FIRST LARGE SCALE SURVEY OF MARINE HABITAT CATEGORIES IN DOMINICA

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General Introduction

The best studied areas of Dominica to date are coral reefs and assemblages. The research has focused on coral community structure (Steiner 2001; Steiner 2003; Diamond 2001), coral diseases (Borger 2001; Borger and Steiner 2005) and bleaching (Byrd *et al.* 2005), assessment of reef fishes (Green 2003; Mohan 2001; Willette 2001), and assessment of echinoid *Diadema antillarum* abundance (Smith *et al.* 2002; Steiner and Williams 2005, Steiner and Williams 2006, Williams 2001). These studies have encompassed approximately 100 sites, primarily along the west coast. However, collectively these sites make up a relatively small area of the sublittoral. This report presents a preliminary finding of a large scale quantitative habitat survey of Dominica. The main objective of this study was to assess the distribution and dimensions of individual habitat categories. For the purposes of this study, Dominica was divided into six regions as follows: North (Capuchin to Melville Hall River); East (Melville Hall River to Delice); South (Delice to Scott's Head), West South (Scott's Head to Layou); West Central (Layou to Pointe Crabier); West North (Pointe Crabier to Capuchin) (Fig. a).

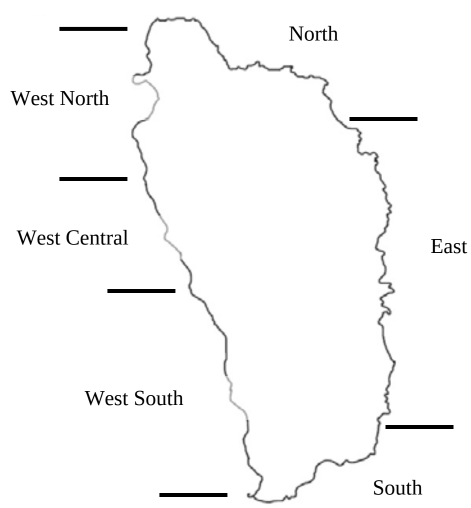

Fig a Map of Dominica (adapted from World Maps Online) depicting regional boundaries.

The two studies presented here focus on the west coast of Dominica and include:

Study I: The distribution of benthic marine habitats in the central and southern regions of Dominica's West Coast by Lori Price. Pages 4-29.

Study II: Distribution of benthic marine habitats of Dominica in the northern region of the West Coast of Dominica by Keira Macfarlane. Pages 30-48.

The data collected from both studies were compiled to illustrate an overview of the abundance of individual habitat categories along the West Coast (Figs. b-d).

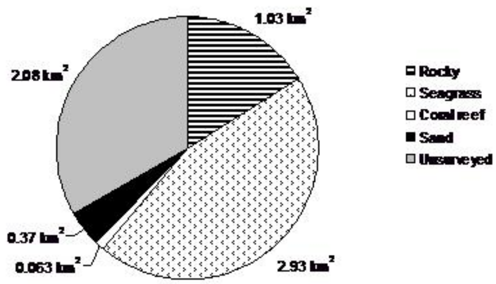

Fig. b Total area of West coast divided into habitat categories.

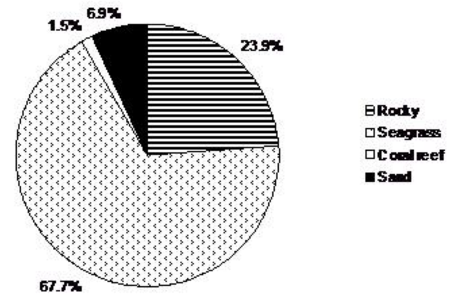

Fig. c Total surveyed area of West coast divided into habitat categories.

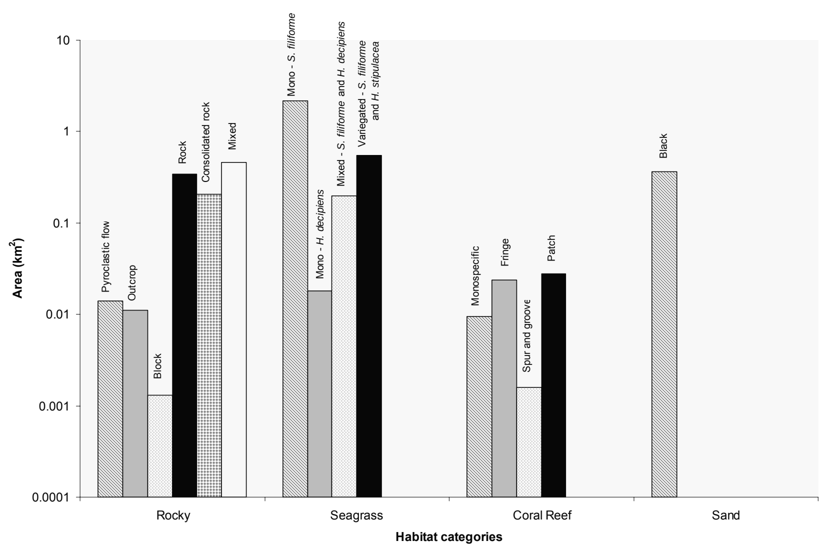

Fig. d Habitat types of the West coast depicting dominant coverage by *S. filiforme* seagrass beds.

Information from this and previous surveys was made available to the public via an interactive website (http://www.itme.org/marinehabitats) which will be updated regularly as new findings become available.

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Study I: The distribution of benthic marine habitats in the central and southern regions of Dominica's West Coast

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Abstract A comprehensive quantitative survey of the area and distribution of benthic marine habitats on the narrow shelf surrounding Dominica was conducted in October and November 2007. This paper focused on the West South and West Central regions to determine (a) the distribution and area of each of the different habitat types (b) the similarities of the sites based on benthic composition, and (c) to assess scleractinian coral recruitment. The assessment consisted of a general "stretch" survey and a more detailed "site" survey. Approximately 2.4 km^2 were surveyed. Habitat categories and types were identified and ranked according to percent cover of specific benthic attributes. Seagrass habitats were found to dominate both the West South and West Central regions (54.5% and 87.1% of the area surveyed, respectively) and were composed mostly of the seagrass *Syringodium filiforme*. All seagrass beds were more than 90% similar. In the West South region, all rocky habitats were more than 85% similar and in the West Central region, all rocky habitats and coral reefs were approximately 80% similar. Twenty-one scleractinian species were identified and of those species, recruits of 11 were identified. *Porites astreoides* had the highest coral cover and number of recruits. Fourteen anthozoans (other than scleractinians) were identified and live *Porifera* abundance and distribution were assessed. Management of these important marine resources is essential, however currently inefficient. Further regulations must be implemented to protect these habitats and the resources they provide.

Keywords Dominica · Marine habitats · Coral reefs · Seagrasses · Coral recruitment · Porifera · Anthozoa

Introduction

Dominica is located in a chain of volcanic islands that make the Lesser Antilles. Due to its volcanic origin and relatively young age (the most recent volcanoes are less than 1.8 million years old), the island has an extremely rugged, mountainous topography with narrow coastal areas (Honychurch 1995; Steiner 2003) and a continental shelf ranging from 0 – 1 km in width (Imray *et al.* 1995). Due to the steep terrain, approximately 80-90% of the small population lives in coastal towns (Diamond 2001), placing them within close proximity to the littoral and sublittoral habitats. This puts many sources of disturbance and pollution (i.e. construction, deforestation, overfishing, sewage, industrial wastes, etc.) close to the coastal marine resources (Steiner 2003), providing a challenge for marine conservation.

In order to effectively manage and conserve the marine resources in Dominica, knowledge and public awareness of the local marine habitats is essential. Several habitats are known to exist along the coast of Dominica, such as coral reefs, seagrass beds, sand flats, and rocky habitats harboring epibenthic organisms. Coral reefs and rocky habitats are the best studied environments to date, including topics focused on coral types and community structure (Steiner and Borger 2000; Steiner 2003), coral diseases (Borger 2001; Borger and Steiner 2005), urchin abundance and distribution (Steiner and Williams 2005; Steiner and Williams 2006), and various studies on reef fish community structure (Green 2003; Klarman 2005; Lowe 2005; Mohan 2001). A broad-scale survey of the distribution of the local marine habitats has not yet been conducted.

Scleractinian recruitment and the comparison of recruits to the adult species present is another area that warrants examination. This is a topic of increasing importance and interest concerning reef health and recovery, especially considering recent and projected global climate changes and anthropogenic disturbances. Coral recruitment rates are affected by multiple factors (i.e. depth, competition, herbivory) and are also influenced by reproductive strategies (Banks and Harriott 1996; Glassom *et al.* 2004; Mumby 2007). Corals are categorized reproductively as either broadcasters, corals that release their gametes (i.e. *Siderastrea siderea*, *Diploria strigosa*, and *Montastraea annularis*) or brooders, corals that retain their larvae (i.e. *Porites astreoides*, and *Favia fragum*). Adult brooders are typically smaller compared to broadcasters and tend to have higher mortality rates. They are considered opportunistic and generally have higher recruitment rates (Szmant 1986). These corals usually have more reproductive cycles per year compared to broadcasters, which may account for the higher recruitment rate (Miller and Szmant 2000; Szmant 1986). The comparison of recruit species to adult colonies can be a sign of the reproductive success of a certain species of coral. The presence of many recruits of reef-building coral species (i.e. *M. annularis*) is an indication of reef health and/or recovery after disturbance (Edmunds 1990).

This study focused on the west coast of Dominica from Scott’s Head to Pointe Crabier and was divided into two regions: West South and West Central (Fig. a). The study had the following objectives: (a) determine the distribution of each of the different habitat types of the area surveyed and estimate the dimensions of each habitat, (b) determine the similarities of the sites based on benthic composition, and (c) assess scleractinian recruitment. This information can be used to identify specific marine habitats in need of protection, and to implement legislation to enforce fishing limitations, control physical destruction to the habitats, and impose restrictions on the input of contaminants. Due to the extent of disturbance of the marine habitats in Dominica (i.e. overfishing, sedimentation, pollution from coastal towns), this study provided important information on the health and reproductive success of corals found in these habitats. This information was made available to the public via an interactive website (http://www.itme.org/marinehabitats) to educate the public on the local marine environment, promote further scientific research, encourage policy makers' protection of the local marine resources, and serve as a reference for visitors to the island.

Materials and methods

The assessment was carried out during October and November 2007. The West South region is delineated as a 110 m wide band from Scott's Head to Layou with a total area of 2.7 km^2. The West Central region is delineated as a 100 m wide band from Layou to Pointe Crabier with a total area of 1.1 km^2.

The habitats were divided into four categories. Based on previous studies, each category was then divided into 2 – 6 different types (Table 1a) (DeVantier *et al* 1998; ITME Research Reports 2005). For the habitat types, a "pyroclastic flow" was categorized as a rocky outcropping formed when volcanic ash entered the ocean and cooled quickly, creating a rocky habitat. "Blocks" were defined as boulders larger than 10 m in diameter and "rocks" were defined as smaller rocks that are less than 10 m in diameter. "Consolidated rock" was an aggregation of rocks cemented together. For seagrass, a "mono" habitat type was a seagrass bed which had 90% coverage of one species, a "mixed" habitat type was a seagrass bed with multiple species intermixed with no single species contributing to more than 90% of the total coverage, and a "variegated" habitat type was composed of two species of seagrass that were not intermixed, but patches of the bed containing one species that excluded the other. Habitat percent cover was an estimate of the percent cover of a given habitat at the specific location. The substrate complexity was ranked as 1 - a completely flat substrate, 2 - a moderately rugose substrate, and 3 - a habitat of very complex structure with overhangs and gullies. These complexity rankings were adapted from Bass and Miller (1996).

Two survey methods were used in the field: (a) the "stretch" surveys were general assessments where the researchers swam along the coast (approximately 1-4 km) from point A to B, and (b) the "site" surveys were a more detailed examination of benthic compositions of specific habitats (Fig. 1).

Stretch survey

Using snorkeling gear, the surveyors swam a predetermined length of the coast to gather information for a general assessment of the distribution and area of the habitats present. For some habitats, SCUBA was used (Table 2a). Surveyors recorded the different habitat categories and types, their location in relation to shore, the approximate area, and the elapsed time spent surveying each habitat. Eight benthic attributes were ranked according to the percent cover over the entire habitat (Table 1a).

Site survey

To attain a more detailed description of certain habitats, a site survey was conducted (Table 2b). Using snorkeling gear (or SCUBA when necessary), the surveyors examined a pre-selected habitat for 10-20 minutes, recording the habitat category and type. Eight benthic attributes were ranked according to the percent cover over the entire habitat (Table 1a).

Quadrats with dimensions of 0.25m x 0.25m, divided into 20 sections (5% cover per division) were then placed strategically 48 times on the substrate to gather information representative of the entire habitat. The quadrats were placed a minimum of 0.5 m apart, usually in a straight line. The organisms within the quadrat were identified to the lowest taxonomic group and percent cover was estimated to the nearest five percent. Organisms composing less than five percent cover were listed as "present." Coral recruits were identified as any coral less than 2 cm in diameter (Table 1b). Anthozoans were identified to species when possible. Percent cover only included the surface area of the holdfast because only that portion of the anthozoan contributed to the percent cover of the substrate.

