Habitat Surveys of the Frederiksted Reef System of Western St. Croix with Observations on Cross-Shelf Distribution Patterns of Fishes

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SUMMARY

Coral reefs and inshore areas that comprise the Frederiksted Reef System of western St. Croix, U.S. Virgin Islands, are threatened by a number of anthropogenic impacts. This reef system has previously received little study. Without baseline information it is difficult to assess changes in fish and benthic communities that may result from anthropogenic activities. The objective of this study was to gather descriptive information on the cross-shelf distribution of hard bottom habitats and to examine differences in associated fish assemblages.

Along inshore-offshore transects, divers identified four distinct habitat zones: intertidal and shallow subtidal (zone I), inshore low relief (zone II), patch or transitional reef (zone III) and reef crest (zone IV). Fishes were surveyed within each of the four zones using a Roving Diver Survey (RDS) methodology to determine relative abundance, sighting frequency, and species composition of assemblages. Results from comparisons among zones indicate that fish assemblage structure changes markedly across the shelf. Average species richness was significantly different among zones and increased with depth and distance from shore. Cumulative species richness generally increased with depth and distance from shore and was highest in zone IV. More species were observed in zone II than zone III. Assemblage composition also differed substantially among zones and the cross-shelf distribution pattern was highly variable. It is suggested that for some species these cross-shelf distribution patterns are indicative of important fish-habitat associations occurring within the Frederiksted Reef system.

INTRODUCTION

Coral reefs are productive, dynamic, and fragile ecosystems which provide food and numerous other resources of nearly inestimable value to over 100 countries from tropical regions (Birkeland 1997). Globally, concern has grown regarding the health and continued productivity of coral reef ecosystems in the face of anthropogenic impacts (Wilkinson 2000). In the United States Virgin Islands, (USVI), coral reefs are threatened by a number of human activities (Catanzaro et al. 2002). Among these, the physical destruction of coral reefs by ship groundings and anchoring is a considered a high priority threat (Evans et al. 2002). Some USVI reefs that have been obliterated by anchoring show no signs of recovery after more than a decade (Rogers and Garrison 2001), suggesting that habitat destruction from anchoring is long term if not permanent.

An extensive but poorly studied coral reef occurs in the coastal waters of western St. Croix, USVI, along the seaward margin of the insular shelf near the port city of Frederiksted (Fig. 1). In this report, the coral reef is called the Frederiksted Reef while the reef plus adjacent nearshore habitats are collectively termed the Frederiksted Reef System. In 1994, two anchorage areas were designated on the Frederiksted Reef System to accommodate large commercial vessel traffic from the Frederiksted pier facility. Although the anchorages encompass large areas of the Frederiksted Reef, little study was devoted to potential habitat impacts of anchoring upon this reef.

The Division of Fish and Wildlife (DFW) initiated a study of anchoring impacts to reef habitats of western St. Croix. A separate report presents results from that study (see Toller 2005). Because previous descriptions of the Frederiksted Reef System were incomplete and the spatial extent of damage was unknown, DFW conducted additional mapping of hard-bottom habitats and surveys of associated fish assemblages in order to provide a context within which to evaluate the magnitude of anchoring impacts. This report presents a brief review of available literature relating to marine habitats of the Frederiksted Reef System together with results from additional habitat mapping studies and surveys of fish communities.

Previous Research on Western St. Croix

A substantial amount of marine research was conducted on St. Croix during the 1970's and 1980's which contributed greatly to our knowledge of structure and function in coral reef ecosystems. Researchers generally worked from one of two St. Croix facilities: the West Indies Laboratory located at Teague Bay on the eastern end of the island (e.g. Hubbard 1989a) or from the Hydrolab facility at Salt River Canyon on the north-central coast (see Kendall et al. 2005). However, facility location appears to have restricted the geographic scope of studies to the northern and eastern parts of St. Croix such that the reefs of western St. Croix were rarely investigated. Those few existing scientific accounts of western St. Croix are identified where appropriate in the discussion below.

Some detailed information on the marine environment of western St. Croix comes from reports prepared for the United States Navy. The Navy's Atlantic Fleet Weapons Training Facility

(AFWTF) maintained an underwater tracking range (UTR) off western St. Croix with its command center located at Estate Sprat Hall. The UTR occupied an offshore area of approximately 51.4 km^2 in water depths of 457 to 1280 meters (Burns 1977). An inshore area (area "A") was also reserved for use by the Navy (Presidential Proclamation No. 4347, eff. Feb. 1, 1975). Anchoring was prohibited in the triangular area seaward of Sprat Hall between 17°44'42"N, 64°54'18"W; 17°43'06"N, 64°54'18"W; and 17°44'30"N, 64°53'30"W (p.82, U.S. Department of Commerce 1983). Area "A" incorporates a substantial segment of the northern extension of the Frederiksted Reef. AFWTF operated the St. Croix UTR facility until its close in 2003. During facility development, installation and operation the Navy sponsored a number of geological, oceanographic, and meteorological studies of western St. Croix to better characterize the physical marine environment. Some of these reports were available to the author. They emphasized factors relating to UTR hydroacoustic operations such as water column stratification, current flow, prevailing weather patterns, and seafloor mapping.

The gray literature provides another source of information for descriptions of the Frederiksted Reef System. Coastal development is the focal theme of this body of information which includes environmental impact reports, governmental planning documents, and other unpublished materials. A number of these reports relate to construction of the Anne E. Abramson Pier Facility (hereafter called the Frederiksted pier) or its reconstruction following damages caused by hurricane Hugo in 1989. The Frederiksted pier is owned and operated by the U.S. Virgin Islands Port Authority and it is presently the only St. Croix facility that can accommodate large cruise ships. Expansion of cruise ship tourism has been considered vital for the economic development of Frederiksted (USVI Government 1977, IRF 1993b).

Physical Setting

The oceanography of western St. Croix has received some study. Early investigations identified water column stratification for temperature and salinity and noted seasonal variations (Ridley et al. 1963). Burns (1977) elaborated upon and synthesized results from previous oceanographic studies for western St. Croix. Burns also presented a summary of meteorological information as it related to the UTR. The Frederiksted Reef System would fall entirely within the "fetch-limited area" of western St. Croix (see Fig.1 in Burns 1977).

Harlan et al. (2002) used high frequency radar-derived surface current measurements to examine flow in waters off northwestern St. Croix. Harlan et al. were unable to demonstrate the existence of an attached meso-scale eddy but they found that prevailing ocean currents from the southeast generated an island wake which formed near Hams Bluff. The island wake gave rise to a persistent convergent zone. Periods of onshore movement of this convergence zone were correlated with bouts of elevated reef fish recruitment (Swearer 2000; also see below).

Despite a number of excellent geological studies of St. Croix in general (e.g. Whetten 1966) and St. Croix coral reefs in particular (see references in Hubbard 1989), there have apparently been no detailed investigations of coral reefs of western St. Croix. Two geological studies which examined areas adjacent to the Frederiksted Reef System (one offshore, the other inshore) are discussed below.

Holcombe et al. (1977) provided detailed bathymetric maps and geological information on the Frederiksted Plateau which lies west of the island slope of western St. Croix in depths of 800 to 1800 m. The small plateau is dissected by three major submarine canyons (Frederiksted, Shephard, and Sprat Hall Canyons). They reported that the island slope which separates St. Croix from the Frederiksted Plateau is a steep scarp with a slope of 5-30°, itself dissected by numerous smaller canyons. In the same report, Holcombe et al. (1977) also presented photographs taken from the deep sea research vessel *Alvin* which illustrated the variation in seafloor topography of the Frederiksted Plateau and provided a rare glimpse of the biological community found there.

The stratigraphy and lithology of the west end terrace system was studied by Hubbard et al. (1989). This "subaerial" (at and above present sea level) carbonate terrace platform extends intermittently along the western shoreline of St. Croix. They estimated that the terrace is approximately 125,000 years old. Fossil materials that they found in the terrace were assigned to extant taxa of scleractinian corals (e.g. *Acropora cervicornis*, *Montastraea annularis*, *Porites astreoides*) or mollusks (*Strombus* sp., *Cittarium* sp.). Hubbard et al. also examined two cores from shallow water "hardgrounds" (< 5 m depth) north of Butler Bay and concluded that the former Pleistocene reef community was better developed than the "sparse benthic community" presently found there.

Previous Habitat Descriptions

Available habitat descriptions for the Frederiksted Reef System are relatively rare. As illustrated by the examples below, separate reports may present very different, even contradictory descriptions of nearshore marine habitats that occur off western St. Croix.

Hubbard (1989a) gave an overview of St. Croix reef types surrounding the island to the east, north, and south. Surprisingly, though, he failed to mention nearshore marine habitats from western St. Croix. Hubbard's description of reef types did include northwestern St. Croix near Hams Bluff (Fig. 1) where he noted that "the shelf is very narrow, and no emergent barrier reefs occur." He stated that the benthic communities there are "widely varied and often quite luxuriant," but are dominated by large basket sponges. Hubbard's account does not appear to apply to the Frederiksted Reef System (see below) and he may well have been unaware of its existence.

Adey et al. (1977) presented brief accounts of seven St. Croix reefs and reef communities which included a western site located at Estate Northside (Fig. 1). Their description included a schematic drawing of reef community profile across depth which resembled that of Hubbard's (above) in terms of the principle zones and faunal characteristics. Adey et al. listed common corals (including *Acropora palmata*), sponges, and other benthic invertebrates encountered on an "eroded carbonate pavement." They reported that the carbonate platform extended from shore 50-100 m seaward to a depth of 8 m, after which occurred a sand halo zone and grass bed comprised of *Syringodium*.

Goenaga and Boulon (1992) described the western insular shelf as "a sand plain with scattered inshore areas of raised pavement supporting communities of hard corals mixed with gorgonians and sponges." These authors stated that "North and west of the Frederiksted pier are scattered patches of corals dominated by *M. annularis*," but concluded that "the shelf edge reef system starts off Butler Bay and extends north towards Hams Bluff." Boulon and Griffin (1999) presented habitat distribution maps for five types of coastal marine ecosystems. They identified areas of seagrass and sand beaches off of western St. Croix but did not note the presence of any coral reefs.

