THE MARINE ENVIRONMENT OF TAROU POINT, COMMONWEALTH OF DOMINICA, WEST INDIES

Student Research Papers of the ITME Spring Semester 2001
ITME Contribution to Marine Science # 6

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AROU POINT

Foreword

The Institute for Tropical Marine Ecology (ITME) is an independent, Dominican not-for-profit educational organization established in 1999. ITME offers university-level programs in marine ecology and conservation, and serves as a research base for marine researchers. Currently, ITME is operating at the Springfield Estate.

The Spring Semester 2001 was ITME's inaugural 12-week program. During their stay in Dominica, the program participants spent a total 209 academic hours engaged in studying marine ecology and conservation. As part of their academic training students spent many hours in the field, identifying and surveying the marine habitats along Dominica's western and north-eastern coast. These activities culminated in independent research projects carried out at Tarou Point and presented in this document.

In the name of ITME and the program participants, I would like to express my sincere thanks to the people of Dominica, as well as to the governmental and non-governmental entities that facilitated the success of ITME . To mention everyone that has assisted us would mean to generate a separate document. I am therefore taking the liberty to mention just a few of those that have played a key role in ITME's young history. We thank the Ministers Hon. Herbert Sabroche (Education), Hon. Reginald Austrie (in his role at the PM's Office), and Hon. Ambrose George (Finance), who have continued to provide support for ITME initiated by the previous government, in particular by the former Ministers Norris Prevost, Peter Carbon, and Ronald Green. Sheridan Gregoire, Ronald Lander, and Stanton Carter of the National Development Corporation were instrumental in the early establishment phases of ITME. Andrew Magloire and Harold Guiste of the Fisheries Division gave valuable guidance regarding the environmental issues relevant to Dominica. Dr. Lennox Honychurch, Dr. Steve John (Bureau of Standards), Arlington James and (Forestry Division), Raphael Joseph (Environmental Health Division), Andrew "Panman" Bellot (Environmental Coordinating Unit), Terry Raymond (Youth Division), Ezechiel Green (SPAT), Shanel Allen (Tour Guide) and Tammy Williams (DCA) have assisted ITME as advisors and / or guest lecturers. Special thanks go to Mona George-Dill (Manager, Springfield Guesthouse) who has been an integral part of ITME's success. Not only has she provided logistic assistance, but she has been a great mediator in bringing the people to ITME and ITME to the community.

The faculty and staff involved in this semester's program were Jill Borger, Lennox Honychurch, Julia Lorber, Elske Hetebry and myself.

Dr. Sascha C.C. Steiner
Marine Biologist, President of ITME

Introduction

Dominica is a young volcanic island, formed 25 million years ago, and located in the Lesser Antilles chain of the Caribbean. While reef communities line the rocky substrates along the entire western coast of the island, this study will focus on the marine organism assemblages at Tarou Point, also called Rodney's Rock (Figure 1).

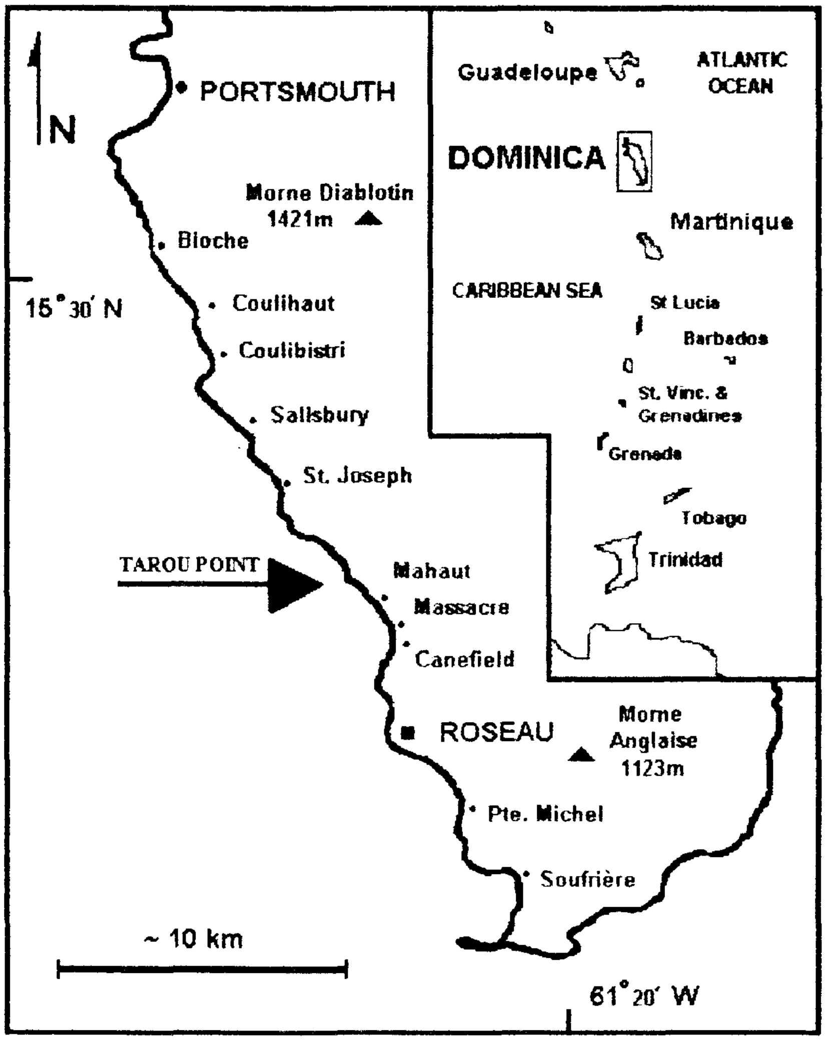

Figure 1: Location of Tarou Point

Tarou Point (Figure 1), located south of the village of Tarou, is a remnant of an ancient lava flow originating from Morne Trois Pitons. The weathered remains of this volcanic event project westward approximately 100m into the Caribbean Sea and dropping to a depth of approximately 12m. Its terrestrial environment is characterized by a W-E succession of plant communities starting with mosses and lichens, and followed by grass, shrub and tree species from 10 Families (Gosselin, this study). This biological zonation goes hand in hand with an increase of topsoil

Pre-Columbian inhabitants of Dominica used the rock to grind stone tools (Honychurch, pers. com.) French settlers named it Islet Tarreau after a bird that lives on nearby cliffs. The rock owes its current nickname, Rodney's Rock, to Admiral George Rodney of England. He led Her Majesty's Navy in a decisive victory over the French at the Battle of The Saints off the north coast of Dominica in 1782. Unfounded rumors still persist that the English (or the French, depending on the source) lit up the rock like a warship to confuse the fleet of their colonial nemesis (Honychurch, pers. comm.).

Today, the rock is used for artisanal fishing (fish pots and line fishing) and as a popular diving site. The rock is encrusted with coral, sponges, and macroalgae. It is also a habitat for reef fishes, some of which are believed to be under heavy pressure due to overfishing.

This document contains three separate studies. Study I looks at zonation patterns within the reef fish community. Study II examines the diversity and percent cover of sessile benthic organisms, such as coral, sponges, and algae, and the occurrence of the long spined sea urchin *Diadema antillarum*. Study III inspects the percent live cover and species abundance of scleractinians, or stony corals. It is hoped that the information collected during these studies can be used to form a baseline data resource from which future monitoring programs of the marine environment at Tarou Point can be employed.

For the purpose of comparative studies, the rock was divided into four sections (see Figure 2). Section A is a wall that drops from the surface to a wide area of rocky substrate encrusted by coral, sponge, and macroalgae. Depth ranges from 0-5m. Section B is a wall that drops from the surface and then gradually decreases in slope to meet a sandy bottom. Depth ranges from 0-12m. Section C is a wall that drops to a sandy bottom. Depth ranges from 0-10m. Section D is composed of two submerged rocky towers, north D and south D, that sit in 15m of water. The smaller tower (north) rises 5m and the larger one (south) rises 10m. These towers sit on a sandy bottom.

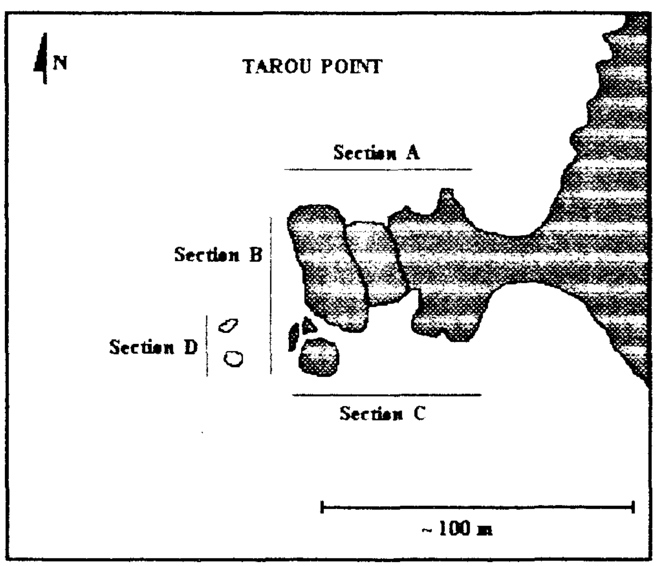

Figure 2: Sections surveyed at Tarou Point

Study I: Reef Fish Inventory and Distribution Patterns at Tarou Point, Dominica, West Indies.

Don Lucas Institute for Tropical Marine Ecology, Springfield, Commonwealth of Dominica.

Abstract. Tarou Point, Dominica, West Indies, is a peninsular projection of volcanic origin that is fringed by coral assemblages. A wide variety of reef fishes live there, but it is widely believed that these are under severe pressure from artisanal fishermen. In this study, fish censuses were taken to create a benchmark against which future studies can test this hypothesis. Clear zonation patterns emerged. Depth and currents were structuring factors for the distribution patterns of key reef fishes.

Introduction

Tarou Point, also known as Rodney's Rock, is of interest to historians, fishermen, dive tourists, and scientists. It is a peninsular projection of volcanic origin that is fringed by coral assemblages. A wide variety of reef fish live there, but it is commonly believed that these are under severe pressure from artisanal fishermen.

In this study, fish censuses and inventories were taken at different locations and depths around the rock, both during the day and at night. This project had two goals. One was to create a benchmark against which future studies could determine whether overfishing is reducing fish numbers. Also, the study examined physical and temporal zonation patterns in the microhabitats of reef fishes, and looked at the physical parameters shaping these patterns. Research on this topic in other locations worldwide is summarized in Williams (1991).

The censuses focused on a few conspicuous fishes. Grazers, such as surgeonfish, damselfish, and parrotfish are of ecological importance in that they consume algae (Choat 1991). This herbivory helps slow-growing scleractinian corals compete against algae. Grunts and snappers are carnivores that make up a significant portion of fish biomass on the reef (Randal 1983, Thresher 1991) and are important to artisanal fishermen. All of the fishes in the census also attract dive tourists.

This study will document the current status of the fish populations at Tarou Point and will hopefully provide a stepping-stone towards an eventual conservation plan.

Methods

Populations of key reef fishes were surveyed. The selected fishes were chosen for their appeal to diving tourists and for their ecological importance. Numbers and size classes of the fish were recorded (Table 1). A worksheet based on this table was used in the census. In one case the census did not identify to species (*Acanthurus* spp., surgeonfish). This was done to facilitate rapid and accurate field identification. However, a count was later made of the three species in this genus to determine a rough estimate of their relative abundances.

Table 1 Fish surveyed, size classes (J=juvenile, IP=initial phase, TP=terminal phase)

Common Name	Scientific Name	Size Classes		
		Small	Medium	Large
French Angelfish	*Pomacanthus paru*	<10cm	>10cm	N/A
Rock Beauty	*Holacanthus tricolor*	<15cm	>15cm	N/A
Banded Butterflyfish	*Chaetodon striatus*	<10cm	>10cm	N/A
Surgeonfish	*Acanthurus spp.*	<15cm	>15cm	N/A
Yellowtail Damselfish	*Microspathodon chrysurus*	<15cm	>15cm	N/A
Sergeant Major	*Abudefduf saxatilis*	<15cm	>15cm	N/A
Orangespotted Filefish	*Canthurhines pullus*	<15cm	>15cm	N/A
Mahogany Snapper	*Lutjanus mahogoni*	<20cm	>20cm	N/A
Coney	*Epinephelus fulvus*	<20cm	>20cm	N/A
Smallmouth Grunt	*Haemulon chrysargyreum*	<20cm	>20cm	N/A
French Grunt	*Haemulon flavolineatum*	<20cm	>20cm	N/A
Yellowtail Parrotfish	*Sparisoma rubripinne*	<15cm, IP	>15cm, IP	TP
Queen Parrotfish	*Scarus vetula*	<15cm, IP	>15cm, IP	TP
Stoplight Parrotfish	*Sparisoma viride*	<15cm, IP	>15cm, IP	TP
Striped Parrotfish	*Scarus croicensis*	<15cm, J/IP	>15cm, IP	TP
Redband Parrotfish	*Sparisoma aurofrenatum*	<15cm, IP	>15cm, IP	TP
Trumpetfish	*Aulostomus maculatus*	<30cm	30-60cm	>60cm

Censuses were taken while diving or snorkeling along the walls of each section. In order to limit section boundaries, only fishes within 5m of the wall were counted. Surface snorkel surveys counted fishes to a depth of 5m, and SCUBA surveys counted fishes below that level. A slow and methodical but efficient swimming pace was used for the surveys. At this speed surveys of each section took 7-10 minutes.