Additional information

The habitat types were numbered from south to north and grouped for data analysis in the West South region (Table 3a) and the West Central Region (Table 3b). The habitat rankings were divided so that ranks 1-4 were in smaller divisions than ranks 5-7 because most benthic organisms in Dominica are very sparse (pers obs 2007). Area was quantified by comparing estimates of the areas of each habitat with satellite imagery using Google Earth (Google). Total area surveyed was calculated as the total length of the region multiplied by the average width of the habitats present. Coordinates for each stretch and site were determined using Google Earth (Table 3a and 3b). Two stretches in the West Central region were not surveyed due to time constraints: Scott's Head to Soufriére and Pointe Michel to Fond Cole.

For both the stretches and sites, habitat descriptions and rankings were determined by consensus among surveyors. Sixteen hours of consistency training was conducted before the data collection began to ensure that all researchers were using identical methods and collecting data in the same way. Field identification of benthic species was based on the Caribbean Reef Identification series by Humann and Deloach (2002), Littler and Littler (2000), and Littler *et al.* (1989). The survey methods were adapted from DeVantier *et al*. (1998). Similarity among sites and stretches based on benthic composition were determined with the Bray Curtis similarity cluster analysis. All calculations were performed in Primer v5 (Clarke and Gorley 2001).

Results

Area of habitat categories and types

Seagrass dominated the West South region with a total area of 0.60 km^2 (54.5% of the area surveyed) out of a total surveyed area of 1.1 km^2 (Fig. 2a and Fig. 3a). Seagrass also dominated the West Central region with a total area of 1.12 km^2 (87.1% of the area surveyed) out of a total surveyed area of 1.29 km^2 (Fig. 2b and Fig. 3b). In both regions, monospecific *Syringodium filiforme* was the dominant habitat type. The mixed *S. filiforme* and *Halophila decipiens* habitat type was present in the West South region, but absent from the West Central region. Coral reefs were surveyed only in the West Central region (Fig. 4a and Fig. 4b), although coral reefs also exist at Scott's Head (West South region).

Similarity of habitats based on benthic composition

A comparison of habitats showed that similarities of the habitats were defined by substrate type, and the benthic composition gave the relationships a finer resolution. In the West South region, the similarity based on benthic composition showed that seagrass habitats were more than 90% homogenous, sand habitats were more than 95% homogenous, and rocky habitats were more than 85% homogenous (Fig. 5a). For seagrass, habitat 10 was a seagrass bed of mixed *S. filiforme* and *H. decipiens*, whereas **A1** represents seagrass beds composed of *S. filiforme* only. For rocky habitats, **B1** represents rocky habitats with turf rankings of 5-7 (26-100%) and **B3** represents consolidated rock substrates. **B2** represents low sponge and macroalgal cover (0-5%). **B4** represents rocky habitats with 1-5% scleractinian cover. **B5** represents mixed rock habitats with 0% cover of both *Millepora sp.* and anthozoans. **B6** represents pyroclastic flow habitats and habitat 7 was an area with high anthozoan cover (26-50%) and 0% scleractinian cover.

A comparison of each habitat surveyed in the West Central region based on benthic composition showed that seagrass habitats were more than 95% homogenous, rocky habitats were more than 85% homogenous, and coral reef habitats were more than 85% homogenous. Rocky habitats and coral reefs were approximately 80% similar to each other (Fig. 5b). Only one sand habitat (**C**) was ranked in this region and was more than 80% similar to the coral reefs. All seagrass habitats were composed of *S. filiforme*. **A1** represents seagrass beds with 26-50% cover and **A2** represents seagrass beds with 51-75% cover. For rocky habitats, **B1** represents mixed rock habitats with 0% macroalgal cover and 6-25% *Millepora sp.* cover. **B2** represents habitats with 0% macroalgal, 0% *Millepora sp*., 0% anthozoan cover, and 1-10% sponge cover. **B3** represents rock habitats with 26-50% *Porolithon sp*. cover and 6-19% scleractinian cover. **B4** represents habitats with 1-5% scleractinian cover. All coral reef habitats had 0% *Millepora sp*. cover and 0-5% *Porolithon sp*. cover. **D1** represents reefs with 1-5% sponge cover. **D2** represents reefs with 6-10% scleractinian cover. Site **#26** had 11-25% scleractinian cover and site **#21** had 51-75% scleractinian cover.

Scleractinian colony vs. recruit abundance and distribution

Twenty-one coral species were identified (Table 4). Anse à Liane had the greatest species richness (17) and Fond Cole had the lowest species richness (9). *P. astreoides* and *S. siderea* were the only two coral species found at all sites. *Acropora palmata* was only found at Champagne and Fond Cole. Large colonies of framework-building corals (i.e. *Madracis mirabilis, Montastraea cavernosa, Montastraea faveolata*) were found in the deeper reefs (~8 – 18 m) and contributed to the greater percentage of coral cover. These corals were also found in the shallower, rocky habitats (~1 – 8 m).

The total live coral cover at each site was consistently less than 1% • m^{-2}, ranging from 0.076% • m^{-2} at Fond Cole to 0.77% • m^{-2} at Floral Gardens (Fig. 6). The coral reefs and corals at Champagne had a higher coral cover than the rocky habitats. *P. astreoides* was the most abundant with 0.12% cover • m^{-2} over all sites. Four coral species (*A. palmata, Eusmilia fastigiata*, *Isophyllia sinuosa*, and *Siderastrea radians*) composed less than 0.001% cover • m^{-2}. Framework-building corals such as *M. faveolata, S. siderea, and M. mirabilis* composed a significant portion of the percent cover, while smaller opportunistic corals such as *F. fragum, Madracis decactis*, and *Stephanocoenia intersepta* composed a small portion of the percent cover (Fig. 7).

Espagnol Bay had the highest number of scleractinian recruits (4.08 recruits • m^{-2}) while Floral Gardens had the lowest number of recruits (0.2 recruits • m^{-2}) (Fig. 8). Although coral reef habitats had high percentages of coral cover (0.48 – 0.77% c, these habitats had low numbers of recruits (0.20 – 1.13 recruits • m^{-2}). However, Champagne had a high coral cover and a high number of recruits (Fig. 6 and Fig. 8).

Eleven coral recruit species were identified. Of these, *P. astreoides* was the most abundant (Fig. 9). The framework-building corals that had high percent cover had low abundance of recruits and the small corals that composed only a small portion of the coral cover had high abundance of recruits (Fig. 7 and Fig. 9). Brooders such as *P. astreoides, S. radians, Agaricia agaricites,* and *F. fragum* (Szmant 1986, Van Moorsel 1983) had high abundances of recruits, whereas broadcasters such as *M. annularis, M. cavernosa, D. strigosa, M. faveolata,* and *S. siderea* (Szmant 1986) had few to no recruits (Fig. 9).

Anthozoa and Porifera abundance and distribution

Fourteen anthozoans were identified (Table 5). Lauro Reef had the highest anthozoan richness (7) and Barry's Dream and Espagnol Bay had the lowest (2). *Lebrunia sp.*, a cryptic anemone, was the most abundant anthozoan found at seven sites. *Palythoa caribaeorum*, an encrusting zoanthid, was found at six sites, usually in shallow areas (~0–2m) with some turbulence. *Erythropodium caribaeorum*, an encrusting gorgonian, was found at six sites, usually in shallow areas.

Errect, encrusting, and boring sponges were present at every site (except for the seagrass bed at Easy Street) with varying percent covers. Sponges were most abundant at Floral Gardens and were least abundant at the Anse à Liane seagrass bed and Toucari Bay. Errect sponges were the most abundant at Rodney's Rock, Barry's Dream, Lauro Reef, Floral Gardens, and Espagnol Bay, while encrusting sponges were most abundant at Fond Cole and the Anse à Liane rocky habitat. Errect and encrusting sponges had approximately the same percent cover at Champagne and Toucari Bay, and sponges were completely absent at Easy Street. Boring sponges only composed significant percent cover at Champagne and Rodney's Rock (.008 and .013% • m^{-2} respectively), but were present at all sites except for the seagrass beds (Fig. 10).

Discussion

Area of habitat categories and types

In the West South and West Central regions, seagrasses covered the largest area (~1.7 km^2 of ~2.4 km^2), and within this category, the monospecific *S. filiforme* type was the most abundant. These seagrass beds covered the majority of the surveyed areas with some *H. decipiens* mixed with the *S. filiforme* beds in the West South region. Rocky habitats composed a small percentage of the area surveyed in both regions (Fig. 2 and Fig. 3). These habitats are important ecologically because they provide solid substrates on which corals, sponges, and other benthic organisms can settle and grow.

Coral reefs were found in the West Central region, particularly around the Salisbury area (Fig. 1). The surveyed area of these reefs composed about 3% of the total area in that region (Fig. 3b), however, the actual area of the habitats was larger as not all reefs were surveyed in their entirety. Of the five reefs that were surveyed, three were fringing reefs, one was a spur and groove reef, and one was a monospecific reef (Table 3b). The fringing reefs covered the greatest area of the reefs, followed by the monospecific reef. This reef was built by *M. mirabilis*, a coral that forms densely packed clumps and large banks of at least 500 m^2 (Steiner 2003). Coral reefs were also found in the West South region in Scott's Head, but this stretch was not surveyed due to time constraints. Sandy habitats composed the remainder of the surveyed area.

These results have implications for management and conservation by identifying seagrass beds as the largest marine resource in these regions. These habitats have important ecological roles such as primary production, protection for other organisms and protection of the shoreline (Duarte 2002). Some seagrass beds, especially those located within close proximity to coastal towns, show evidence of decline such as the presence of garbage and epiphytic macroalgal growth (Duarte 1995) (pers obs 2007). If this resource is not managed properly, the health of these beds will continue to deteriorate. Management practices could include, but are not limited to, enforcing restrictions on fishing, limiting the trash and contaminants that are put into these environments (from industry, sewage, and other human activities), and placing additional limitations on sand mining and deforestion would help to reduce sedimentation and potential burial.

These results also identify the habitats in these regions that are small and most susceptible to irreversible damage, most notably the coral reefs and rocky habitats with similar composition (i.e. Champagne). These reefs are overfished, as seen by the absence of large herbivores (pers obs 2007). They are also sites which are frequented by SCUBA divers, which contribute to additional physical damage of these habitats. Due to the fact that these reefs are a very small resource in Dominica, many practices must be restricted, if not completely stopped (i.e. fishing, recreational diving, etc.) to preserve these habitats.

Similarity of habitats based on benthic composition

In the West South region, the seagrass habitats were found to be more than 90% similar, suggesting that these habitats were homogeneous in their composition. The monospecific *S. filiforme* beds were more than 95% similar; the 5% difference was attributable to differences in shoot density. The seagrass beds did not have a significant percent cover of other organisms (i.e. sponges, macroalgae) to factor in with the benthic composition, although those organisms were present. Rocky habitats were also very similar in composition (85%) considering the different habitat types that were found. The rocky habitats grouped according to the benthic composition (i.e. high turf algae cover, low sponge and macroalgal cover, etc) rather than the actual substrate of the habitat (i.e. rock, consolidated rock, etc). The sand habitats grouped differently because some habitats had small rocks interspersed (Habitats 4 and 9) and others had some seagrass present (Habitat 17) (Fig. 5a).

In the West Central region, the seagrass habitats were more than 95% similar because only the monospecific *S. filiforme* seagrass beds were present. The density of the seagrass shoots defined the habitat groupings. Rocky habitats and coral reefs were similar (approximately 80%) because of the comparable live benthic cover found in both of these categories. Rocky habitats have a very important ecological role in Dominica due to the island geography. Because the shelf surrounding Dominica is very narrow, the available area for the accretion of corals to develop into true reef habitats is restricted. Therefore, the rocky habitats that are scattered along the coast cover more surface area than the true reefs. These rocks are important in harboring benthic organisms (corals, sponges, algae, etc), although these benthic assemblages are different than those found in coral reefs (Fig. 5b).

The differences between rocky habitats and coral reefs were due in part to the depth of the reefs. In general, the reefs were deeper than the rocky habitats, providing a more stable environment with less disturbance from wave energy. Larger, framework-building corals (i.e. *M. cavernosa*, *M. faveolata*) were found in the deeper water, whereas the smaller, opportunistic corals (i.e. *F. fragum, S. radians*) were found in the shallow, more turbulent water. Some framework-building corals were found at shallower depths, but were generally smaller colonies and covered less surface area as compared to those found in the deeper water. Some corals such as *Meandrina meandrites*, *P. astreoides*, *P. porites*, and *S. siderea* were found at all sites regardless of depth. Some colonies of *S. siderea* were very large (~3 m in diameter) in shallow water (~3 m deep), suggesting that these corals can survive in a wide range of habitats and depths. Some rocky habitats, however, were found in deeper water and had the same large corals and sponges as the reefs (pers obs 2007).

These comparisons help identify which habitats are the most unique in their species composition and benthic cover, such as the coral reefs. These habitats should be the focus of conservation efforts because their complexity and diversity are unique to Dominica and could be lost if not protected from increasing anthropogenic disturbances.