The St. Croix Coral Reef System Areas of Particular Concern (APC) Management Plan (IRF 1993a) was formulated by the USVI Government Planning Office. The delineation of the coral reef APC boundaries encompassed only reefs to the north, northeast, and southeast of the island. These reefs were selected for inclusion in the APC because they were considered among the "best developed reef systems in the Caribbean" with "significant ecological, economic, aesthetic, and recreational values" (IRF 1993a). The authors of the APC Management Plan acknowledged the existence of a "largely monotypic [*Montastraea annularis*] reef system along the coast from Frederiksted north to Sprat Hole." They also noted that the reef had been damaged by anchoring of large vessels (p.1, IRF 1993a). However, the authors did not include the Frederiksted Reef System within the coral reef APC and they did not discuss the reef further in their document.

The Frederiksted Waterfront was identified as an APC in 1979 by the USVI Government Planning Office (IRF 1993b). Authors of the Frederiksted Waterfront Management Plan mentioned that a "rich coral community offshore provides excellent snorkeling and diving." The scope of their description of marine habitats was restricted to waters directly offshore of Frederiksted, within about 0.5 km of the Frederiksted Pier. A habitat map, adapted from BioImpact (1989), was provided which identified a "deep reef system" located offshore from the pier [Coulston and Tonnemacher (1991) presented a similar habitat map which identified a larger "coral community" north of the pier]. The authors of the Management Plan also made passing mention (p.15) of a proposal to establish anchorage areas near the pier which could thereby restrict the spatial extent of damage caused by anchoring. Notwithstanding the limited scope of habitat descriptions in the Frederiksted Waterfront Management Plan, this plan presents what may be the best existing summary of threats to the Frederiksted Reef System. Most of the identified threats are still relevant more than a decade later.

The CFMC (2004) was apparently the first to apply the name "Frederiksted Reef System" to the reef tract which occurs off of western St. Croix. These authors described the reef as a largely monotypic reef system dominated by *Montastraea annularis* that extends from "north and south of the Frederiksted Pier to Sprat Hole", with coral coverage exceeding 70% on the seaward slope (CFMC 2004). The authors noted that anchoring of commercial vessels had crushed corals and reduced the vertical relief to < 50 cm on some portions of the reef. The CFMC considered the Frederiksted Reef System an Essential Fish Habitat (EFH) which met Habitat Area of Particular Concern (HAPC) criteria for the Coral Fisheries Management Plan (CFMC 2004).

Working at a larger spatial scale ($\geq$ 1 acre), maps from Benthic Habitats of Puerto Rico and the U.S. Virgin Islands (Kendall et al. 2001) provided a more comprehensive and updated delineation of the Frederiksted Reef System. These maps showed a substantial "linear reef" that occupies the offshore margin of the bank/shelf zone and bank/shelf escarpment zone (Fig. 1). The semi-contiguous reef system extends from 0.5 km WSW of Butler Bay (N17°44.865', W64°53.871') to an area north of Sandy Point (N17°41.321', W64°54.139'), spanning a straight-line distance of > 6.5 km. The reef is wider north of the Frederiksted pier. It is considerably narrower in its southern extension from the pier towards Sandy Point. The large-scale, low-resolution maps of coral reef habitats from Kendall et al. (2001) are assumed to be the most accurate existing depiction of Frederiksted Reef System. These maps are considered further in the subsequent sections of this report.

At much smaller spatial scales (1 to 10's of meters), several reef sites from western St. Croix have recently received more detailed study. As part of a larger USVI coral reef monitoring program, a permanent monitoring station was established at Sprat Hole (Nemeth and Herzlieb 2002). The Sprat Hole site falls within the Frederiksted Reef system (Fig. 1) and benthic communities have been monitored here on an annual basis since 2001 (Nemeth et al. 2004b). Among eight St. Croix sites studied, Sprat Hole had the highest coral cover (24.5%), with species composition dominated (78%) by corals of the *Montastraea annularis* species complex (Nemeth and Herzlieb 2002). Studies of coral disease have also been conducted at this site (Rothenberger 2004).

Two recent studies have provided additional information on inshore benthic communities near the Frederiksted Reef System. Kaczmarsky et al. (2005) studied the prevalence of disease among corals in very shallow inshore waters at Frederiksted and Butler Bay. They concluded that higher incidence of coral disease near Frederiksted may be a consequence of frequent exposure to sewage spills which are unknown from the upcurrent site. Vicente & Associates (2003) examined inshore benthic communities in the vicinity of Butler Bay to evaluate the long-term impacts of a bentonite spill which occurred during drilling operations.

Invertebrate communities associated with submerged structures of the Frederiksted Pier have received a great deal of attention in the gray literature but have not received any detailed biological investigation. The unusual and biologically diverse pier fauna (Gladfelter 1988) creates a colorful, aesthetically pleasing diving experience. The Frederiksted Pier has been an internationally-renowned dive site since 1977 (Lopez and Vicente 1990) and it forms an important local tourist attraction (Coulston and Tonnemacher 1991).

Fish Assemblages

The Frederiksted Reef System is likely to be of great importance to the commercial and recreational fisheries of St. Croix. Of the seven areas that were considered "high productivity" on St. Croix, three of them correspond to the Frederiksted Reef System (IRF 1977). The same document identified the "west coast shelf" as a critical area that was heavily fished (IRF 1977). Based upon reported landings from 1997 to 1999, the commercial harvest from western St. Croix was approximately 10% of the island-wide harvest (Tobias et al. 2000). However, DFW collects area-of-landing statistics for the commercial fishery on spatial scales which are larger than individual reefs or reef systems (Adams 2001, Toller pers. obs.). Therefore the amount of fishing effort directed towards the Frederiksted Reef System, as well as its overall contribution to the island's fisheries, is not known.

Only a few studies of reef fish assemblages exist for the Frederiksted Reef System. Fishes at the Sprat Hole monitoring station (see above) have been surveyed bi-annually or annually since 2001 (Nemeth and Herzlieb 2002). Toller (2002) provided a general description of the reef fish assemblages at Sprat Hole and six other St. Croix reef sites. Planktivorous fishes were numerically dominant and herbivorous fishes (acanthurids and scarids) were common. Piscivores (serranids and lutjanids) were relatively rare and larger individuals were notably uncommon. Compared to other St. Croix reef sites, the Sprat Hole fish assemblage was ranked among the highest in terms of abundance, diversity and species richness. Several pomacentrid species (blue chromis, *Chromis cyanea*, and brown chromis, *C. multilineata*) and scarid species (princess parrotfish, *Scarus taeniopterus*, and redband parrotfish, *Sparisoma aurofrenatum*) reached their highest local abundances at the Sprat Hole site.

Additional studies of fish assemblages have been conducted near the Frederiksted Reef System. At Butler Bay, located ~ 1.8 km north of Sprat Hole, DFW has deployed various artificial reef structures on soft-bottom habitats since about 1975 (W. Tobias pers. com.). Although DFW has investigated the enhancement effects of artificial reefs on fish communities, few published materials exist from these studies. However, Adams (2001) studied fish assemblages from the adjacent natural reefs at Butler Bay using stationary visual surveys conducted at monthly intervals. He found that fishes from a structurally complex reef edge habitat were significantly more abundant and more diverse than fishes from the nearby low-relief reef platform (61 species vs. 53 species, respectively). Adams demonstrated a significant declining trend in fish abundance and assemblage diversity during more than two years of observation. This decline was not attributed to impacts of Hurricane Marilyn. Adams speculated that factors contributing to the decline were fishing mortality, variable recruitment, and/or habitat alteration due to chronic sedimentation stress.

Some study has been directed towards fish assemblages of the Frederiksted pier. Kaczmarsky (1991) reported 74 fish species associated with the pier, although he suggested that the actual number is likely to be in excess of 200 species based upon his years of personal observation. Coulston and Tonnemacher (1991) identified the pier structure as a habitat for many economically important food fish species and suggested that adjacent habitats are "nursery grounds" for commercially and recreationally important species. Gladfelter (1988) also commented on fish assemblages found at the Frederiksted pier, noting that the "fish fauna around the pilings is one of the most unique around St. Croix."

Recruitment of reef fishes to the Frederiksted Reef System has not been studied. However, two studies of reef fish recruitment have included sites from Butler Bay. Caselle and Warner (1996) observed comparatively higher levels of recruitment by bluehead wrasse (*Thalassoma bifasciatum*) at leeward sites (western and northern shores) than at windward sites on St. Croix. Island wide, they observed the highest densities of *T. bifasciatum* recruits at Butler Bay. Swearer et al. (1999) compared otolith elemental signatures of *T. bifasciatum* recruits at Butler Bay and Jacks Bay (an eastern site) and concluded that approximately 70% of recruits to St. Croix's leeward shores were of local origin. They suggested that larval retention may contribute greatly to island populations.

Specific Objectives

The goal of this study was to collect preliminary, base-line information that would enable a better evaluation of the ecosystem impacts of anchoring to the Frederiksted Reef System. The specific objectives were: 1) to provide a preliminary survey of the cross-shelf distribution of nearshore, hard-bottom habitats, and 2) to characterize the fish assemblages associated with those habitats.

MATERIALS AND METHODS

Habitat Surveys

The study area is located on western St. Croix, USVI, near the town of Frederiksted (Fig. 1). This relatively open coastline lies to the lee of the island and is generally protected from prevailing easterly tradewinds and ocean swells (Burns 1977). A shallow insular shelf extends $\leq$ 1 km offshore. Only the northern portion of the Frederiksted Reef System was included in the study because previous reports indicated that anchor damage was more extensive on this (northern) segment of Frederiksted Reef. The study area encompassed nearshore waters from the northern end of Fort Frederik Beach to the UTR located about 2.2 km to the north (see Fig. 2). Thus, at a maximum, the study area incorporated about 2.2 km^2, or about 2,200 hectares.