Surface surveys were made at A, B, and C. SCUBA surveys were taken at D and at the lower levels of B and C. Thus, six distinct sections were surveyed—A, B, B deep (12m deep at bottom), C, C deep (10m deep), and D deep (15m deep).

Ten surveys were taken on each region during the day. In order to average out day-to-day variations, each section was surveyed on three different days over the course of two weeks. Midway through the process the number of fishes surveyed was cut to save time as the study became more focused. T-tests (two-sample assuming unequal variances) were used to analyze the results.

In addition to the fish censuses, roving diver surveys were taken. Divers scoured the area, creating an inventory of every fish found. These surveys were taken both during the day and at night to form a comparison. Rough estimates of the abundance of each fish were made.

Results

Table 2 summarizes the census results.

Table 2. Summary of fish census (averages, S=small, M=medium, L=large, see Table 1 for definition of size classes)

	A shallow				B shallow				C shallow			
Fish	S	M	L	# of samples	S	M	L	# of samples	S	M	L	# of samples
Yellowtail Damselfish	7.1	6.4	N/A	10	9.0	4.0	N/A	10	11.4	7.0	N/A	10
Seargant Major	10.8	2.5	N/A	10	46.9	5.1	N/A	10	8.3	3.3	N/A	10
Surgeonfish (Family)	29.6	8.0	N/A	10	18.2	4.6	N/A	10	18.2	5.6	N/A	10
Mahogany Snapper	0.4	0.1	N/A	10	31.9	0.6	N/A	10	10.6	0.2	N/A	10
Smallmouth Grunt	5.2	0.3	N/A	10	0.6	0.0	N/A	10	23.3	0.2	N/A	10
French Grunt	0.8	0.0	N/A	10	1.4	0.0	N/A	10	28.1	0.0	N/A	10
Yellowtail Parrotfish	0.3	0.2	0.0	10	0.3	0.8	0.0	10	1.5	0.8	0.0	10
Queen Parrotfish	0.1	0.0	0.0	10	0.6	0.1	0.0	10	0.0	0.3	0.0	10
Stoplight Parrotfish	1.9	0.0	0.0	10	0.8	0.8	0.0	10	1.7	0.1	0.0	10
Striped Parrotfish	4.5	0.3	0.0	10	1.2	0.3	0.0	10	5.3	2.7	0.0	10
Redband Parrotfish	2.2	0.8	0.4	10	1.0	0.2	0.8	10	0.5	0.5	0.0	10
Banded Butterflyfish	0.83	0.00	N/A	6	1.00	0.17	N/A	6	0.83	1.50	N/A	6
French Angelfish	0.33	0.33	N/A	6	0.33	0.33	N/A	6	0.00	0.00	N/A	6
Rock Beauty	0.17	0.00	N/A	6	1.33	0.33	N/A	6	0.33	0.00	N/A	6
Orangespotted Filefish	0.33	0.17	N/A	6	1.33	0.17	N/A	6	1.17	0.00	N/A	6
Coney	0.17	0.00	N/A	6	0.00	0.00	N/A	6	0.83	0.00	N/A	6
Trumpetfish	0.33	0.50	0.00	6	2.67	2.00	0.00	6	1.33	4.33	0.83	6

	deep D				deep B				deep C			
Fish	S	M	L	# of samples	S	M	L	# of samples	S	M	L	# of samples
Yellowtail Damselfish	0.4	0.8	N/A	10	2.5	4.6	N/A	10	4.2	1.9	N/A	10
Seargant Major	121.2	32.9	N/A	10	104.8	30.5	N/A	10	4.6	2.7	N/A	10
Surgeonfish (Family)	6.4	6.6	N/A	10	13.4	11.7	N/A	10	6.3	6.9	N/A	10
Mahogany Snapper	0.4	7.3	N/A	10	60.0	23.7	N/A	10	3.1	0.0	N/A	10
Smallmouth Grunt	0.2	0.0	N/A	10	3.0	1.0	N/A	10	1.2	0.0	N/A	10
French Grunt	0.3	0.1	N/A	10	7.1	0.6	N/A	10	1.0	0.1	N/A	10
Yellowtail Parrotfish	0.0	0.1	0.0	10	0.0	1.2	0.0	10	0.0	0.6	0.0	10
Queen Parrotfish	0.1	0.0	0.0	10	0.8	0.3	0.0	10	0.1	0.3	0.0	10
Stoplight Parrotfish	0.2	1.0	0.1	10	1.4	1.0	0.0	10	0.1	0.3	0.0	10
Striped Parrotfish	0.9	2.8	3.2	10	2.9	2.1	0.4	10	0.6	1.5	0.5	10
Redband Parrotfish	0.0	0.3	0.4	10	0.0	2.2	2.2	10	0.2	0.8	1.2	10
Banded Butterflyfish	0.0	0.5	N/A	2	1.50	0.00	N/A	4	1.00	1.00	N/A	4
French Angelfish	0.0	0.5	N/A	2	0.50	0.25	N/A	4	0.25	0.75	N/A	4
Rock Beauty	0.0	0.5	N/A	2	0.00	0.00	N/A	4	0.50	0.00	N/A	4
Orangespotted Filefish	0.0	0.0	N/A	2	0.00	0.00	N/A	4	0.25	0.00	N/A	4
Coney	2.5	4.5	N/A	2	0.75	1.75	N/A	4	0.50	1.00	N/A	4
Trumpetfish	0.5	3.0	0.0	2	1.50	2.00	0.75	4	0.25	1.25	0.25	4

A count of 116 surgeonfish at sections A, B, and C revealed that among this genus, 51% were ocean surgeonfish, 35% were blue tangs, and 14% were doctorfish.

Some interesting patterns emerged in the fish distribution patterns. Depth zonation was obvious between the shallow (<5m) and deep zones (5m to bottom [10-15m]). The following patterns were observed:

1. Yellowtail damselfish were three times more abundant in shallow water than below ($P<.001$).
2. Small surgeonfish (<15cm) were more than twice as abundant in shallow water than in deep ($P<.001$). However, surgeonfish in the larger size class (>15cm) showed no significant difference in their abundances in shallow and deep water ($P=.110$).
3. Large mahogany snappers (>20cm) were over thirty times more abundant in deep water than shallow ($P<.001$), while smaller ones (<20cm) no significant difference in their abundances in the two depth zones ($P=.289$).
4. Grunts were four times more common in shallow water than in deep ($P<.001$). Also, among shallow zones (A, B, and C) they were about twelve time more abundant at C than at A or B ($P<.001$).
5. Juvenile and small initial phase parrotfish (<15cm) were three times more common in shallow water than in deep ($P<.001$). However, larger initial phase and terminal phase parrotfish (>15cm) were over two times more prevalent in deep water than in shallow ($P<.001$).

A horizontal zonation pattern in sergeant major distribution was evident between sections at the end of the point (B, B deep, and D deep) and those on the sides (A, C, C deep). These fish were over ten times more common at the end of the point than on the sides ($P<.001$).

In the preceding statistical tests, quantities of fish found in each section were used instead of concentrations. While the areas of each section were not precisely measured, all were roughly equal in size. Censuses of each section required approximately equal times. Therefore, quantities could be used as a substitute for concentrations. Because of the drastic, black and white statistical comparisons, this assumption most likely did not affect the results.

The fish inventory (Table 3) of Tarou Point lists every fish seen during the research, as well as an estimation of their abundances.

Table 3 Fish inventory (Very Abundant=present in extremely large groupings (>100), Abundant=present in large numbers (dozens), Common=not present in large numbers but seen on almost every dive, Rare=one to few sightings) (for night, not enough samples were taken to use the previous scale; for these, Abundant=present in large numbers, Present=sighted at least once)

Family	Common Name	Scientific Name	Abundance Day	Night
Acanthuridae	Blue Tang	*Acanthurus coeruleus*	Abundant	Present
	Doctorfish	*Acanthurus chirurgus*	Abundant	
	Ocean Surgeonfish	*Acanthurus bahianus*	Abundant	Present
Aulostomidae	Trumpetfish	*Aulostomus maculatus*	Abundant	Present
Balistidae	Ocean Triggerfish	*Canthidermis sufflamen*	Rare	
	Orangespotted Filefish	*Canthurhines pullus*	Common	
	Scrawled Filefish	*Aluterus scriptus*	Rare	
	Unicorn Filefish	*Aluterus monoceros*	Rare	
	Whitespotted Filefish	*Canthurhines macrocerus*	Rare	
Blennidae	Redlipped Blenny	*Ophioblennius atlanticus*	Abundant	
Bothidae	Peacock Flounder	*Bothus lunatus*	Common	
Carangidae	Bar Jack	*Caranx ruber*	Common	
	Horse-Eye Jack	*Caranx latus*	Common	
Chaetodontidae	Banded Butterflyfish	*Chaetodon striatus*	Common	Present
Cirrhitidae	Redspotted Hawkfish	*Amblycirrhitus pinos*	Common	
Dasyatidae	Southern Stingray	*Dasyatis americana*	Common	
Gobiidae	Cleaning Goby	*Gobiosoma genie*	Abundant	
Haemulidae	French Grunt	*Haemulon flavolineatum*	Abundant	Present
	Smallmouth Grunt	*Haemulon chrysargyreum*	Abundant	Present
	Spanish Grunt	*Haemulon macrostomum*	Rare	
	White Grunt	*Haemulon plumieri*	Rare	
Holocentridae	Blackbar Soldierfish	*Myripristis jacobus*	Abundant	Abundant
	Squirrelfish	*Holocentrus adscensionis*	Rare	Present
Labridae	Bluehead Wrasse	*Thalossoma bifasciatum*	Abundant	
	Clown Wrasse	*Halichoeres maculipinna*	Rare	
	Creole Wrasse	*Clepticus parrae*	Very Abundant	
	Puddingwife	*Halichoeres radiatus*	Common	
	Spanish Hogfish	*Bodianus rufus*	Common	
	Yellowhead Wrasse	*Halichoeres garnoti*	Common	
Lutjanidae	Mahogany Snapper	*Lutjanus mahogoni*	Abundant	Present
	Mutton Snapper	*Lutjanus analis*	Rare	
	Yellowtail Snapper	*Ocyurus chrysurus*	Common	
Mullidae	Spotted Goatfish	*Pseudupeneus maculatus*	Common	Present
	Yellow Goatfish	*Mulloidichthys martinicus*	Common	
Muraenidae	Chain Moray	*Echidna catenata*	Rare	
	Goldentail Moray	*Gymnothorax miliaris*	Common	
	Spotted Moray	*Gymnothorax moringa*	Common	
Ostraciidae	Smooth Trunkfish	*Lactophrys triqueter*	Common	Present
Pempheridae	Glassy Sweeper	*Pempheris schomburgki*		Present

Family	Common Name	Scientific Name	Abundance Day	Night
Pomacanthidae	French Angelfish	*Pomacanthus paru*	Common	
	Rock Beauty	*Holacanthus tricolor*	Common	
	Queen Angelfish	*Holacanthus ciliaris*	Common	
Pomacentridae	Bicolor Damselfish	*Stegastes partitus*	Abundant	
	Blue Chromis	*Chromis cyanea*	Common	
	Brown Chromis	*Chromis multilineata*	Very Abundant	Present
	Dusky Damselfish	*Stegastes fuscus*	Common	
	Longfin Damselfish	*Stegastes diencaeus*	Rare	
	Night Sergeant	*Abudefduf taurus*	Common	
	Sergeant Major	*Abudefduf saxatilis*	Very Abundant	Present
	Threespot Damselfish	*Stegastes planifrons*	Common	Present
	Yellowtail Damselfish	*Microspathodon chrysurus*	Abundant	
Priacanthidae	Bigeye	*Priacanthus arenatus*	Rare	
Scaridae	Princess Parrotfish	*Scarus taeniopterus*	Rare	
	Queen Parrotfish	*Scarus vetula*	Common	
	Redband Parrotfish	*Sparisoma aurofrenatum*	Common	
	Redtail Parrotfish	*Sparisoma chrysopterum*	Rare	
	Stoplight Parrotfish	*Sparisoma viride*	Common	Present
	Striped Parrotfish	*Scarus croicensis*	Common	
	Yellowtail Parrotfish	*Sparisoma rubripinne*	Common	
Scianidae	Highhat	*Equetus acuminatus*	Rare	Present
	Spotted Drum	*Equetus punctatus*	Common	Present
Scorpaenidae	Spotted Scorpionfish	*Scorpaena plumieri*	Rare	
Serranidae	Barred Hamlet	*Hypopectrus puella*	Rare	
	Coney	*Epinephelus fulvus*	Common	Present
	Creole Fish	*Paranthias furcifer*	Common	
	Gag	*Mycteroperca microlepis*	Rare	
	Greater Soapfish	*Rypticus saponaceus*		Present
	Harlequinn Bass	Serranus tigrinus	Common	
	Rock Hind	*Epinephelus adscensionis*	Rare	
	Tobaccofish	Serranus tabacarius	Common	
Synodontidae	Sand Diver	*Synodus intermedius*	Common	
Tetraodontidae	Balloonfish	*Diodon holocanthus*	Common	
	Bandtail Puffer	*Sphoeroides spengleri*	Common	Present
	Sharpnosed Puffer	*Canthigaster rostrata*	Common	

Discussion

The fish census and inventory data provide a good baseline against which future studies can chart the health of the reef community at Tarou Point. The fish inventory should by no means be considered exhaustive. Even up to the last day of research new species were recorded. Also, this study did not look very closely at gobiid and blennid fishes.

