DOMINICA CORAL REEF STATUS 2002: Assessment of the Sea Urchin *Diadema antillarum*, Reef Fishes, and Algal Cover.

ITME Research Reports – Number 12 (1-4)

Student Research Reports
Fall Semester 2002

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Introduction

The sea urchin *Diadema antillarum* is an important herbivore on coral reefs. Its consumption of algae is a significant factor in maintaining the balance between coral and algal growth. In 1983 there was a mass-mortality of *D. antillarum* across the entire Caribbean, leading to 100 percent mortality at some locations. Recovery has been slow, and in some areas the populations remain small. However, in Dominica, it has been found that average size and abundance of *D. antillarum* is higher than elsewhere in the Caribbean.

Study I (pages 1 - 9), Q Smith assessed the test size and abundance of *D. antillarum* in Dominica's waters. Study II (pages 10 - 14), J McKinney assessed the percent cover of macro and turf algae. Study III (pages 15 - 20), L Komoroske surveyed abundance and body size distribution of algal grazing fish and fish predators of *D. antillarum*. Study IV (pages 21 -25), L Pettersen surveyed size class and distribution of fish and invertebrate predators of *D. antillarum*.

These studies were carried out on reefs at 8 locations on the west coast of Dominica (Figure 1).

Location 1: Tabby Bay – 3.2 km south of Portsmouth. This was the northern most location in these studies. This site had very high rugosity and a substrate that consisted of large boulders surrounded by sand flats. Water depth was approximately 1-3 m. One river emptied into the sea near this location.

Location 2: Salisbury West – A deep reef site located 150 m off the shore and 200 m north of the Lauro Club. Water depth was approximately 6-7 m. The substrate consisted of an elevated non-rugose coral assemblage half a meter above the surrounding sand flats.

Location 3: Salisbury East – A site approximately 100 m directly east of Location 2 with a depth of 2 m. The substrate consisted of non-rugose coral assemblages surrounded by sand.

Location 4: Macoucherie – A reef site approximately 100 m northwest of the Macoucherie River with a depth of approximately 4 m. The substrate consisted of extensive convoluted coral assemblages surrounded by sand flats.

Location 5: Tarou Point – Sites located to the north and north west of this small peninsula, about 1 km south of the town of Tarou. Due to roadwork above the point there was a large amount of sediment in the waters around this area, considerably reducing visibility. Depth varied from 1 to 8 m.

Location 6: Canefield – Located off the causeway between the cities of Roseau and Canefield. Substrate consisted of large boulder slabs averaging 30 m in length. Depth varied from 0.3 to 3 m and had high rugosity in the shallow areas. Two rivers drained into the surrounding area. Due to high ship traffic it is likely that this area has the highest level of human impact.

Location 7: Champagne – Located 2 km south of Point Michele, on the southern end of the Champagne pebble beach. This area ranged between 1 and 4 m in depth. The substrate included boulders and high coral assemblages.

Location 8: Scott's Head – The surveyed sites were on a shallow shelf to the north of the peninsula. The sites were located in 1-2 m of water. The substrate consisted of flat rock.

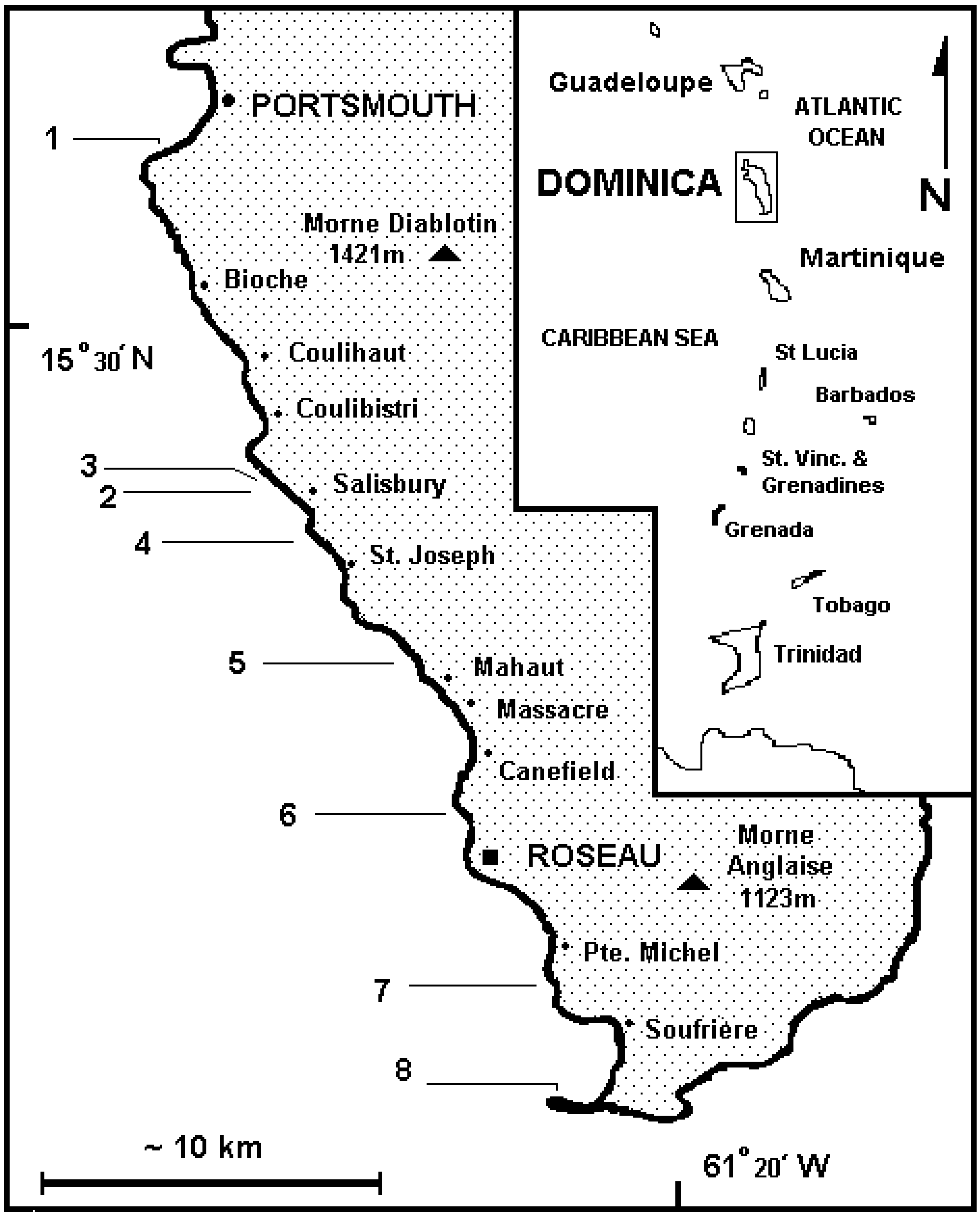

Figure 1: Survey Locations Along the West Coast of Dominica.

25 November 2002 Quinn Smith, Jennifer McKinney, Lisa Komoroske, and Louise Pettersen

Study I: Abundance and Test Size of *Diadema antillarum* Along the West Coast of Dominica (Lesser Antilles) 2002.

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Keywords: *Diadema antillarum*, mass mortality, Dominica

Abstract *Diadema antillarum* is an important grazer on macro algae, and thus an important factor in maintaining coral reefs. In 1983 it suffered the largest mass mortality ever recorded for any marine species, with some sites having up to 100% mortality. However, it has been found that *D. antillarum* in Dominica are more abundant and have a larger test size than elsewhere in the Caribbean. Abundance ranged from 0.42 m^{-2} to 3.48 m^{-2} with a mean of 1.46 m^{-2}, while test size ranged from 1.72 to 9.27 cm with a mean of 5.90 cm. No significant relationship was found between *D. antillarum* test size and algal abundance, or predator abundance. There was also no significant relationship between *D. antillarum* and algae or predators.

Introduction

Diadema antillarum is a tropical sea urchin, which is an important factor in controlling macroalgae populations in coral aggregations (Szmant 2001). In 1983-1984 *D. antillarum* suffered the largest mass mortality event ever recorded for any marine organism. This mortality is believed to have been caused by the Pacific pathogen *Clostridia* (Lessios 1988). The mortality event was first reported off the coast of Panama. Within one year, the pathogen traveled with the ocean currents 2000 km east to Bermuda, and 3000 km west to Tobago, affecting a total benthic area of 3.5 million square kilometers in the Caribbean (Lessios 1988).

Since that time, populations studied in Panama, Jamaica, and Barbados have exhibited very slow recovery (Lessios 1995). However, it has been found that populations of *D. antillarum* in Dominica surpass those reported for Panama, Jamaica, Belize, Grand Cayman, and Cuba in abundance (Williams 2001). Based on mean test size measurements, it has also been found that *D. antillarum* in Dominica are larger than elsewhere in the Caribbean before the mass mortality.

Since 2000, researchers at the Institute for Tropical Marine Ecology (ITME) in Dominica have been studying this phenomenon at permanent monitoring sites along the west coast. The purpose of this ongoing study is to monitor the abundance and test size of populations of *D. antillarum*. This information serves as a reference for monitoring reef health in Dominica.

The objectives of the November 2002 survey were to:

A) determine the abundance of *D. antillarum* on the west coast of Dominica,
B) determine the test size of these individuals,
C) note any trends between this survey and earlier studies, and
D) compare the results of these surveys to surveys conducted on algal, and predator densities.

This data will be compared to the benthic algal cover recorded by McKinney's (2002), to further assess a correlation between *D. antillarum* density and macroalgal abundance in Dominica.

Methods

Surveys were carried out at Tabby Bay, Salisbury East, Salisbury West, Macoucherie, Tarou Point, Canefield, Champagne and Scott's Head Marine Reserve.

At each of these locations, two 50 m^2 belt transects were surveyed. *D. antillarum* individuals were counted if any portion of their test laid within the transect. In order to make the survey replicable only individuals on the surface or on vertical substrate were counted.