The motivation for this study derived from a critical need to evaluate impacts of anchoring to the Frederiksted Reef (see Toller 2005). A means of identifying damaged areas was required. The otherwise excellent habitat maps of Kendall et al. (2001) were not useful for this purpose nor were alternative survey methods (e.g. sidescan sonar) immediately available, so a towed-diver survey method was chosen as the most expedient way to locate anchor scars. However, results from preliminary towed-diver surveys showed that the areal extent of anchor damage was quite large and patterns of habitat damage greatly exceeded that of isolated scars (see Toller 2005). Thus, the identification of anchor damage using visual scoring criteria required additional knowledge of adjacent unimpacted habitats. The scope of the study was therefore expanded to collect information on cross-shelf habitat zones and to incorporate data collection from unimpacted reefs.

Habitat surveys were done between January and July of 2004. Cross-shelf surveys were conducted by towing an observer on snorkel behind a small vessel. Divers examined bottom topography and coral coverage while searching for evidence of physical damage caused by anchoring (see below). When necessary, divers released the tow line and free dived to examine habitat features in greater detail. Conspicuous habitat transition points were identified and the information conveyed to a shipboard observer. Onboard, an observer recorded GPS location of the feature/habitat transition using a handheld Garmin GPS Map 76 with WAAS correction (observed accuracy of 5-15 m during studies). Depth was recorded on a Furuno FMV-605 video depth sounder equipped with a 50/200kHz duel frequency transducer. Depth recordings (and GPS position) were made at each habitat feature and at regular intervals along transects. Positional information was downloaded directly from the handheld unit to computer using MapSource version 4.08 (Garmin, Corp.) software or imported into ArcView GIS 3.2a (Environmental Systems Research Institute, Inc.) using DNR Garmin 4.3 software developed by Minnesota Department of Natural Resources.

Eight towed-diver transects were run perpendicular to shoreline, along east-northeast to west-southwest lines (~ bearing 255º) with transects roughly evenly spaced from south to north across the study area (Fig. 2). They ran from shore to the 60-foot depth contour, at which point the bottom profile dropped rather sharply and surface based observations became impractical. The shoreward-most segments of transects were too shallow to negotiate by boat and observations here were completed by a snorkeler assisted with kayak. In addition, two partial transects (offshore segments only) were completed: one each in the northern and southern portions of the study area (Fig. 2).

A pronounced cross-shelf trend in habitat structure was readily apparent in transects. Benthic communities also showed persistent zonation patterns along the same cross-shelf gradient. To understand how fish assemblages changed in concert, I adopted the approach of Williams (1991) who identified discrete "physiographic reef zones" along a cross-shelf transect to examine correlated changes in fish assemblage structure. In the present study, four broad habitat zones were discerned along cross-shelf transects of the Frederiksted Reef System. These habitat zones were as follows: habitat zone I - intertidal/shallow subtidal (Fig. 3), habitat zone II - inshore low relief (Fig. 4), habitat zone III - transitional/patch reef (Fig. 5), and habitat zone IV- reef crest (Fig. 6). Attributes of each habitat zone are presented in Table 1.

Reef Fish Community Surveys

To characterize fish assemblages within each of the four habitat zones, a Roving Diver Survey (RDS) method was selected. Compared to other visual fish census methods, the RDS method provides the most complete information on species richness (Rogers et al. 1994). A primary limitation of RDS is that it yields relative estimates of fish abundance rather than quantitative estimates of fish density. Also, the RDS method used in this study did not include recording of information on the size structure of fish populations.

All fish surveys were conducted between January and March of 2005. Divers swam a haphazard circuit through specified habitat zones recording fish abundance on a logarithmic scale as follow: I = 1 individual, II = 2 to 10 individuals, III = 11 to 100 individuals, IIII = 101 to 1,000 individuals, or IIIII > 1,000 individuals. Each survey was 1.0 hr in duration. Divers also recorded general habitat features (topographic relief, substrate composition, predominant coral and algal species, and other related observations). Surveys were conducted on snorkel (zones I and II) or on Scuba (zones III and IV). Individual replicates generally fell along the cross-shelf transects described above. From these data, average abundance index (AI) and percent sighting frequency (SF) were computed.

Fish were identified to species using standard field references (Randall 1968, Human and DeLoach 2002, Lieske and Myers 2002). In instances where species-level identification was uncertain, digital photos were taken with a PowerShot A70 (Canon, 3.2 Megapixel resolution) in an underwater housing (Canon WP-DC700). In practice, most taxa were adequately diagnosed in the field. The following fish were exceptions. Very small scarids (juvenile *Sparisoma* sp.) were commonly observed as mixed-species groups hiding in shallow macroalgal beds. These groups were thought to be comprised primarily of bucktooth parrotfish (*Sparisoma radians*), redtail parrotfish (*S. chryospterum*), and yellowtail parrotfish (*S. rubripinne*) although their similar appearance, cryptic behavior and small size precluded reliable identifications. Similarly, the large and often mixed-species schools of recently recruited grunts (juvenile *Haemulon* sp.) which occurred in zones I and II were not identified to species. These compound taxa were retained in analyses because their distributions were unequal among habitat zones, as both were frequently seen in zones I or II but not in zones III and IV. Jawfish species (*Opistognathus macrognathus*, *O. maxillosus*, and *O. whitehurstii*) were lumped together exclusive of *O. aurifrons*. Two species of chubs (*Kyphosus sectatrix* and *K. incisor*) reportedly occur in the area but were not distinguished in the field, nor were two similar appearing gobies – masked and glass gobies (*Coryphopterus personatus* and *C. hyalinus*, respectively). Some inter-observer discrepancies arose in distinguishing adult longfin damselfish (*Stegastes diencaeus*) from dusky damselfish (*S. dorsopunicans*) although juveniles were readily separable.

In addition to the four hard-bottom habitat zones (i.e. habitat zones I-IV), the study area also encompassed large areas comprised of two other habitat types: soft bottom and damaged reef. Soft bottom habitats were primarily sand plains with only sparse or patchy cover of seagrasses and/or algae. Fish surveys were not conducted in sand habitats however several soft-bottom associated species were noted in surveys (see Results). The occurrence of damaged reef habitat is noted in this report but discussed in detail elsewhere (Toller 2005). The fish surveys reported here were not specifically targeted to damaged reef habitats.

During fish surveys, it became apparent that juvenile and adult stages of some species were unequally distributed among habitat zones. To record these potentially important observations, the following modification to the RDS protocol was made: When recruits or juvenile stages were judged to be more abundant than adults within a given survey the abundance estimates for that species were annotated with an asterisk (see Appendices 1-4).

Data Analysis

Statistical tests were performed on personal computer using either Statistica (Statsoft, Inc., Tulsa, OK) or Microsoft Excel. To examine differences in species richness among habitats, replicated observations (total number of species observed per survey) were tested with one-way ANOVA.

A community coefficient was used to compare fish assemblages among habitat zones. Jaccard's coefficient (JC) - a similarity index commonly used by terrestrial ecologists to compare plant communities (Barbour et al. 1987) - was calculated using species presence/absence data according to the following formula:

$$JC = C / (A + B - C)$$

where A = total number of species in habitat zone A , B = total number of species in habitat zone B, and C = total number of species in both habitat zones A and B. JC was calculated utilizing either all observations or after excluding those species which were only observed in a single survey within a habitat zone.

Data from towed-diver surveys were converted into GIS files and examined further using ArcView GIS 3.2a (Environmental Systems Research Institute, Inc.). Transect information was first assembled using depth data and plotted GPS positions. Depth profiles were then prepared by calculating segment distance along each transect (using ArcView measure distance function) and plotting against depth for each recorded point.

To determine the width of habitat zones, the GPS data (above) were filtered to retain only "transition points" between adjacent zones along each transect. In addition to the aforementioned habitat zones (i.e. zones I –IV), the definition of transition point was expanded to include sand and damaged reef categories. Thus, a transition was considered to have occurred whenever the observer moved between any of the six categories (e.g. from sand to zone III, from zone IV to damaged reef, etc). Cumulative width of each habitat zone was calculated along each cross-shelf transect by measuring individual segment distances between pairs of transition points. These data were compared to available habitat maps for western St. Croix (Benthic Habitats of Puerto Rico and the U.S. Virgin Islands, Kendall et al. 2001).

RESULTS

Habitat Surveys

Estimates for the linear width of habitat zones are shown in Table 2. The cross-shelf width of entire insular platform in the study area (to the 60 foot depth contour) was, on average, 851 m wide ± 82 (St.Dev.). Soft bottom habitat (avg = 288 m ± 124) accounted for most of the observed habitat zones (33.8 %) but was quite variable among transects (range 124 to 444 m). The variable distribution of sand habitat is also suggested by aerial photos of the study area (e.g. Fig. 2). Habitat zone II (avg = 187 m ± 84) also accounted for a substantial portion of observed habitat zones (21.9%). Zones III and IV formed 15.4% and 14.1% of observed habitat zones, respectively. Intertidal/shallow subtidal (zone I) was the narrowest zone (13.5 m ± 6.4) and contributed least to observed habitats along transects (1.6%). Damaged habitat contributed 13.1%.

Calculations for width of the reef crest habitat zone (zone IV) were complicated by the presence of extensive damaged habitat. This was particularly evident in the southernmost transects (Table 2). Considering the spatial evidence, most of this damaged area would correspond to (former) reef crest habitat zone. Were the widths of these two habitat zones combined (i.e. reef crest + damaged reef crest), the zone would be 231 m (± 69) across, forming 27.2 % of cross-shelf habitat zonation. The large disparity between the two ways of estimating reef crest width underscore the magnitude of impacted habitat, as discussed further in a separate report (Toller 2005).

Cross-shelf depth profiles (Fig. 8) were somewhat variable among transects. A generalized profile is discussed here. At the shore's edge, an abrupt limestone step (0.5 to 1 m) was typically observed corresponding to the rocky intertidal zone. Beaches were also abruptly stepped to ~ 0.5 m depth with sand usually being replaced by beach rock and rubble subtidally. The shallow subtidal area extended only a short distance offshore (< 15 m) corresponding to the terminus of habitat zone I. Seaward of this, (usually habitat zone II) a moderate and generally uniform slope extended some 150-200 m offshore. Along most transects, the uniform depth profile of zone II was a reflection of the smooth carbonate pavements commonly found there. Farther offshore, the slope was more gradual and uniform - usually coincident with wide areas of sand. Within ~ 300 m of the shelf edge (habitat zones III and IV), depth profiles became quite irregular and variable among transects. At ~ 800 m offshore a rather abrupt drop off occurred at 10-12 m depths. The slope of the drop off was also quite variable among transects. Examination of the depth profiles across all transects did not suggest the presence of a lagoon-like feature.