Bouchon-Navaro *et al.* (1997) demonstrated the importance of depth as a structuring factor for reef fishes across the entire West Indies. The results of this study reinforce their conclusions. Yellowtail damselfish and haemulids showed clear depth structuring. Acanthurids, mahogany snappers, and scarids showed variations in vertical zonation within different size and maturity classes.

Sergeant majors were much more abundant at the end of the point than on the sides. This probably has to do with the current patterns at the site. A slow current runs northward up the coast, hitting Tarou Point and curling around it. On the southern side of the point the currents hit the wall and usually stir up the sandy bottom here, severely reducing visibility. The currents run along the end of the point at B and D and then curl around behind A. The water here stagnates. It is usually still and the surface is often covered in floating organic material. The sergeant majors most likely prefer the clear and open moving water found at the end of the point. This theory was based on field observations but not experimentally tested.

The reef fish communities of Dominica need more research. Only one study has been done on this topic in Dominica (Summers 1985), but it was rather preliminary in nature. Studies looking at regional biogeography (Briggs 1974, Acero 1985, Bouchon-Navaro *et al.* 1997) have identified regional provinces of reef fishes within the Caribbean. A border between the southern and northern provinces has been estimated as occurring anywhere between San Andres Island (Colombia) (12°N) and Guadeloupe (16°N). Dominica (15°N) lies between these two and could be the key to defining more precisely the border between regional reef fish communities.

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Study II - The Benthic Community at Tarou Point, Dominica: Organism Diversity and Percent Cover of Sessile Organisms; Composition of Substrate; Abundance of *Diadema antillarum*.

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Abstract. Through the use of transects and 1 m^2 quadrats, the composition of the benthic community at Tarou Point was determined. Four designated sections within this location were evaluated via snorkeling and SCUBA diving. Surveys of both shallow and deep portions of each section resulted in an inventory of substrate and sessile organisms present. Macroalgae, sponges, corals, and annelids were determined to be the prevalent organism groups. The long spined urchin *Diadema antillarum* was also considered. Rock was the primary substrate. A pre-determined sample size of 20 square meters was used for each survey. This inventory will serve as baseline data for future monitoring and conservation programs implemented at this location, thus the marine environment of the 'nature island' can be maintained.

Introduction

The benthic community of a marine ecosystem is influenced by a number of factors. Most importantly, the stability of the substrate plays a role in determining the organisms that can survive there. Tarou Point is rocky, harboring a variety of sessile organisms in an area that is otherwise sandy with little epiflora and fauna. Given the increasing use of this site, conservation measures may become necessary to save this resource. The organism diversity and percent cover of organisms within this community was determined. Organisms targeted for this study were macroalgae and sessile animals. Within the macroalgae, four phyla were considered; Rhodophyta (red algae), Phaeophyta (brown algae), Chlorophyta (green algae), and Cyanophyta (blue-green algae). Within the animal group, three phyla were considered; Porifera, Cnidaria, and Annelida. In addition, the distribution of the sea urchin *Diadema antillarum* (Echinodermata) was assessed. Descriptive accounts of substrate type were also recorded. These groups shape and form the reef community structure.

Information gathered depicts the current status of live percent cover of organisms (ie. coral, algae). With this data, future phase shifts and changes in composition within the community can be monitored. If changes are detected, they can be investigated and the cause, natural or human induced, may be determined. Should it be decided that conservation policies need to be implemented, monitoring will be a necessary management tool. This study provides some of the necessary ecological data.

Methods and Materials

Four sections of the research site were evaluated (see Figure 1). Sections A, B, and C were surveyed twice, once via snorkeling for benthos 3 - 4 m deep, and once via SCUBA diving for benthos 7 - 10m deep. Section D was surveyed only once via SCUBA due to the depth at which it exists, but more so because of it's small size of approx. 10 m diameter.

Each survey involved a 60 m transect, either physically placed or visually projected, along the substrate. A pre-determined sample size of 20 m² was used (Steiner pers. com.). A 1 m² quadrat was subdivided into 100, 10x10 cm squares. Each square represented 1 %, thus facilitating estimation of percent cover. Twenty quadrats were placed at each section using a variety of placement methods (See Table 1). Each organism within the quadrat was identified and recorded on an underwater slate. Sponges were primarily categorized by growth form (boring, encrusting, barrel, tube). Any remaining growth form was designated only as "sponge". Macroalgae were identified by genus; filamentous algae were categorized separately. Stony corals were only identified as Order *Scleractinia.* The substrate was categorized as rock, sand, gravel, coral rubble, dead coral, and carbonate. Gravel consisted of small rocks or pebbles mixed with sand. Coral rubble consisted of broken bits of identifiable coral on the substrate floor. Dead coral consisted of coral skeleton still identifiable by genus. Carbonate consisted of dead coral or coral skeleton not identifiable by species. All other organisms within the quadrat were identified by phylum, genus, and/or species (see Table 2). *Diadema antillarum* was recorded by occurrence rather than area covered. Organisms covering less than one percent of the quadrat were recorded only as being "present".

The distribution of quadrats and the placement method used (transect tape, line, or random) depended upon the area available and the substrate inclination (See Table 1). Sections A and C were measured to be 60 m in length while section B was only 40 m in length. North and South D were approx. 10 m in diameter. North D had a circumference of 20 m while South D had a circumference of 30 m. Quadrats were placed in 3 m intervals along the transtect when substrate was available. In some cases, the total area of a section was not large enough to place quadrats in 3 m intervals. Some sections were not large enough to accommodate 20 quadrats. In these cases the intervals were condensed to 2 m or quadrats were placed randomly in increments of 1 m or less, often covering the entire area of substrate available. Because of limited substrate availability, five quadrats were surveyed on North D while 15 were surveyed on South D. (For the remainder of this document, North D and South D will only be referred to as section D). In some cases, the inclination of the substrate required an additional SCUBA diver to hold the quadrats while data was recorded.

Table 1: Sampling Methods

Section	Depth (m)	Quadrat (Q)Interval	Placement Method	SCUBA diver holding quadrat
A shallow	3-4	3	transect tape - placed and weighed down with rocks	N
A deep	6-7	3	transect line - was nailed to substrate	N
B shallow	4-5	<1	random - quadrats placed at given intervals at cosistent depth	N
B deep	6-7	3	transect line	Y
C shallow	3-4	2	random	Y
C deep	6-7	2	Q1-10 transect line; Q11-20 random	Y
D north	10-11	2	5Q random	N
D south wall	9-10	2	10Q random	Y
D south top	5	2	5Q random	N

Results

(Note: Figures 2 – 13 are located at the end of this document)

A total of 28 species of benthic organisms and six different substrate types were identified at sections A, B, C, and D collectively (See Table 2).

Section A deep was the habitat for the greatest diversity and largest quantities of macroalgae (See Figure 3). Of all sections, encrusting algae was most prevalent at C shallow (See Figure 6). Brown algae had the largest average cover calculated from all sections to be 0.58%, followed closely by red algae with 0.55%. Encrusting algae and pink segmented algae (*Jania adherens*), both Phylum Rhodophyta, each covered an average of 0.81% of the substrate for all sections, the highest average cover of any other macroalgae phyla. Filamentous algae were most abundant of all algae groups, calculated from all sections to have an average of 0.91%. However, it was primarily found at section A deep (see Table 3a).

Average percent cover of sponges was greatest at section D, with barrel sponges covering the largest area (See Figure 8). Encrusting sponges had the greatest average percent cover calculated from all sections to be 3.8%.

Hydrozoans were most abundant in shallow water, section B having the largest quantity. *Millepora sp.* was identified at every section and averaged 7.55% cover (see Figures 4 and 5).

Scleractinians were most prevalent at section C deep with 15.8% cover (see Figure 7), though percent cover was relatively consistent between sections. It ranged from 8.75-15.8%.

The occurrence of sessile annelids was limited to polychaetes and social feather dusters (*Bispira brunnea*). Polychaetes and christmas tree hydroids (*Halocordyle disticha*) did not occur in quantities exceeding 0.14%. Though present at all sections except A deep, the polychaete *B. brunnea* only averaged 0.19% cover for all sections (see Table 3a).

Diadema antillarum occurred most frequently in shallow sections of Tarou Point. They were most abundant at section A shallow with 69 occurrences within the 20 quadrats surveyed, followed closely by section B shallow with 64 occurrences (see Figure 2 and Table 3b).

Substrate consisted mostly of rock averaging 57.2%. Remaining categories of substrate were coral rubble, carbonate, sand, and gravel, and each appeared in quantities of 3% or less. (see Table 3a).

Table 2: Inventory of Benthos at Tarou Point

MACROALGAE	Section A		Section B		Section C		Section D
PHYLUM RHODOPHYTA	Dive	Snorkel	Dive	Snorkel	Dive	Snorkel	Dive
Jania adherens	34	P	0	38	28	3	10
Galaxaura sp.	2	0	1	0	0	0	0
Red Encrusting algae	8	0	22	15	1	37	30
P. PHAEOPHYTA							
Dictyota sp.	19	0	34	2	4	2	20
P. CHLOROPHYTA							
Caulerpa sp.	5	0	0	0	0	0	0
Halimeda sp.	52	0	0	0	0	0	0
Dasycladus vermicularis	4	0	0	0	0	0	0

Ventricaria ventricosa	0	0	P	0	0	0	P
P. CYANOPHYTA							
Blue-green algae	0	0	0	0	0	20	0
FILAMENTOUS ALGAE	39	4	13	0	20	24	27
P. PORIFERA							
Boring sponge	1	3	4	18	2	3	45
Encrusting sponge	69	35	26	33	140	80	149
Barrel sponge	6	0	6	19	41	11	203
Tube sponge	2	0	0	2	0	14	50
Sponge	50	21	149	53	125	25	159
P. HYDROZOA							
Millepora sp.	12	278	47	371	136	134	79
Stylaster roseus	0	0	P	0	0	0	P
Halocordyle disticha	0	0	2	P	2	0	15
P. CNIDARIA							
Scleractinia	175	185	297	179	316	263	239
Pseudopterogorgia sp.	0	0	6	0	0	0	0
Pterogorgia sp.	0	0	0	0	0	6	0
Lebrunia sp.	0	0	1	0	0	0	0
Erythropodium carib.	0	2	4	6	60	9	37
Corallimorpharia	0	0	0	1	7	1	0
Palythoa caribaeorum	0	18	1	7	0	0	2
P. ANNELIDA							
Polychaeta	0	0	1	2	0	1	4
Bispira brunnea	0	P	P	21	5	P	P
P. ECHINODERMATA							
Diadema antillarum	9	69	15	64	7	27	23
Crinoid	0	0	0	0	1	0	1
SUBSTRATE							
Rock	1280	1299	1074	1161	1084	1273	841
Sand	85	20	239	6	9	52	P
Gravel	65	0	0	0	1	5	0
Coral rubble	14	0	0	0	0	0	1
Dead coral	17	8	17	0	0	0	14
Carbonate	53	60	11	4	8	20	49

TABLE 3a: Percent Cover of Organisms Covering > 0.5% of Benthos, Substrate at Tarou Point

ORGANISM	A deep	A shallow	B deep	B shallow	C deep	C shallow	D	Average
Boring sponge	0.05	0.15	0.2	0.9	0.1	0.65	2.25	0.61
Encrusting Sponge	3.35	1.75	1.3	1.65	7	4	7.45	3.8
Barrel sponge	0.3	0	0.3	0.95	2.05	0.55	10.15	2.04
Sponge	2.5	1.05	7.45	2.65	6.25	1.25	7.95	4.16
Dictyota sp.	0.95	0	1.7	0.1	0.2	0.1	1	0.58
Jania adherens	1.7	P	0	1.9	1.4	0.15	0.5	0.81
Encrusting algae	0.4	0	1.1	0.75	0.05	1.85	1.5	0.81
Filamentous algae	1.95	0.2	0.65	0	1	1.2	1.35	0.91

Erythropodium caribaeorum	0.1	0.1	0.2	0.3	3	0.45	1.85	0.84
Millepora sp.	0.6	13.9	2.35	18.55	6.8	6.7	3.95	7.55
Coral	8.75	9.25	14.85	8.95	15.8	13.15	11.95	11.8
Total % Cover	20.65	26.4	30.1	36.7	43.65	30.05	49.9	
SUBSTRATE								
Carbonate	2.65	3	0.55	0.2	0.4	1	2.45	1.46
Rock	64	65	53.7	58.1	54.2	63.7	42.1	57.2
Sand	4.25	1	11.95	0.3	0.45	2.6	P	2.94
Gravel	3.25	0	1	0	0.05	0.25	0	0.65
Total % Cover	74.15	69	67.2	58.6	55.1	67.55	44.55	62.25