Scleractinian colony vs. recruit abundance and distribution

The reef habitats (Barry's Dream, Lauro Reef, and Floral Gardens) had higher percent coral cover compared to the rocky habitats. This was expected because the reefs had a larger continuous surface area on which larger coral colonies could grow as opposed to the smaller, scattered rocks. Champagne and Toucari Bay also had high coral cover, indicating that these rocky habitats were similar to the reefs in terms of percent cover, but not necessarily coral composition. Fond Cole had the lowest coral cover because this habitat is very shallow and mostly covered by other encrusting anthozoans (i.e. *P. caribaeorum*) (Fig. 6).

The reefs that had the highest adult coral cover percent had low recruit abundance. This could be due to the lack of available substrate for larval settlement. Champagne was the only site that had high species richness (13), high coral cover, and high recruit abundance (Table 4, Fig. 6, and Fig. 8). This site was located in the Soufriére – Scott's Head Marine Reserve where fishing is limited and therefore a greater number of large herbivorous fish were present (pers obs 2007). Herbivorous fish control macroalgal growth and increase the area of available substrate for coral larval settlement (Hughes *et al.* 2007). This site's location in the marine reserve might contribute to its apparent productivity. Alternatively, Anse à Liane and Espagnol Bay had low coral cover, but the highest recruit abundance, possibly because of substrate availability. Fond Cole had the lowest adult coral cover and the lowest abundance of recruits. This could be due to the shallow depth of the habitat and resulting disturbance from wave energy, and sediment disturbances due to close proximity to fluvial inputs. More importantly, this site is located next to a customs port where large ships dock and unload their cargo. These waters are polluted from this human activity, as are most areas near ports (Cambridge *et al.* 1986), making the habitat unsuitable for extensive coral growth.

The most common coral species found at all sites was *P. astreoides* (Table 4). This coral had the highest live cover of all species identified and also had the greatest number of recruits, indicating that this species is very successful in Dominica and confirms the findings of Steiner (2003). *P. astreoides* is categorized reproductively as a brooder, which tends to have higher recruitment rates compared to broadcasters (Szmant 1986). Another common coral species found in Dominica is *S. siderea*. This coral was found at every site, but despite its larger colony size had only half the coverage of *P. astreoides* (Fig. 7). *S. siderea* is a strong, robust species and has some of the oldest colonies on the island (pers com S. Steiner). Although some recruits of this species were identified, it was among the lowest recruiters (Fig. 8). This species is a broadcaster, which tends to have larger colony sizes and lower recruitment rates (Szmant 1986). *M. mirabilis* has high percent cover because when present, it is found in large, dense clumps that cover significant surface area. This species is a brooder, but no recruits were identified in this study. This could indicate that the adult colonies are not producing enough larvae, the larvae that are being produced are not healthy enough to survive, or conditions may not be suitable for this recruit species to survive.

The massive corals (i.e. *S. siderea, M. annularis, M. cavernosa,* and *M. faveolata*) had the lowest recruitment rates, whereas the opportunistic species (i.e. *S. radians, P. astreoides, A. agaricites,* and *F. fragum*) had the highest recruitment rates. This is due to differences in reproductive strategies. The massive corals are all broadcasters and invest more energy into colony growth, rather than gamete production (Szmant 1986). The opportunistic species are brooders and invest more energy into larval production rather than growth (Van Moorsel 1983; Szmant 1986). The recruit abundance is promising for *A. agaricites*. This particular species of coral was abundant before the bleaching event in 2005 (Jordan 2005) and was not observed alive in 2006, suggesting that it was heavily impacted by the bleaching (Sabattis 2006). Its recruit abundance suggests that this species may be recovering (Fig. 9).

Because the large, framework-building corals are important in the coral reef ecosystem but have low recruitment rates, the habitats that harbor these corals must be protected. Otherwise, these corals would take much longer to recover from damage compared to the smaller, opportunistic corals with higher recruitment rates. These results also show the positive effects of a marine reserve. The comparison of Champagne to Fond Cole depicts the importance of the Soufriére – Scott’s Head Marine Reserve in comparison to the polluted waters around the port at Fond Cole. More regulations on fishing and pollution must be implemented in more areas along the coast, such as around the coral reefs at Salisbury.

Anthozoa and Porifera abundance and distribution

Sessile anthozoans (other than scleractinians) generally covered less surface area than hard corals, partially because of their growth forms. Many soft corals (i.e. *Gorgonia sp., Pterogorgia sp., Pseudopterogorgia sp.*, and *Plexaura sp.*) were attached to the substrate by a holdfast and the majority of the biomass extended into the water column. *P. caribaeorum* was most abundant at Fond Cole because this anthozoan is colonial and can cover large surface areas (Humann 2002). It also out-competes other species and can inhabit shallow habitats with turbulence that are not readily inhabited by other species (Bastidas and Bone 1996). This particular species covers the majority of the area at this site. Anemones were also recorded, but did not compose a significant percentage of the habitats because they are usually solitary organisms (except for *Stichodactyla helianthus*) (Humann 2002).

Sponges are less abundant in seagrass beds compared to reefs and rocky habitats because of the lack of solid substrates on which to grow. Between reefs and rocky habitats, the substrate type did not influence the abundance of sponges or a specific growth form. Boring sponges did not compose significant percent cover at any site because they are typically small and bore into the substrate, thereby not covering a considerable surface area.

In Dominica, anthozoans and sponges contribute to a large percent of live benthic cover, where they outcompete corals, such as areas of Fond Cole and Espagnol Bay where depth and proximity to shore limits coral growth. Additionally, anthozoans and sponges are ecologically important filter feeders because they enhance water quality by removing particulate matter from the water column (Reiswig 1971).

Conclusions

This comprehensive marine habitat survey shows that seagrass beds dominated by *S. filiforme* are the largest marine resource in the West South and West Central regions of Dominica. These habitats are in danger of damage from human activity and pollution. Not only is their ecological role important, but economically they function as a fishery that many locals depend on. These habitats also serve as a nursery for many ecologically and economically important fishes. If not managed properly, such as regulating fishing, limiting contamination, and reducing sedimentation, irreversible damage can be done to these ecosystems and the resources they provide will be lost.

Due to the small surface area covered by coral reefs on Dominica's narrow shelf, these habitats are extremely vulnerable and must be protected. These areas could be declared marine reserves, or fishing could be restricted to help restore the health of these reefs. Because reefs are so scarce, rocky habitats are important in harboring benthic organisms similar to those found on reefs. The Soufriére – Scott's Head Marine Reserve indicates the importance of restricted fishing and demonstrates that even a rocky habitat, with some protection, can have a high percentage of live benthic cover. The current management of Dominica's coastal marine resources is inefficient and the resource users that depend on them must take initiative to halt or even reverse the current situation if the habitats are to have any chance of survival.

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map

Table 2a List of stretches from south to north of the West South region and West North region. An asterix (*) indicates the stretches surveyed using SCUBA.

West South region	**West North region**
Soufriére to Champagne	Layou to Mero
Champagne to Pointe Michel	*Maggie's Point
Fond Cole to Canefield	Mero to Salisbury
Canefield to Mahaut	*Easy Street
Mahaut to Rodney's Rock	*Brain Reef to Rena's Reef
Tarou to Layou	Salisbury to Battalie Beach
	Battalie Beach to Colihaut
	Colihaut to Pointe Crabier

Table 2b List of sites assessed using quadrats for a more detailed description of benthic composition. An asterix (*) indicates the sites surveyed using SCUBA. Easy Street and an Anse à Liane site were the only seagrass beds surveyed. All other sites were rocky habitat categories.

Sites
Champagne
Fond Cole
Rodney's Rock
*Barry's Dream
*Easy Street
*Lauro Reef
*Floral Gardens
Anse à Liane - rocky
Anse à Liane - seagrass
Espagnol Bay
Toucari Bay

[redacted]

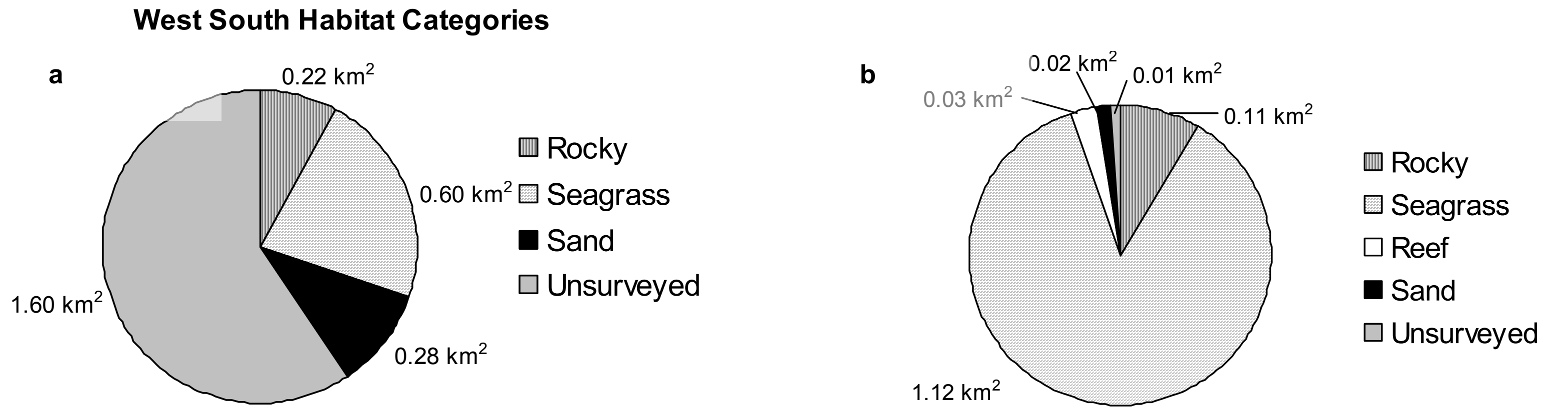

Fig. 2 Total area of the (a) West South region, and (b) West Central region divided into habitat categories.

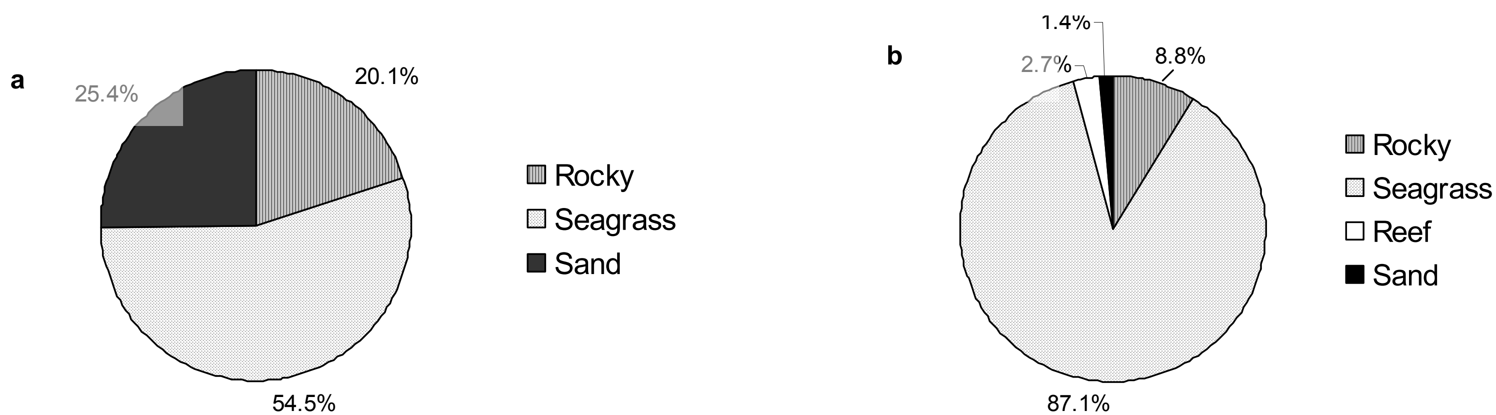

Fig. 3 Total area that was surveyed of the (a) West South region, and (b) West Central region divided into habitat categories.