Comparison to NOAA Benthic Habitat Maps

The NOAA benthic habitat map shows 16 polygons that fall partially or wholly within the study area [after excluding land and unknown/overdepth polygons]. Six habitat types are delineated. They are: colonized bedrock (1), colonized pavement (2), sand (8), colonized pavement with sand channels (2), scattered coral/rock in unconsolidated sediment (1), and linear reef (2). All of these fall within the bank/shelf zone except for the seaward-most linear reef polygon which occurs on the bank/shelf escarpment. The distribution of these habitats is shown in Figure 7.

As noted previously, the NOAA benthic habitat map provides a delineation of the Frederiksted Reef as "linear reef." The reef occurs at the shelf edge (Fig. 1) and extends from Butler Bay (N17°44.865', W64°53.871') to Sandy Point (N17°41.321', W64°54.139'). On NOAA benthic habitat maps, the entirety of the Frederiksted Reef is enclosed within four polygons with a combined area of 889,559 m^2 (or 89 hectares). Within the study area under consideration here, the NOAA maps indicate that linear reef occupies an area of ~ 350,000 m^2 (or 35 hectares).

Zone I was typified by high topographic complexity formed from broken, fissured, and eroded limestone rock where fish were often locally quite abundant. Beaches also interrupted zone I although sand bottom typically gave way to unconsolidated rubble and beachrock close to the sea-shoreline contact.

Zone IV best corresponds to the Linear Reef classification used by NOAA. This zone had the greatest topographic complexity owing to the predominance of *Montastraea annularis*. Live coral cover was quite high. Species diversity was high relative to inshore zones. In the two northern transects (7 and 8), hydroacoustic cables from the UTR were seen. Cables were heavily fouled with large sponges, gorgonians and scleractinian corals.

In general, there was good agreement between the cross-shelf transect data collected in this study and the NOAA habitat maps. The degree of consistency between datasets varied according to depth, type of habitat, and location of transects (Fig. 7). Agreement between datasets was best for the shallowest habitat zones/types. For example, intertidal/shallow subtidal (=colonized bedrock), inshore low relief (=colonized pavement), and sand (=sand), were almost always coincident (Fig. 3). Agreement was also best for northern transects (e.g. near perfect agreement along transect #8). Interestingly, the two sets of mapping data were progressively more inconsistent in the offshore segments along the southernmost transects. For example, the 60' depth contour (identified in towed-diver surveys) was coincident with the edge of the linear reef (from NOAA map) along transects 3, 4, 5, 6, 7, 8 and 9. However along transects 0, 1, and 2 the NOAA maps placed the edge of the linear reef 150-250 m further offshore. The source of this discrepancy is unclear.

Reef Fish Community Surveys

Eight RDS replicates were completed within each habitat zone for a total of 32 surveys. Surveys were completed at 27 sites, with duplicate surveys conducted at 5 of these (Appendix 5). The location of RDS sites is shown in Figure 9.

In total, 176 fish taxa were observed representing 50 fish families (Table 3). When analyzed collectively (data from all zones combined), six species were highly abundant, with an average AI $\geq$ 3.0. These species were bluehead, *T. bifasciatum* (SF=100%); ocean surgeonfish, *Acanthurus bahianus* (SF=100%); bicolor damselfish, *Stegastes partitus* (SF=75.0%); French grunt, *Haemulon flavolineatum* (SF=100%); slippery dick, *Halichoeres bivittatus* (SF=78.1%); and blue tang, *A. coeruleus* (SF 100%). Forty species were moderately abundant (average AI between 1.0 and 3.0). However, the majority of species (130) were less abundant (average AI < 1.0). Twenty-eight species were observed in only one replicate survey and 17 of these were represented by observation of a single individual.

There were clear differences in the diversity of fish assemblages among habitat zones. Comparisons among zones showed that average species richness (number of species observed per survey) increased from inshore to offshore (Table 4, Fig. 10). Average richness was significantly different among habitats (one-way ANOVA, $F_{31} = 17.47$, $p < 0.001$). This result was again obtained when rare species (species observed in a single survey within a zone) were removed from the comparison (one-way ANOVA, $F_{31} = 16.33$, $p < 0.001$, Fig. 10).

Cumulative number of species (Table 4) was least in zone I (86 species) and greatest in zone IV (110 species). Examination of species-area curves showed that asymptotic values were approached in each habitat zone (Fig. 11A). This suggests that > 90% of the fish assemblages had been sampled. Species-area curves also showed a trend of increasing cross-shelf fish diversity. Zone II was somewhat exceptional (Fig. 11A) in that cumulative species richness was high (106 species) and the species-area curve suggested that less of the fish assemblage had been sampled. When data from zone II were re-evaluated after eliminating rare species, this pattern was not seen (Fig. 11B).

Table 5 shows the similarity of fish assemblages from different habitat zones calculated using Jaccard's Community coefficient (JC). Fish assemblages from zone III and IV were most similar to one another (JC = 0.68). The fish assemblage of zone I was least similar to that of zone III and IV (JC = 0.30, 0.31) and more similar to the assemblage of zone II (JC = 0.45). Zone II was slightly more similar to zone III (JC = 0.53) than it was to zone I (JC = 0.45). When rare species were excluded from calculations, JC values were lower but the rank order of similarity observed between habitat zones was qualitatively unchanged (Table 5).

Further examination of cross-shelf distributions for individual species suggested that distribution patterns are distinct and non-random. Four types of fish distribution were distinguished: broad, wide, restricted, and narrow (Table 6). Although the number of species was approximately equal within the four types of distributions, the species were not evenly distributed among habitat zones. For example, species with narrow distributions were generally found in zone I or zone IV but not zones II and III. Species with wide distributions were generally found in zones II, III and IV but were absent from zone I. Those fish with restricted distributions were most commonly found in zones III+IV.

Cross-shelf distribution patterns were variable among closely related species. For example, parrotfishes of the family scaridae are important herbivores on Caribbean reefs. Scarids showed pronounced interspecific variation in their cross-shelf distribution patterns (Fig. 12). Selected serranids, lutjanids and haemulids also showed variable cross-shelf distribution patterns (Fig. 13).

For 14 species, juvenile fish stages were judged qualitatively to be more abundant than adults during RDS surveys (as annotated in Appendices 1-4). Juveniles were unequally distributed among habitat zones and predominated in observations of 13 species in zone I, 10 species in zone II, 2 species in zone III, and 1 species in zone IV. Fishes were acanthurids (*Acanthurus bahianus*, *A. chirurgus*, *A. coeruleus*), chaetodontids (*Chaetodon striatus*), haemulids (*Haemulon carbonarium*), lutjanids (*Lutjanus apodus*, *L. mahogoni*, *Ocyurus chrysurus*), mullids (*Mulloidichthys martinicus*, *Pseudupenus maculatus*), pomacanthids (*Pomacanthus paru*, *Holacanthus ciliaris*), pomacentrids (*Abudefduf saxatilis*) and scarids (*Sparisoma rubripinne*). In addition, juvenile *Sparisoma* sp. and juvenile *Haemulon* sp. were recorded only from zones I and II.

DISCUSSION

Habitat Zones and Reef Structure

This report provides only a preliminary account of the Frederiksted Reef System and associated fish assemblages. However, results from this study should provide some resolution of the ambiguities raised by previous contradictory accounts of the nearshore marine habitats of western St. Croix (see Introduction). In particular, this study (and another report; Toller 2005) provide clarification on the spatial extent and benthic community composition of the Frederiksted Reef near the shelf break. Robust stands of scleractinian corals, dominated by the columnar *Montastraea annularis*, occur in the reef crest habitat zone. These corals contribute high vertical relief to the reef crest which in turn forms habitat for a diverse assemblage of fishes.

The geologic origin of the Frederiksted Reef System is unstudied. Therefore it is difficult to classify the reef using conventional geomorphological terms. The reef might be considered a relatively shallow shelf edge reef system (*sensu* Hubbard 1989a). Alternatively, it may be a bank barrier reef which has subsided over geological time, although depth profiles do not suggest the presence of a lagoon. A third possibility is that the reef crest is comprised of corals that have grown atop unconsolidated sea floor (i.e. a "rubble reef"). Evidence for the latter derives from sediment cores taken during reconstruction of the Frederiksted Pier. Only sand, rather than consolidated carbonate material, was taken from cores of the shelf slope despite drilling to > 60' beneath the sediment surface (J. Lawlor, pers. com.).

In cross-shelf profile, the Frederiksted Reef System resembles the reefs at Cane Bay and Davis Bay on St. Croix (Hubbard 1989b). However, unlike Cane and Davis Bays, a well developed spur and groove zone was not observed in the reef crest habitat zone of the Frederiksted Reef System. Spur and groove systems are thought to be essential for "flushing" away from the reef the excess sediments produced by bioerosion (Hubbard 1989b). Sediments generated on the Frederiksted Reef System must be flushed from the reef via a different mechanism. In this respect, the Frederiksted canyon deserves study as a potential channel for sediment movement.

Some accounts of the Frederiksted Reef System have given conflicting information about the abundance and distribution of seagrass beds. In the present study, substantial areas of seagrass were not observed. *Thalassia testudinium* was either very uncommon or absent from the study area. Sparse stands of *Syringodium filiforme*, *Halophila decipens*, and *Halodule wrightii* were seen in the soft bottom habitats, resembling the communities described by Vicente (2003) from Estate Northside. Kendall et al. (2001) did not map sea grass habitats within the study area. Although Boulon and Griffin (1999) stated that inshore areas have abundant sea grasses, it seems likely that their account was based upon pre-Hugo observations. Lopez and Vicente (1990) reported that the healthy seagrass beds (*Thalassia* and *Syringodium*) near Frederiksted pier were largely eliminated during hurricane Hugo in 1989. Two years later, Coulston and Tonnemacher (1991) reported that these areas had not shown any substantial recovery of seagrasses. Thus, it appears that *Thalassia* has failed to recolonize soft bottom habitats of the Frederiksted Reef System despite the passage of more than 15 years.

