

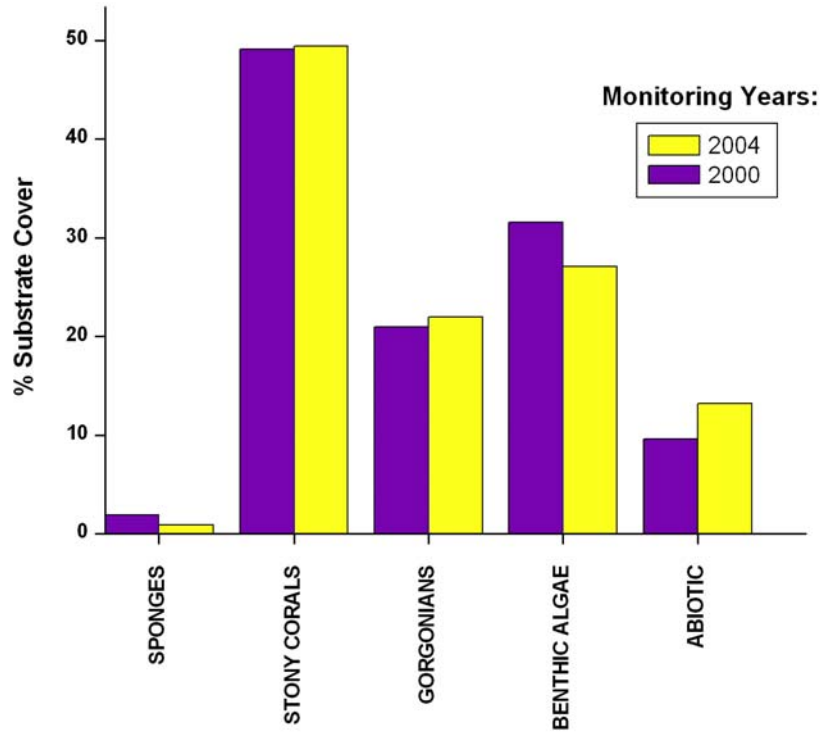
	TRANSECTS					MEAN
	1	2	3	4	5	
Reef Rugosity (m)	2.39	2.37	1.80	2.34	2.89	2.36
SUBSTRATE CATEGORIES						
<i>CORAL SPECIES</i>						
<i>Montastrea annularis</i>	11.37	18.11	19.34	14.27	10.94	14.81
<i>Madracis mirabilis</i>		41.07				8.21
<i>Porites astreoides</i>	5.24	4.69	10.86	2.27	3.18	5.25
<i>Porites porites</i>	6.82	1.25	3.31	5.84	8.07	5.06
<i>Dendrogyra cylindrus</i>	10.45			7.54	1.86	3.97
<i>Colpophyllia natans</i>	6.37		10.77			3.43
<i>Agaricia fragilis</i>			2.37	5.35	2.64	2.07
<i>Agaricia sp.</i>	3.98	0.57		1.37	1.86	1.56
<i>Agaricia agaricites</i>	0.45	3.31		3.08	0.85	1.54
<i>Montastrea cavernosa</i>		0.80	1.43	1.14	1.55	0.98
<i>Meandrina meandrites</i>		0.46	1.79	1.14	0.76	0.83
<i>Diploria labyrinthiformis</i>		1.94				0.39
<i>Madracis decactis</i>	0.34			0.46	1.09	0.38
<i>Millepora alcicornis</i>				1.30		0.26
<i>Diploria strigosa</i>					0.98	0.20
<i>Stephanocoenia mechelini</i>	0.80					0.16
<i>Eusmilia fastigiata</i>			0.48			0.10
<i>Acropora cervicornis</i>	0.45					0.09
<i>Leptoseris cucullata</i>	0.45					0.09
STONY CORALS	46.69	72.19	50.38	42.46	33.77	49.10
ENCRUSTING GORGONIAN	1.61	2.59	1.19	3.89	4.27	2.71
ZOANTHIDS	2.74		1.27	0.80	0.44	1.05
SPONGES	1.29			1.70	1.40	0.88
ABIOTIC						
Rubble	13.39		10.77		5.25	5.88
Reef Overhangs	5.89	4.45	5.60	11.51	9.16	7.32
TURF ALGAE	23.63	15.84	26.38	30.79	38.74	27.08
FLE ALGAE	4.76	4.93	4.41	6.97	6.99	5.61
CAL ALGAE				0.57		0.11
ERECT GORGONIANS (# Col)	13	29	15	28	24	21.80
Coral species outside transects: <i>Siderastrea siderea</i> , <i>Manicina areolata</i> , <i>Mycetophyllia lamarkiana</i> , <i>Mycetophyllia sp.</i> , <i>Millepora squamosa</i>						