TABLE 3b: Occurrence of Diadema at Tarou Point

	A shallow	A deep	B shallow	B deep	C shallow	C deep	D
*Diadema antillarum**	9	69	15	64	7	27	23
Ave Occurrence shallow and deep/sq meter**		A 1.95		B 1.98		C 0.85	D 1.15

*numbers refer to total occurrence per section (A shallow,A deep, etc.)
**Average occurrence calculated for sections A,B,C,D

Discussion

Benthic macroalgae play an important role on coral reefs. The abundance and composition are critical to the reefs' ecological, aesthetic, and socioeconomic value. Calcareous algae are major contributors to reef building and often occupy a great deal of space (Adley as cited in Lessios 1995). This fact supports the findings that calcareous red algae were most abundant in average percent cover for all sections. Brown algae flourish in reef environments with rocky substrates, around the base of coral heads, vertical walls, and protected areas (Humann 1993). Sections A and B deep both exhibit these conditions, thus the greatest abundance of *Dictyota sp.* occurred here. Species of green algae thrive in shallow, sandy areas on or between reefs (Humann 1993), thus the occurrence of *Caulerpa sp.* and *Halimeda sp.* only in section A shallow. Grazing fish, primarily Surgeonfish (Family Acanthuridae) and Damselfish (Family Pomacentridae), that feed on filamentous algae, were found in consistent numbers throughout the shallow waters of each section. Sergeant Majors (Family Pomacentridae) were most abundant at section D (Lucas 2001). These frequencies are associated with the feeding behaviors of these fish and their tendencies to maintain and protect algal gardens (Humann 1994). Because it was determined that the same number of these fish appear at all sections, the abundance of filamentous algae (see Table 3a) and grazing fish are not related at this particular site, as would be expected.

Optimal habitats for sponges include reefs and walls as well as shaded ledges and overhangs (Humann 1992). Section D contains each of these habitats and is the most flushed. The greatest percent cover of these suspension feeders is found here. It was expected that barrel sponges would cover the most area. Despite the large growth form of these sponges, non-encrusting sponges (excluding boring and tube sponges) and encrusting sponges each covered an area almost twice as large (see Table 3a). Barrel sponges covered an average of 2.04% for all sections while non-encrusting sponges covered an average of 4.16% and encrusting sponges covered an average of 3.8%. This is related to the fact that barrel sponges grow up or out towards the water column while other growth forms spread over the substrate.

Stony corals are subject to a variety of ecological and biogeographical parameters. Light and substrate availability are the two most important (Humann 1993). Due to the relationships between endosymbiotic algae and corals, depth is also a limiting factor related to light penetration. Energy must be obtained from the sun for these endosymbionts to photosynthesize. Availability of substrate greatly affects the percent cover of coral species. In the case of Tarou Point, average coral cover ranged from 8.75-15.8 %. Fifteen percent is the average cover for Dominica's west coast coral assemblages, however, some sites such as Scott's Head and Coral Gardens reach 50-60 % coral cover (Steiner pers com).

The number of sessile annelids found at Tarou Point is quite low compared to other organisms found in this community. These organisms are small, take up little substrate, and do not form large aggregations, thus comprising a small component of the benthic cover.

Diadema antillarum is found in rocky and reefal habitats in the euphotic zone. They hide during the day in sheltered locations and feed on algae at night. Sections A, B, and D averaged greater than 1 per m^2. Section C averaged slightly less than 1 per m^2 (see Table 3b). The abundance of this species was determined to be much greater in shallow sections. The incline of the substrate influenced the frequency of the sea urchins. Sections A and B shallow exist as boulders and a rocky ledge. Both provide relatively flat, stable substrate that offers protection and allows the urchins to scrape away algae/substrate forming shallow pits in which they live. In this study, *D. antillarum* occurred in all sections. Where macroalgae formed less than 7 % of the benthos *D. antillarum* occurred in numbers ranging from 7 - 69. At one section, A shallow, 9 *D. antillarum* were recorded, but macroalgae were virtually absent (see Figure 13). While the occurrence ot *D. antillarum* seems to control the growth of macroalgae, other grazers are likely to be equally involved in this process. Eliminating the presence of selected grazers (caging experiments) may elucidate the role of *D. antillarum* in shaping the occurrence of macralgae.

The current status of *D. antillarum* in Dominica is quite different than in other parts of the Caribbean and Atlantic. In 1983-1984, the catastrophic death of these urchins occurred in Panama and other Caribbean regions, the most extensive and severe mass mortality ever recorded for a marine animal (Lessios 1995). In the last 15 years, Jamaican reefs have shifted from corals to macroalgae. One contributing factor is thought to be the mass mortality of these urchins in this area as well (Woodley et al 1999). In each location, an unidentified pathogen facilitated the death of *D. antillarum*. One *D. antillarum* per 1m^2 is considered to be abundant compared to other places in the Caribbean such as the Turks and Caicos Islands, but not compared to numbers existing before this mass mortality (Steiner pers. com.). It is unknown whether this die off occurred in Dominica and the urchins have already recuperated, or if this die off never occurred here.

Dominica is a volcanic island. Therefore, the primary substrate is rock. Organisms that grow here are influenced by this factor. Organisms that require hard, stable substrate for settlement, such as stony corals and sponges, flourish in this area. The existence of rocky substrate is a major contributor to the diversity of Tarou Point (see Figures 9-12). If the substrate consisted mostly of coral rubble, sand, and gravel, the diversity of sessile organisms would be greatly diminished due to the lack of a stable attachment site.

This study successfully produced an inventory of sessile organisms including *D. antillarum* at Tarou Point. This baseline data may be used in the future by governmental agencies monitoring the health of this tourist attraction and fishing site. This information can also be used in long term studies focusing on phase shifts within this reefal community. To effectively manage this location, changes in macroalgae composition and fish populations should be carefully observed. These organisms are closely related and changes in either group will affect the community structure. Algal growth may also serve as an indicator for pollutants, thus monitoring growth may provide early clues of contamination. Live coral cover will serve as an indicator of water quality, nutrient availability, and sedimentation. Each of these factors are affected by agriculture, thus may provide a connection between the importance of resource management both on land and in the sea. Monitoring *Diadema antillarum* would offer an interesting comparison to other locations in which abundance of this urchin is severely diminishing or has already suffered from mass mortality. Change in substrate will be indicative of erosion.

Monitoring each of these elements will increase the ecological understanding of Tarou Point. By educating the people about what exists in this precious marine environment, the need for conservation programs may be met. Protection of Tarou Point means a beautiful ecosystem that will continue to flourish on the 'Nature Island'.

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STUDY III: Species Richness and Frequency Distribution of Scleractinians at Tarou Point, Dominica, West Indies

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Abstract. Tarou Point, located on the west coast of Dominica, is a volcanic outcrop covered with coral assemblages. Four different sections within Tarou Point were surveyed for scleractinian species richness and frequency distribution analyses. Twenty-two species of scleractinians were identified, among which *Porites astreoides*, *Agaracia agaricites*, *Siderastrea siderea*, and *Meandrina meandrites* represented the highest average abundance over all sections observed. The deep portion of section B showed the highest species diversity, while sections North D and the deep portion of section A represented the lowest. Frequency distribution trends among species depended on factors including substrate type and availability, light, depth, wave energy, and sedimentation. Because Tarou Point is a popular fishing and diving site, this data will serve as a baseline for future monitoring of the coral assemblages in attempts to prevent degradation of this natural resource.

Introduction

Scleractinians, or stony corals, are sessile cnidarians capable of forming colonies and secreting calcium-carbonate exoskeletons, which contribute to the construction of coral reefs. A coral polyp (the living animal) requires specific conditions for optimal growth, including a stable substrate for settlement and nutrient-poor waters that are well illuminated and have low sedimentation rates. Scleractinians are stenothermal organisms, thereby existing only within a narrow temperature range of approximately 18-30°C, with 26°C being most optimal (Veron 1995).

While the tropical waters of Dominica provide stony corals with most of these conditions, as a young volcanic island, Dominica has a narrow shelf which drops off sharply to very deep waters, thus limiting the amount of available well-illuminated space for coral reef formation. There is little evidence here of coral buildup, in which corals build on top of corals, which would constitute a biogenous substrate and thus define a true reef (in geological terms). Instead, most coral growth here occurs on igneous rock. The areas most optimal for coral growth on the west coast are areas with rocky outcrops (Point Guignard, Rodney's Rock) or boulder fields (Grand Savanne) that provide stable substrate for coral growth, and other locations such as Scotts Head, which are not in close proximity to large rivers and thus high sediment input.

Tarou Point was chosen as the study site because it represents the characteristic coral growth formation of Dominica and is an area used not only as fishing grounds, but is also gaining popularity as a tourist destination for snorkelers and scuba divers. The coral-encrusted boulders here provide structural microhabitats for many benthic organisms, including several reef fish that are exploited by artisanal fishermen. However, no detailed benthic marine ecology studies have been conducted at Tarou Point. This study presents the scleractinian species identified, the percent live cover of the species, and their frequency of distribution at this site. These results will be used for future monitoring of this natural resource.

Methods and Materials

In order to estimate percent live coral cover and scleractinian species frequency of distribution, a predetermined sampling size of 20m² was used for all observations (Steiner, pers.com.). A 1m² quadrat, divided into 100 10x10 cm squares (each square representing 1%), was used for all surveys, thus facilitating estimations of percent cover. Twenty quadrats were placed in each section.

The length of substrate available at each section was measured to determine the sampling method. Sections A and C were approximately 60 m, while site B was 40 m. North D and South D pillars were both found to be 10 m in diameter. The circumference of North D was 20 m, while that of South D was 30 m. The distribution of quadrats and placement method used (i.e., transect tape, line, or random) thus depended on the area available and the substrate inclination of each section. When two 30 m transect tapes or lines were employed (i.e., for a total 60 m transect at one depth), quadrats were laid down along the line every 3 m. However, in areas of limited available substrate, 3 m intervals were condensed to 2 m increments or a random placement method of < 1 m intervals, without a transect, was used. In the case of South D, only 5 quadrat surveys were conducted to account for the limited space. In some cases, an additional SCUBA diver was needed to hold the quadrats in place (i.e., along vertical wall sections of deep B, shallow and deep C, and the wall of South D). Both shallow (0-5 m) and deep (6-7 m) surveys of scleractinians in sections A, B, and C were carried out through snorkel and SCUBA observation, respectively. Surveys at North D and South D were done through SCUBA observation only, at a depth range of 5-11 m. A summary of observation depths and sampling methods used for each section were recorded on Table 1.

The *in situ* identification of scleractinian species according to Humann (1993), as well as estimations of percent live cover (counting coral colonies within each quadrat) were recorded on underwater slates during each observation period. Shannon-Weaver diversity indices were calculated for each of the sections to analyze species diversity and evenness in frequency distribution within each section (i.e. shallow versus deep) and among all sections (Shannon & Weaver 1948) (see Table 3).

Table 1: Sampling Methods

Section	Depth (m)	Quadrat (Q)Interval	Placement Method	SCUBA diver holding quadrat
A shallow	3-4	3	transect tape - placed and weighed down with rocks	N
A deep	6-7	3	transect line - was nailed to substrate	N
B shallow	4-5	<1	random - quadrats placed at given intervals at cosistent depth	N
B deep	6-7	3	transect line	Y
C shallow	3-4	2	random	Y
C deep	6-7	2	Q1-10 transect line; Q11-20 random	Y
D north	10-11	2	5Q random	N
D south wall	9-10	2	10Q random	Y
D south top	5	2	5Q random	N

Results

The overall scleractinian species richness found at Tarou Point was 22 (see Table 2). The frequency distributions of scleractinians for each section, along with the average frequency distribution per species over all sections, were also recorded (see Figures 2, 3, 4, 5, and 6).

These were examined for the existence of possible distribution patterns between and/or within sections. Small-colony species such as *Favia fragum* and *Siderastrea radians*, which were present in some surveys but never represented a 1% cover area, were marked (*) on each of the figures.

The species that covered the most area (in terms of percent live cover) within the shallow portions of sections A and B was *Porites astreoides*, while *Agaracia agaricites* was the most abundant in the shallow portion of section C. Other species commonly found within shallow surveys included *Meandrina meandrites* and *Siderastrea siderea*. The species covering the most area within the deep surveys varied between sections. *S. siderea* was the most abundant within section A, while *A. agaricites* was the most abundant within sections B and C. *M. meandrites* represented the highest percent cover at both North D and South D, while *Dichocoenia stokesii* and *Madracis decactis* were also abundant within the latter section.

The results of the Shannon-Weaver diversity indices showed that section B deep represented the section of both highest possible maximum diversity (H'max = 2.48) and highest actual species diversity (H' = 1.96), while sections D north and A deep represented the lowest (H' = 1.33, 1.34). However, only 5 quadrats were completed at section D north. Thus differences in sampling size could account for these results. Section C deep showed the highest degree of evenness of frequency distribution (J = .88), while A deep showed the lowest (J = .58).