The long-spined sea urchin, *Diadema antillarum*, was frequently observed in surveys and appeared to be locally quite abundant in nearshore areas (zone II). *Diadema* abundance has been stable or increasing during more than two years of observation, suggesting a recovery from the Caribbean-wide die off (Lessios et al. 1984). Other researchers have reported signs of *Diadema* population recovery on St. Croix (Miller et al. 2003) and elsewhere in the Caribbean (Edmunds and Carpenter 2001).

Benthic communities observed in the inshore pavement habitat zone (zone II) were dominated by turf algae or macroalgae, small head corals, and gorgonians growing atop a limestone platform. Algal turfs were often infiltrated with fine sands. These organisms are relatively sediment-tolerant forms which suggest that sediment movement and scour likely play an important role in structuring benthic communities found here. However it is not clear whether such sediments are terrestrial or marine in origin. Seasonal movements of sands along beach habitats (zone I) are commonplace, and are probably indicative of such movements occurring further offshore (zones II and III) as well (W. Tobias, pers. com.). In addition to re-sculpting beach formations, storm waves and seasonal swells are also known to dramatically reduce inshore water clarity. However terrestrial sediments are carried into the waters through "guts" during periods of major rainfall. Influence of terrestrial sediments may be restricted to zones I and II, with diminishing impacts in III and IV. Movement of coarse-grained sands may also impact zones II and III. A generalized model is suggested which predicts that terrestrial and oceanographic influences form a reciprocal gradient from inshore to offshore. This is an area that needs further study.

Fish Assemblages and Fish-Habitat Associations

Fish assemblages of the Frederiksted Reef System were observed to be quite diverse. Total species richness was comparable to (or greater than) fish assemblages surveyed using a similar method at Cane Bay and various other sites throughout the U.S. and British Virgin Islands (Nemeth et al. 2003). The list of species is not exhaustive, as species-area curves indicate that further sampling would reveal more diversity and subsequent observations also suggest that seasonality contributes more species richness to the system (Toller pers. obs.). Nonetheless, it is surprising that total species richness of the Frederiksted Reef System is comparable to that reported for Salt River (Kendall et al. 2005) where a greater variety of habitats occur including mangroves and seagrass beds. Mangroves and seagrasses, which are currently considered important nursery habitats for many reef fish species, are absent from the Frederiksted Reef System. How this may affect local fish diversity is discussed below.

Among the habitat zones studied, the reef crest (zone IV) supported the richest fish assemblage with 110 species. Of these, 18 species were only observed in reef crest habitat. This richness is perhaps not surprising. The reef crest is topographically more complex than the other habitat zones and it is characterized by a high percentage of live coral cover (Toller 2005b). Fish species richness is positively correlated with both topographic complexity of habitat (Luckhurst and Luckhurst 1978) and with coral cover (Carpenter et al. 1981, Nemeth et al. 2003).

Compared to zones III and IV, total species richness of fishes from the inshore low-relief habitat zone (zone II) was high, although average species richness was low. High fish diversity would not be expected given the low coral cover and low topographic complexity of zone II. A possible explanation is that fish assemblages from zone II are more strongly influenced by rare species. Transient species may be more common to zone II. For example, some of the rare species observed were apparent transients from adjacent soft bottom habitat such as saucereye porgy (*Calamus calamus*), eyed flounder (*Bothus ocellatus*), and rosy razorfish (*Xyrichtys martinicus*). Alternatively, rare fish may represent species with unrecognized ecological specializations for the low-relief substrate features (or associated communities) which typify zone II.

The intertidal/shallow subtidal (zone I) supported the most distinct fish assemblage among the zones studied. Of the 86 species observed in zone I, 20 species were not observed in other habitat zones. An additional 16 species were observed only in zones I + II. Many of these fish appear to be specialized to the intertidal and/or shallow subtidal habitat. Species included gobiids such as the frillfin (*Bathygobius soporator*), nineline (*Ginsburgellus novemlineatus*) and greenbanded (*Gobiosoma multifasciatum*) gobies, labrisomids such as the hairy blenny (*Labrisomus nuchipinnis*), and blenniids such as the pearl blenny (*Entomacrodus nigricans*) and molly miller (*Scartella cristata*). Other fish may utilize the refuge afforded by shallow, rocky subtidal areas as daytime resting areas. For example, the night sergeant, *Abudefduf taurus* (Pomacentridae) and copper sweeper, *Pempheris schomburgki* (Pempheridae) were common in this zone. Schooling species such as the redear sardine, *Harengula humeralis*, dwarf herring, *Jenkinsia lamprotaenia* (Clupeidae), and hardhead silverside, *Atherinomorus stipes* (Atherinidae) were also abundant, but patchy in distributions, in zone I.

Mangroves and seagrass areas are generally considered vital habitat for juvenile stages of many Caribbean fish species (e.g. Delgado and Stedman 2004, Mumby et al. 2004). On St. Croix, researchers have identified mangroves, seagrasses, and backreef lagoons as important nursery habitats for reef fishes (Mateo and Tobias 2001, 2004, Adams and Ebersole 2002). In this study, a preponderance of juvenile fishes were also observed in shallow areas (zones I and II). For example, the schoolmaster, *Lutjanus apodus* (Lutjanidae) had a disjunct distribution among habitats, being common in zone I (as juveniles) and zone IV (as adults). These observations are suggestive of a nursery habitat function for the shallow, inshore zones for at least some fish species. However, the habitats observed in this study were not readily ascribable to any of the foregoing habitat categories. It is possible that juveniles of some species may utilize hard bottom areas (rocky intertidal, shallow subtidal, and inshore low relief zones) as alternate nursery habitat when preferred nursery habitat is unavailable. Nagelkerken et al. (2000) reported a more broad usage of various types of shallow biotopes by juvenile fishes on Bonaire. The possible role of inshore habitats of western St. Croix as nursery habitat should receive additional study.

The foregoing results suggest that the Frederiksted Reef System is important habitat for local fish fauna. Anecdotal observations also indicate that fishes found here are heavily harvested by local fishers. During the study, commercial fishers were frequently observed fishing over the reef using various methods (handline, scuba and spear, fish traps). Discarded or lost gears representing each of the major commercial gear types (monofilament line, trammel nets, fish pots) were also observed with some frequency. Fishers also frequently utilized shallow inshore areas to harvest baitfish with cast nets – especially “sprat” (principally the redear sardine) and to a lesser extent “fry” (dwarf herring and hardhead silverside). Commercial and recreational fishers were commonly observed fishing for yellowtail snapper (*Ocyurus chrysurus*; Lutjanidae) at the shelf drop off north of Sprat Hole.

It seems likely that the fish assemblages of the reef crest and adjacent habitats are functionally linked. The different inshore zones identified in this study are probably best considered a “system” of interconnected habitat elements. Although the deep reef slope of the Frederiksted Reef System remains unstudied - and its fish assemblage is likely to be distinctive - the deeper reef may also be functionally linked to inshore zones. As an example, the blackfin snapper (*Lutjanus bucannella*) is a fish of commercial importance and adult blackfin are generally found at depths below 100 feet. Recently, the author observed blackfin snapper recruits in moderate abundance in zone II.

This preliminary survey of fishes from the Frederiksted reef system suggests a complex and rich community. Patterns of cross-shelf distribution raise several questions about connectivity among shallow nearshore habitats. They also suggest a nursery ground function for some species. The shallow, calm waters found off of Frederiksted make the area ideally suited for future studies of reef fish recruitment, patterns of post-settlement movement and mortality, and ontogenetic movements among habitats.

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LIST OF TABLES AND FIGURES

Table 1. Habitat zones* identified in this study.

habitat zone	I	II	III	IV
descriptor	intertidal/shallow subtidal	inshore low relief	transitional/patch reef	reef crest
cross-shelf location	inshoremost	inshore	midshelf	shelf-edge
approx. depth range, ft (m)	0 to 3 (0 to 1)	3 to 20 (1 to 7)	18 to 35 (6 to 11)	30 to 60 (10 to 20)
predominant substrate	limestone bedrock, rubble, beachrock or sand	limestone plates or pavements, rubble, sand	limestone ridges separated by wide sand or rubble channels	structurally complex limestone with narrow sand/rubble channels
substrate configuration	limestone spurs at shoreline, pavements, sand or cobble beaches	low relief pavements with seams or holes and rubble/sand areas	moderate relief patches or ridges with grooves oriented offshore	high vertical relief reefs, either continuous reef or forming wide ridges
approx. coral cover	low (< 5%)	low (< 5%)	intermediate (5 to 15%)	high (10 to >25%)
coral community	low coral cover, mostly shallow-water forms	low coral cover, mostly sediment tolerant forms	abundant head corals, some branching and ecrusting forms	large colonies of columnar, branching and plating forms
characteristic hard corals	*Diploria clivosa* *Siderastrea radians* *A. palmata* (occasional)	*Diploria strigosa* *Siderastrea siderea* *Solenastrea bournoni*	*M. faveolata* *M. cavernosa* *A. cervicornis* (occasional)	*Montastraea annularis* *M. faveolata* *Colpophyllia natans* *Agaricia sp.*
characteristic algae	*Laurencia papillosa* *Sargassum polyceratium* *Padina* sp. various filamentous algae encrusting red corallines	*Dictyota* sp. *Bryothamnion triquetum* dense algal turf	*Lobophora variegata* *Dictyota* sp.	*Lobophora variegata* *Halimeda opuntia* *Halimeda goreaui* *Dictyota* sp.
other characteristic organisms	vermetid worms abundant gastropods *Echinometra lucunter*	*Psudopterogorgia* sp. *Pterogorgia* sp. *Diadema antillarum*	*Xestospongia muta* *Neofibularia nolitangere* *Diadema antillarum*	*Xestospongia muta* *Neofibularia nolitangere* *Callyspongia plicifera*

* Soft bottom habitats (i.e. large areas of sand) were not surveyed in this study and have been excluded from this habitat classification scheme.