Soft corals (gorgonians) were highly abundant, with an average of 21.8 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 7.3 % and contributed markedly to the topographic rugosity of 2.36 m. Turf algae, comprised by a mixed assemblage of short filamentous red and brown macroalgae presented an average substrate cover of only 27.1 % (range: 15.8 - 38.7 %) (Table 33). Turf algae was found overgrowing rocky substrates, as well as dead coral sections and other hard ground. Fleshy macroalgae (*Dictyota sp.*, *Lobophora sp.*) were present in all transects.

Compared to our previous assessment in June, 1999 (García-Sais et al. 2001), the sessile-benthic community from El Tourmaline Outer Reef at 10 meters did not show any major shifts in taxonomic structure and/or differences in live coral cover (Figure 7). García-Sais et al. (2001) reported a mean stony coral cover of 49.5 % along permanent transects. Five years later, reef substrate cover by stony corals was measured as 49.4 %. The difference of 0.1 % is within the sampling error margin. Minor differences in cover by corals, sponges (-1.1%), zoanthids (-0.05%), encrusting gorgonians (- 2%), and benthic algae (- 1.2%) appear to be within an estimated sampling variability error of 3%. The increment of cover by abiotic substrates in the 2004 survey (+ 3.2 %) may be associated with the seasonal transport of sand and rubble by large waves during early winter swells. DNER (2003) reported an increment in coral cover of almost 11 % for El Tourmaline Reef at 10 m. Such change in live coral cover over one year appears to be in error and needs to be corroborated against the original field data. Our survey in 2004 validated the baseline characterization values of live coral cover with the minor variations already discussed.

In terms of stony coral taxonomic structure, the present survey included four small (< 0.5 % cover) coral colonies of species not previously intersected by transects, one each of Sunrise Lettuce Coral, *Leptoseis cucullata*, Ten-Ray Star Coral, *Madracis decactis*, Blushing Star Coral, *Stephanocoenia mechelini* and Branching Fire Coral, *Millepora alcornis*. These may either be new coral recruits or colonies that have grown into the