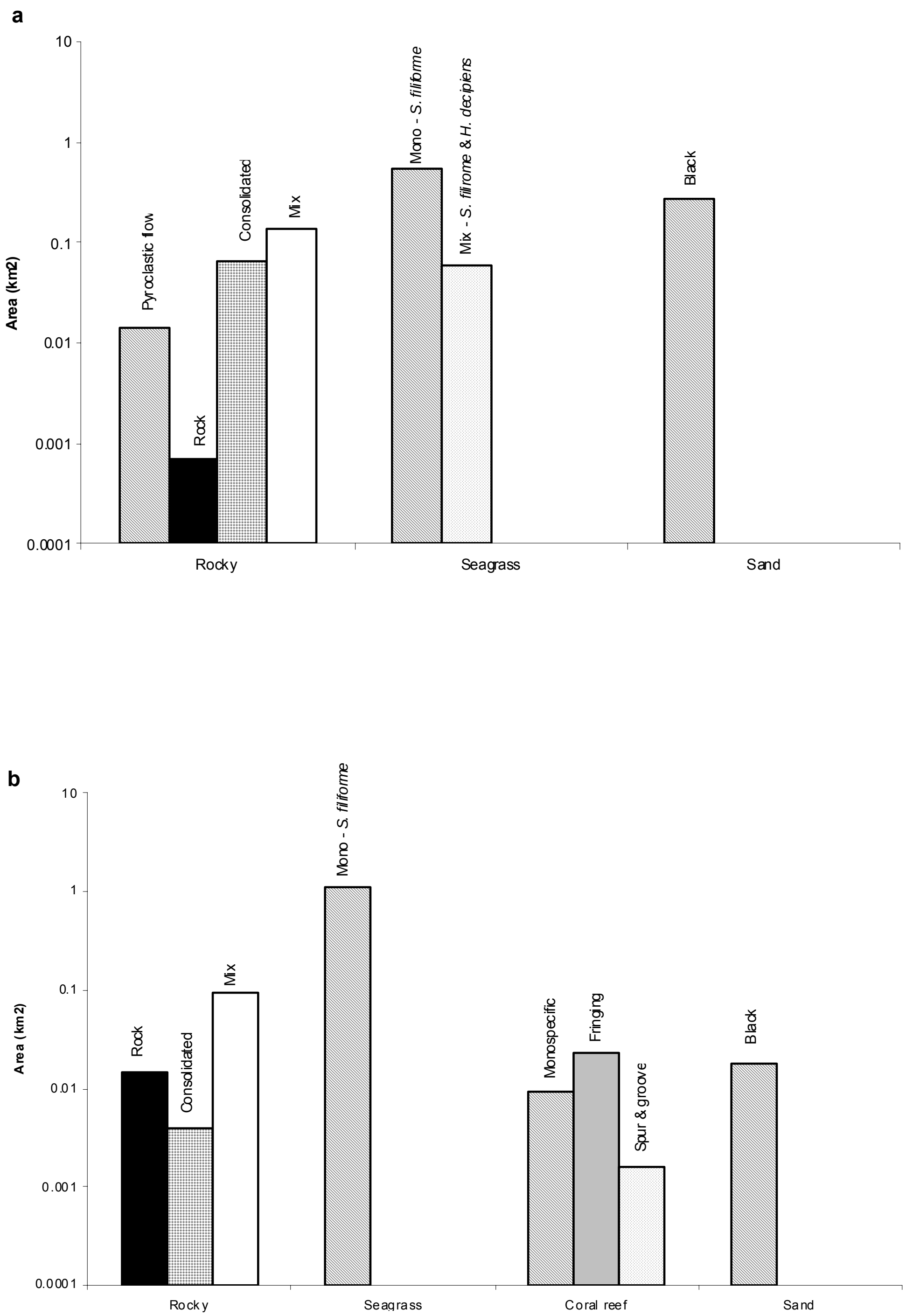

Fig. 4 Habitat types in the (a) West South region, and (b) West Central region.

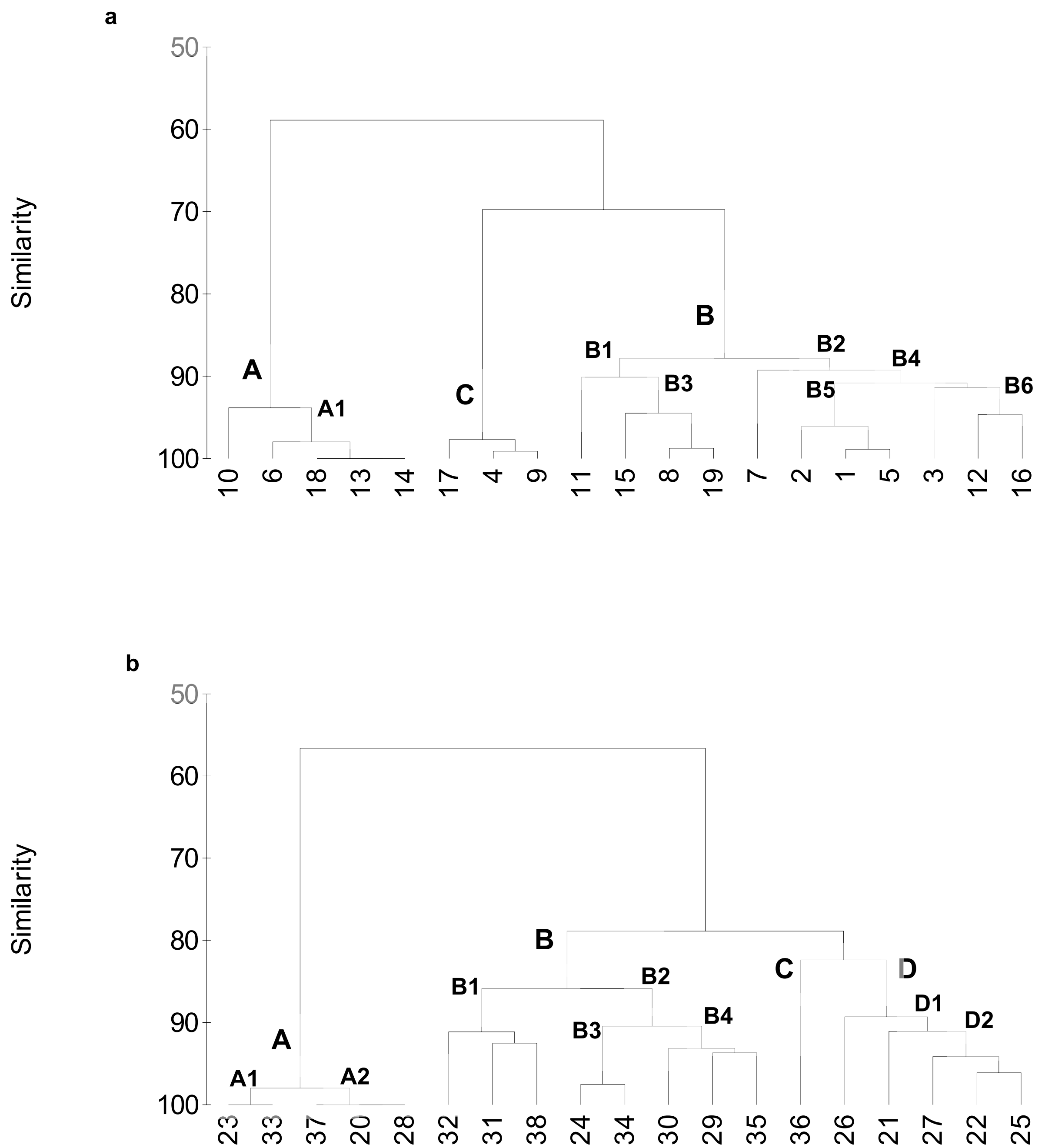

Fig. 5 Similarity index of the habitats in the (a) West South region, and (b) West Central region based on benthic composition. The habitat categories are as follows: A – seagrass, B – rocky, C – sand, D – coral reef. See description in results. Habitat type number reference is found in Table 3.

Table 4 Live scleractinian cover per site. A black circle (●) indicates coral cover per site > 0.001% per m^2 and a white circle (○) indicates coral cover per site < 0.001% per m^2. An asterix (*) indicates the coral reef sites that were surveyed using SCUBA.

	Champagne	Fond Cole	Rodney's Rock	*Barry's Dream	*Lauro Reef	*Floral Gardens	Anse à Liane	Espagnol Bay	Toucari Bay
Acropora palmata	●	○							
Agaricia agaricites	○	○	○		○	○	●		○
Colpophyllia natans	●		○		●		●		
Dichocoenia stokesii		○			●		○	●	
Diploria clivosa		●					●	●	
Diploria labyrinthiformis	●	●	○		●			●	
Diploria strigosa	○		○		●		●	●	
Eusmilia fastigiata			○	○		○			○
Favia fragum	○		○				●		
Isophyllia sinuosa								●	
Madracis decactis				○	○	○	●		○
Madracis mirabilis	●			●	●	●	●		●
Meandrina meandrites	●		○	●	●	●	●	●	●
Montastraea annularis							○	●	●
Montastraea cavernosa				●	●	●	●	●	○
Montastraea faveolata		●	●	●	●	●	●	●	
Porites astreoides	●	●	●	●	●	●	●	●	●
Porites porites	●		○	○	●	●	●	●	●
Siderastrea radians	○	○					○	○	○
Siderastrea siderea	●	●	●	○	●	●	●	●	●
Stephanocoenia intersepta	●		○	○	○		○	●	

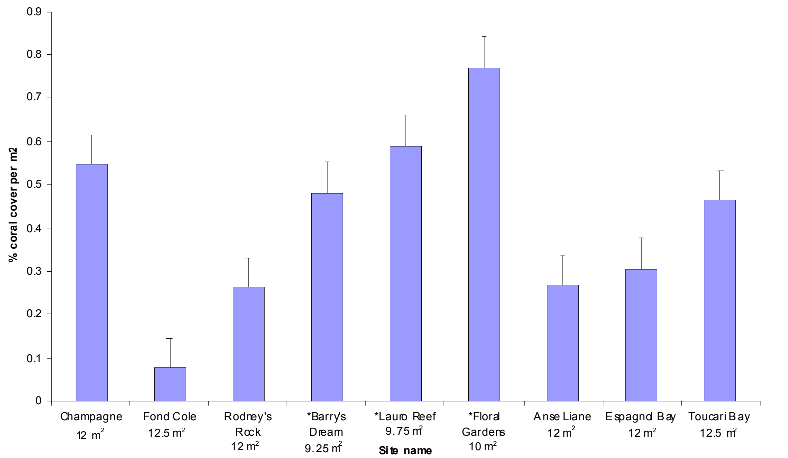

Fig. 6 Total live scleractinian cover per site. An asterix (*) indicates a coral reef site surveyed using SCUBA gear. The values below each site name is the total area surveyed using quadrats.

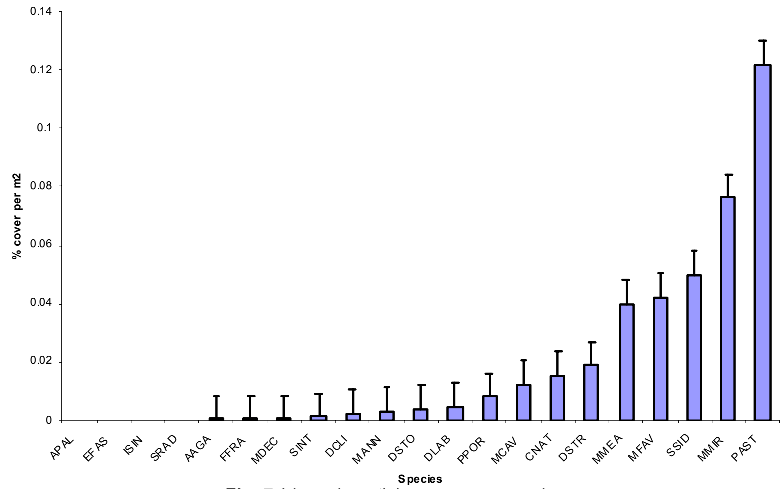

Fig. 7 Live scleractinian cover per species.

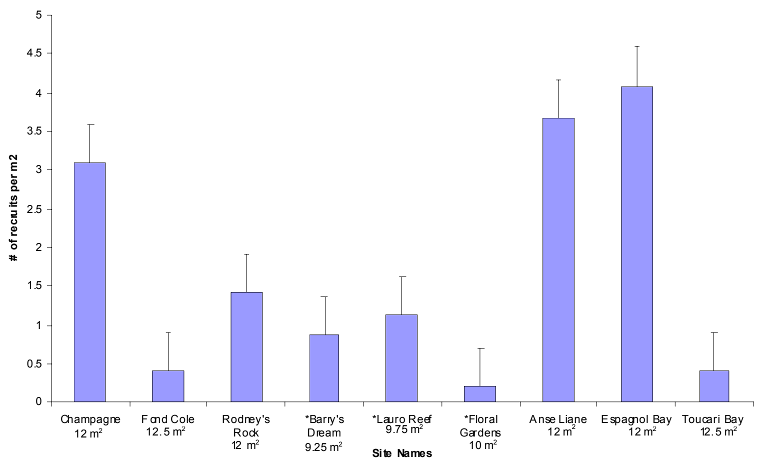

Fig. 8 Scleractinian recruit abundance per site. An asterix (*) indicates a coral reef site surveyed using SCUBA gear. The values below each site name is the total area surveyed using quadrats.

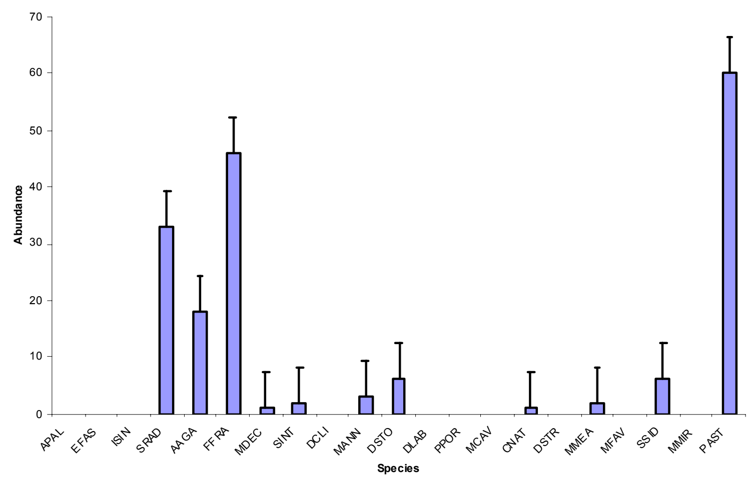

Fig. 9 Scleractinian recruit species abundance.