Table 2. Width of habitat zones based upon towed-diver observations.

	Cumulative Segment Length (m)						
Transect	Zone I	Zone II	Zone III	Zone IV	Sand	Damage*	Total
1	14.7	263.5	120.9	0	195.6	229.2	823.9
2	14.9	307.9	198.5	0	123.6	247.4	892.3
3	4.8	220.5	269.1	111.4	134.2	256.1	996.0
4	8.9	124.0	282.6	95.9	283.1	108.9	903.3
5	9.8	78.3	129.1	271.2	393.1	0	881.5
6	11.1	117.1	77.0	93.5	444.2	49.0	791.8
7	19.6	168.4	26.0	220	337.7	0	771.7
8	24.7	162.3	0	168.6	394.7	0	750.3
Average	13.5	180.2	137.9	120.1	288.3	111.3	851.4
St.Dev.	6.4	78.3	105.2	96.6	124.5	116.2	82.0
Max.	24.7	307.9	282.6	271.2	444.2	256.1	996.0
Min.	4.8	78.3	0	0	123.6	0	750.3

Table 3. Frequency and abundance of fish observed in four habitat zones.

		Zone I			Zone II			Zone III			Zone IV		
Family	Species	SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*
Ginglymostomatidae													
nurse shark	*Ginglymostoma cirratum*	-	-	-	-	-	-	12.5%	0.13	0.13		-	-
Dasyatidae													
southern stingray	*Dasyatis americana*	-	-	-	12.5%	0.13	0.13	12.5%	0.13	0.13	25.0%	0.38	0.26
Muraenidae													
chain moray	*Echidna catenata*	37.5%	0.63	0.32	12.5%	0.13	0.13	-	-	-	-	-	-
goldentail moray	*Gymnothorax miliaris*	-	-	-	25.0%	0.38	0.26	-	-	-	-	-	-
spotted moray	*Gymnothorax moringa*	12.5%	0.13	0.13	37.5%	0.38	0.18	12.5%	0.13	0.13	12.5%	0.13	0.13
Ophichthyidae													
sharptail eel	*Myrichthys breviceps*	-	-	-	62.5%	0.63	0.18	-	-	-	-	-	-
Congridae													
brown garden eel	*Heteroconger longissimus*	-	-	-	12.5%	0.38	0.38	25.0%	0.75	0.49	37.5%	1.50	0.73
Belonidae													
flat needlefish	*Ablennes hians*	12.5%	0.25	0.25	12.5%	0.25	0.25	-	-	-	-	-	-
keeltail needlefish	*Platybelone argalus*	25.0%	0.38	0.26	-	-	-	-	-	-	-	-	-
Hemirhamphidae													
ballyhoo	*Hemiramphus brasiliensis*	-	-	-	12.5%	0.38	0.38	12.5%	0.38	0.38	-	-	-
Clupeidae													
redear sardine	*Harengula humeralis*	37.5%	1.88	0.91	12.5%	0.63	0.63	-	-	-	-	-	-
dwarf herring	*Jenkinsia lamprotaenia*	87.5%	4.38	0.63	12.5%	0.50	0.50	12.5%	0.63	0.63	-	-	-
Atherinidae													
hardhead silverside	*Atherinomorus stipes*	37.5%	1.75	0.86	14.3%	0.50	0.50	-	-	-	-	-	-
Synodontidae													
sand diver	*Synodus intermedius*	25.0%	0.38	0.26	37.5%	0.50	0.27	37.5%	0.50	0.27	75.0%	1.13	0.35
Holocentridae													
squirrelfish	*Holocentrus adcensionis*	12.5%	0.13	0.13	100.0%	2.38	0.26	50.0%	1.13	0.44	25.0%	0.25	0.16
longspine squirrelfish	*Holocentrus rufus*	25.0%	0.25	0.16	12.5%	0.25	0.25	75.0%	1.50	0.33	87.5%	2.13	0.35
blackbar soldierfish	*Myripristis jacobus*	-	-	-	25.0%	0.38	0.26	37.5%	0.75	0.37	100.0%	2.75	0.16

Table 3. continued.

		Zone I			Zone II			Zone III			Zone IV		
Family	Species	SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*
Holocentridae													
longjaw squirrelfish	*Neoniphon marianus*	-	-	-	-	-	-	37.5%	0.75	0.37	75.0%	1.63	0.38
cardinal soldierfish	*Plectrypops retrospinis*	-	-	-	-	-	-	-	-	-	12.5%	0.13	0.13
reef squirrelfish	*Sargocentron coruscum*	62.5%	0.75	0.25	50.0%	0.75	0.31	-	-	-	-	-	-
dusky squirrelfish	*Sargocentron vexillarium*	75.0%	1.50	0.38	12.5%	0.13	0.13	-	-	-	12.5%	0.25	0.25
Fistulariidae													
Bluespotted cornetfish	*Fistularia tabacaria*	-	-	-	25.0%	0.25	0.16	-	-	-	-	-	-
Aulostomidae													
trumpetfish	*Aulostomus maculatus*	25.0%	0.25	0.16	25.0%	0.25	0.16	25.0%	0.50	0.33	87.5%	1.75	0.25
Scorpaenidae													
spotted scorpionfish	*Scorpaena plumieri*	62.5%	1.00	0.33	75.0%	1.50	0.33	25.0%	0.25	0.16	12.5%	0.13	0.13
reef scorpionfish	*Scorpaenodes caribbaeus*	-	-	-	12.5%	0.13	0.13	-	-	-	-	-	-
Serranidae													
graysby	*Cephalopholis cruentatus*	-	-	-	12.5%	0.13	0.13	87.5%	1.75	0.31	100.0%	3.13	0.23
coney	*Cephalopholis fulvus*	-	-	-	62.5%	1.50	0.50	100.0%	2.88	0.13	100.0%	2.25	0.31
rock hind	*Epinephelus adcensionis*	-	-	-	-	-	-	-	-	-	37.5%	0.38	0.18
red hind	*Epinephelus guttatus*	-	-	-	25.0%	0.25	0.16	50.0%	0.63	0.26	12.5%	0.25	0.25
yellowtail hamlet	*Hypoplectrus chlorurus*	-	-	-	-	-	-	-	-	-	62.5%	1.13	0.35
shy hamlet	*Hypoplectrus guttavarius*	-	-	-	-	-	-	-	-	-	12.5%	0.13	0.13
indigo hamlet	*Hypoplectrus indigo*	-	-	-	-	-	-	-	-	-	12.5%	0.13	0.13
black hamlet	*Hypoplectrus nigricans*	-	-	-	-	-	-	87.5%	1.13	0.23	50.0%	0.75	0.31
barred hamlet	*Hypoplectrus puella*	-	-	-	-	-	-	-	-	-	100.0%	2.13	0.13
butter hamlet	*Hypoplectrus unicolor*	-	-	-	-	-	-	25.0%	0.25	0.16	62.5%	0.75	0.25
peppermint basslet	*Liopropoma rubre*	-	-	-	-	-	-	-	-	-	25.0%	0.25	0.16
greater soapfish	*Rypticus saponaceus*	12.5%	0.25	0.25	62.5%	0.88	0.30	12.5%	0.13	0.13	-	-	-
lantern bass	*Serranus baldwini*	-	-	-	37.5%	0.63	0.32	25.0%	0.25	0.16	-	-	-
tobacco fish	*Serranus tabacarius*	-	-	-	12.5%	0.13	0.13	25.0%	0.38	0.26	12.5%	0.13	0.13
harlequin bass	*Serranus tigrinus*	-	-	-	12.5%	0.13	0.13	87.5%	2.50	0.38	87.5%	2.00	0.33
Grammatidae													
fairy basslet	*Gramma loreto*	-	-	-	-	-	-	50.0%	1.00	0.38	75.0%	2.00	0.46
Apogonidae													
barred cardinalfish	*Apogon binotatus*	-	-	-	-	-	-	50.0%	1.38	0.53	-	-	-

Table 3. continued.

		Zone I			Zone II			Zone III			Zone IV		
Family	Species	SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*
Apogonidae													
flamefish	*Apogon maculatus*	-	-	-	87.5%	2.00	0.33	12.5%	0.25	0.25	-	-	-
Cirrhitidae													
redspotted hawkfish	*Amblycirrhitus pinos*	-	-	-	-	-	-	37.5%	0.38	0.18	12.5%	0.13	0.13
Priacanthidae													
glasseye snapper	*Heteropriacanthus cruentatus*	-	-	-	-	-	-	-	-	-	62.5%	1.00	0.33
bigeye	*Priacanthus arenatus*	-	-	-	-	-	-	-	-	-	25.0%	0.25	0.16
Malacanthidae													
sand tilefish	*Malacanthus plumieri*	-	-	-	75.0%	1.50	0.38	87.5%	2.00	0.33	62.5%	1.00	0.33
Gerreidae													
Irish pompano	*Diapterus auratus*	12.5%	0.38	0.38	-	-	-	-	-	-	-	-	-
spotfin mojarra	*Eucinostomus argenteus*	12.5%	0.25	0.25	-	-	-	-	-	-	-	-	-
mottled mojarra	*Eucinostomus leyfroi*	62.5%	1.75	0.53	12.5%	0.25	0.25	-	-	-	-	-	-
yellowfin majorra	*Gerres cinereus*	50.0%	0.63	0.26	37.5%	0.88	0.44	-	-	-	25.0%	0.25	0.16
Carangidae													
blue runner	*Caranx crysos*	12.5%	0.25	0.25	25.0%	0.25	0.16	-	-	-	-	-	-
horse-eye jack	*Caranx latus*	62.5%	1.25	0.45	12.5%	0.25	0.25	-	-	-	-	-	-
bar jack	*Caranx ruber*	37.5%	0.88	0.44	75.0%	1.63	0.42	87.5%	2.00	0.33	100.0%	2.25	0.16
permit	*Trachinotus falcatus*	50.0%	0.88	0.35	-	-	-	-	-	-	-	-	-
palometa	*Trachinotus goodei*	62.5%	1.13	0.40	-	-	-	-	-	-	-	-	-
bigeye scad	*Selar Crumenophthalmus*	-	-	-	12.5%	0.63	0.63	-	-	-	-	-	-
mackerel scad	*Decapterus macarellus*	-	-	-	12.5%	0.38	0.38	12.5%	0.38	0.38	25.0%	0.75	0.49
Lutjanidae													
mutton snapper	*Lutjanus analis*	-	-	-	-	-	-	12.5%	0.13	0.13	-	-	-
schoolmaster	*Lutjanus apodus*	87.5%	1.38	0.26	-	-	-	12.5%	0.25	0.25	100.0%	2.00	0.27
gray snapper	*Lutjanus griseus*	12.5%	0.13	0.13	-	-	-	12.5%	0.13	0.13	12.5%	0.25	0.25
mahogany snapper	*Lutjanus mahogoni*	100.0%	3.00	0.27	87.5%	2.50	0.38	87.5%	1.63	0.32	87.5%	2.13	0.40
lane snapper	*Lutjanus synagris*	-	-	-	12.5%	0.25	0.25	-	-	-	-	-	-
yellowtail snapper	*Ocyurus chrysurus*	37.5%	0.50	0.27	75.0%	1.00	0.27	25.0%	0.38	0.26	50.0%	0.75	0.31

Table 3. continued.