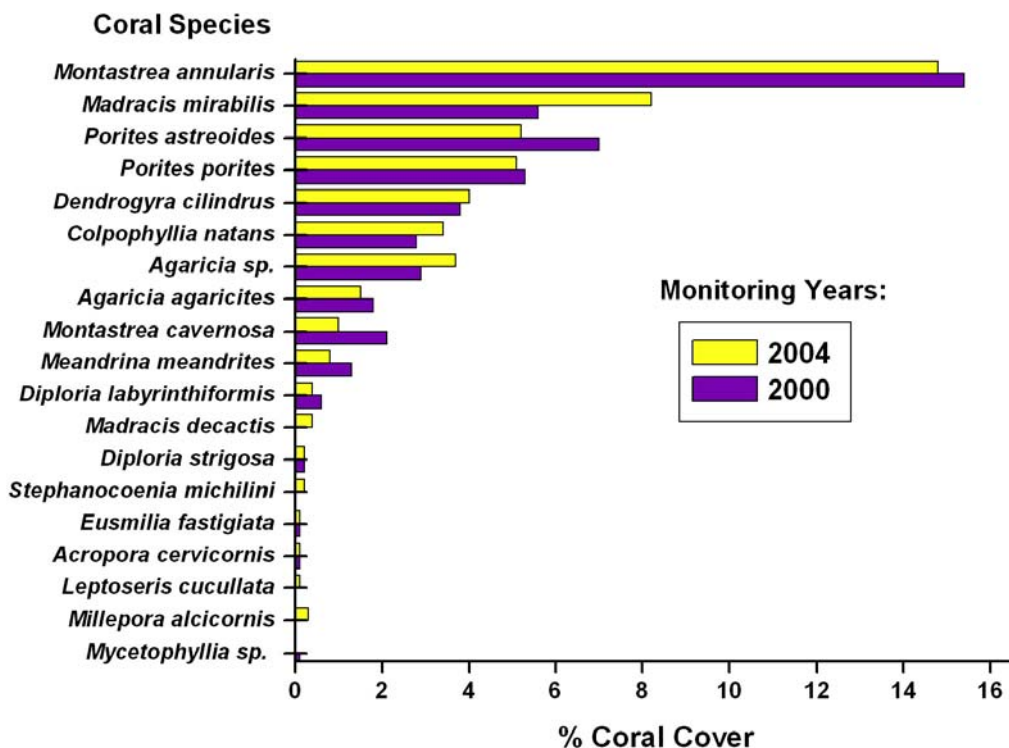
Figure 7. Monitoring trends 2000 and 2004. Percent cover by reef benthic substrate categories at El Tourmaline Outer Reef - 10 m



transect lines. Conversely, one small (0.1 % cover) colony, or branch of Cactus Coral, *Mycetophyllia sp.* was missing in the present survey.

The largest difference in cover by stony coral species was an increment of 2.6 % by Yellow Finger Coral (*Madracis mirabilis*). Conversely, Mustard-Hill Coral (*Porites astreoides*) and Great Star Coral (*Montastrea cavernosa*) presented declines of 1.8 and 1.1 %, respectively (Figure 8). All other coral species maintained their respective substrate cover within 1 % from the previous assessment in 1999. Soft corals remained within a mean density of 1 colony per transect. There were increments in soft coral colonies from transects 2 - 5 and a loss of 9 colonies in transect 1. Aside from such minor changes, the taxonomic assemblage and substrate cover by corals along permanent transects remained stable.

Figure 8. Monitoring trends 2000 and 2004. Percent cover by stony coral species from El Tourmaline Outer Reef - 10 m



3.2 Fishes and Motile Megabenthic Invertebrates - Outer Reef 10 m.

A total of 53 fish species, including 39 within belt-transects were identified from El Tourmaline Outer Shelf Reef at a depth of 10 meters during our monitoring survey in November, 2004. Mean abundance within belt-transects was 105.2 Ind/30 m² (range: 73 - 124 Ind/30 m²). The mean number of species per transect was 22.4 (range: 19 - 26). Fish abundance within belt-transects remained within 10 % and the number of species was similar to our previous fish survey in 1999 (García-Sais et al. 2001b). The Bluehead Wrasse, *Thalassoma bifasciatum* was the numerically dominant species with a mean abundance of 17.0 Ind/30 m² (range: 8 – 35 Ind/30 m²), representing 16.2 % of the total abundance within belt-transects (Table 34). The Bluehead Wrasse is an opportunistic

Table 34. Taxonomic composition and abundance of fishes within belt-transects at El Tourmaline Outer Shelf Reef-10m during November, 2004