One hundred *D. antillarum* were collected at each location. The test sizes were measured *in situ* at each of the 6 locations using calipers. *D. antillarum* were collected between 25 m and 150 m from the transect areas so as not to disrupt the ongoing surveys. Correlations were tested using the statistical analysis program in Microsoft Excel.

Results

Test Size

The mean test size was 5.90 cm (Table 1). Tarou Point had the highest mean test size (6.65 cm, s=1.01) (Table 1); those at Champagne had the smallest mean test size (5.06 cm, s=1.14). The largest test sizes were recorded at Tarou Point (9.27 cm) and Salisbury (8.865 cm) (Figure 1), while the two smallest test sizes were recorded at Salisbury and Champagne (1.72 cm at both) (Figure 1). Tarou Point had the highest amount of large individuals (>7.1 cm). Champagne had the highest amount of small individuals (<5 cm) (Figure 1). None of the test sites had equally distributed size classes (Figure 1).

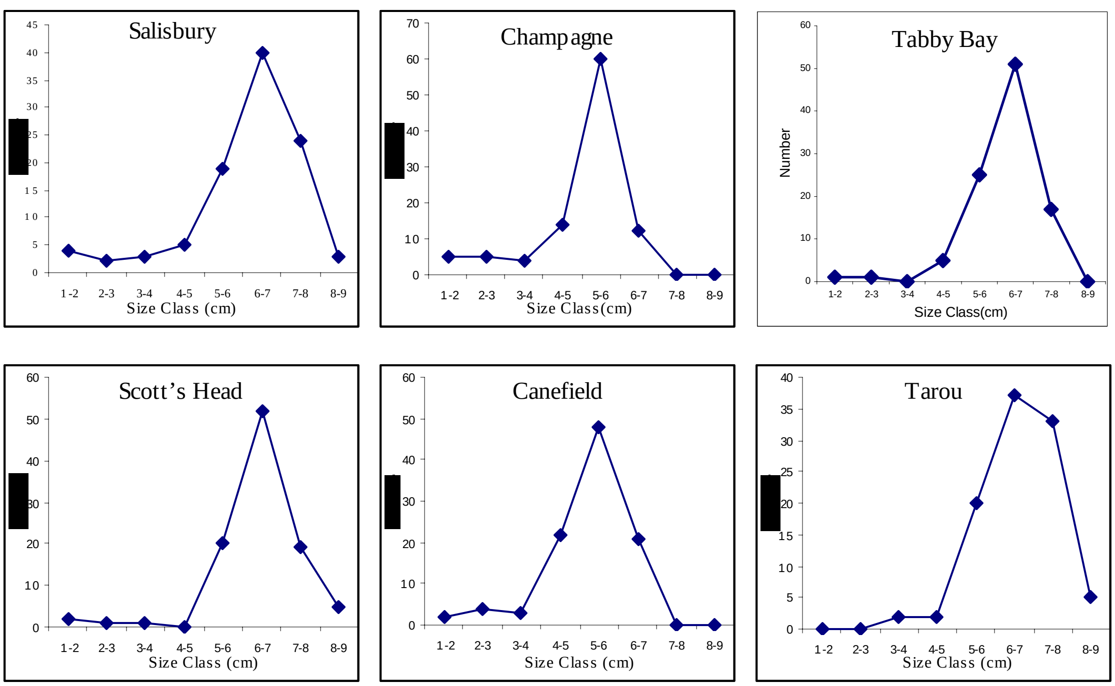

Figure 1: Test Size Distribution at Each Location

Table 1: Test Size Data at Each Location and Total Means

	Minimum test size	Maximum test size	Mean test size	Standard deviation
Salisbury	1.72	8.87	6.17	1.44
Champagne	1.72	6.93	5.06	1.14
Tabby Bay	1.82	7.85	6.28	0.93
Scott's Head	1.83	7.83	5.97	1.01
Canefield	1.83	6.75	5.24	1.04
Tarou	3.08	9.27	6.65	1.01
Total Mean	2.00	7.92	5.90	1.09

Density

One thousand one hundred forty-two *D. antillarum* individuals were counted in the 800 m^2 surveyed. The average density for the study was 1.46 $\cdot$ m^{-2}. Canefield had the highest density of *D. antillarum* individuals (3.48 $\cdot$ m^{-2}) (Table 3). Salisbury had the lowest density (0.42 $\cdot$ m^2) (Table 2).

Table 2: Density for each site surveyed.

Locations	Sites	Surveying Methods	Depth (m)	Abundance of *D. antillarum*	Abundance per m^2	Average Density per m^2 for location
Salisbury East						
	1	Snorkel	2-4	46	0.92	0.95
	2	Snorkel	2-4	49	0.98	
Salisbury West						
	3	SCUBA	9-10	21	0.42	0.50
	4	SCUBA	9-10	29	0.58	
Macoucherie						
	5	SCUBA	5-6	24	0.48	0.75
	6	SCUBA	5-6	24	1.02	
Champagne						
	7	Snorkel	2-4	60	1.2	1.26
	8	Snorkel	2-4	66	1.32	
Scott's Head						
	9	Snorkel	1-2	55	1.10	1.46
	10	Snorkel	1-2	91	1.82	
Tabby Bay	11	Snorkel	2-4	72	1.44	1.47
	12	Snorkel	2-4	78	1.56	
Canefield						
	13	Snorkel	1-4	58	1.16	2.32
	14	Snorkel	1-4	174	3.48	
Tarou Point						
	15	Snorkel	1-4	138	2.76	2.95
	16	SCUBA	2-6	157	3.14	

Discussion

Test Size

There was no significant difference between test measurements taken in 2001 (Williams 2001) and 2002 (this study) (P=0.05, t=0.196736). However, the mean test size found in this study (5.90 cm) was smaller than that reported by Williams (2001) (6.13cm) but is still higher than that reported before (1.73-3.52 cm) and after (4.2 cm) the mass mortality (Lessios 1995). Thus, this data supports Williams (2001) in suggesting that the mass die-off may have never affected Dominica, or that Dominica may have a higher recovery rate, similar to Barbados (Hunte and Younglao 1988). Qualitative observations of a population decline in *D. antillarum* in Dominica during the early 80's (Dominica Fisheries Officer A. Magloire, pers. comm.) supports the possibility of a higher recovery rate.

Size distribution varied greatly between the sites. One of the most extreme examples is Tarou Point, which had no individuals with a test size smaller than 3 cm (Figure 1), compared to Champagne, which had no individuals with test sizes greater than 7 cm (Figure 1). The most probable explanation for this phenomenon is that of spatial competition. It has been found by Levitan (1989) that *D. antillarum* adjust their test size to the amount of food available. The individuals measured at Champagne were all from one large rock surrounded by sand. This high density may have been a limiting factor in controlling test size. At Tarou Point, however, individuals measured came from a much larger area where intraspecific competition for food may not have played such an important role in controlling test size.

Table 3: Mean Test Size vs. Fish Predator Density

	Mean Test Size	Number of Predators per m^2
Salisbury East	6.17	0.12
Champagne	5.06	0.09
Scott's Head	5.97	0.05
Tabby Bay	6.28	0.10
Canefield	5.24	0.07
Tarou Point	6.65	0.11

Evenness of size distribution also varied greatly. The most notable examples are from Tabby Bay and Tarou Point. Both of these locations had few small (<4cm) individuals (Figure 1). Pettersen (2002) found that these two locations had high density of fish known to prey on *D. antillarum* (Table 3). Though there is no significant relationship between these two factors (P=0.05, F=4.03), the possibility remains that smaller individuals are more preyed upon than larger individuals.

Density

The mean density found ($1.46 \cdot m^{-2}$) in this study is higher than the densities recorded by Williams (2001) ($1.35 \cdot m^{-2}$). This is most likely because this study included Tarou Point, which had the highest densities of the study, and Williams' (2001) study did not.

There are many possible causes of the variation in densities seen between the sampled sites. One major factor is the rugosity of the substrate. *D. antillarum* tend to be located in very rugged areas; they are most often in nooks and holes as opposed to on flat substrate (pers. obs.). The survey sites at Tarou Point have many drop offs and heavily pitted areas, in which *D. antillarum* can avoid predators. In contrast, Salisbury West is characterized by a less rugose topography, providing less protection for *D. antillarum*.

The difference in densities may also be related to algal cover. Areas with higher *D. antillarum* densities would be likely to have lower algal cover due to heavier grazing pressure. When the abundance data from this study was compared to McKinney's (2002) data on turf algae cover, no significant correlation was found (S_r=-0.67). It was, however, found that when the three locations with the lowest *D. antillarum* abundances were excluded, there was a negative correlation of –0.99 between *D. antillarum* and algal cover (Figure 2). Thus, it is likely that *D. antillarum* contribute to low algal cover.

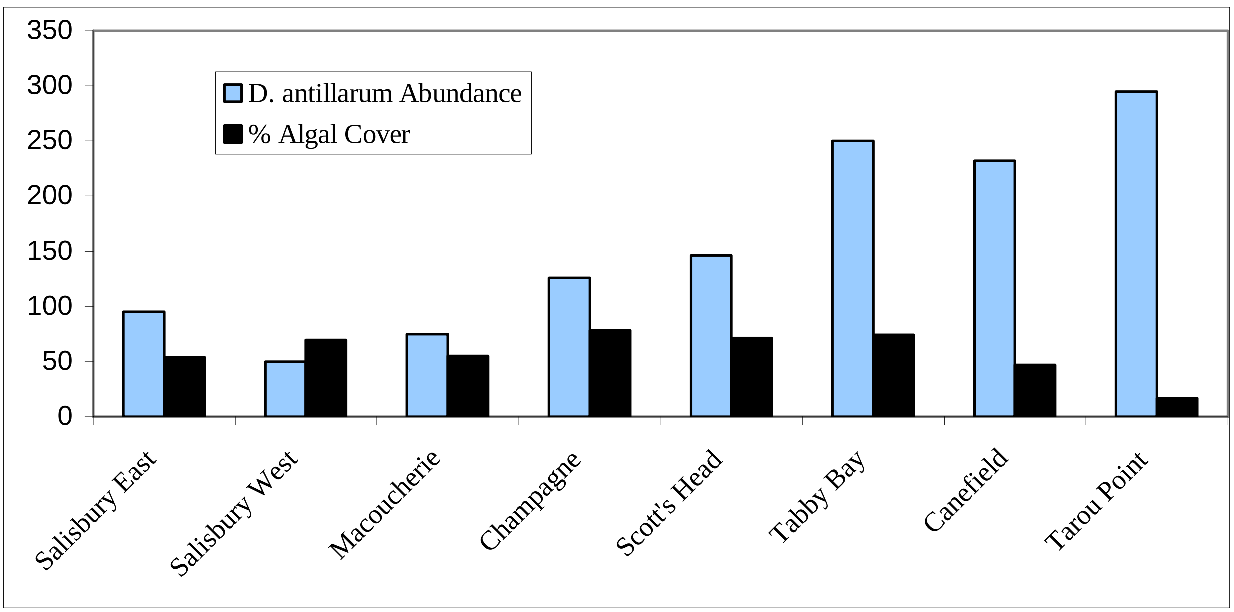

Figure 2: *D. antillarum* abundance vs. % algal cover

A third explanation for the differences in abundances may be the abundance of *D. antillarum* predators (Figure 3). The data collected by Pettersen (2002) showed no significant relationship between fish predator density and *D. antillarum* density (S_r= -0.30). However, due to the small sample sizes in these studies it cannot be assumed that predatory fishes do not have an important role in controlling *D. antillarum* populations.