		Zone I			Zone II			Zone III			Zone IV		
Family	Species	SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*
Haemulidae													
black margate	*Anisotremus surinamensis*	12.5%	0.13	0.13	-	-	-	-	-	-	-	-	-
porkfish	*Anisotremus virginicus*	-	-	-	-	-	-	-	-	-	12.5%	0.13	0.13
tomtate	*Haemulon aurolineatum*	12.5%	0.13	0.13	-	-	-	-	-	-	-	-	-
caesar grunt	*Haemulon carbonarium*	87.5%	1.75	0.37	87.5%	1.88	0.40	75.0%	1.38	0.38	87.5%	1.50	0.27
smallmouth grunt	*Haemulon chrysargyreum*	87.5%	2.13	0.35	-	-	-	-	-	-	62.5%	1.88	0.61
french grunt	*Haemulon flavolineatum*	100.0%	3.63	0.18	100.0%	3.50	0.19	100.0%	3.63	0.18	100.0%	3.00	0.19
spanish grunt	*Haemulon macrostomus*	12.5%	0.13	0.13	-	-	-	-	-	-	12.5%	0.13	0.13
cottonwick	*Haemulon melanurum*	-	-	-	12.5%	0.13	0.13	-	-	-	-	-	-
sailors choice	*Haemulon parra*	12.5%	0.25	0.25	-	-	-	-	-	-	-	-	-
white grunt	*Haemulon plumieri*	-	-	-	37.5%	0.63	0.32	50.0%	0.63	0.26	87.5%	1.38	0.26
bluestriped grunt	*Haemulon sciurus*	12.5%	0.13	0.13	62.5%	1.13	0.35	62.5%	1.25	0.37	75.0%	1.13	0.30
unid. juv. grunt	*Haemulon* sp.	40.0%	0.63	0.42	100.0%	2.00	0.46	-	-	-	-	-	-
Inermiidae													
boga	*Inermia vittata*	-	-	-	-	-	-	-	-	-	37.5%	1.38	0.68
Sparidae													
saucereye porgy	*Calamus calamus*	-	-	-	12.5%	0.13	0.13	-	-	-	-	-	-
Sciaenidae													
highhat	*Pareques acuminatus*	25.0%	0.38	0.26	62.5%	0.88	0.30	12.5%	0.13	0.13	-	-	-
spotted drum	*Equetus punctatus*	-	-	-	-	-	-	25.0%	0.25	0.16	50.0%	0.75	0.31
reef croaker	*Odontoscion dentex*	-	-	-	-	-	-	-	-	-	12.5%	0.13	0.13
sand drum	*Umbrina coroides*	25.0%	0.50	0.38	-	-	-	-	-	-	-	-	-
Mullidae													
yellow goatfish	*Mulloidichthys martinicus*	87.5%	2.63	0.42	100.0%	2.63	0.18	75.0%	1.75	0.41	100.0%	3.13	0.23
spotted goatfish	*Psuedupeneus maculatus*	87.5%	2.13	0.35	100.0%	2.50	0.27	87.5%	1.63	0.26	75.0%	1.13	0.30
Pempheridae													
glassy sweeper	*Pempheris schomburgki*	87.5%	1.75	0.49	-	-	-	-	-	-	-	-	-
Kyphosidae													
chub	*Kyphosus sectatrix/incisor*	25.0%	0.50	0.38	-	-	-	-	-	-	-	-	-

Table 3. continued.

Family	Species	Zone I			Zone II			Zone III			Zone IV		
		SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*
Chaetodontidae													
longsnout butterflyfish	*Chaetodon aculeatus*	-	-	-	-	-	-	-	-	-	87.5%	1.25	0.25
foureye butterflyfish	*Chaetodon capistratus*	-	-	-	75.0%	1.50	0.33	100.0%	2.75	0.16	100.0%	2.75	0.16
spotfin butterfly	*Chaetodon ocellatus*	-	-	-	37.5%	0.38	0.18	25.0%	0.38	0.26	-	-	-
reef butterflyfish	*Chaetodon sedentarius*	-	-	-	-	-	-	-	-	-	12.5%	0.13	0.13
banded butterfly	*Chaetodon striatus*	50.0%	0.75	0.31	75.0%	1.63	0.38	100.0%	1.88	0.13	75.0%	1.63	0.38
Pomacanthidae													
queen angelfish	*Holacanthus ciliaris*	-	-	-	50.0%	0.50	0.19	37.5%	0.50	0.27	12.5%	0.13	0.13
rock beauty	*Holacanthus tricolor*	-	-	-	-	-	-	75.0%	1.38	0.32	62.5%	1.13	0.35
french angelfish	*Pomacanthus paru*	25.0%	0.25	0.16	100.0%	2.00	0.19	50.0%	0.88	0.35	37.5%	0.50	0.27
Pomacentridae													
sergeant major	*Abudefduf saxatilis*	100.0%	3.13	0.35	100.0%	2.63	0.18	37.5%	1.13	0.58	75.0%	2.25	0.53
night sergeant	*Abudefduf taurus*	100.0%	2.75	0.31	-	-	-	-	-	-	-	-	-
blue chromis	*Chromis cyanea*	-	-	-	-	-	-	87.5%	3.50	0.57	100.0%	4.63	0.18
brown chromis	*Chromis multilineata*	-	-	-	50.0%	1.13	0.48	100.0%	3.50	0.33	100.0%	4.38	0.18
yellowtail damsel	*Microspathodon chrysurus*	37.5%	0.88	0.44		-	-	12.5%	0.13	0.13	37.5%	0.63	0.32
dusky damselfish	*Stegastes adustus*	100.0%	3.50	0.27	100.0%	3.00	0.19	37.5%	0.63	0.38	50.0%	1.38	0.53
longfin damselfish	*Stegastes diencaeus*	-	-	-	25.0%	0.50	0.33	100.0%	2.88	0.35	87.5%	2.50	0.38
beaugregory	*Stegastes leucostictus*	75.0%	1.63	0.38	100.0%	2.88	0.23	100.0%	1.88	0.30	87.5%	2.13	0.35
bicolor damselfish	*Stegastes partitus*	-	-	-	100.0%	4.50	0.19	100.0%	4.88	0.13	100.0%	4.75	0.16
threespot damsel	*Stegastes planifrons*	-	-	-	12.5%	0.25	0.25	87.5%	2.25	0.37	100.0%	4.00	0.19
cocoa damselfish	*Stegastes variabilis*	-	-	-	-	-	-	12.5%	0.13	0.13	25.0%	0.38	0.26
Labridae													
spanish hogfish	*Bodianus rufus*	-	-	-	-	-	-	87.5%	1.63	0.32	100.0%	2.38	0.18
creole wrasse	*Clepticus parrae*	-	-	-	-	-	-	37.5%	1.25	0.62	100.0%	4.63	0.18
slippery dick	*Halichoeres bivittatus*	100.0%	4.25	0.25	100.0%	4.88	0.13	100.0%	4.00	0.27	12.5%	0.25	0.25
yellowhead wrasse	*Halichoeres garnoti*	-	-	-	12.5%	0.13	0.13	87.5%	3.50	0.53	100.0%	3.63	0.18
clown wrasse	*Halichoeres maculipinna*	87.5%	2.63	0.42	87.5%	2.38	0.42	75.0%	2.00	0.46	37.5%	0.75	0.37
rainbow wrasse	*Halichoeres pictus*	-	-	-	-	-	-	62.5%	1.25	0.41	37.5%	0.75	0.37
blackear wrasse	*Halichoeres poeyi*	100.0%	2.25	0.16	87.5%	2.00	0.33	-	-	-	-	-	-
pudding wife	*Halichoeres radiatus*	87.5%	2.13	0.40	87.5%	1.88	0.30	37.5%	0.63	0.32	12.5%	0.13	0.13
bluehead wrasse	*Thalassoma bifasciatum*	100.0%	4.25	0.25	100.0%	4.63	0.18	100.0%	4.63	0.18	100.0%	4.63	0.26
rosy razorfish	*Xyrichtys martinicus*	-	-	-	12.5%	0.13	0.13	-	-	-	-	-	-
green razorfish	*Xyrichtys splendens*	-	-	-	87.5%	1.75	0.31	-	-	-	-	-	-

Table 3. continued.