		TRANSECTS					
Depth: 10 m		1	2	3	4	5	
		(Individuals/30 m ²)					
SPECIES	COMMON NAME						MEAN
<i>Thalassoma bifasciatum</i>	Bluehead Wrasse	19	14	9	35	8	17.0
<i>Chromis cyanea</i>	Blue Chromis	18	26	6	22	8	16.0
<i>Stegastes partitus</i>	Bicolor Damselfish	12	23	20	8	13	15.2
<i>Clepticus parrae</i>	Creole Wrasse	15				40	11.0
<i>Scarus iserti</i>	Stripped Parrotfish	11	13	8	5	10	9.4
<i>Haemulon flavolineatum</i>	French Grunt	2	3	3	8	2	3.6
<i>Halichoeres garnoti</i>	Yellow-head Wrasse	3	5	1	5	4	3.6
<i>Coryphopterus lipernes</i>	Peppermint Goby	3	1	3	5	1	2.6
<i>Sparisoma viride</i>	Stoplight Parrotfish	4	3	3		3	2.6
<i>Sparisoma radians</i>	Bucktooth Parrotfish	1	1		6	3	2.2
<i>Stegastes planifrons</i>	Yellow-eye Damselfish	3	3	2	1	2	2.2
<i>Myripristis jacobus</i>	Blackbar Soldierfish			1	8		1.8
<i>Sparisoma aurofrenatum</i>	Redband Parrotfish	3	2	2		2	1.8
<i>Cephalopholis cruentatus</i>	Graysby	1	2	2	3		1.6
<i>Chaetodon capistratus</i>	Foureye Butterflyfish	2	2	2		2	1.6
<i>Stegastes leucostictus</i>	Beaugregory	1	1		3	3	1.6
<i>Acanthurus bahianus</i>	Ocean Surgeon	2	1	1	1		1.0
<i>Gramma loreto</i>	Fairy Basslet	2		1	2		1.0
<i>Acanthurus coeruleus</i>	Blue Tang			2	1	1	0.8
<i>Canthigaster rostrata</i>	Caribbean Puffer	1	1	2			0.8
<i>Gobiosoma evelynae</i>	Sharknose Goby	2			2		0.8
<i>Holocentrus rufus</i>	Squirrelfish	2	1	1			0.8
<i>Anisotremus virginicus</i>	Porkfish			1	2		0.6
<i>Flammeo marianus</i>	Longspine Squirrelfish	1	1			1	0.6
<i>Holocentrus coruscus</i>	Reef Squirrelfish		2		1		0.6
<i>Hypoplectrus puella</i>	Barred Hamlet	1			2		0.6
<i>Serranus tigrinus</i>	Harlequin Bass		1	1		1	0.6
<i>Acanthurus chirurgus</i>	Doctorfish	1				1	0.4
<i>Amblycirrhitis pinos</i>	Redspotted Hawkfish					2	0.4
<i>Carangoides ruber</i>	Bar Jack	2					0.4
<i>Holacanthus tricolor</i>	Rock Beauty		1		1		0.4
<i>Aulostomus maculatus</i>	Trumpetfish	1					0.2
<i>Epinephelus guttatus</i>	Red Hind	1					0.2
<i>Equetus acuminatus</i>	Highhat				1		0.2
<i>Haemulon chrysargyreum</i>	Smallmouth Grunt				1		0.2
<i>Hypoplectrus unicolor</i>	Butter Hamlet			1			0.2
<i>Scarus taeniopterus</i>	Princess Parrotfish		1				0.2
<i>Scarus vetula</i>	Queen Parrotfish			1			0.2
<i>Stegastes dorsopunicans</i>	Dusky Damselfish				1		0.2
	TOTAL INDIVIDUALS	114	108	73	124	107	105.2
	TOTAL SPECIES	26	22	22	23	19	22.4

carnivore that feeds upon small benthic invertebrates. The Peppermint Goby, Bicolor and Yellow-eye Damselfishes, Bluehead and Yellowhead Wrasses, French Grunt, Striped Parrotfish and Blue Chromis were present within all five transects surveyed and along with schooling Creole Wrasse, comprised the most abundant fish assemblage from the outer shelf reef at a depth of 10 meters.

Small, opportunistic micro-invertebrate predators (wrasses, gobies, basslets, and squirrelfishes), demersal and pelagic schooling zooplanktivores (Bicolor Damselfish, 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 groupers such as Coneys and Graysbies were common. One juvenile Nassau Grouper and two adult Red Hinds were observed during the ASEC survey (Table 35). 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. Pelagic predators included the Cero Mackerel and Blue Runner.