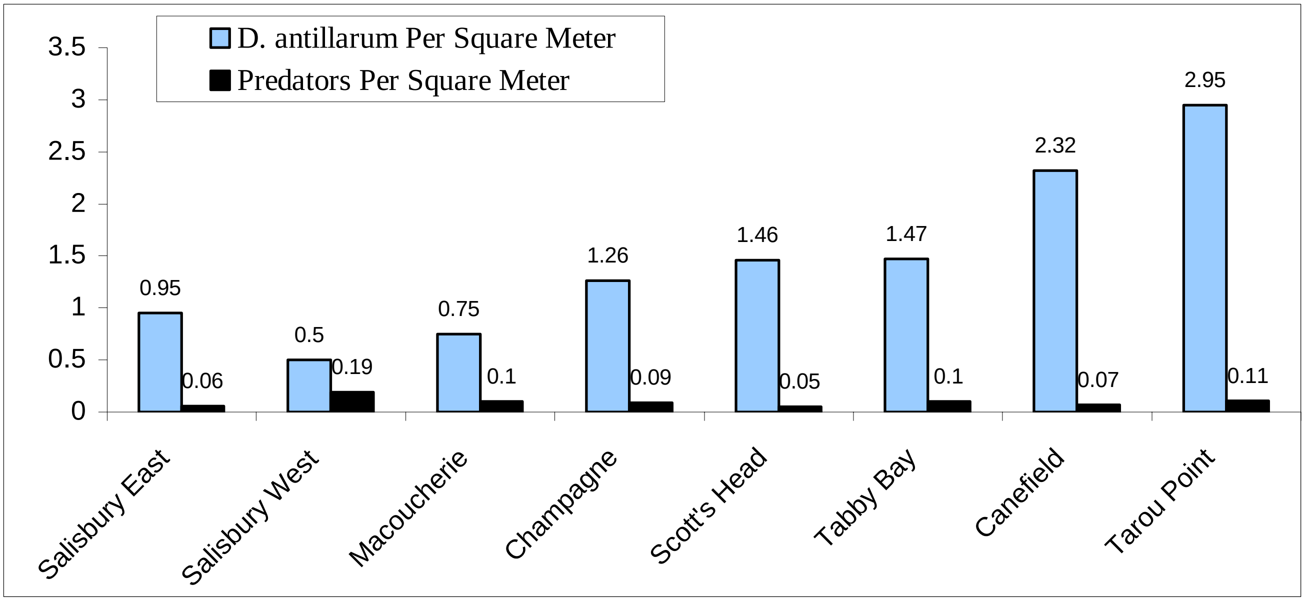

Figure 3: *D. antillarum* Density vs. Fish Predator Density

Due to the health (large test size and high density) of *D. antillarum* in Dominica, and the length *D. antillarum's* pelagic larval stage (4-6 weeks) (Hunte and Younglao 1988), it is possible that *D. antillarum* in Dominica may act to replenish downstream islands. If this is true, Dominica's population of *D. antillarum* would be an important part in controlling reef health in the Caribbean.

In conclusion, the steep rugged substrate on the Dominican shelf is a good habitat for *D. antillarum*, which has a higher abundance than elsewhere in the Caribbean. *D. antillarum* are important in controlling reef algae, and therefore coral abundance (Edmunds and Carpenter 2001). It is possible that the larvae from *D. antillarum* populations in Dominica replenish downstream islands. This makes Dominica's *D. antillarum* populations an important resource for both the tourism and fishing industries in the Caribbean.

References

Carpenter RC (1990) Mass mortality of *Diadema antillarum*. Marine Biology 104:67-77

Edmunds P, Carpenter R (2001) Recovery of *Diadema antillarum* reduces macroalgal cover and increases abundance of juvenile corals on a Caribbean reef. PNAS 98:5067-5071

Forcucci D (1994) Population density, recruitment and 1991 mortality event of *Diadema antillarum* in the Florida Keys. Bull. Mar. Sci. 54(3):917-928

Huges T, Reed D, Boyle MJ (1987) Herbivory in coral reefs: community structure following mass mortalities of sea urchins. J. Exp. Mar. Biol. Ecol. 113:39-59

Humann P, Deloach N (2002) Reef Creature Identification. New World Publications Inc, Jacksonville, Florida. pp 372

Hunte W, Younglao D (1988) Recruitment and population recovery of *Diadema antillarum* (Echinodermata; Echinoidea) in Barbados. Marine Ecology 45:109-119

Lessios HA (1995) *Diadema antillarum* 10 years after mass mortality: still rare, despite help from a competitor. Proc. R. Soc Lond. B 259:331-336

Lessios HA (1988) Mass mortality of *Diadema antillarum* in the Caribbean: what have we learned? Ann. Rev. Ecol. Syst. 19:371-393

Levitan D (1989) Density-dependant size regulation in *Diadema antillarum*: effects on fecundity and survivorship. Ecology 70(5):1414-1424

Pettersen L (2002) Study IV: Fish and Invertebrate Predators of *Diadema antillarum* in Dominic. ITME Research Reports 12:21-25

Sammarco P (1980) *Diadema* and its relationship to coral spat mortality: grazing, competition, and biological disturbance. J. exp. Biol. Ecol. 45:245-272

Szmant AM (2001) Introduction to the special issue of Coral Reefs on "Coral Reef Algal Community Dynamics". Coral Reefs 19:299-302

Williams Stacey (2001) Abundance and Size Distribution of *Diadema antillarum* Along the West Coast of Dominica, West Indies. ITME Research Reports 9:3-9

Study II: Algal Cover versus *Diadema antillarum* Abundance Along the West Coast of Dominica, West Indies.

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Keywords Algae, *Diadema antillarum*, Dominica

Abstract As a result of the 1983/84 mass-mortality event on *Diadema antillarum* throughout the Caribbean, algal cover has increased dramatically resulting in changes in the benthic composition. This study determined the percent algal cover at eight sites along the west coast of Dominica, encompassing a total of 400 m^2. Turf algal cover ranged from 16.86% to 69.64%. Macroalgae cover ranged from 0.06% to 21.08%. Environmental conditions such as depth, rugosity, and turbulence have been noted to influence algal cover. Convoluted areas typically have more algae because the wave impact is dissipated and there are more crevices in which *D. antillarum* cannot reach. High algal cover in turbulent areas may be due to a low abundance of grazers. Nutrient input from rivers and depth are also important factors in algal growth. Areas with a high abundance of *D. antillarum* had lower percent algal cover.

Introduction

In the early 1980s, a mass-mortality event severely decreased populations of the sea urchin *Diadema antillarum* throughout the Caribbean (Lessios 1995), and in many regions recovery of this organism has remained low (Lessios 1995, Williams and Polunin 2001). *D. antillarum* is largely responsible for controlling algal densities. After the die-off, algal growth dramatically increased all over the Caribbean, doubling in some regions (Liddell and Ohlhorst 1986). The overgrowth of corals by algae can and has been detrimental to reef health; in Jamaica after the die-off, reef composition changed from one that was mostly coral to one dominated by algae (Boyle *et al*. 1987, Carpenter 1990). Studies found that even an increase in grazing fish populations was not enough to control the growth of algae (Carpenter 1990). In Dominica, *D. antillarum* densities are higher than those of other Caribbean islands (Williams 2001). It is uncertain whether the pathogen that caused the mass-mortality on *D. antillarum* ever affected Dominica, or whether the recovery rate was faster than that of other regions. This study aimed to determine the percent algal cover (turf versus macroalgae) on a total of 400 m^2 at eight monitoring sites along the west coast of Dominica. The algal abundance was then compared with current *D. antillarum* densities in Dominica (Smith 2002) to determine the effect this herbivore has on the reefs surveyed. It was expected that a high abundance of *D. antillarum* would result in lower algal cover than areas of low abundance.

Methods

Percent algal cover was determined at eight sites surveyed: Tabby Bay, Salisbury West, Salisbury East, Macoucherie, Tarou Point, Canefield, Champagne and Scott's Head Marine Reserve. At each site, 25 m belt transects were placed parallel to shore. A 1 m^2 quadrat was placed on alternating sides of the transect covering a total of 25 m^2. Percent cover of macroalgae and turf algae was recorded. A 'Turf' alga is defined as short, thin, filamentous algae, which was 1 mm to 1 cm in height (Steneck and Dethier 1994). Species of turf algae could not be identified. Macroalgae are larger and bushy, with a height of 1-5 cm (Steneck and Dethier 1994). Species commonly seen include, but are not limited to, *Dictyota sp.* and *Galaxaura sp.*

Results

Total algal cover ranged from 78.18% at Champagne to 16.92% at Tarou Point. (Figure 1) Macroalgae cover ranged from 21.08% at Tabby Bay to 0.06% at Tarou Point. (Figure 1) Turf algae cover was highest at Champagne (69.64%) and lowest at Tarou (16.86%) (Figure 1). High algal cover (>70%) was found in areas characterized by (a) convoluted topography (Tabby Bay and Champagne, Table 1) and (b) flat, turbulent sites (Scott's Head, Table 1). Algal cover ranging from 69.64% to 47.04% was found in areas characterized by (a) approximate depth of 5m (Salisbury West and Macoucherie, Table 1) and (b) sites shallower than 5m (Salisbury East and Canefield, Table 1). The lowest algal cover (16.92%) was at Tarou Point, which is characterized by depths ranging from 1 to 5m.