Table 2: Scleractinian species identified at Tarou Point

Porites astreoides (PA)	*Leptoseris cucullata (LC)*	*Montastraea faveolata (MF)*
Porites porites (PP)	*Favia fragum (FF)*	*Stephanocoenia intercepta (SI)*
Porites colonensis (PC)	*Diploria clivosa (DC)*	*Madracis decactis (MD)*
Siderastrea siderea (SS)	*Diploria strigosa (DStg)*	*Madracis mirabilis (MM)*
Siderastrea radians (SR)	*Diploria labrynthiformis (DL)*	*Mycetophyllia danaana (MyD)*
Agaricia agarices (AA)	*Dichocoenia stokesii (DStk)*	*Colpophyllia natans (CN)*
Agaricia humilis (AH)	*Montastraea annularis (MA)*	
Meandrina meandrites (MM)	*Montastraea cavernosa (MC)*	

Figure 2: Scleractinian distribution frequency at section A, Tarou Point

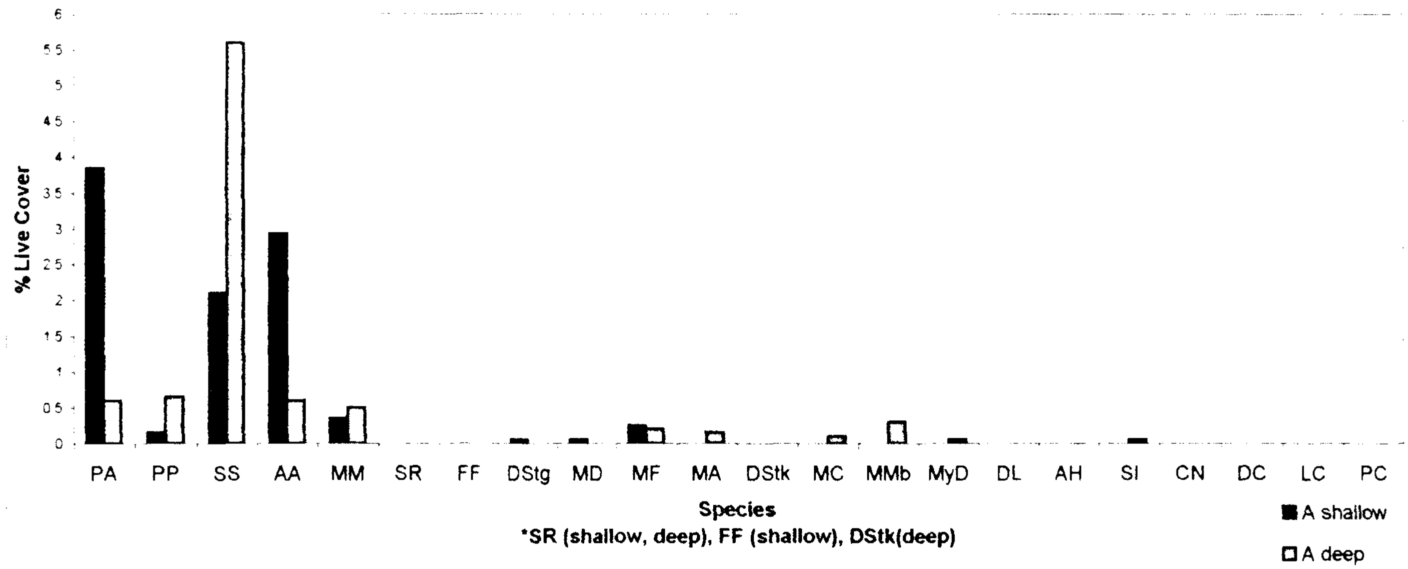

Figure 3: Scleractinian Distribution Frequency at section B, Tarou Point

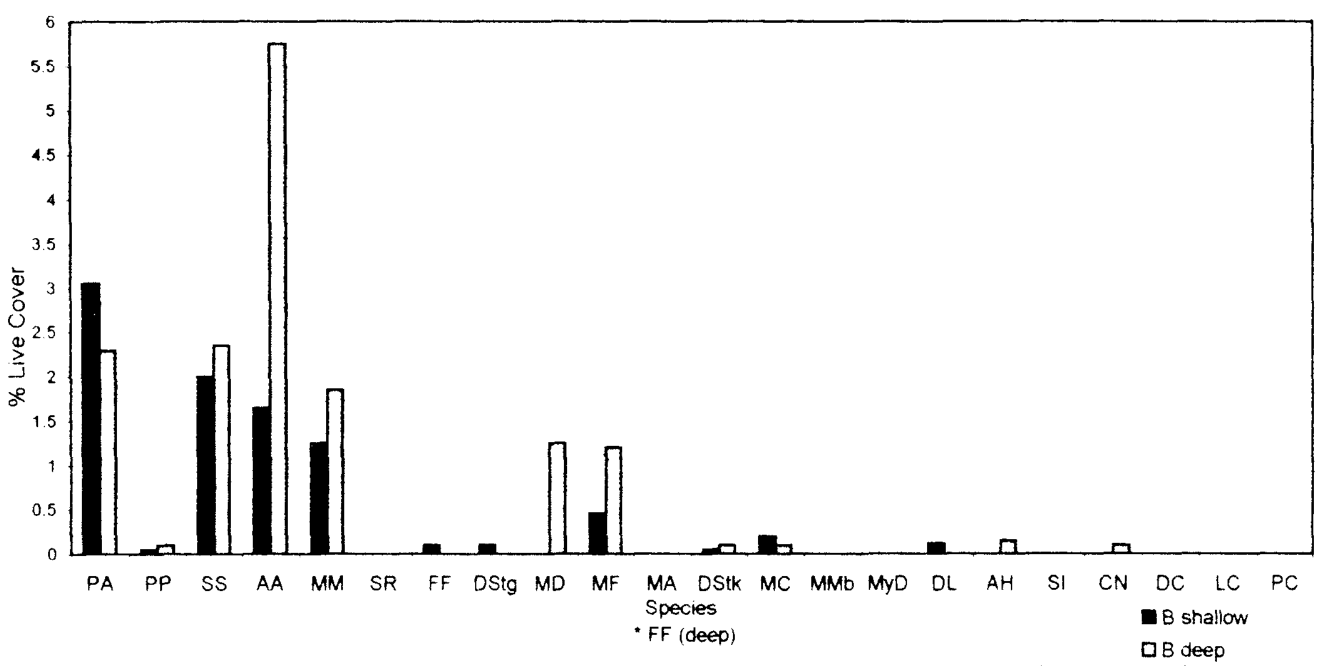

Figure 4: Scleractinian distribution frequency at section C, Tarou Point

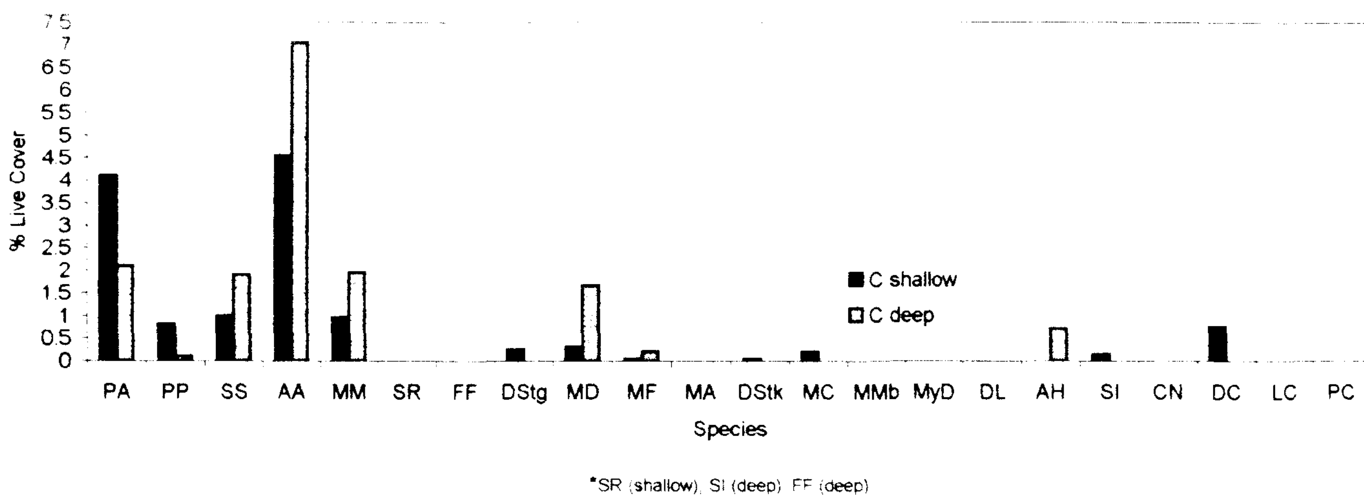

Figure 5: Scleractinian Distribution Frequency at North D and South D, Tarou Point

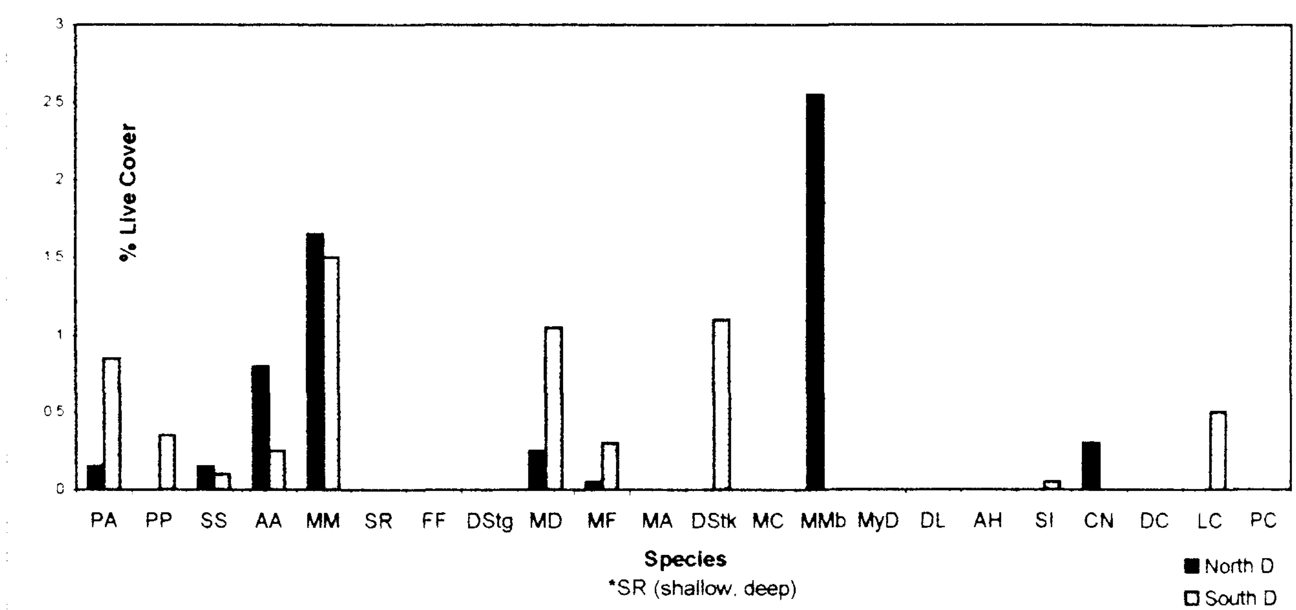

Figure 6: Average Scleractinian Distribution Frequency, Tarou Point

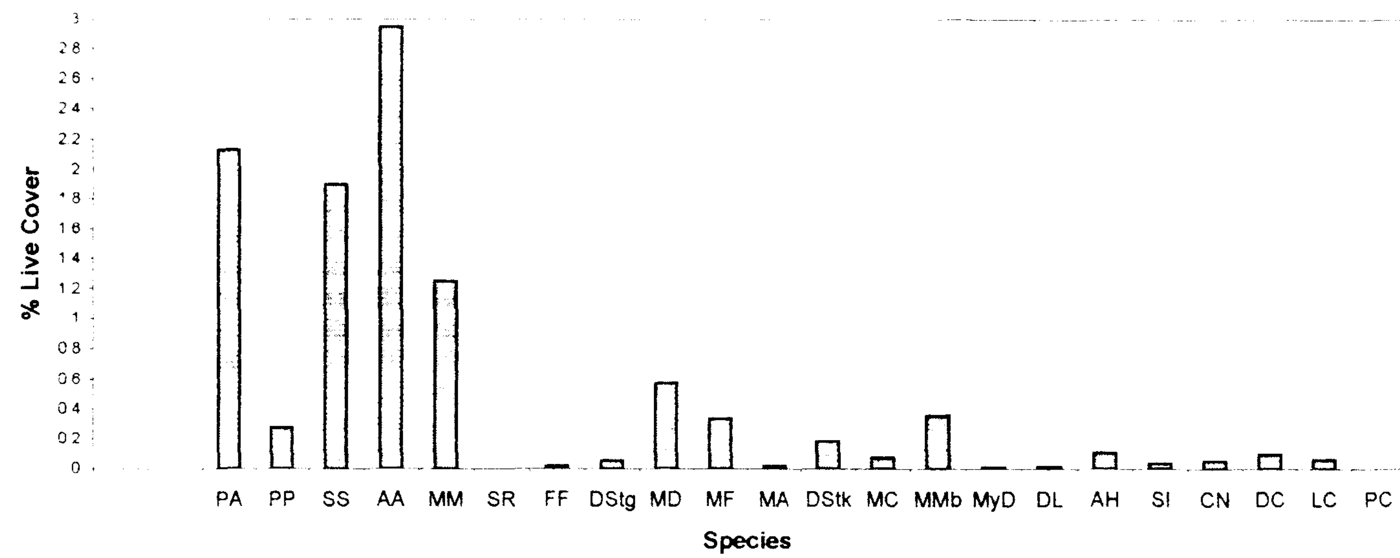

Table 3: Results of Shannon-Weaver diversity indices

Section A	Shallow	Deep	Section C	Shallow	Deep
H'max	2.08	2.30	H' max	2.48	2.08
H'	1.45	1.34	H'	1.84	1.83
J	.70	.58	J	.74	.88
Section B	**Shallow**	**Deep**	**Section D**	**North D**	**South D**
H'max	2.40	2.48	H' max	2.08	2.30
H'	1.58	1.96	H'	1.33	1.51
J	.66	.78	J	.64	.66