Table 5 Live anthozoan cover per site. A black circle (●) indicates anthozoan cover per site > 0.001% per m^2 and a white circle (○) indicates anthozoan cover per site < 0.001% per m^2. An asterix (*) indicates the coral reef sites that were surveyed using SCUBA

	Description	Champagne	Fond Cole	Rodney's Rock	*Barry's Dream	*Lauro Reef	*Floral Gardens	Anse à Liane	Espagnol Bay	Toucari Bay
Discosoma sp.	Corallimorph								●	
Palythoa caribaeorum	Encrusting zoanthid	○	●	○		○		●	○	
Parazoanthus sp.	Colonial zoanthid	○		●						
Palythoa grandis	Zoanthid					○				
Stichodactyla helianthus	Colonial anemone		●				●			
Bartholomea annulata	Cryptic anemone				○		○			
Lebrunia sp.	Cryptic anemone	○	○	○		○	○	○		○
Gorgonia sp.	Sea fans		●							
Pterogorgia sp.	Sea whips		○							
Pseudopterogorgia sp.	Sea plumes					○				
Plexaura homomalla	Black sea rod					○				
Plexaura flexuosa	Bent sea rod									○
Pseudoplexaura sp.	Porous sea rods					○				
Erythropodium caribaeorum	Encrusting gorgonian		●	●	●	○		●		●

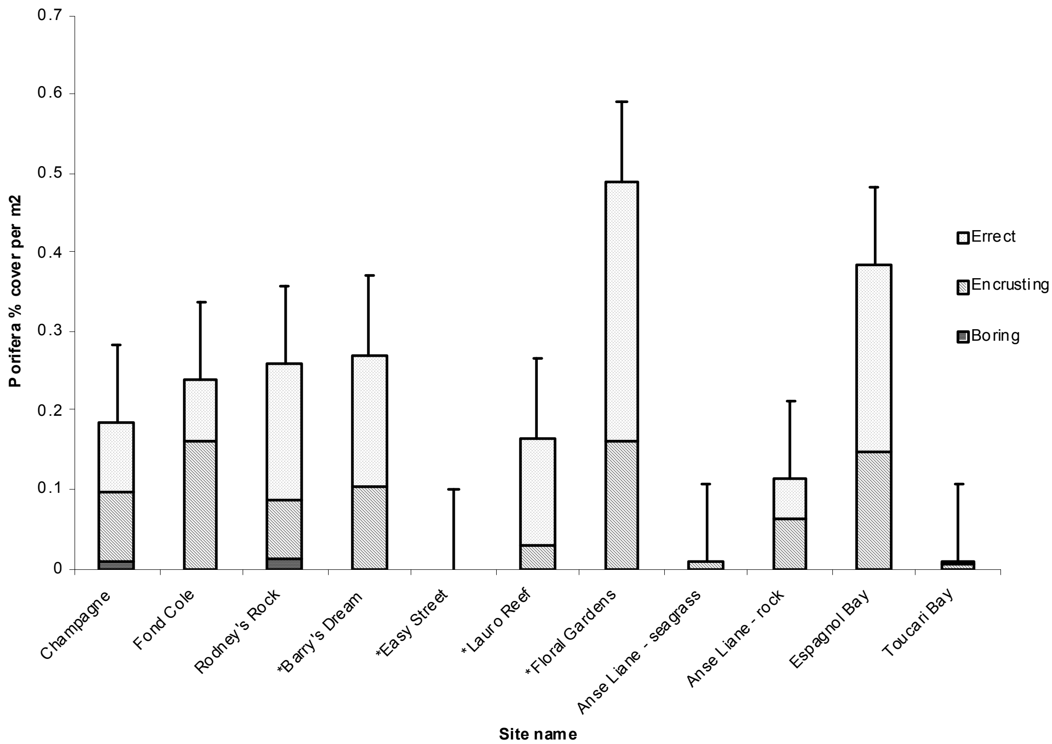

Fig. 10 Abundance and distribution of boring, encrusting, and erect sponges within the sites. An asterix (*) indicates a coral reef site that was surveyed using SCUBA

Study II: Distribution of the benthic marine habitats in the northern region of the West Coast of Dominica, W.I.

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Abstract A broad scale quantitative survey was conducted of the benthic habitats covering 2.5 km^2 of the West North coast of Dominica. Seagrass beds were identified as the dominant habitat (62.4% of total area surveyed) with homogenous organismal composition. Variegated *Syringodium filiforme* and *Halophila stipulacea* seagrass beds contributed to the largest cover of all seagrasses ($0.55 km^2$). Rocky habitats contributed to the second highest cover (36.1% of area surveyed) and had more variation of benthic organism cover between habitat types. These rocky substrates provided an alternate substrate for scleractinians and other sessile organisms to settle and grow. Furthermore, high algal cover of *Porolithon sp.* and *Diadema antillarum* was shown to decrease the density of turf algal growth. Serpulid polychaetes preferred the stony corals *M. annularis* and *P. astreoides* as a substrate. Knowledge of the type, size and location of these habitats will identify those worth protecting from overfishing, sedimentation and damage from large ports and coastal construction. The information gathered from this survey is aimed at providing decision-makers with a point of reference to begin conservation initiatives.

Keywords Benthic habitats · Seagrass · Coral reef · Echinoids · *D. antillarum* · Polychaetes · Dominica

Introduction

Dominica is a rugged island whose population relies heavily on its natural resources for agriculture, timber and fishing (Honychurch 1995). The need to conserve these resources has become increasingly evident as the once small coastal villages are rapidly expanding to accommodate the growing number of inhabitants. Many Dominicans are moving away from the interior to within ½ km of the sea edge, with 80 to 90% of the population living along the 148 km coastline (Diamond 2003). The society has shifted its focus from rural agriculture to a more urban lifestyle with the majority of the population now living within city boundaries (pers com S Steiner). This trend is common across the Caribbean, however Dominica is more susceptible to marine habitat damage from urban sprawl due to the very narrow shelf (<1km wide)(Diamond 2003) harbouring benthic resources. This narrow shelf is a result of the volcanic nature of the island and has created deep valleys, dormant volcanoes and mountain ranges which shape Dominica's interior (Honychurch 1995). The rough terrain provides a challenge for settlement as suitable land for development is limited to the coastal regions of the island. From a marine perspective, a narrow shelf provides less space for sublittoral benthic communities. Thus, the effects of overfishing, sedimentation, increased damage from ports and coastal development have an impact on the surrounding marine environment.

Overfishing has lead to the demise of many top carnivores. In order to sustain current human population demands, fishing “down food webs” has occurred and consecutively depleted fish species of lower trophic levels (Jackson 2001). During this study, overfishing was evident throughout Dominica as there were no large schools of top carnivores. Instead fish populations were composed primarily of small juvenile herbivores such as parrotfish (pers obs 2007). Hughes *et al.* (2007) has shown that overfishing herbivores had indirect affect on the fecundity, recruitment and survival of coral species in the Great Barrier Reef. It is likely that a similar affect has occurred in Dominica given the current status of the fish population. Due to the decreased populations of adult herbivorous fish, the role of *Diadema antillarum* as a grazer has become important for the control of algal growth (Hughes 1994). Therefore, the health of coral reefs in Dominica may not be as greatly affected by algal growth as the Great Barrier Reef, because the number and density of *D. antillarum* have increased along the West coast (Steiner and Williams 2006a). In Dominica, road expansion and quarrying at multiple locations along the west coast have resulted in landslides which lead to large sediment inputs that run directly into the ocean (pers obs 2007). Sedimentation has resulted in the suffocation of reef organisms and decreased light which was required for photosynthesis (Rogers, 1990). Local sediment inputs have also been shown to result in the burial and erosion of seagrass beds located kilometres away from the source (Pascualini e*t al.* 1999). In addition, construction, infrastructure maintenance, port activity and shoreline development have caused major disturbances to seagrass habitats (Duarte 2002).

An emerging industry in Dominica is tourism, which has primarily focused on the terrestrial environment with a minor emphasis on marine life through SCUBA diving. The dive industry has been slowly expanding over the past twenty years, which has increased interest in marine environments. In addition, the work conducted by the Institute for Tropical Marine Ecology over the past eight years has increased knowledge primarily on environments with coral growth (ITME 2005). However there are still many sections of Dominica’s coast that have yet to be quantitatively assessed. The goal of this study was to conduct a broad scale survey that will identify benthic habitats and their distribution. Here, the total area and size of each habitat was assessed for the first time.

Habitats were mapped across Dominica's West North coast (Figure 1) from Point Crabier north to Capucin and were compared based on attributes of benthic cover. A detailed assessment of benthic composition with respect to macroalgal cover, turf and echinoid densities was also conducted for 11 sites along the West coast ranging from West South to West North. In addition, this study will examine the distribution of burrowing polychaetes (Families Sabellidae and Serpulidae) and determine preference for substrate type.

An important component of conservation involves an extensive knowledge of the environment to determine habitats worth protecting. The information gathered from this survey is aimed at providing decision-makers with a starting point for marine conservation initiatives. The information gathered from this extensive survey will be shared globally via an interactive website. The availability of this resource will aid in spreading awareness of Dominica's marine habitats, provide an avenue for future research and promote conservation of these valuable resources.

Methods and materials

Habitat surveys of were conducted between October and November 2007. The locations chosen for this survey were based on ease of access and therefore some locations were excluded due to steep cliffs or treacherous water conditions. Locations were classified and surveyed as either i) a site or ii) a stretch. In this study, areas examined as "sites" were located throughout the West coast while "stretches" were located only in the West North region (Table 1).

i) Site

Surveyors identified the habitat category and type at each site (Table 2a). Rocky habitats were divided into six types; i) pyroclastic flow - a remnant of hardened volcanic material that moved rapidly into the water column, ii) blocks - large rock components (>10 m in diameter), iii) Rocks - small rock components (<10 m in diameter), iv) Mix - a location that contained both blocks and rocks, v) Consolidated rock - combination of rock and rubble resulting in a solid substrate, and vi) Outcrop - partially submerged rocky land mass extending offshore. Coral reefs were also divided into four types; i) fringing, ii) spur and groove - composed of large ridges and valleys, iii) patch - an isolated reef, and iv) monospecific- a reef with 90 percent cover of one coral species. Seagrass habitats were divided into three types; i) monospecific - a seagrass bed which had 90% coverage of one species, ii) mixed - multiple species intermixed within a seagrass bed with no single species contributing to more 90% of total coverage, and iii) variegated - two species of seagrass not intermixed with patches of the bed containing one species, which excluded the other with greater than 90% cover. Depth of the habitat, habitat percent cover and complexity of each site were also recorded (Table 2a). Complexity was rated as follows, 1 - flat substrate, 2 - substrate rugosity was low, giving a general uneven appearance, and 3 - substrate rugosity was high, resulting in a very complex appearance (i.e. containing caves and/or overhangs). Complexity ratings were adapted from Bass and Miller (1996). Data was recorded at each site by surveyors who swam with snorkel gear along the habitat (in a few cases SCUBA was required) from haphazardly chosen starting points. Each swim took 10-20 minutes to be completed and covered most of the available surface of the habitat. During the swim surveyors examined 8 biological benthic attributes (Table 2b) and ranked their percent cover using an ordinal ranking scale (Table 2c). The ranking scale was divided with more ranks for low coverage because the majority of Dominica's marine habitats and benthic attributes had very low coverage (see ITME 2005). After the swim was completed, forty-eight $1/4m^2$ quadrats were placed in lines on the most representative aspect of the habitat and placed no less than ½ m apart. This gave a total area surveyed of $12\ m^2$ for each site. Percent cover was ranked for 12 predetermined benthic attributes present in the quadrat and was estimated to the nearest 5% (Table 2d). Species that had less than 5% coverage were documented as present (P). Coral recruits (< 2cm diameter) were identified to species when possible, and burrowing polychaete families and the substrate they burrowed into were also recorded.

ii) Stretch

A location was considered a stretch if the location was a band "stretching" along the coast. Stretches ranged from 0.8 to 3.6 km and were 0.2 to 1 km wide. A single stretch often contained multiple habitats and duration of the stretch depended on the distance covered. Habitat category and type, depth, habitat percent cover and complexity were recorded for each habitat encountered within the stretch (Table 2a). Surveyors spread out across the habitat, ensuring the majority of the habitat was observed. The 8 predetermined biological benthic attributes were ranked as in the initial swim of site survey (Table 2b and c). Each habitat encountered receives a separate ranking for the biological attributes. Surveyors recorded the amount of time spent surveying each habitat. Data from all participating surveyors was compiled per stretch and rankings of benthic composition were compared between surveyors. A consensus was made about the rankings and the information was compiled to one final data set for each stretch.

Six surveyors took part in 16 hours of consistency training that ensured proper field identification and consistent data interpretation. Field identification of species was based on references from Humann (2006), Littler and Littler (2000) and Littler *et al.* (1989). The survey methods for this paper were adapted from DeVantier *et al.* (1998).

Data Analysis

Approximate areas of the surveyed locations, including individual habitat areas were noted in the field and then habitats compared using internet satellite imaging using Google Earth v. 4.0.2737 (Google). The total area of the West North coast was calculated using Google Earth to determine the length of the coast (21.5 km) and then multiplied this length by the average distance surveyed off shore (115 m) (Table 3).