Table 1: Algal Percent Cover (Macro and Turf), Site descriptions

Site	Total (%)	Depth (m)	Benthic Substrate
Tabby Bay	74.16	1-2	Convoluted
Salisbury West	69.64	9-10	Flat
Salisbury East	55.16	1-2	Flat
Macoucherie	54.02	5-6	Flat
Tarou Point	16.92	1-6	Convoluted
Canefield	47.04	1-2	Flat
Champagne	78.18	1-3	Convoluted
Scott's Head	71.46	1-2	Flat

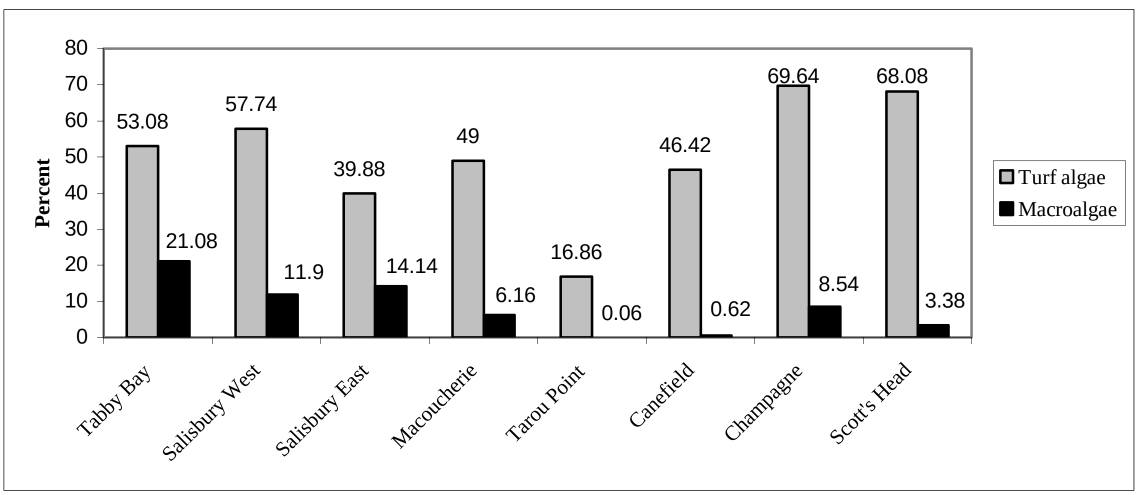

Figure 1: Percent Cover Turf and Macroalgae

Discussion

Environmental factors can strongly influence the presence or absence of certain species in an area. Algae seen on Dominica's reefs are no exception. Tabby Bay and Champagne, which have the highest algal cover, were convoluted (Table 1), which may explain the algal cover because these areas contained more crevices in which *D. antillarum* cannot reach to graze while they are grazing. Also, the water movement in convoluted areas is dissipated so the wave impact, which could easily tear algae from the substrate, is decreased. Tabby Bay is also influence by a river input of fresh water that brings with it nutrients that feed the algae. Likewise, sulphur vents at Champagne may contribute to the growth of algae or may deter herbivores. Scott's Head, which also has high algal cover, is found on flat substrate (Table 1) but is subject to very turbulent conditions brought in by the Atlantic Ocean. These conditions may be too rough for herbivores; therefore the grazing pressure at this site may be low. Salisbury West and Macoucherie are found in deeper waters (Table 1); lower levels of sunlight at theses sites may not be enough for algae, which depends on sunlight for photosynthesis. Salisbury East and Canefield, in comparison to Salisbury West and Macoucherie, are found in shallower waters (Table 1). Theoretically, this would allow for more algal cover because of more sunlight reaching the substrate, but here the abundance of *D. antillarum* (Smith 2002) applies more grazing pressure. Tarou Point is affected by the input of a river and is very convoluted (Table 1). These conditions seen at other sites have supported lots of algal growth, but here the algal cover is the lowest, most likely because the abundance of *D. antillarum* is the highest of the surveyed sites (Smith 2002).

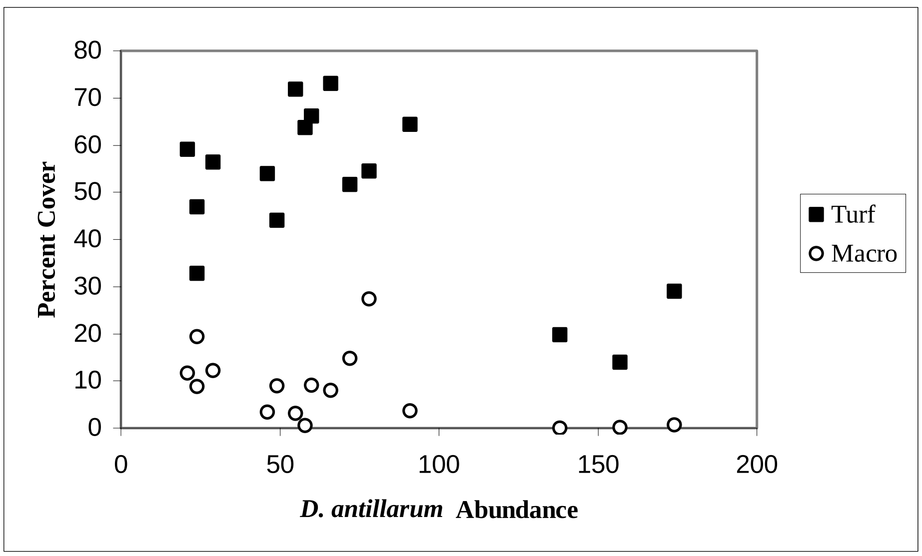

Figure 2: Algal Cover versus *D. antillarum* abundance. Percent cover of macroalgae and turf algae percent cover. *D. antillarum* abundance based on Smith's (2002) data collected at the same sites.

Another important factor in algal composition on reefs is the presence of herbivores. This study focuses solely on the influence of the long spine sea urchin, *Diadema antillarum* at each site (Smith 2002). *D. antillarum* is an important grazer on the reefs, keeping macro and turf algae cropped short (Carpenter 1990). In areas where *D. antillarum* abundance was high (Smith 2002) the macroalgal cover was low and the turf algal cover is high (Figure 2). In areas where *D. antillarum* densities are low there is a higher amount of macroalgae (Figure 2). *D. antillarum* was seen in the greatest abundance at Tarou Point and Canefield (Figure 4), which have the lowest cover of both turf and macroalgae (Figure 3). In this study macroalgae are mostly seen in areas which *D. antillarum* could not access, such as the base of corals and sponges, and in cracks. If *D. antillarum* were not present it would be possible for macroalgae to dominate where turf algae are currently prominent. An example of this is at Tabby Bay where approximately 5 meters along the transect line was entirely covered with large bushy macroalgae. There were no urchins, corals or other sessile benthic organisms present. The rest of the transect resembled most areas surveyed, which are covered in turf algae and inhabited by many *D. antillarum*.

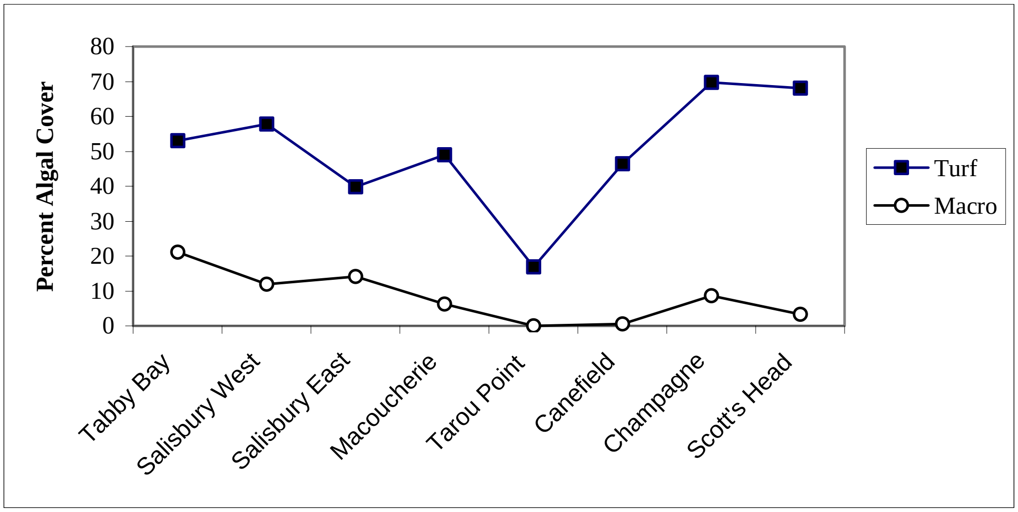

Figure 3: Percent Cover of Turf and Macroalgae.

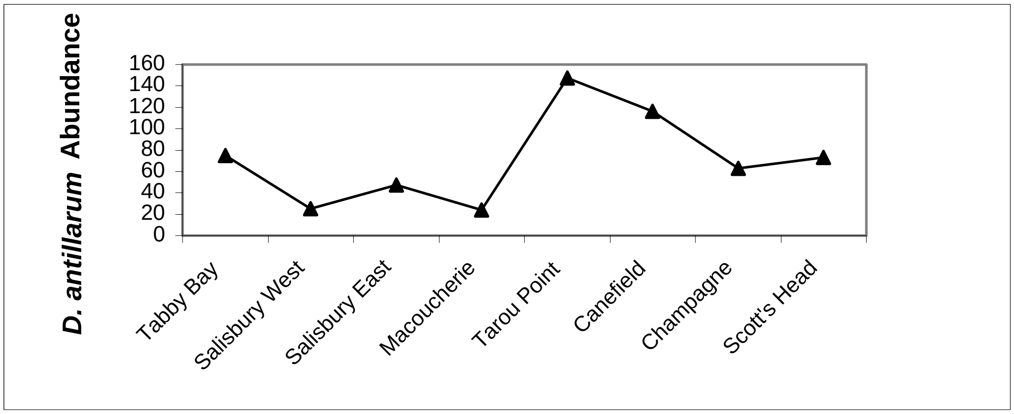

Figure 4: *Diadema antillarum* Abundance. *D. antillarum* abundance based on Smith's (2002), data collected at the same sites.