H'max = maximum possible species diversity within area (H'max = ln S, where S=number of scleractinian species found in each section) ; H'max range: 0<H'max<5, where 5 represents maximum diversity
H' = actual (calculated) scleractinian species diversity (H' = - ΣPi (lnPi), where Pi = % species cover/S)
J = species evenness (J = H'/H'max) ; J range: 0<J<1, where 1 represents highest evenness of species distribution

Discussion

Because coral reef ecosystems are complex natural communities, there are several factors that can affect scleractinian community structure. Depth, along with light and substrate availability, are key abiotic factors controlling coral distribution and abundance (Cornell & Karlston 2000; Huston 1985). This is especially the case in Dominica, in which the narrow, deep shelf limits the amount of appropriate available substrate for coral growth. Physical or environmental stresses such as sedimentation, turbidity, wind and wave action, temperature changes, and eutrophication, may also contribute to local species richness and distribution patterns (Edmunds, et al. 1990). Depending on the size (area) of habitat and the resources available within that area, species interactions, both inter-and-intra-specific, can also play a role (Cornell & Karlston 2000). The function that disturbance has in shaping coral community structure has also been discussed (Connell 1978; Karlson & Hurd 1993). An intermediate level of disturbance may help maintain local species richness by keeping species interactions at low levels and preventing the elimination of inferior competitors. Scleractinians are polymorphic organisms and thus have species-specific responses to environmental and biotic parameters, as well as adaptive variability among individuals within a population. Connell (1978) concluded that species diversity is a nonlinear function of disturbance frequency, but that this response is dependent on coral growth rates (light levels and water clarity). Species diversity is also a nonlinear function of coral growth rates and again, is dependent on disturbance frequency. All of these factors and suggested controlling mechanisms should be considered when discussing the local species richness and community structure of scleractinians.

The overall species richness of the sections at Tarou Point was 22 species, which, when compared against the background data of 32 species found along the entire west coast of Dominica (Steiner & Borger 2000), represents a relatively diverse site. The majority of the species identified at Tarou Point were massive or encrusting species, such as *P. astreoides*, *A. agaricites*, *M. meandrites*, and *S. siderea*, which were the four species found at the highest average abundance over all sections observed. Very few branching corals were seen. While some branching species like *Acropora palmata* prefer high wave impact conditions (i.e., along the west coast of Dominica during tropical storms), because they are fast-growers and are capable of fragmentation and rebuilding, the level of wave energy, along with Dominica's characteristic narrow, deep shelf, would cause branching colonies to break, fall, and get washed away into deep waters. For example, a large *A. palmata* located at a site along the west coast of the island was toppled over by the force of Hurricane Lenny in November 1999. This colony fell into the sand of deeper waters and has never regrown (Steiner, pers.com.). However, there is also evidence of a regional decline of *A. palmata* over the entire Caribbean (Lewis 1984; Steiner pers. com.). Therefore it is possible that this decline contributed to the reason this species was not seen here.

The most abundant species found among the shallow areas of sections A and B was *P. astreoides*. This species, along with *A. agaricites*, covered the most area (4-4.5%) in the shallow portion of section C, which consisted of a rocky wall located in a heavy surge zone. Colonies of *P. astreoides* observed in the shallow, surging waters of sections A and C (3-4m) were relatively flat and encrusting, while those found at section B (4-5m), which consisted of a flat, submerged rocky ledge, were more mound-like. Because it is completely submerged and flat, this section does not suffer as much wave action or disturbance as the shallow sections of A and C. However, this section also receives less light than the other areas. Forming mounds may be an adaptive advantage to increase the surface area of coral exposed to light. *A. agaricites* also has the ability to take on many growth forms (Humann 1993) Thick or flat encrusting plates, thick bifacial upright lobes, and thick plates with bifacial extensions were all observed during this study. This polymorphism may be what enables these two species to be so successful here. They are sturdy enough to withstand the rough conditions in shallow areas, yet can still capture sufficient light by taking on different growth forms. These species are also relatively fast-growing species (Steiner, pers.com.) and may outcompete other corals or marine organisms for substrate and light. Conversely, *S. siderea,* a slow-growing massive coral that forms large domes or boulders, was also a common species at section B. This species is most likely successful here because of its sturdiness and consequent longevity (i.e., colonies of 2-3 m diameter).

S. siderea was the most abundant species found at the deeper portion of section A, covering a total area of 5.5%, while other scleractinians covered only minimal areas of 0.5 % or less. This survey was conducted along the seafloor, at 6-7 m depth, and consisted of sandy patches interspersed with coral-covered boulders. Because section A receives less wave action than section C, it is subjected to increased sedimentation because the area functions as a small circulating gyre. In addition, because of the increased nutrients circulating in the water column, macroalgae species, which compete with coral for light and space, were the most abundant at section A, covering 6.2% of the area (Lehman 2001). All of these factors may account for the low species diversity and low species evenness found here (see Table 3). Again, as a sturdy and massive species, *S. siderea* is more likely than other corals to withstand a higher degree of sedimentation or unstable substrate that exists in this sandy area.

A. agaricites was the most abundant species found in the deeper portions of sections B and C. Colonies were also commonly found in shaded areas of the vertical rocky walls at these sections, and thus may be able to grow in minimal light conditions as well as in exposed shallow areas. *M. decactis* is another species adapted to low light areas of rocky walls, forming thinly encrusting small colonies. Colonies were also seen as tightly bunched lobes or knobs in more exposed areas of the walls. Both forms of this species composed approximately 1.5-2% area in both sections. *M. meandrites* was also prevalent in these sections. Again, this polymorphic species can form hemispherical heads or flattened plates and is adapted to a variety of conditions. Some are able to form in areas of coral rubble and sand and may not need to be firmly attached to the substrate (Humann 1993). These characteristics are in accordance with the *M. meandrites* colonies found on the more unstable area of section B that contained an increased amount of dead coral (.85%) and sand (11.95%) (Lehman 2001).

North D and South D were two submerged rocky pillars found in 15m of water. *M. mirabilis* was the most abundant species found at North D, in which the flat top of the pillar, at approximately 10-11m depth, was surveyed. This species was one of the few branching, non-massive species found during this study, and was found here because these fragile colonies require deeper waters and less disturbance from wave energy (Humann 1993). They are unable to grow outward on the rocky walls that were surveyed in other sections, and instead tend to form dense clumps of small branches. However, this species covered only a 2.5% patch area, whereas the most abundant species at other sections covered 5-7% area. This is most likely due to the lack of substrate available at this section. Only five quadrat surveys were completed at North D. This also accounts for the lowest species diversity and the low species evenness observed here (see Table 3).

M. meandrites was the most abundant species at South D, in which both the vertical rocky wall (9-10m) and the top of the pillar (5m) were surveyed. *D. stokesii*, *M. decactis*, and *P. astreoides* were also prevalent species. However, each of these covered less than 1.5% area within the section. This pillar was mainly composed of barrel and encrusting sponges, as well as bare rock (Lehman 2001).

It should also be noted that colonies of some species, such as *F. fragum* and *S. radians*, were found in high individual counts throughout a majority of the sections surveyed. Both of these species seem to tolerate high levels of surge and sedimentation. However, because colonies of these species reach a maximum size of only 5 cm and 30 cm, respectively (Humann 1993), they did not compose more than 1% of area within any of the quadrats during this study. Therefore in terms of volume and cover, these species do not represent a major component of scleractinian community structure at Tarou Point.

While the overall species richness at Tarou Point was relatively high, the results from the Shannon-Weaver diversity indices showed that species diversity within each section was relatively low. This may simply be because of the previously mentioned lack of available appropriate substrate in Dominica for coral growth. However, the maximum possible diversity calculated was in the deeper portion of section B ($H'max = 2.48$), while the actual species diversity found here was 1.96. This section consisted of a vertical rocky wall, as well as a sandy area interspersed with a few coral-covered boulders located along the side of a submerged rocky ledge. Therefore it is possible that the highest diversity was obtained here because a more varied area of habitats were surveyed, which provide different conditions for various species of coral to settle and grow, according to their species-specific requirements. In addition, the shallow portion of section C also exhibited high species diversity. Because this area is subjected to a high degree of wave action, especially when tropical storms occur, these results may be attributed to the intermediate disturbance hypothesis discussed earlier, in which small, but frequent disturbances, help maintain local species richness. Conversely, the highest degree of evenness of frequency distribution resulted at the deeper portion of section C (see Table 3). This may be due to the fact that section C is a more nutrient-poor site with well-flushed sediments and increased water clarity (because of high wave energy). These are optimal growth conditions for many species of scleractinians.

Determining what factors shape local scleractinian community structure is difficult not only because of the high degree of polymorphism and species-specific responses of these organisms, but also because researchers always employ different survey methods. In addition, various definitions are constantly used to describe things such as substrate heterogeneity, amount of sedimentation, disturbance, etc.

The results of this study provide the baseline data for the present status of scleractinian richness and frequency distribution at Tarou Point. With this information, Tarou Point can be monitored on a regular basis to determine changes in scleractinian community structure and why these changes are occurring. Because Tarou Point is an important marine resource in Dominica, both economically and ecologically, it is important that we use this information to help conserve this area for the future.

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APPENDIX TO : Study II - The Benthic Community at Tarou Point, Dominica: Organism Diversity and Percent Cover of Sessile Organisms; Composition of Substrate; Abundance of *Diadema antillarum*.