Algal cover, echinoid and poychaete abundance were summed for each site and then divided by the total area surveyed (m^2). Polychaete density per substrate was calculated by dividing the number of polychaetes found on each substrate by the total area of each substrate (m^2). The values for *D. antillarum* abundance and turf cover per m^2 were log transformed and a Wilcoxon Signed Rank (Nonparametric) test was conducted using StatView v.5.0.1 (SAS).

Similarity among sites and stretches based on benthic composition were determined with the Bray Curtis similarity cluster analysis. All calculations were preformed in Primer v5.2.4 (Clarke and Gorley 2001).

Results

Area of surveyed habitat categories and sites

The area surveyed of the West North coast of Dominica was 1.94 km^2 (Fig. 1). Benthic environments in this region were composed of primarily of seagrasses (1.21 km^2) and rocky habitats (0.70 km^2). Coral reef environments covered 0.03 km^2 and the remaining 0.53 km^2 of this region were not surveyed (Fig. 2a). Seagrasses dominated the West North coast with 62.4% of total cover (Fig 2b) and the largest seagrass beds were composed of either variegated *Syringodium filiforme* and *Halophila stipulacea* beds (0.55 km^2) or monospecific *S. filiforme* beds (0.50 km^2) (Fig. 3). Rock (0.33 km^2) and mixed rock and consolidated rock (0.22 km^2) were the largest contributors to rocky habitats which formed 36.1% of the total cover.

Similarities between surveyed habitat types based on benthic composition

Benthic composition within each habitat category regardless of geographic location was 85% similar (Fig. 4). The similarities of seagrasses (**A**) ranged from 85% to 95%. Variegated seagrass beds (**A1**) and monospecific *S. filiforme* seagrass beds (**A2**) had identical attributes within their respective clades. High turf cover (26-75%) and the absence of *Millepora sp*. and anthozoans resulted in 95% similarity of both patch reefs (**D**). The largest variation in benthic composition occurred within rocky habitats (**B**). Low cover (0-5%) of macroalgae, anthozoans and *Millepora sp.* and an average turf cover of 26-50% resulted in more than 90% similarity between five rocky rock habitats (**B1**). The overall low coverage (< 5%) of macroalgae, *Porolithon sp*., sponges, *Millepora sp*., anthozoans, and scleractinia grouped a rocky outcrop and a mixed rocky habitat with 90% similarity (**B2**). The absence of macroalgae, low sponge cover (1-5%) and moderate coverage of *Porolithon sp*. (average of 11-25%) resulted in more than 90% similarity between rocky rock, consolidated rock and rocky block habitats (**B3**). Moderate coverage (average of 11-25%) of both turf and sponges and 6-10% scleractinian cover grouped rocky consolidated, rocky mixed and rocky rock habitats with more than 85% similarity (**B4**). Sand habitats (**C**) were not found in the West North region.

Algal cover

Algal abundance varied across the 11 sites with the lowest species richness (3) identified at Anse Liane seagrass and highest species richness (9) was at Toucari Bay (Table 4). *Porolithon sp.* was present at 9 of 11 sites and had the greatest benthic cover (21.59 m^2 of total area surveyed). *Dictyota spp*. were identified at all sites, however its combined cover for all sites was low (0.53 m^2). *Galaxaura sp.* was identified at 10 sites and had a combined cover of 0.03 m^2, whereas *Halimeda spp.* were identified at only 4 sites and had a higher overall cover (0.05 m^2). Phaeophyta and Rhodophyta species were the most frequent across all sites (Table 4). The total algal cover varied between sites and was highest at Barry's Dream where 4% (0.39 m^2) of the total area was covered by algae (Fig. 5).

Cover of turf algae and Diadema antillarum abundance

Turf algae cover varied from 0 to 4.48 m^2 of the 11 surveyed sites (Fig.6). Toucari Bay had the highest echinoid species richness (4) and the herbivorous *Diadema antillarum* was the most abundant echinoid at each site (Fig. 7). *D. antillarum* abundance was inversely related to turf cover turf (Wilcoxon Signed Rank test Z = -2.52, P<0.05). Sites that had a high density of *D. antillarum* (>2/m^2) had less turf cover and sites with low density of *D. antillarum* (<2/m^2) had more turf cover per m^2 (Fig. 6).

Polychaete distribution and preference for substrate

The distribution of burrowing polychaetes varied between sites for both Sabellidae and Serpulidae. The most common species identified across all sites were *Sabellastarte magnifica*, *Bispira brunnea* and *Spirobranchus giganteus*. Thirty nine percent of the total Serpulidae identified were found at Champagne. Sabellidae polychaetes were the most abundant at all sites, 36% of which were located at Rodney's Rock (Fig. 8). Assessment of Sabellidae preference for substrate type determined low densities (generally 1-3 individuals per m^2) on 10 of the 12 substrates, resulting in no definitive preference for a particular substrate. Substrate preference was evident for Serpulidae which had high densities on the scleractinians *M. annularis* (53 individuals per m^2) and *P. astreoides* (11 individuals per m^2) and low densities on other substrates.

Discussion

Area of surveyed habitat categories and sites

The West North region contains two large bays, Prince Rupert and Douglas Bay where the narrow shelf increases to 450 m and 1400 m in width respectively (Imray *et al.*1995). The wider shelves in these bays have large sandy areas that are well protected and ideal for seagrass beds. Seagrass beds play a pivotal role in the marine environment through provision of food and oxygen to the surrounding area, sediment stabilization, wave attenuation and shoreline protection (Duarte 2002). Seagrasses are also recognized as being one of the main nursery habitats for juvenile reef fishes (Nagelkerken *et al.* 2000; Duarte 2002). The greater cover of variegated seagrass beds compared to monospecific *Syringodium filiforme* beds (Fig 3) is due to the high density of the invasive species *Halophila stipulacea* (Ruiz and Ballantine 2004). This invasive species was present in various patches (2 - >125 m in diameter) and contributed to 20-25% of the total seagrass bed cover. These patches often occurred along the deeper edges of the seagrass bed (pers obs 2007). With a high growth rate (4-12 days for new leaves to be produced) (Wahbeh 1984), *H. stipulacea* has the potential to quickly expand laterally. The arrival of the invasive is most likely a result of being transported via ballast water (Di Martino *et al.* 2006) or transportation on anchors (Ruiz and Ballantine 2004) from ships which frequent Prince Rupert and Douglas Bays. This is a cause for concern as native Caribbean seagrass beds are home to many economically important fish species (Nagelkerken *et al.* 2000) and should be protected. High boat traffic in these bays also causes physical damage to the seagrass beds through anchors and trash accumulation. Anchor placement on seagrasses uproot portions of the bed resulting in large blowouts (Creed *et al.* 1999; pers obs 2007). Trash that has been tossed overboard gets trapped in the seagrass bed (pers obs 2007), which ultimately lead to habitat loss. Implementation of legislations which reduce the mobility of invasive species, enforcement of proper mooring line use and increased waste management would aid in preventing further damage to this valuable ecosystem.

Similarities between surveyed habitat types based on benthic composition

Eighty percent of the benthic composition of all seagrass beds were assigned a rank of 1 (0%) for the predetermined biological attributes (Fig 4). The only distinct difference across the different seagrass habitat types was the density of the seagrass itself. It is for this reason that all seagrasses were more than 85% similar to each other. The largest variation in benthos was found in the rocky category, and unlike seagrasses, rocky habitat types did not group together. This could be a result of grouping rock into six different habitat types, all of which had the same the rock substrate. These rocky habitat types were scattered at various location throughout the West North region and provided another substrate for scleractinians, sponges and other anthozoans to attach and grow. These habitats are not coral reefs, but do contain reef-like attributes in terms of benthic composition. Patch reefs were present in the West North but provided a minor contribution to overall coverage (0.03 km^2). The absence of large coral reefs in this region only emphasizes the importance of each rocky habitat as a unique and highly diverse location harbouring many reef organisms. The increased coastal activity, specifically road expansions and quarrying in Dominica threaten these environments primarily by increasing sediment inputs.

Algal cover

The high cover of *Porolithon sp*. compared to all other algae is explained by the encrusting nature of this rhodophyte (Table 4). *Porolithon sp*. plays a pivotal role as a reef builder and acts like cement that holds the structure together and protects the reef from physical destruction (Humann 2006). This “cement” can expand across entire reefs covering a large area where as other macroalgae such as *Dictyota sp*. grows in small clusters ranging from 10 to 45 cm (Humann 2006). The high macroalgal cover at Barry’s Dream reef may reflect the overfishing of herbivorous fish. Lower populations of grazers cannot control algal growth effectively. This is a cause for concern as this reef is often frequented by SCUBA divers. Increased cover of algae reduces the space for coral recruits and overall reduces coral survival (Hughes *et al.* 2007). In addition, there is less area for other reef organisms to attach and grow. In order to sustain the dive industry and marine tourism in Dominica, additional marine reserves could be created to protect the current low populations of herbivorous fish. Furthermore, enforcement of the reduced daily catch limits of fisherman would help reduce the loss of adult fishes. These adults can reproduce and overtime lead to an increase in grazing fish populations. These fish will control algal growth and improve reef health, ultimately increasing the quality and attractiveness of Dominica’s coral environments for divers.

Cover of turf algae and Diadema antillarum abundance

High turf (16-19% of total cover of all sites) cover at the two deeper sites, Barry’s Dream (depth 15-17 m) and Lauro Reef (depth10-30 m) corresponds to the lowest densities of *Diadema antillarum* (Figure 6). The reduction of herbivorous fish and the high algal cover demonstrates the important role of *D. antillarum* play as a grazer (Hughes 1994). This is evident in Dominica, where *D. antillarum* densities have increased since 2001 (Steiner and Williams 2006a). It is not surprising that *D. antillarum* was the most abundant echinoid at all sites due to the absence of large predatory fish (Steiner and Williams 2006b). The results of this study are consistent with the work done by Steiner and Williams (2006a, b) where *D. antillarum* controlled turf algal growth and ultimately contributed to reef health. Therefore, protection of these species should be considered in terms of coastal development and construction. Destruction of *D. antillarum* habitats could have devastating effects on Dominica’s coral reef and rocky habitats.

Polychaete distribution and preference for substrate

This higher abundance of Sabellidae is due to the colonial species *Bispiria brunnea*, which typically grows in clusters compared to the Serpulidae *Spirobranchus giganteus* which were often solitary (Humann 2006). High densities of serpulid polychaetes on *M. annularis* and *P. astreoides* (Fig 9) suggest that these polychaetes are specialists in terms of substrate preference. This concept of specializations of serpulids is demonstrated by the mutualistic relationship that occurs between *Spirobranchus giganteus* and large *Porites* colonies. This relationship provides protection for the polychaete, which in return physically protects the polyps of *Porites* from predation by *Acanthaster planci* (DeVantier, Reichelt and Bradbury 1986). The lower densities of sabellid polychaetes across a variety of substrates suggests that these polychaetes are generalists or perhaps less competitive, thus do not specifically prefer one substrate over another. The role of some burrowing polychaetes has been shown to help preserve the survival of large reef building corals (DeVantier, Reichelt and Bradbury 1986). This aspect makes these organisms important for potentially restoring reef health.

Conclusions

This broad scale survey of the benthic habitats of the West North coast of Dominica provides preliminary findings of the size and distribution of these habitats. Seagrass habitats dominated the region with variegated beds contributing to the largest area of all seagrasses. Rocky habitats comprised the second largest area. Knowing the location and composition of these habitats will provide guidance in ascertaining further environmental degradation and determining the source of its causative disturbances. In addition, this information allows the development of measures which can counter the current trend. Decision-makers now have a point of reference which can be used to implement conservation initiatives to the areas worth protecting.

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Table 1 List of surveyed locations and date surveyed listed from South to North a) Stretches for the North West region b) Sites at various locations along the West coast (* depicts sites surveyed using SCUBA).

a)

Date	Stretch Name
23/10/2007	Bioche to Espagnol Bay
23/10/2007	Espagnol Bay to Ti Bay
31/10/2007	Ti Bay to Lamoins River
01/11/2007	Cabrits South to Douglas Bay
01/11/2007	Douglas Bay to Toucari Bay
08/10/2007	Toucari to Capucin

b)

Date	Stretch Name
22/10/2007	Champagne
02/11/2007	Fond Cole
20/10/2007	Rodney's Rock
30/10/2007	Barry's Dream*
30/10/2007	Easy Street*
29/10/2007	Lauro Reef*
29/10/2007	Floral Gardens*
17/10/2007	Anse Liane-seagrass
17/10/2007	Anse Liane –rocky
09/10/2007	Espagnol Bay
01/11/2007	Toucari Bay

Table 2 Method sheet used in this survey: **a** habitat classification **b** 8 predetermined biological attributes **c** ordinal ranks of percentage cover, **d** 12 predetermined site attributes used for quadrats

a Habitat Classification		**b** Attributes	**c** Cover		**d** Site Attributes (Quadrats)
Habitat Category	**Habitat Type**	**Biological**	**Rank**	**Coverage**	**Biological Attributes**
Rocky	i) Pyroclastic flow	Macroalgae	1	None recorded	Macroalgae
	ii) Blocks			Present (p)	
	iii) Rocks	*Porolithon*	P	<5%	Turf algae
	iv) Mix				
	v) Consolidated Rock	Turf algae	2	1-5%	*Porolithon*
	vi) Outcrop	Seagrass	3	6-10%	Seagrass
Sand	i) Black	Sponges	4	11-25%	Sponges
	ii) White	Anthozoa	5	26-50%	Anthozoa
Seagrass	i) Monospecific	*Millepora*	6	51-75%	*Millepora*
	ii) Mix				
	iii) Variegated	Sceractinia	7	76-100%	Sceractinia
Coral Reef	i) Fringing				Dead coral
	ii) Spur and groove				Coral Recruits
	iii) Patch				Urchins
	iv) Monospecific				Polychaete
Habitat % cover					Other
Depth					
Complexity					

[redacted]

Table 4 Abundance of algal species per site, (●) represents algae species with a cover greater than 0.001% per m^2 and (○) represents algae species with a cover less than 0.001% per m^2. Phyla listed for each species; (C) Chlorophyta, (P) Phaeophyta (R) Rhodophyta.