Algae are an important primary producer, which feeds and houses many reef organisms. However, in great abundance it can be detrimental to corals as has occurred throughout the Caribbean after the mass-mortality of *D. antillarum* (Liddell and Ohlhorst 1986). One study in Jamaica gives hope to those regions of the Caribbean, whose reefs are still suffering from overgrown macroalgae. The study showed that an increase in *D. antillarum* resulted in a decrease of macroalgae and an increase in coral recruits (Edmunds and Carpenter 2001). This shows that the effects of the mass-mortality are reversible and that reef herbivores may be able to restore conditions to that which they were before the mass-mortality. A similar recovery may be responsible for the low algal cover seen on Dominica's reefs.

References

Boyle M, Hughes TP and Reed DC (1987) Herbivory on coral reefs: community structure following mass mortalities of sea urchins. J. Exp. Mar. Biol. Ecol. 113:39-59

Carpenter RC (1990) Mass Mortality of *Diadema antillarum* I. Long-term effects on sea urchin population-dynamics and coral reef algal communities. Marine Biology 104:67-77

Carpenter RC (1990) Mass Mortality of *Diadema antillarum* II. Effects on Population Densities and Grazing Intensities of Parrotfishes & Surgeonfishes. Marine Biology 104:79-86

Edmunds P, Carpenter RC (2001) Recovery of *Diadema antillarum* reduces macroalgae cover and increases abundance of juvenile corals on a Caribbean reef. PNAS 98.9:5067-5071

Hughes TP , Keller BD, Jackson JBC and Boyle MJ (1985) Mass mortality of the echinoid *Diadema Antillarum* Philippi in Jamaica. Bulletin of Marine Science 36(2):377-384

Lessios HA (1995) *Diadema antillarum* 10 years after mass mortality: still rare, despite help from a competitor. Proc. R. Soc. Lond. B 259: 331-336

Liddell WD, Ohlhorst SL (1986) Changes in benthic community composition following the mass mortality of *Diadema* at Jamaica. J. Exp. Mar. Biol. Ecol. 95:271-278

Smith Q (2002) Study I: Abundance and Test Size of *Diadema antillarum* along the West Coast of Dominica (Lesser Antilles). ITME Student Research Reports 12:3-9

Steneck RS, Dethier MN (1994) A functional group approach to the structure of algal-dominated communities. OIKOS 69:476-498

Willette DAS (2001) Algal cover versus grazing fish abundance of shallow and mid-depth coral reefs of Dominica. ITME Student Research Reports 9:19-25

Williams ID, Polunin NVC (2001) Large-scale associations between macroalgal cover and grazer biomass on mid-depth reefs in the Caribbean. Coral Reefs 19:358-366

Williams SM (2001) Abundance and size distribution of *Diadema antillarum* along the west coast of Dominica, West Indies. ITME Research Reports 9:3-9

Study III: Predatory and Grazing Fish Associated with *Diadema antillarum* in Western Dominican Coral Reefs

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Keywords *Diadema antillarum*, predatory reef fish, grazing reef fish, Dominica.

Abstract Using random transect sampling, this study was conducted at eight reef sites on the western coast of Dominica. Overall, Sharpnose Puffers and French Grunts were found to be the most abundant predators of *D. antillarum*, however no significant correlation between predator and *D. antillarum* abundances was found. Labridae and Pomacentridae were collectively found to be the most frequent grazing fish families, however the majority of individuals in both families were juveniles. Grazing fish density was not significantly correlated with *D. antillarum* density nor algal percent cover. Further and more in depth studies are recommended to determine the true predatory and competitive relationships between predatory and grazing fish and *Diadema antillarum* in western Dominican coral reefs.

Introduction

Species of fish from over eight different families have been found to prey on *D. antillarum* according to digestive tract analysis studies done in the West Indies. Species include some triggerfishes, jacks, porcupinefishes, wrasses, trunkfishes, grunts, porgies, and puffers. While only Puddingwifes and Spanish Hogfish are documented predators of *D. antillarum*, other wrasses that are opportunistic feeders have also been known to feed upon urchin remains (Randall 1964). The greatest predators however are the grunts, which feed specifically at night when *D. antillarum* often move out into the open reef (Randall 1964). While only half of the species found to be *D. antillarum* predators are commonly seen on Dominican reefs, three species of grunts have been found to be abundant and many species of wrasses, including Puddingwifes and Spanish Hogfish, have been listed as common in studies of western Dominican reefs (Mohan 2001). This first component of the study was conducted to record the abundance and species diversity as well as body size distribution of the reef fish predators of *D. antillarum*. The main objective in collecting this data was to determine any relationships between predatory reef fish populations and *D. antillarum*.

Herbivorous fish families can be direct competitors for food and nutrient resources with *D. antillarum*, since this echinoderm is known to feed on sea grasses, silt, algae, and detritus (Randall 1964). A disruption in abundance of either group can cause rapid population growth in the alternate group. Studies in Panama have found that populations of some species of Acanthuridae increased by 160% after the mass mortality of *D. antillarum* in 1983 (Robertson 1991). Studies in the Virgin Islands also support the hypothesis that the sea urchin and members of the Scaridae and Acanthuridae compete for benthic algal food resources. However, populations of herbivorous fishes do not always expand to fill the niche of *D. antillarum*, resulting in explosions in benthic cover and biomass of algal mats (Carpenter 1990). After populations of grazing fish were already drastically reduced due to overfishing in Jamaica, a mass mortality of *D. antillarum* in 1983 was followed by an algal population increase up to 95%

cover (Hughes 1987). In Dominica, grazing fish populations of Acanthuridae, Pomacentridae, Scaridae, and Labridae are all common to very abundant (Mohan 2001). The second component of this study was conducted to record the abundance and body size class distribution of families of these grazing fishes in order to determine any correlations between grazing fish populations and both *D. antillarum* density and percent reef algal cover.

Methods

This study was conducted at eight reef sites: Tabby Bay, Salisbury East, Macoucherie, Canefield, Champagne, Scott's Head, Salisbury West and Tarou Point. Sites are specifically described in the introduction of the ITME Reef Status (2002). At each site three twenty-five meter transects were randomly placed on the reef. Using either snorkeling or SCUBA equipment, depending upon depth, data were collected by swimming over the transect line. All fishes listed in Table 1 that were observed within one meter on either side of the transect line (from the bottom to the surface of the water column) were recorded. Depth measurements were taken, however average volume surveyed was $150m^3$ (approximately 3 m up from the reef or sea floor) because all fishes surveyed showed demersal behavior. Both abundance and body length were recorded in 5 cm increments. Predatory fish of *D. antillarum* were recorded according to species and the algal grazers were classified by family (Table 1).

Table 1: Species and Families surveyed

Species of Predatory fishes of *Diadema antillarum* (Common names)	**Families of Algae Grazing Reef Fishes**
Spanish Hogfish	*Labridae (Wrasses)*
Puddingwife	*Scaridae (Parrotfishes)*
Smooth Trunkfish	*Acanthuridae (Surgeonfishes)*
Caesar Grunt	*Pomacentridae (Damselfishes)*
French Grunt	
Sharpnose Puffer	
Balloonfish	

Results

The overall abundance and frequency of predatory fishes of *D. antillarum* were found to be low (mean density = $0.13{\cdot}m^{-2}$). Sharpnose Puffers were overall the most abundant predatory fish with a mean density of $0.06{\cdot}m^{-2}$ (Figure 1) and were mainly found in small size classes (Figure 2). Although there was no relationship between their abundance and depth, they were absent from the transects in Tabby Bay and Scott's Head, which were both in very turbulent shallow waters. French Grunts were also commonly observed and had a higher mean body size (Figure 3). They were most commonly observed in areas of varying depth where there were reef splits or overhangs, underneath which they can swim. Predatory fish density was greatest at Macoucherie ($0.207{\cdot}m^{-2}$) (Figure 4).

Grazing fishes were abundant on all reefs, however family composition did vary (Figure 6). The two families that consume the most algae, Scaridae and Acanthuridae (Carpenter 1990), had low frequencies in comparison to Pomacentridae and Labridae. The majority of Pomacentridae (57%) and Labridae (80%) observed were < 5cm (Figure 7, 8). Scaridae and Acanthuridae abundances were less common in the shallow, turbulent waters of Scott's Head and Tabby Bay. However, overall grazer density was greatest at Champagne ($4.19{\cdot}m^{-2}$) and Canefield ($4.06{\cdot}m^{-2}$) (Figure 5) even though both these areas included transects in shallow water with strong wave action.

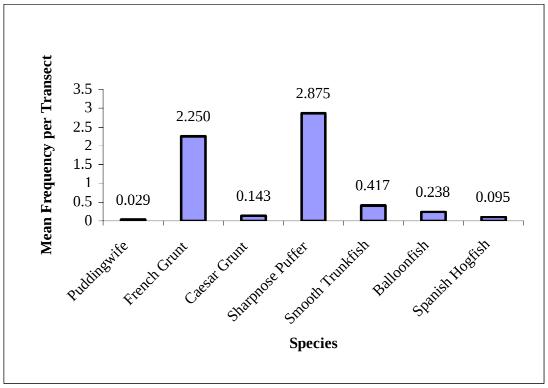

Figure 1: Frequency of Predatory Fishes.