Wendy Lehman

Figure 2: % Cover of A shallow

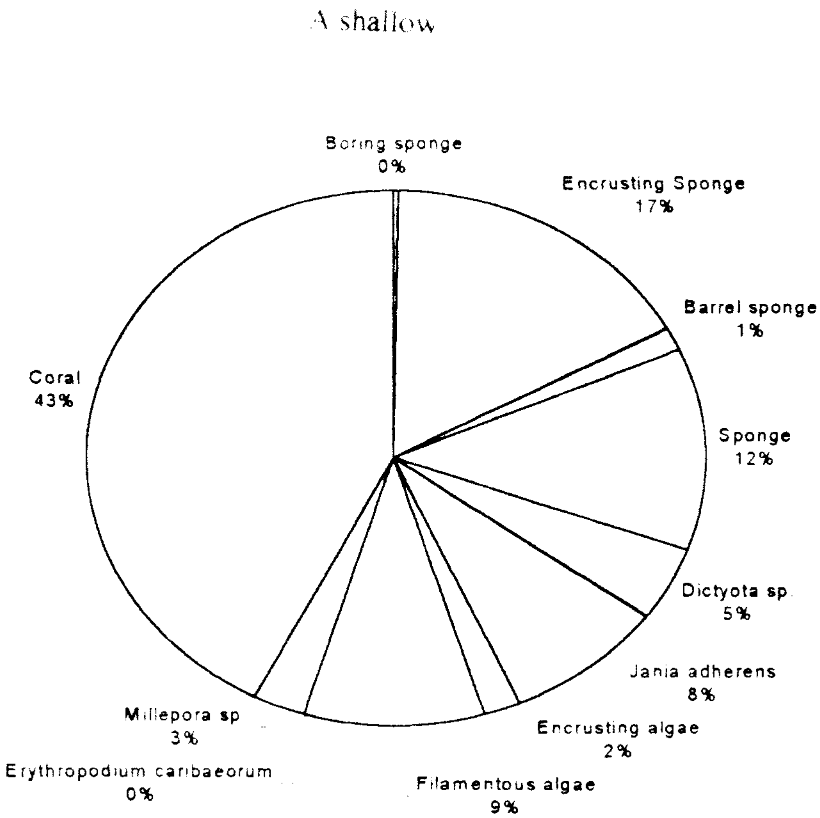


Figure 3: % Cover of A deep

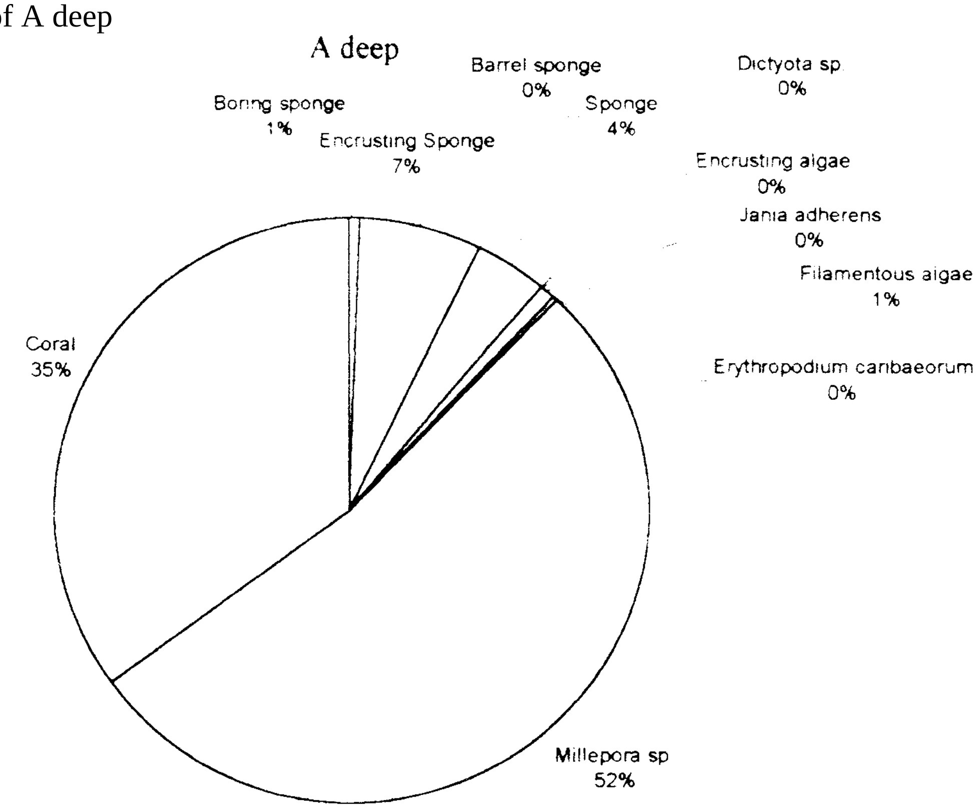


Figure 4: % Cover of B shallow

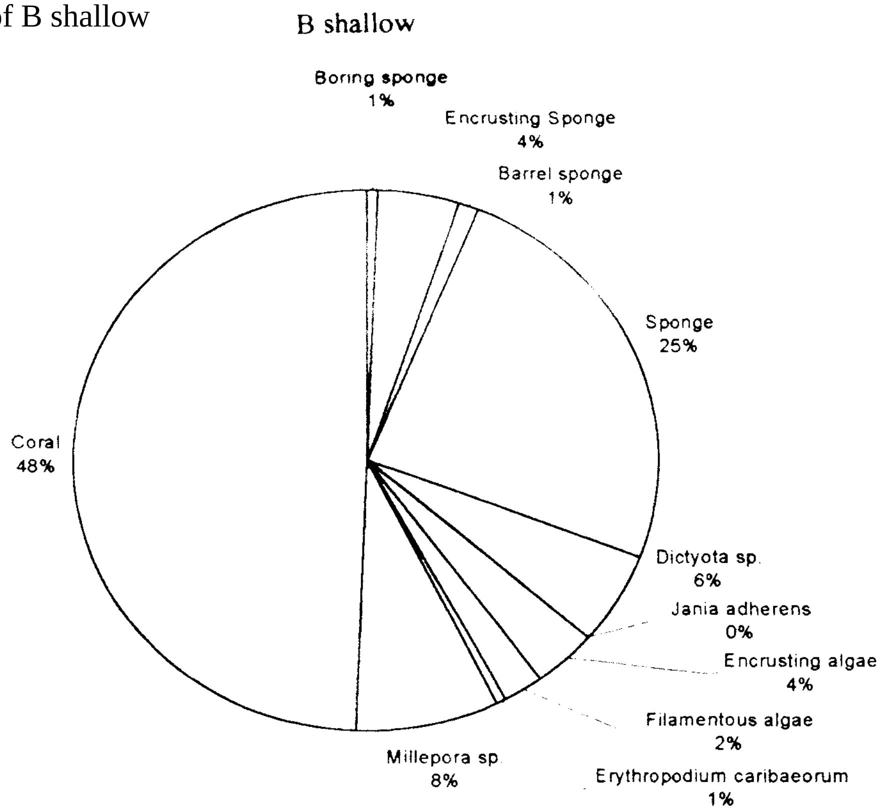


Figure 5: % Cover of B deep

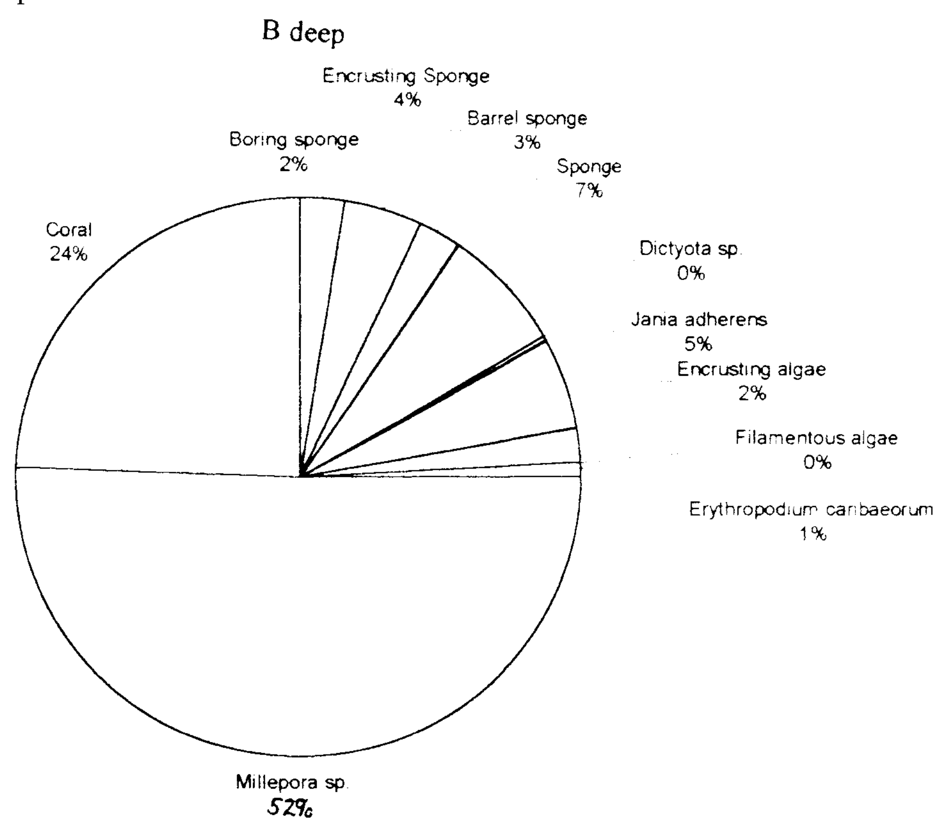


Figure 6: % Cover of C shallow

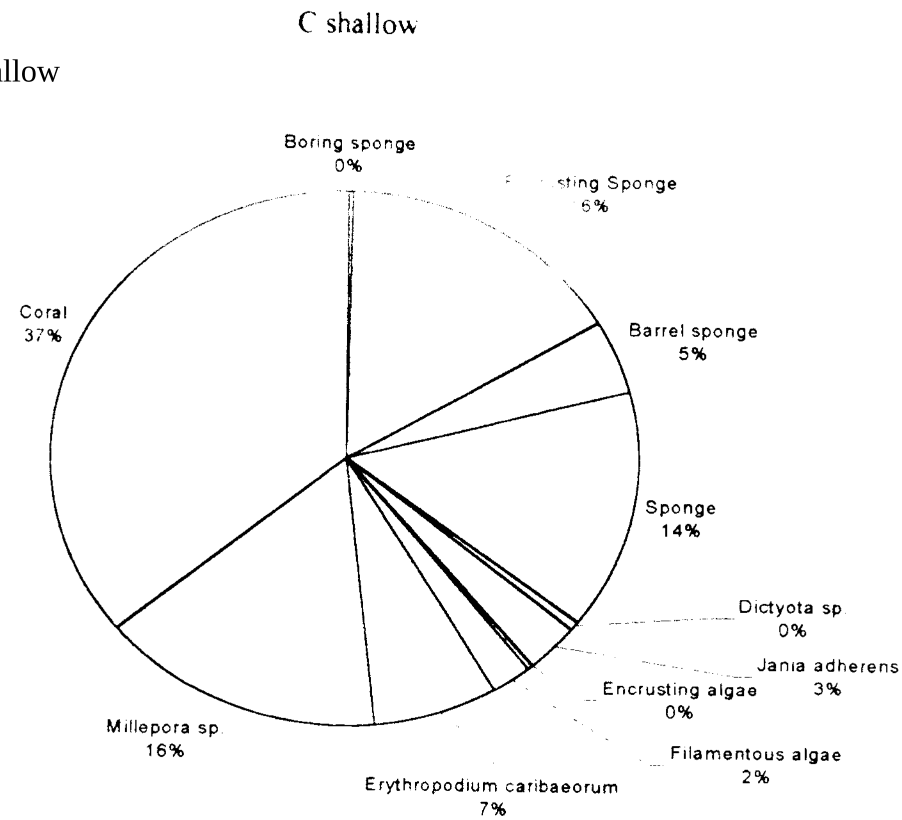


Figure 7: % Cover of C deep

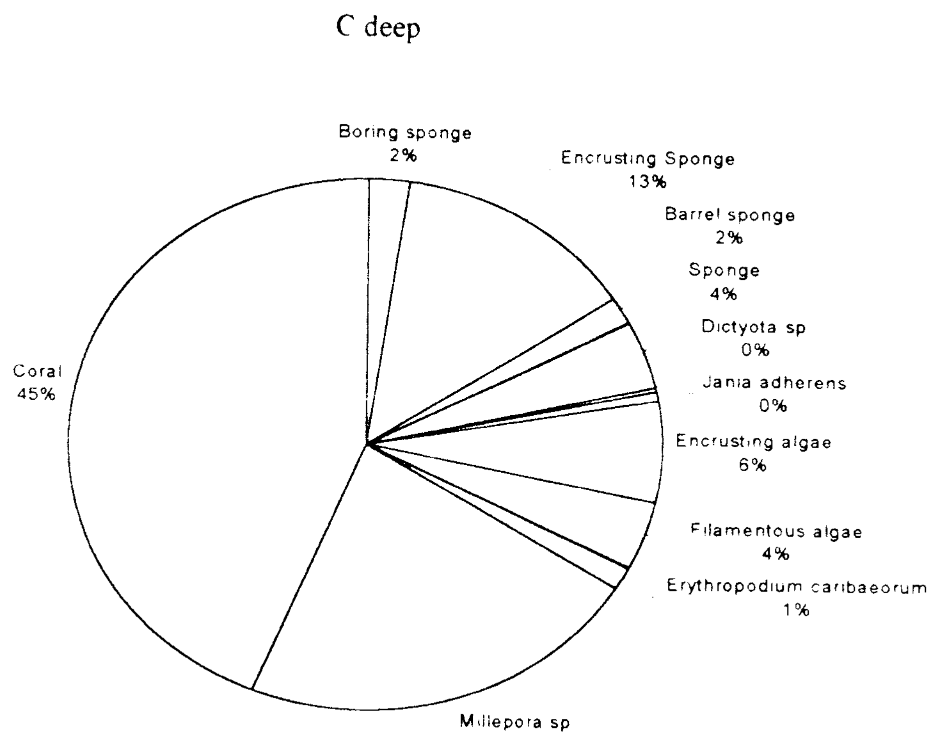


Figure 8: % Cover of D

D

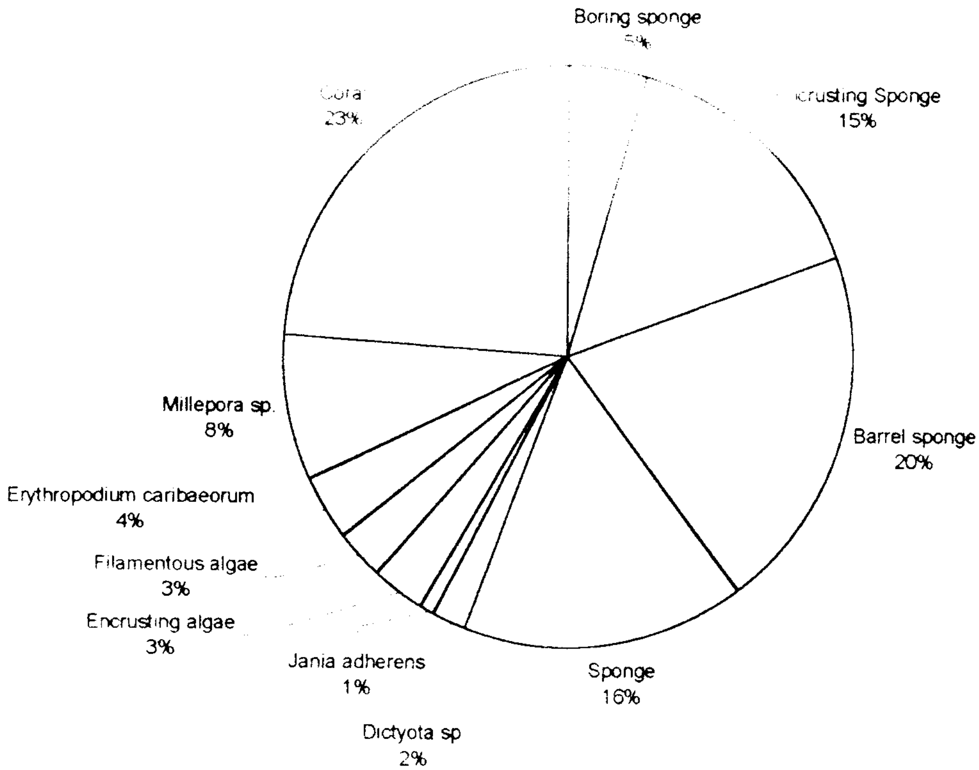


Figure 9

Percent Cover of Organisms vs Substrate: Section A

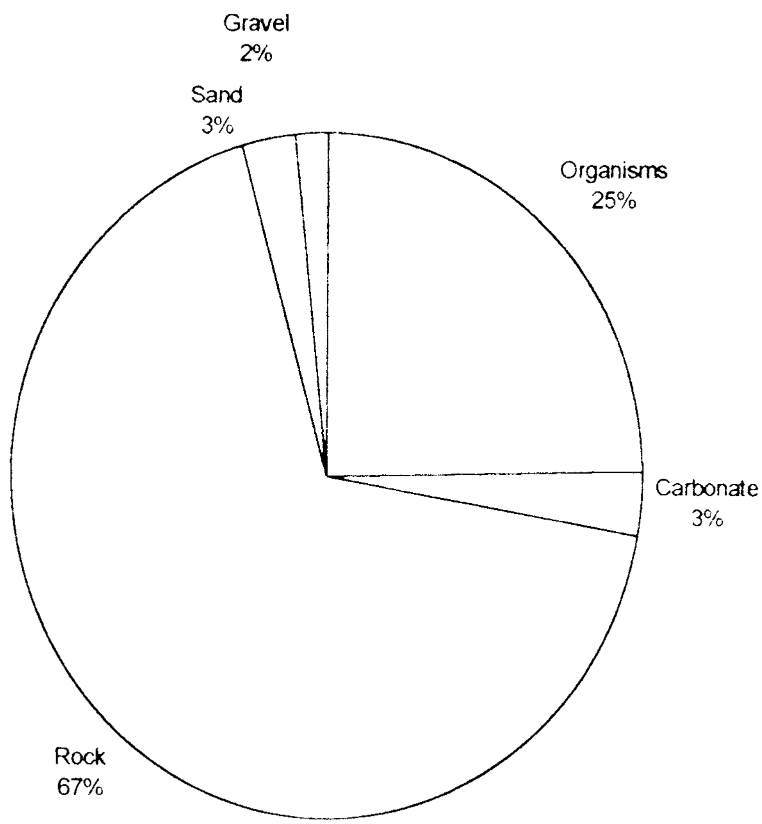