Algal Species	Champagne	Fond Cole	Rodney's Rock	Barry's Dream *	Easy Street *	Lauro Reef *	Floral Gardens *	Anse Liane Seagrass	Anse Liane Rocky	Espagnol Bay	Toucari Bay
Caulerpa sp.(C)										○	○
Halimeda sp. (C)				●	○			○			●
Penicillus sp. (C)					○						
Dictyosphaeria cavernosa (C)		○							○	○	○
Valonia sp. (C)	○		○								○
Ventricaria ventricosa (C)	○	○	○	○		○			○	○	○
Dictyota sp. (P)	○	○	○	●	○	○	●	○	○	●	●
Liagora sp.(R)	○	○			○		○		○	○	○
Galaxaura sp. (R)	○	●	○	○	○		○	○	●	○	●
Porolithon sp. (R)	●	●	●	●		●	●		●	●	●

(* depicts sites surveyed using SCUBA)

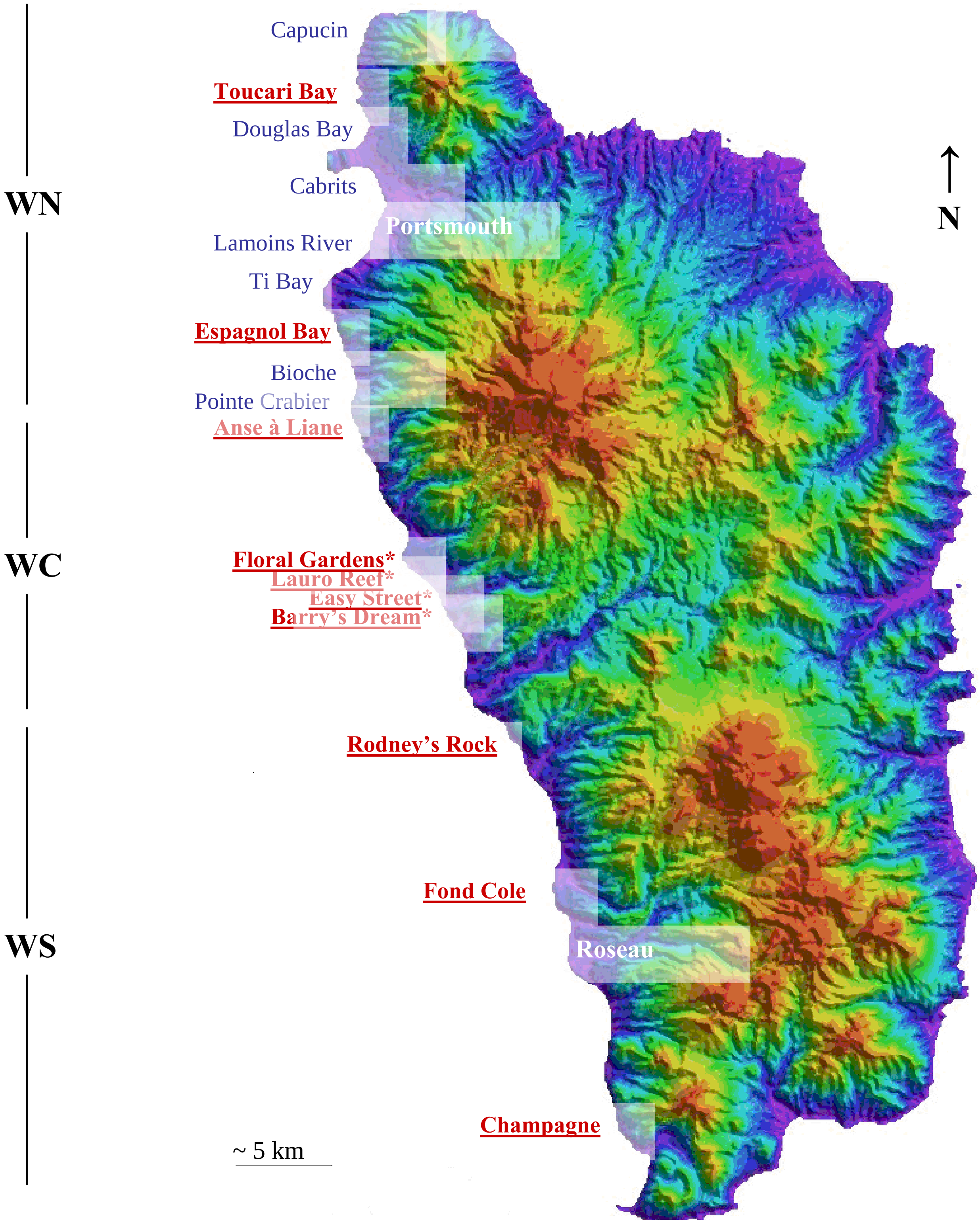

Fig. 1 Map of Dominica depicting stretches along the North West (NW) region and sites various locations along the West coast (WC-West Central region WS-West South region). Large cities, Roseau and Portsmouth noted for reference. Sites are listed in bold and underlined font, an * represents sites surveyed using SCUBA. Adapted from ICF Stewart

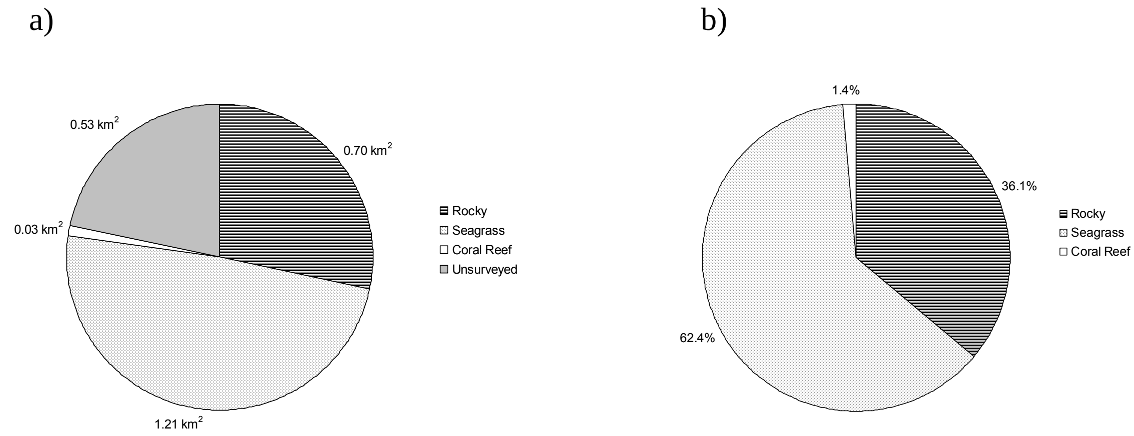

Fig. 2 Habitat categories (rock, seagrass, coral reef and sand) of the North West coast of Dominica a) Total area of each habitat including unsurveyed regions b) Total percent cover of each surveyed habitat.

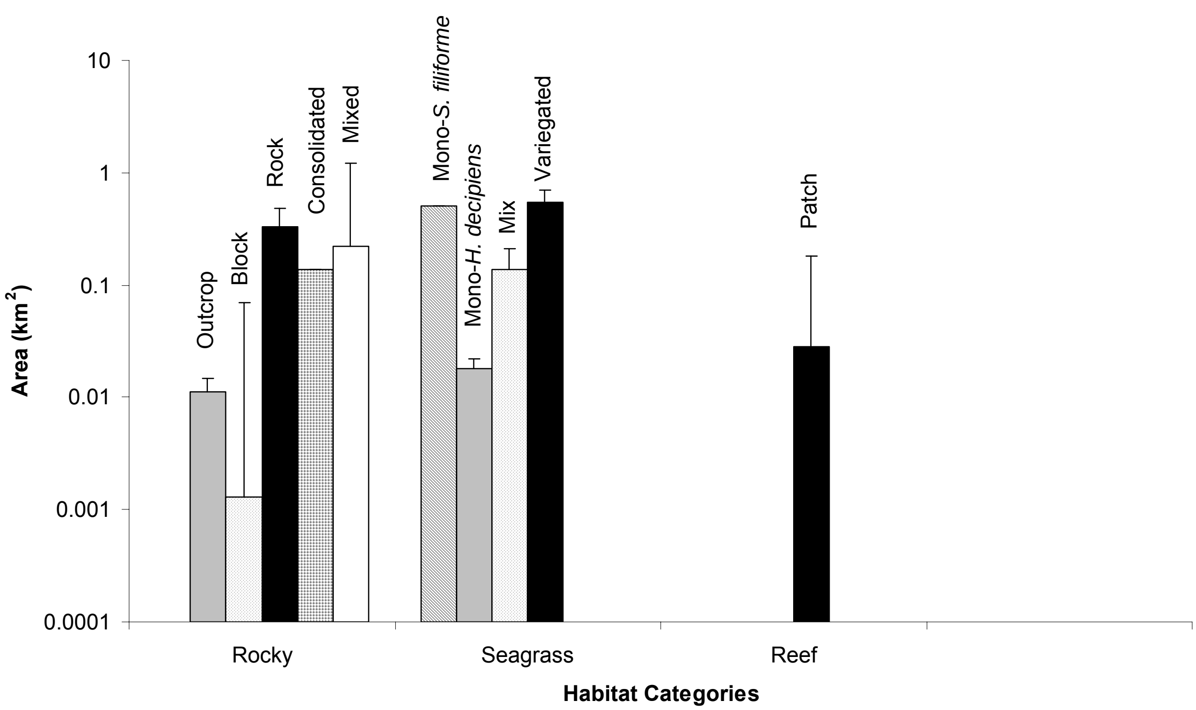

Fig. 3 Total area (km^2) ± S.E. of each habitat type per habitat category for North West coast of Dominica illustrating dominant coverage by seagrass and rocky habitat categories.

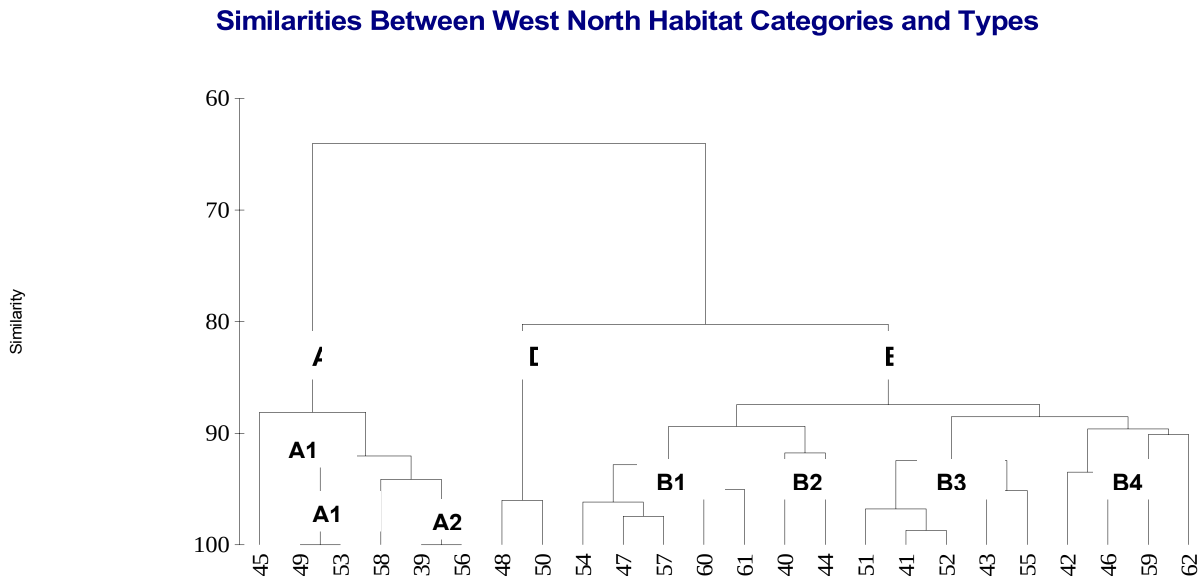

Fig. 4 Dendrogram illustrating similarity of benthic composition within habitat categories. Categories are as follows, Seagrasses (**A**), Rocky habitats (**B**) and Coral reefs (**D**). *Note: sand habitats (**C**) are not present in this region.*