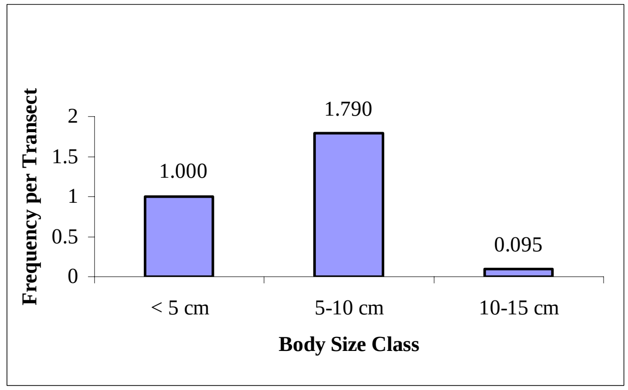

Figure 2: Size Class Frequency of Sharpnose Puffer.

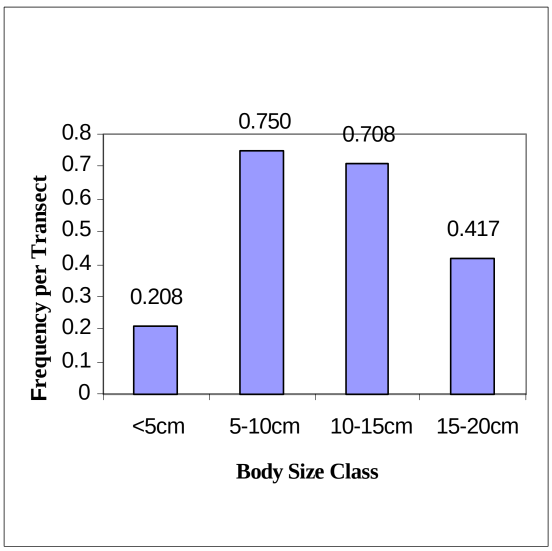

Figure 3: Size Class Frequency of French Grunts.

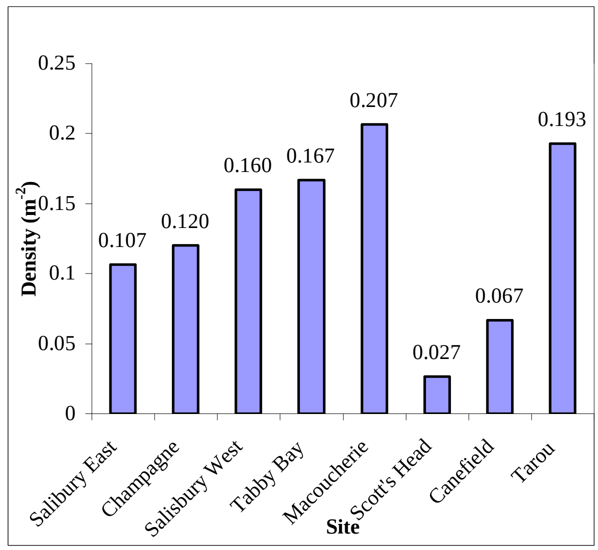

Figure 4: Predatory Fish Density at eight surveyed sites.

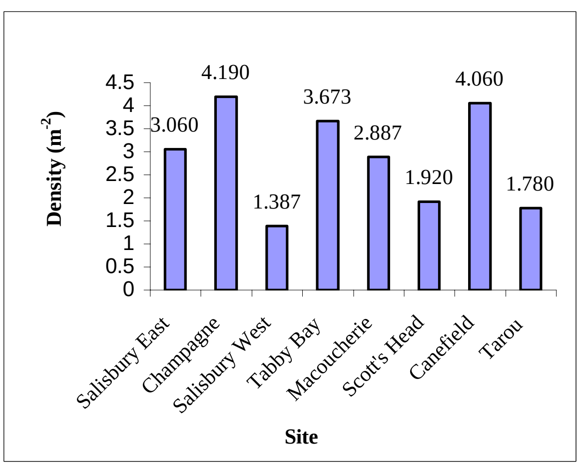

Figure 5: Grazing Fish Density at eight surveyed sites.

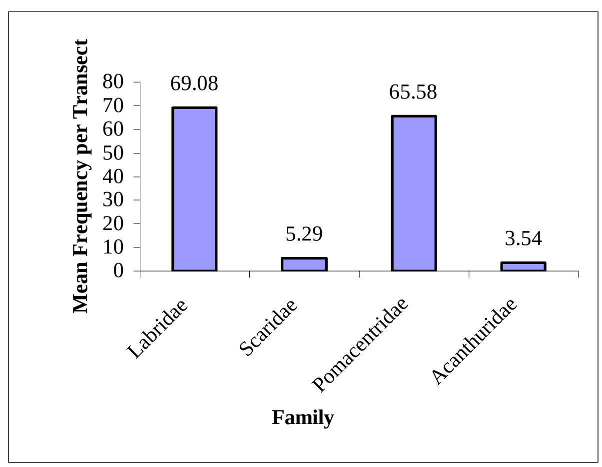

Figure 6: Overall Frequency of Grazing Fish Families.

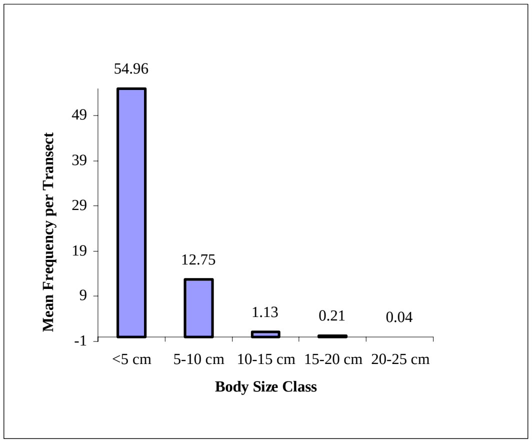

Figure 7: Size Class Frequency of Labridae.

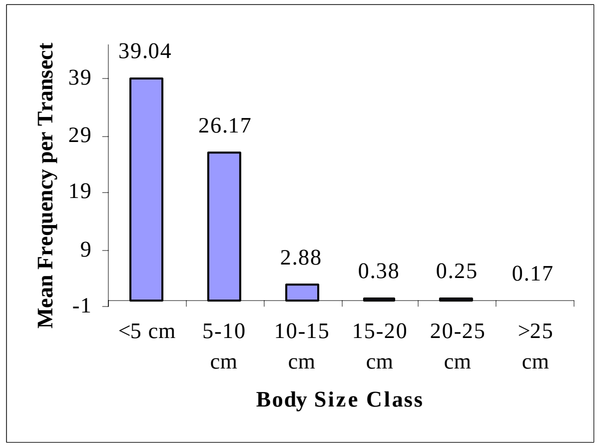

Figure 8: Size Class Frequency of Pomacentridae.

Discussion

The abundance and frequency of both predatory and grazing fishes have important impacts on coral reef community structure. The low frequency of predatory fishes at the surveyed sites may contribute to the high abundance of *D. antillarum* found in Dominica. While the negative relationship found between the two in this survey was not significant (s_r = -0.12), the two sites with the highest predator densities also had the lowest *D. antillarum* densities (Figure 9).

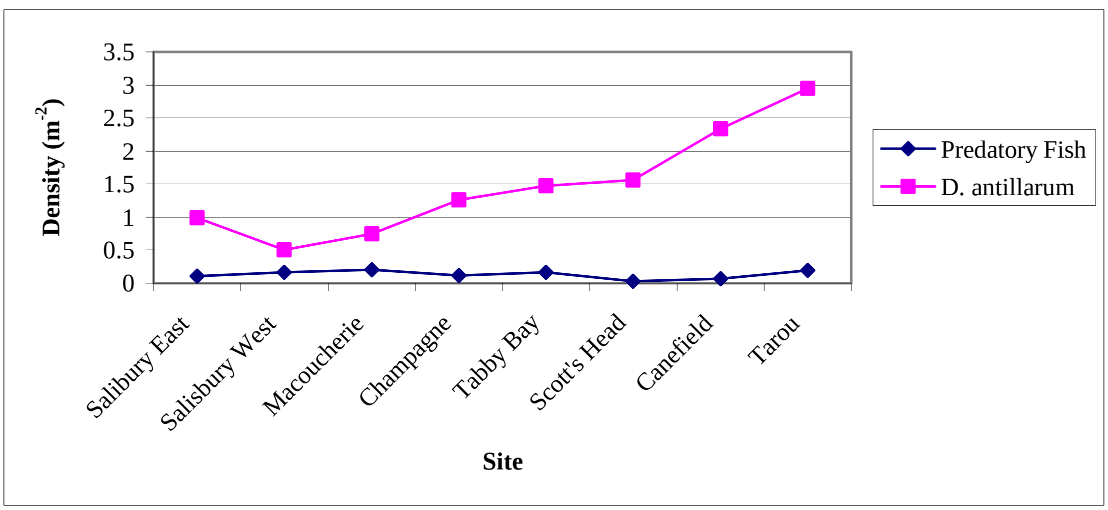

Figure 9: *D. antillarum* and Predatory Fish Density (s_r = - 0.12).

This weak relationship may be associated with the body size classes of the most abundant predator, the Sharpnose Puffer (Figure 2). Although the abundance of this species was much higher than any other predatory fishes, they may have less of an impact on *D. antillarum* since smaller fish generally consume less than larger predators. However, the low number of predatory fishes observed in this survey also may not be a completely accurate depiction of species frequency due to fish behavior. Many of the listed predators are schooling fish or spend most of their time in areas adjacent to reefs, which often makes their abundance underrepresented in the transect areas. Other known predatory fishes such as Black Durgon, Caesar and Bluestriped

Grunts, Queen Triggerfish, Porcupinefish, Plumas, and Bandtail Puffers were observed at different sites during data collection but were not found in any of the transects, suggesting that either their populations were very low or that the sample size of this study was too small. Survey methods also limited data collection, specifically in Scott's Head. While it was observed that the highest abundance and diversity of reef fishes were in deeper waters, the constrictions of snorkeling limited data collection to the turbulent and shallow reef flat, therefore possibly misrepresenting the true fish community composition.