Figure 10:

Percent Cover of Organisms vs. Substrate Section B

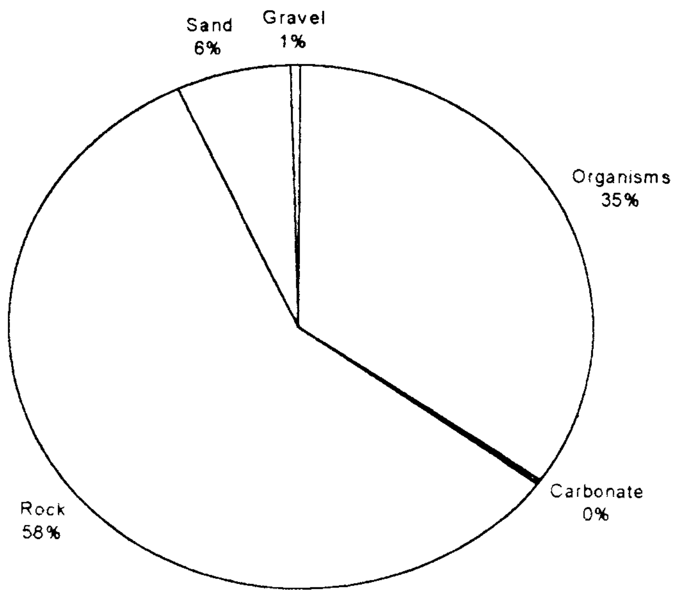


Figure 11

Percent Cover of Organisms vs. Substrate Section C

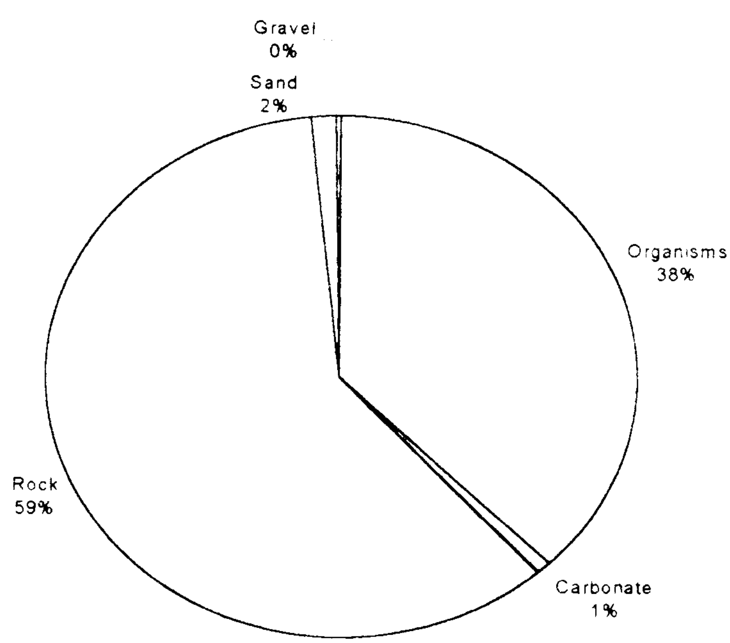
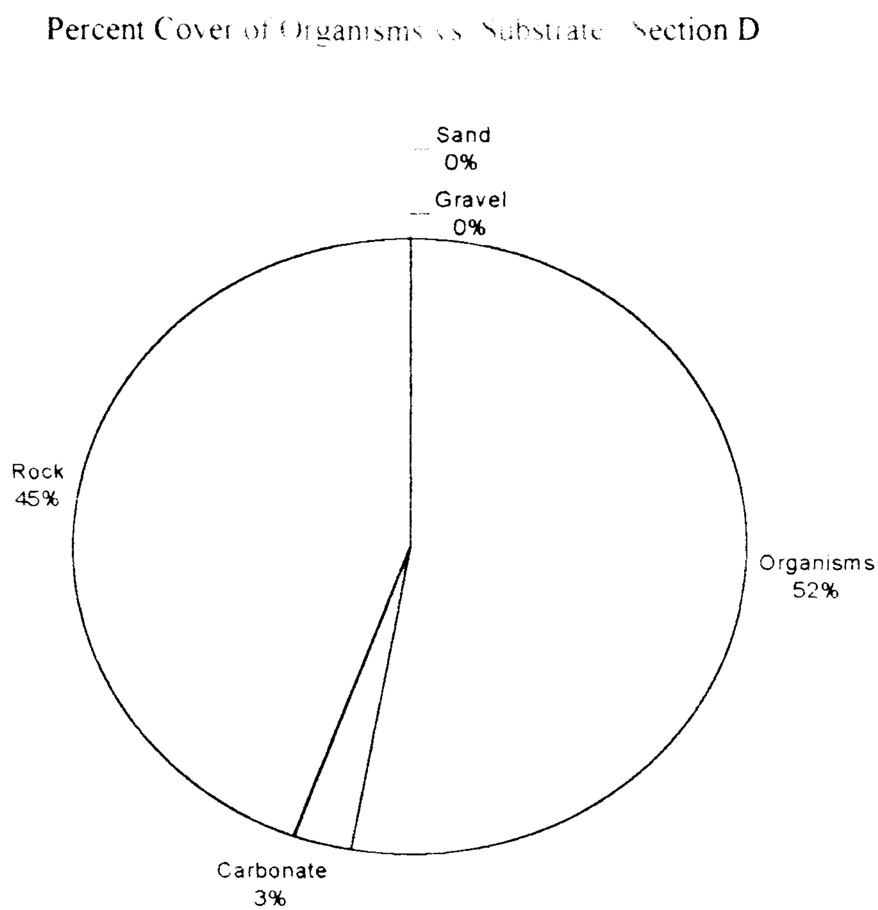
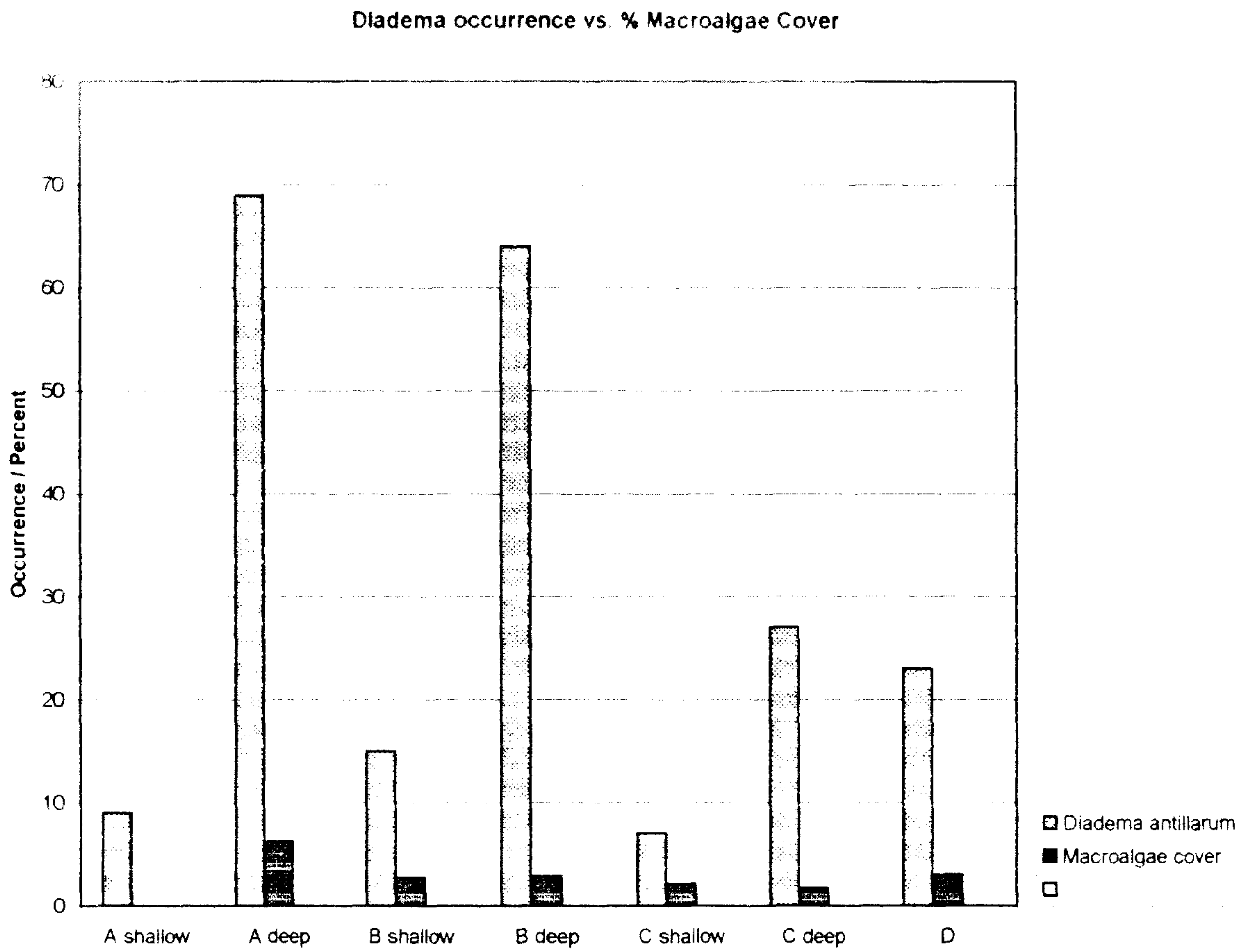


Figure 12:



Percent Cover of Organisms vs Substrate Section D
Sand
0%
Gravel
0%
Rock
45%
Organisms
52%
Carbonate
3%

Figure 13:


Diadema occurrence vs. % Macroalgae Cover
Occurrence / Percent
0
10
20
30
40
50
60
70
80
A shallow
A deep
B shallow
B deep
C shallow
C deep
D
Diadema antillarum
Macroalgae cover