As in deeper zones of El 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 absence, or 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. 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 and 2004 appear to be an indication that this fish population has not recovered from the intense fishing effort during the previous decade.

Table 35. Size-frequency distribution of large and/or commercially important reef fishes identified during an ASEC survey at El Tourmaline Outer Shelf Reef - 10 m. November, 2004

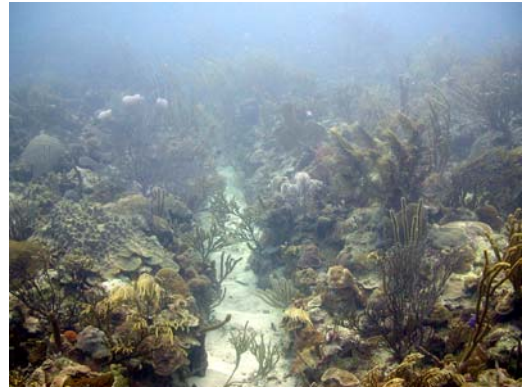
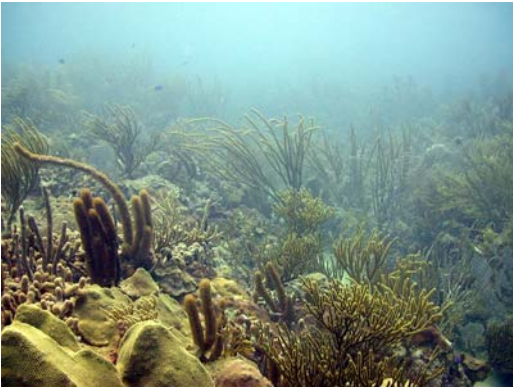
Depth range : 10 - 13 m
Duration - 20 min.

SPECIES	COMMON NAME	# - (cm)		
<i>Balistes vetula</i>	Queen Triggerfish	1 - (35)	1 - (40)	
<i>Carangoides crysos</i>	Blue Runner	1 - (40)		
<i>Chaetodon aculeatus</i>	Longsnout Butterflyfish	1 - (10)		
<i>Chaetodon ocellatus</i>	Spotfin Butterflyfish	2 - (12)		
<i>Chaetodon striatus</i>	Banded Butterflyfish	2 - (10)		
<i>Epinephelus guttatus</i>	Red Hind	1 - (35)		
<i>Epinephelus striatus</i>	Nassau Grouper	1 - (25)		
<i>Lutjanus apodus</i>	Schoolmaster	3 - (25)	2 - (30)	
<i>Lutjanus synagris</i>	Lane Snapper	2 - (15)	1 - (17)	1 - (20)
<i>Ocyurus chrysurus</i>	Yellowtail Snapper	1 - (18)	1 - (25)	1 - (30)
<i>Scomberomorus regalis</i>	Cero Mackerel	1 - (60)		
<i>Sphyræna barracuda</i>	Great Barracuda	1 - (50)		
<i>Holacanthus tricolor</i>	Rock Beauty	1 - (15)	1 - (17)	
<i>Gramma loreto</i>	Fairy Basslet	3 - (3)	17 - (4)	6 - (5)
Other Fish Species				
<i>Pseudupeneus maculatus</i>	Spotted Goatfish			
<i>Mulloidon martinicus</i>	Yellowtail Goatfish			
<i>Decapterus macarellus</i>	Mackerel Scad			
Invertebrates				
<i>Panulirus guttatus</i>	Rock Lobster	1 - (20)		
<i>Panulirus argus</i>	Spiny Lobster	3 - (20)*	1 - (25)*	

* Carapace length (cm)

Motile megabenthic invertebrates were rare at the outer shelf reef. Only one Arrow Crab, *Stenorhynchus seticornis* was present within belt-transects. Four small Spiny Lobsters, *Panulirus argus* were observed outside transects during the ASEC survey.

3.3 Photo Album 9





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