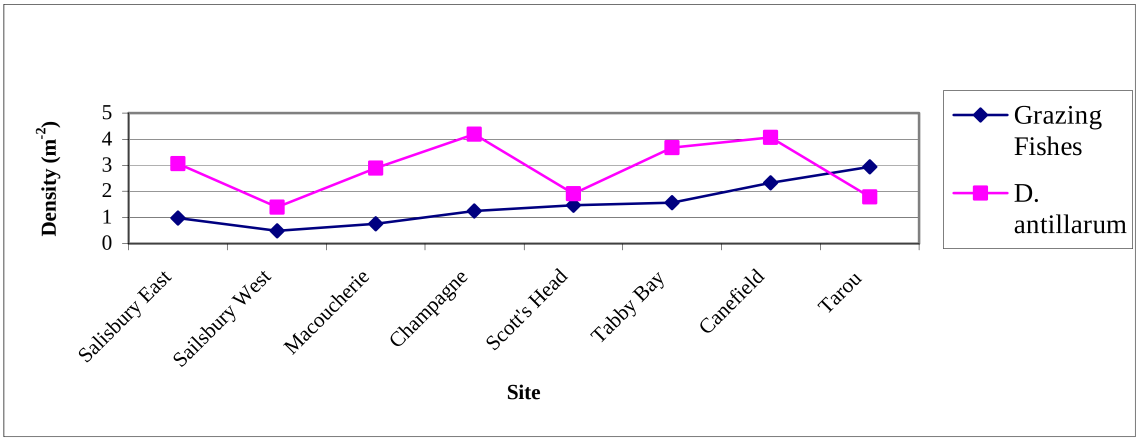

Figure 10: *D. antillarum* and Grazing Fish Density (s_r = 0.09).

While the correlation between *D. antillarum* and grazing fish densities was less than the critical value, generally sites with larger abundances of *D. antillarum* also had higher abundances of grazing fishes (Figure 10) (Smith 2002).

Grazing fishes overall density tended to be higher in shallow areas, however there was no relationship determined between turf algal cover and grazing fish abundance (s_r= 0.23) according to data from McKinney 2002. This could be due to the high percentages of opportunistic Pomacentridae and Labridae. These omnivorous fishes exert a lower grazing pressure than Scaridae and Acanthuridae that solely feed on algae (Hughes 1987). Also, since reef fish most often breed in the warmest months (June, July, and August) (quoted in Mohan 2001), the large percentage of small body sized juveniles found during this fall survey may only be seasonal, and may change during the following months. This could increase both grazing pressure on turf algae and competition between *D. antillarum* and grazing fishes. Further monitoring of body size distribution and algal cover should continue throughout the year, especially since relationships may be easier to identify in the tropics where light and nutrient levels tend to remain constant.

Limitations encountered in this study due to various factors can be mitigated in future studies by increasing sample size and combining different types of sampling methods. A more in depth study combining the methods of random transect sampling and roving swim surveys as was done by Schmitt (2002) is recommended for further analysis of both predatory and grazing fish abundance and body size class composition in western Dominican reefs. Determining the true relationships between these types of fishes, algae, and *D. antillarum* is imperative in understanding community structure in Dominican coral reefs and therefore is necessary in order to conserve, restore, or preserve these unique marine habitats.

References

Carpenter RC (1990) Mass Mortality of *Diadema antillarum.* Mar Bio. Vol. 104:79-86

Hughes T (1987) Herbivory on Coral Reefs: Community Structure Following Mass Mortalities of Sea Urchins. J Exp Biol Vol. 113:39-59

McKinney J (2002) Study II: Algal Cover vs. *Diadema antillarum* Abundance along the West Coast of Dominica, West Indies. ITME Research Reports 12:10-14

Mohan E (2001) Fish Species Composition and Size Class Distribution of Dominica, West Indies. ITME Research Reports 9:10-17

Rakitin A (1996) Effect of a Marine Reserve on the Distribution of Coral Reef Fishes in Barbados. Mar Ecol Prog Ser Vol. 131: 97-113

Randall JE (1964) Notes on the Biology of the Echinoid *Diadema antillarum*. Caribbean Journal of Science. Vol. 4:426-430

Schmitt EF (2002) Evaluating the use of roving diver and transect surveys to assess the coral reef fish assemblage off southeastern Hispaniola. Coral Reefs. Vol. 21: 216-223

Smith Q (2002) Study I: Abundance and Test Size of *Diadema antillarum* Along the West Coast of Dominica (Lesser Antilles). ITME Research Reports 12:3-9

Study IV: Fish and Invertebrate Predators of *Diadema antillarum* in Dominica.

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Keywords *Diadema antillarum*, predators, coral reefs, Dominica

Abstract Eight sites off the west coast of Dominica were surveyed in order to determine what predators of *Diadema antillarum* were present. The data was collected by using 50 m^2 belt transects. Size and abundance of these predators was recorded and compared to *D. antillarum* densities. Densities of predators at each site were low suggesting that low predation pressure may be one of the reasons that the *D. antillarum* population is abundant in Dominica.

Introduction

During the early 1980s there was a mass die off of *Diadema antillarum* in the Caribbean. The population of this sea urchin has still not recovered (Lessios 1995). *D. antillarum* is an important grazer that controls the algal growth on a coral reef. Surveys in Dominica performed in 1999 and 2001 have shown that *D. antillarum* has a higher abundance and a larger test-size than elsewhere in the Caribbean (Williams 2001). These results have raised several questions for study: (1) whether or not *D. antillarum* in Dominica ever was affected by the mass mortality, and (2) if *D. antillarum* in Dominica recovered at a faster rate.

Predatory reef fishes play an important role in the community dynamics of coral reefs through their interactions with corals, algae and herbivores (AGGRA 1999). The loss of these species can cause shifts in the structure of fish communities as well as other components of coral communities. Disruptions in reef fish assemblages can increase algal abundance and decrease coral cover. There are several predators of *D. antillarum* found in coral reef communities, including fish and invertebrates. The objective of this study was to assess the density and size classes of predators of *D. antillarum* commonly occurring in Dominica.

Methods

The survey was carried out along the West coast of Dominica at eight different locations. The sites were Tabby Bay, Salisbury East, Tarou Point, Canefield, Champagne, Scott's Head, Salisbury West and Macoucherie. The latter two were surveyed using SCUBA; all others by snorkeling.

In order to accurately record the predatory fishes, four belt transect surveys were conducted at each site. The belt surveys were conducted by dropping a weighted end a transect tape and then swimming 25 m while recording fishes within 2 meters of the tape (National Park Service 1994). A one-meter T-bar was carried ahead of the surveyor. This provided a constant reference to help estimate 2 m in width. Swimming in a straight line all species listed in Table 1 were counted and recorded. Using the T-bar, marked with 10 cm increments, the size of each fish was estimated and assigned to one of the following categories: <10, 11-20, 21-30, >30. All transects were carried out at least 5 m away from the previous position.
The following rules were applied when recording data:

- No fish smaller than 5 cm were recorded

- All fishes in the water column from the benthos to the surface were recorded. This meant the overall volume of water surveyed was larger at deeper sites.
- Fish that were only partly within the transect were recorded and counted.
- Size of Spiny Lobster was estimated excluding antennae.

Fish were identified *in situ* based on Human and Deloach (2002).

Table 1: Predators of *D. antillarum* from Randall (1964).

Famliy /Class	Species name	Common name
Balistidae	*Balistes vetula*	Queen Triggerfish
	Canthidermis sufflamen	Ocean Triggerfish
	*Melichthys niger**	Black Durgon
Carangidae	*Trachinotus falcatus*	Permit
Diodontidae	*Diodon hystrix**	Porcupinefish
Labridae	*Bodianus rufus**	Spanish Hogfish
	*Halichoeres radiatus**	Puddingwife
Ostraciidae	*Lactophrys bicaudalis**	Spotted Trunkfish
Pomadasyidae	*Anisotremus surinamensis*	Black Margate
	*Haemulon carbonarium**	Caesar Grunt
	Haemulon macrostomum	Spanish Grunt
	Haemulon plumieri	White Grunt
	Haemulon sciurus	Bluestriped Grunt
Sparidae	*Calamus bajonado*	Jolthead Porgy
	Calamus calamu	Saucereye Porgy
Tetraodontidae	*Spheroides spengleri**	Sharpnose Puffer
Gastropoda	*Cassis tuberosa*	Helmet Head
Palinuridae	*Panulirus argus**	Spiny Lobster

* Species observed in this study.

Results

Eight species of predators were observed (Table 1). The Porcupinefish had the highest average size (30.0 cm), while the Sharpnose Puffer had the lowest average size (11.98 cm) (Table 1).

Table 2: Overall size class distribution.

Species	<10	11-20	21-30	>30	Density per m^2	St. Dev.	Average size
Black Durgon	0	3	0	0	0.02	1.50	20.00
Caesar Grunt	0	7	0	0	0.04	3.50	20.00
Porcupinefish	0	0	2	0	0.01	1.00	30.00
Puddingwife	16	13	1	0	0.15	8.19	15.00
Sharpnose Puffer	65	16	0	0	0.41	30.77	11.98
Spanish Hogfish	6	16	0	0	0.11	7.55	17.27
Spiny Lobster	1	1	1	1	0.02	0.00	25.00
Spotted Trunkfish	0	1	0	0	0.01	0.50	20.00

The most abundant species recorded was the Sharpnose Puffer (0.41 · m^{-2}). The lowest abundance was recorded in the Spotted Trunkfish and the Porcupinefish (0.01 · m^{-2}) (Figure 1).