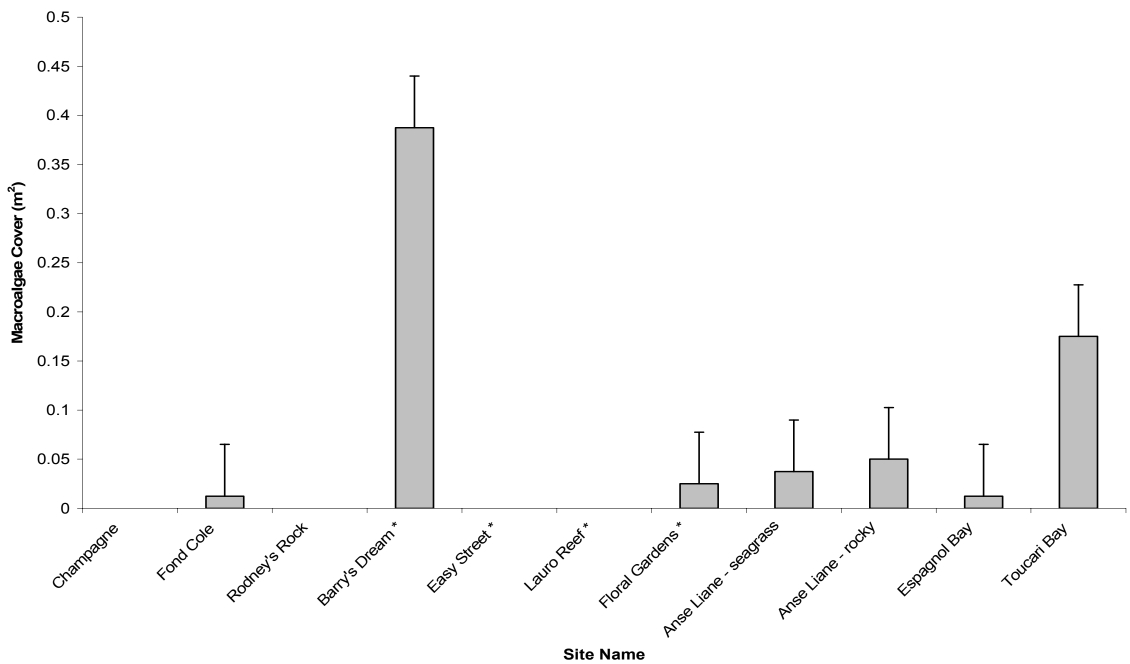

Fig. 5 Total algal cover (m^2) ± S.E. for each of the 11 surveyed sites, an * represents sites surveyed using SCUBA.

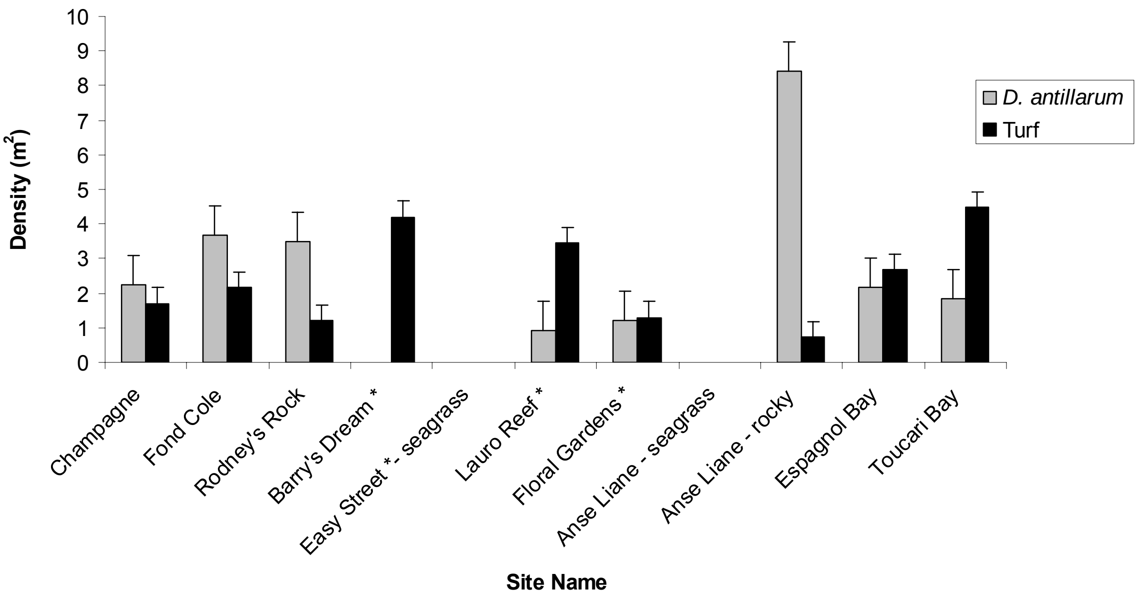

Fig. 6 Turf algae cover (m^2) compared to *Diadema antillarum* density (m^2) ± S.E. per site. An * represents sites surveyed using SCUBA.

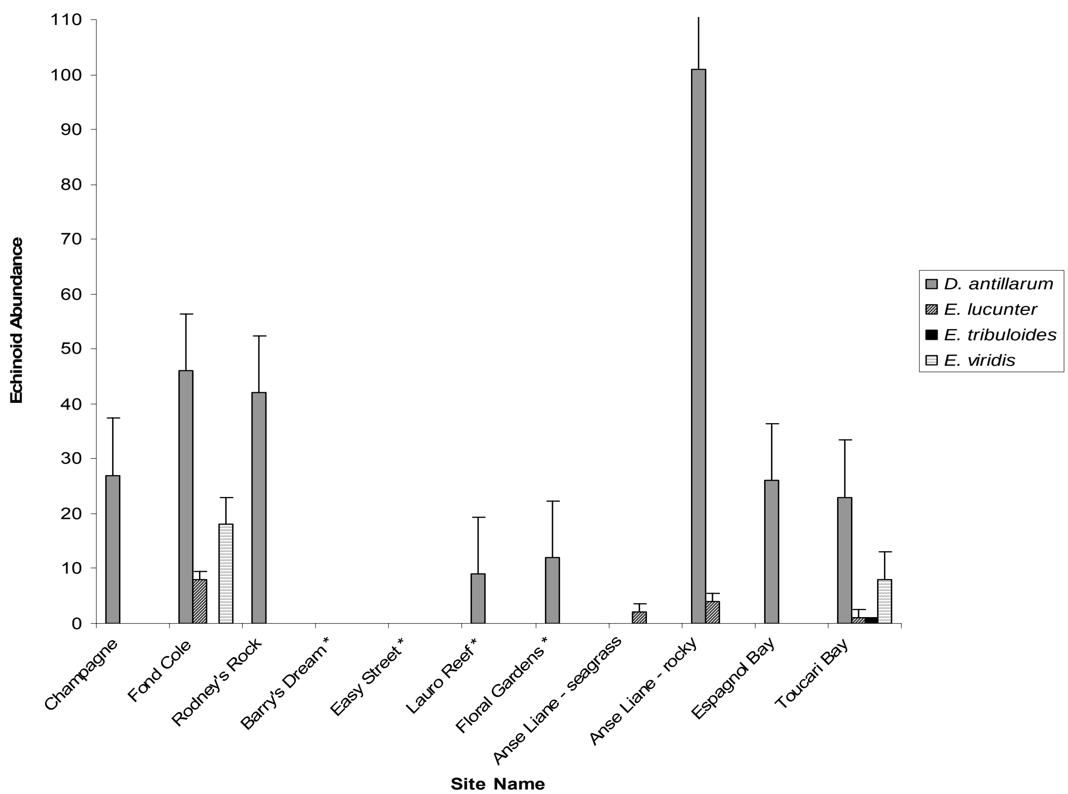

Fig. 7 The abundance of echinoids (*Diadema antillarum, Echinometra lucunter, Eucidaris tribuloides* and *Echinometra viridis*) ± S.E. at 11 surveyed sites. An * represents sites surveyed using SCUBA.

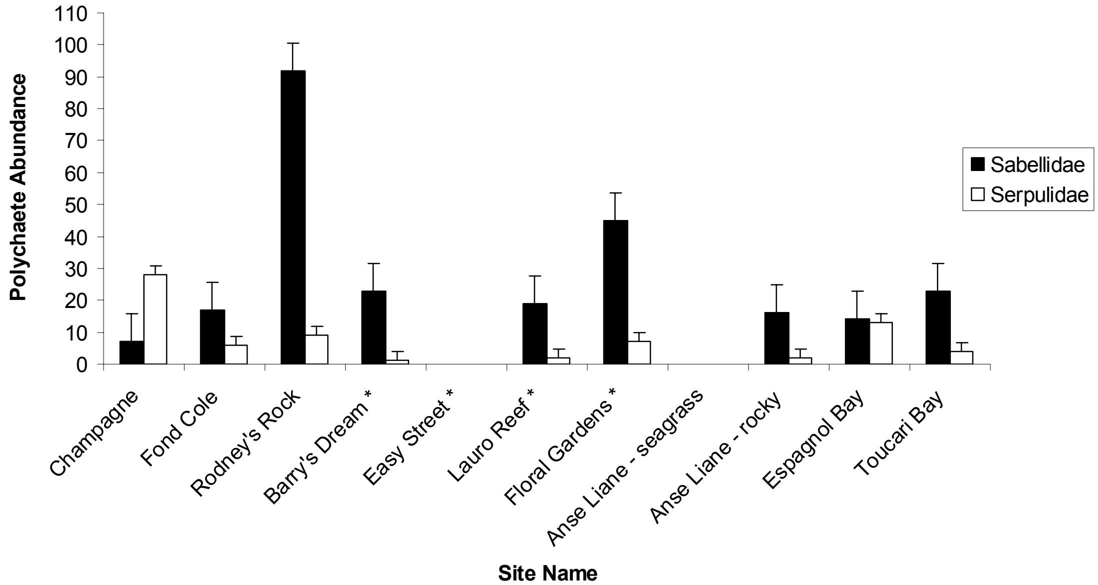

Fig. 8

Abundance of Sabellidae and Serpullidae polychaetes ± S.E. for 11 surveyed sites. Sites surveyed using SCUBA are depicted with *.

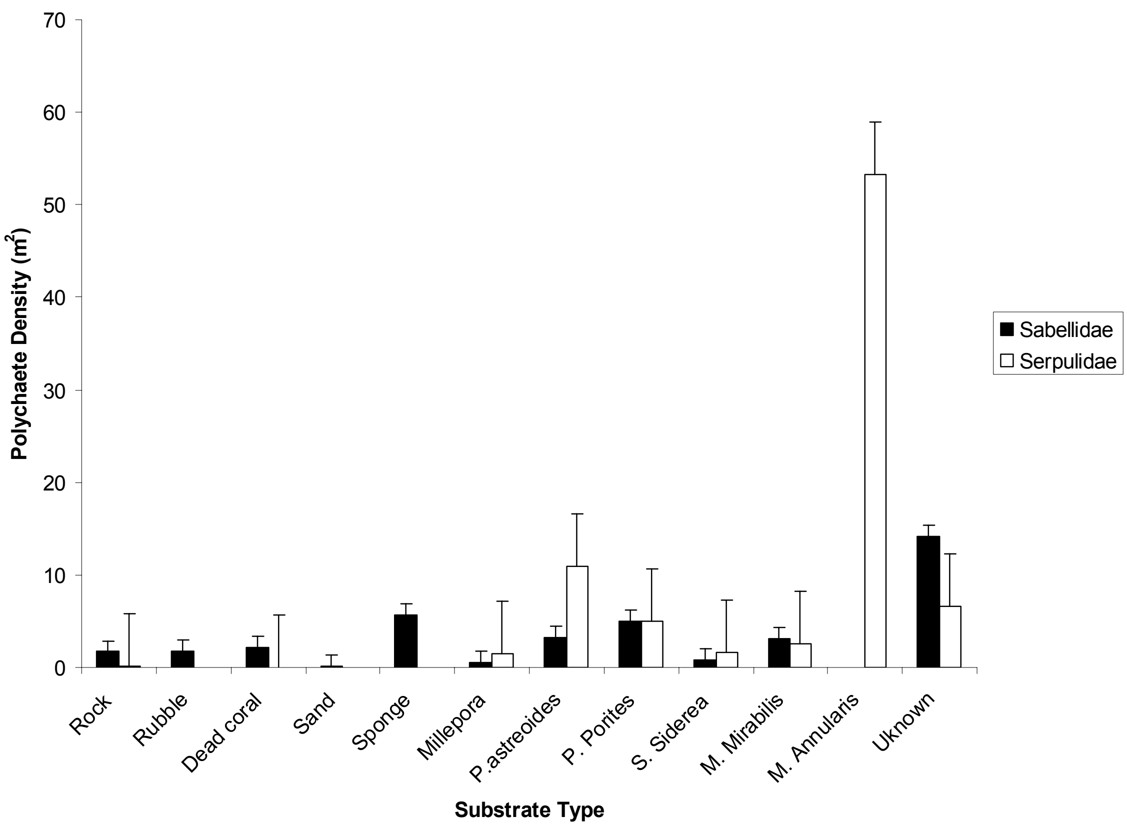

Fig. 9 Density (m^2) of Sabellidae and Serpulidae polychaetes per substrate ± S.E for all surveyed sites.