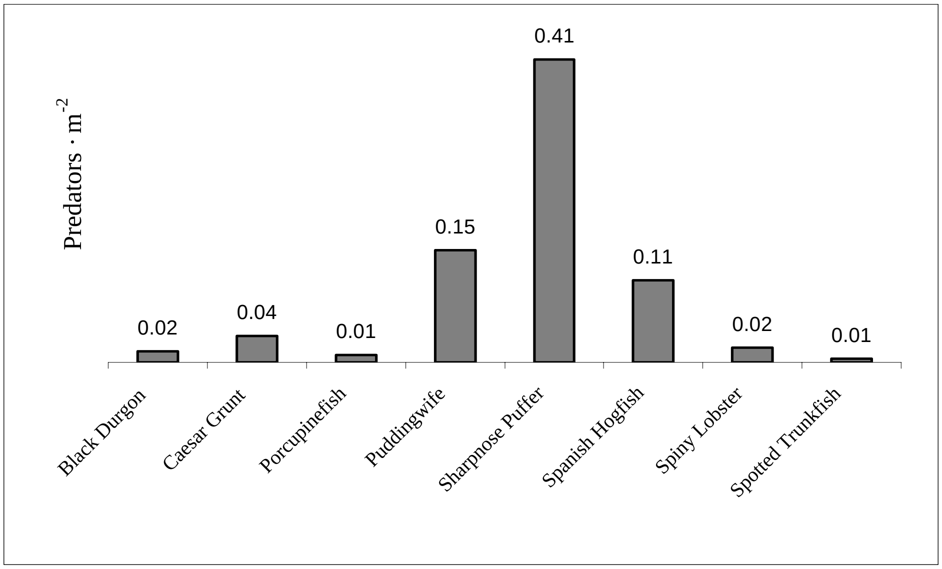

Figure 1: Density of predators · m^{-2}

Comparisons between the eight sites showed that Salisbury West had the highest abundance of predators (0.19 · m^{-2}). Scott's Head had the lowest density of predators (0.05 · m^{-2}) (Figure 2).

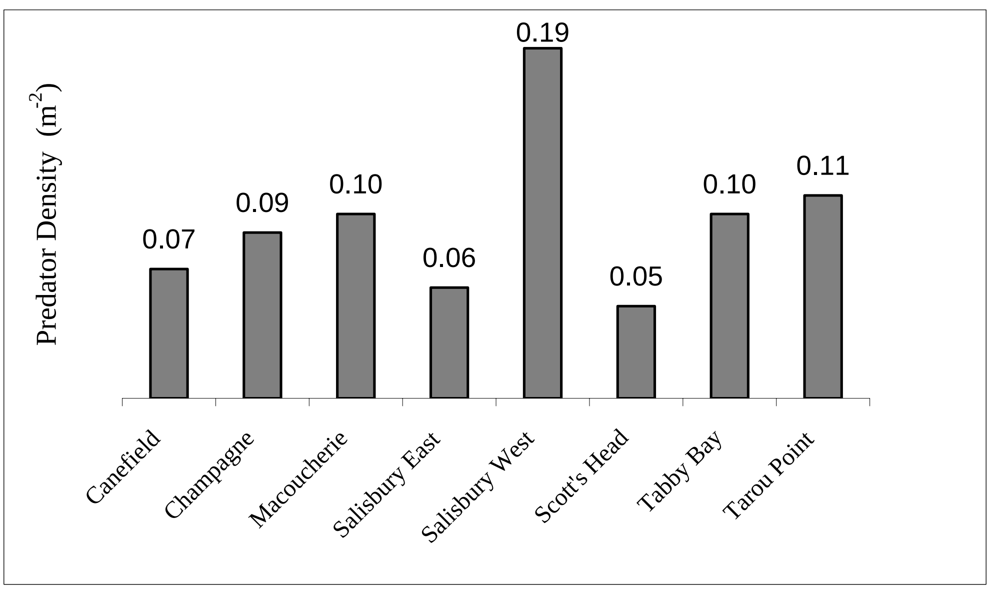

Figure 2: Predator density (m^{-2}) at each site.

Discussion

The comparison between predator densities (this study) and *D. antillarum* densities (Smith 2002) show that at Salisbury West, predator abundance is highest and *D. antillarum* abundance is lowest, with a density of 0.5 · m^{-2} (Figure 3). This may suggest that the predators limit the *D. antillarum* population at this location. However, comparisons of other sites show predator densities to be noticeably lower than at Salisbury West. These sites also have noticeably higher *D. antillarum* densities. So although the fish recorded in these transects are known predators of *D. antillarum*, the data suggests that in Dominica predation pressure is too low to have any impact on the *D. antillarum* population. This could be one of the reasons why *D. antillarum* populations are higher in Dominica than elsewhere in the Caribbean.

Of the 15 known predators of *D. antillarum* (Randall 1964), only eight species were observed in Dominica. Only one Puddingwife and two Spiny lobsters were recorded with sizes greater than 21 cm. Barring the Sharpnose Puffer, all of the predators should normally reach sizes greater than 21 cm when they are fully grown. This suggests that predators observed are relatively small and that they don't reach their full adult size in Dominica. A reason for this may be high fishing pressure.

The Sharpnose Puffer has the highest density and is most abundant in the smallest size class (Table 2). This species has an adult size of approximately 12 cm (Human and Deloach 2002). This small size, in all likelihood, allows this species to escape any fishing traps and nets. This may be the reason why the Sharpnose Puffer was observed in noticeably higher densities than the other predators, suggesting that this fish is one of the main predators of *D. antillarum*.

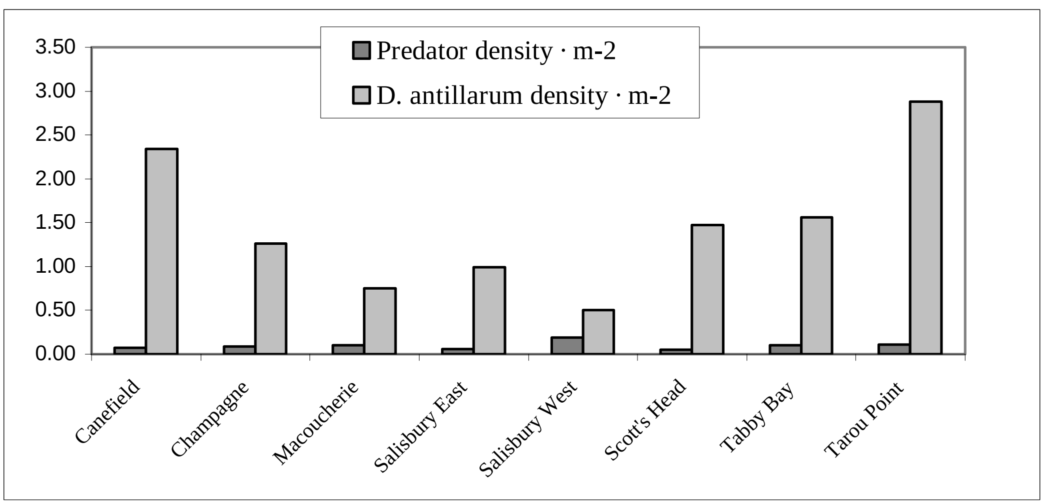

Figure 3: Densities of predators and *D. antillarum* · m^{-2}.

At the Salisbury West location, where data was collected using SCUBA, the density of predators was highest (Figure 2), whereas at the second SCUBA location, Macoucherie, the abundance was the same as that of Tabby Bay suggesting that the density of predators is not only dependent on depth. Observations at these locations and at Scott's Head do, however, suggest that there are several physical factors such as topography that influence the occurrence of these fishes. In the Scott's Head area, where the lowest density of predators was recorded, transects were carried out on a reef flat. This area was very turbulent and dominated by encrusting cnidarians. Scott's Head also has a vertical reef slope which drops to approximately 50 meters. This area is difficult to survey, due to its depth. Numerous large Black Durgon, Spanish Hogfish and Caesar Grunts were observed swimming off this wall. This means that it is likely that the predator density recorded at Scott's Head is not entirely representative of the location.

Dominica is a young volcanic island and has a narrow continental shelf (Honychurch 1995). The island has high rainfall and numerous rivers, which leads to high terrestrial run-off. Although several areas along the West coast have aggregations of corals and small coral reefs, these factors cause high degrees of physical stress limiting reef aggregation along the coast. All the predator species that have been recorded in Dominica during this survey are fishes that live in close association with the reef. Patchy distribution of corals and small reef areas will lead to smaller densities. As a small island nation with most of the population living close to the coast, fishing is one of the main occupations. Fishing in Dominica is indiscriminate, and any fish that are caught in traps or nets are brought up disregarding both size and species (pers. obs.). Although there are regulations regarding what is legal to catch, there is little to no enforcement of these laws (pers. obs.). The abundance of *D. antillarum* may be elevated in areas with high fishing pressure (Carpenter 1984). The low densities and sizes of predators (Table 1 and Figure 3), combined with fishing pressure, suggest these are contributing factors to the high densities of *D. antillarum* observed in Dominica

References

Atlantic and Gulf Rapid Reef Assessment Project August 1999 (AGGRA), Marine Environmental Research Institute.

Carpenter RC (1984) Predator and population density control of homing behavior in the Caribbean echinoid *Diadema antillarum*, Marine Biology 101-108

Deloach N (1999) Reef Fish Behavior, Florida, Caribbean, Bahamas, New World Publications Inc., Florida, pp.359.

Honychurch L (1995) The Dominica Story, MacMillan Education Ltd., London and Basingstoke, pp. 318.

Hughes RN, Hughes HPI (1971) A study of the Gastropod *Cassis tuberosa* (L.) Preying upon Sea Urchins. J. exp. Mar. Biol. Ecol. 7:305-315.

Human P, Deloach N (2002) Reef Fish Identification, Florida, Caribbean, Bahamas, New World Publications Inc., Florida, pp. 481.

Lessios HA (1995) *Diadema antillarum* 10 years after mass mortality: still rare, despite help from a competitor. Proc. R. Soc. Lond. B 259:331-336.

National Park Service (1994) Coral Reef Monitoring Manual for the Caribbean and Western Atlantic, Virgin Islands National Park.

Randall JE, Schroeder RE, Starck, WA (1964) Notes on the biology of the Echinoid *Diadema antillarum.* Carib. J. Sci. 4:421-433.

Smith Q (2002) Abundance and Test Size of *Diadema antillarum* along the West Coast of Dominica (Lesser Antilles) 2002. ITME Research Reports 12:3-9

Williams SM (2001) Survey of abundance and size distribution of *Diadema antillarum* along the west coast of Dominica, W. I. ITME Research Reports 9:3-9.