Family	Species	Zone I			Zone II			Zone III			Zone IV		
		SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*
Scaridae													
bluelip parrotfish	*Cryptotomus roseus*	-	-	-	-	-	-	12.5%	0.25	0.25	-	-	-
striped parrotfish	*Scarus iserti*	12.5%	0.25	0.25	-	-	-	100.0%	3.13	0.23	100.0%	3.25	0.25
princess parrotfish	*Scarus taeniopterus*	-	-	-	-	-	-	100.0%	3.50	0.27	100.0%	3.75	0.16
queen parrotfish	*Scarus vetula*	-	-	-	-	-	-	100.0%	2.13	0.23	100.0%	2.88	0.13
greenblotch parrot	*Sparisoma atomarium*	-	-	-	-	-	-	37.5%	0.75	0.37	37.5%	1.00	0.50
redband parrotfish	*Sparisoma aurofrenatum*	-	-	-	87.5%	2.13	0.35	100.0%	3.75	0.16	100.0%	3.50	0.19
redtail parrotfish	*Sparisoma chrysopterum*	-	-	-	100.0%	2.75	0.25	62.5%	1.25	0.41	37.5%	0.50	0.27
bucktooth parrot	*Sparisoma radians*	37.5%	0.88	0.44	50.0%	1.38	0.53	-	-	-	-	-	-
yellowtail parrot	*Sparisoma rubripinne*	100.0%	3.50	0.27	100.0%	3.63	0.18	62.5%	1.25	0.41	62.5%	0.88	0.30
stoplight parrotfish	*Sparisoma viride*	-	-	-	25.0%	0.38	0.26	100.0%	2.88	0.30	100.0%	3.13	0.23
unid. juv. scarid	*Sparisoma* sp.	33.3%	0.88	0.58	100.0%	0.75	0.49	-	-	-	-	-	-
Opistognathidae													
yellowhead jawfish	*Opistognathus aurifrons*	-	-	-	-	-	-	62.5%	1.25	0.37	-	-	-
unident. jawfish	*Opistognathus* sp.	-	-	-	62.5%	0.88	0.30	-	-	-	-	-	-
Mugilidae													
white mullet	*Mugil curema*	12.5%	0.38	0.38	-	-	-	-	-	-	-	-	-
Sphyraenidae													
great barracuda	*Sphyraena barracuda*	12.5%	0.13	0.13	12.5%	0.13	0.13	12.5%	0.13	0.13	12.5%	0.13	0.13
southern sennet	*Sphyraena picudilla*	-	-	-	-	-	-	-	-	-	12.5%	0.25	0.25
Scombridae													
cero mackerel	*Scomberomorus regalis*	-	-	-	12.5%	0.13	0.13	25.0%	0.38	0.26	50.0%	0.88	0.35
Labrisomidae													
palehead blenny	*Labrisomus gobio*	12.5%	0.25	0.25	-	-	-	-	-	-	-	-	-
hairy blenny	*Labrisomus nuchipinnis*	87.5%	1.50	0.27	-	-	-	-	-	-	-	-	-
goldline blenny	*Malacoctenus aurolineatus*	87.5%	1.88	0.30	12.5%	0.13	0.13	-	-	-	-	-	-
dusky blenny	*Malacoctenus gilli*	50.0%	0.88	0.35	12.5%	0.25	0.25	-	-	-	-	-	-
rosy blenny	*Malacoctenus macropus*	-	-	-	37.5%	0.50	0.27	12.5%	0.13	0.13	-	-	-
saddled blenny	*Malacoctenus triangulatus*	37.5%	0.38	0.18	100.0%	2.38	0.32	12.5%	0.38	0.38	-	-	-
Blenniidae													
pearl blenny	*Entomacrodus nigricans*	62.5%	1.13	0.35	-	-	-	-	-	-	-	-	-
redlip blenny	*Ophioblennius atlanticus*	87.5%	2.63	0.38	62.5%	1.50	0.46	50.0%	1.13	0.44	-	-	-

Table 3. continued.

		Zone I			Zone II			Zone III			Zone IV		
Family	Species	SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*
Blenniidae													
molly miller	*Scartella cristata*	25.0%	0.50	0.33	-	-	-	-	-	-	-	-	-
Chaenopsidae													
spinyhead blenny	*Acanthemblemaria spinosa*	-	-	-	50.0%	1.00	0.38	62.5%	1.25	0.37	25.0%	0.50	0.33
sailfin blenny	*Emblemaria pandonis*	-	-	-	12.5%	0.25	0.25	-	-	-	-	-	-
Gobiidae													
frillfin goby	*Bathygobius soprator*	50.0%	1.13	0.44	-	-	-	-	-	-		-	-
bridled goby	*Coryphopterus glaucofrenatum*	-	-	-	87.5%	2.38	0.42	100.0%	3.50	0.19	87.5%	2.50	0.38
peppermint goby	*Coryphopterus lipernes*	-	-	-	-	-	-	12.5%	0.13	0.13	62.5%	1.50	0.50
masked/glass goby	*C. personatus/hyalinus*	-	-	-	-	-	-	75.0%	2.25	0.53	87.5%	4.25	0.62
cleaning goby	*Elacatinus genie*	-	-	-	-	-	-	-	-	-	12.5%	0.25	0.25
sharknose goby	*Elacatinus evelynae*	-	-	-	-	-	-	75.0%	1.63	0.38	62.5%	1.38	0.42
nineline goby	*Ginsburgellus novemlineatus*	50.0%	0.88	0.35	-	-	-	-	-	-	-	-	-
goldspot goby	*Gnatholepis thompsoni*		-	-	87.5%	2.88	0.44	87.5%	2.75	0.45	62.5%	1.63	0.50
shortstripe goby	*Gobiosoma chancei*		-	-	-	-	-	12.5%	0.25	0.25	12.5%	0.13	0.13
greenbanded goby	*Gobiosoma multifasciatum*	50.0%	0.88	0.35	-	-	-	-	-	-	-	-	-
broadstripe goby	*Gobiosoma prochilos*	-	-	-	-	-	-	12.5%	0.13	0.13	-	-	-
Acanthuridae													
ocean surgeonfish	*Acanthurus bahianus*	100.0%	3.88	0.23	100.0%	4.38	0.26	100.0%	4.00	0.27	100.0%	3.25	0.16
doctorfish	*Acanthurus chirurgus*	50.0%	1.00	0.42	87.5%	2.13	0.35	37.5%	0.88	0.44	50.0%	1.25	0.53
blue tang	*Acanthurus coeruleus*	100.0%	2.38	0.32	100.0%	2.88	0.23	100.0%	3.50	0.19	100.0%	3.25	0.16
Bothidae													
peacock flounder	*Bothus lunatus*	50.0%	0.50	0.19	62.5%	0.88	0.30	-	-	-	12.5%	0.13	0.13
eyed flounder	*Bothus ocellatus*	-	-	-	12.5%	0.13	0.13	-	-	-	-	-	-
Balistidae													
queen triggerfish	*Balistes vetula*	-	-	-	12.5%	0.13	0.13	25.0%	0.38	0.26	12.5%	0.13	0.13
black durgon	*Melichthys niger*	-	-	-	-	-	-	-	-	-	87.5%	2.00	0.33
Monocanthidae													
scrawled filefish	*Aluterus scripta*	-	-	-	-	-	-	-	-	-	25.0%	0.25	0.16
whitespotted filefish	*Cantherhines macrocerus*	-	-	-	37.5%	0.38	0.18	37.5%	0.38	0.18	62.5%	0.88	0.30
orangespotted filefish	*Cantherhines pullus*	62.5%	1.25	0.37	75.0%	1.25	0.31	62.5%	0.75	0.25	37.5%	0.38	0.18
slender filefish	*Monacanthus tuckeri*	25.0%	0.25	0.16	25.0%	0.25	0.16	-	-	-	-	-	-

Table 3. continued.

		Zone I			Zone II			Zone III			Zone IV		
Family	Species	SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*	SF*	AI*	SEM*
Ostraciidae													
honeycomb cowfish	*Acanthostracion ploygonia*	12.5%	0.13	0.13	12.5%	0.25	0.25	12.5%	0.13	0.13	75.0%	1.00	0.27
spotted trunkfish	*Lactophrys bicaudalis*	25.0%	0.25	0.16	12.5%	0.13	0.13	62.5%	0.63	0.18	50.0%	0.63	0.26
trunkfish	*Lactophrys trigonus*	-	-	-	12.5%	0.13	0.13	-	-	-	-	-	-
smooth trunkfish	*Lactophrys triqueter*	12.5%	0.13	0.13	50.0%	0.88	0.35	75.0%	1.13	0.30	75.0%	1.13	0.30
Tetraodontidae													
sharpnose puffer	*Canthigaster rostrata*	12.5%	0.25	0.25	50.0%	1.00	0.38	87.5%	1.88	0.30	87.5%	2.25	0.41
bandtail puffer	*Sphoeroides spengleri*	25.0%	0.25	0.16	12.5%	0.13	0.13	37.5%	0.63	0.32	12.5%	0.13	0.13
checkered puffer	*Sphoeroides testudineus*	12.5%	0.13	0.13	12.5%	0.13	0.13	-	-	-	-	-	-
Diodontidae													
web burrfish	*Chilomycterus antillarum*	-	-	-	-	-	-	25.0%	0.25	0.16	12.5%	0.13	0.13
balloonfish	*Diodon holocanthus*	12.5%	0.13	0.13	12.5%	0.13	0.13	25.0%	0.25	0.16	25.0%	0.25	0.16
porcupinefish	*Diodon hystrix*	37.5%	0.50	0.27	25.0%	0.25	0.16	-	-	-	37.5%	0.38	0.18

*note: SF = Sighting Frequency (%), AI = average Abundance Index (see text), SEM = Standard Error of the Mean.

Table 4. Fish species richness in four habitat zones.

Habitat Zone	No. of RDS* Replicates	Cumul. No. of Species	No. of Fish Species Observed per Survey			
			Avg.	St. Dev.	Max.	Min.
I	8	86	41.4	6.2	47	28
II	8	106	50.5	4.5	57	44
III	8	102	54.8	5.7	64	48
IV	8	110	62.0	8.6	73	53

* Replicate 60 minute Roving Diver Surveys (RDS) were conducted in each habitat zone.

Table 5. Similarity of fish assemblages among habitat zones.

		Habitat Zone			
		I	**II**	**III**	**IV**
Habitat Zone	**I**	-	0.45	0.31	0.30
	II	0.37	-	0.53	0.44
	III	0.24	0.48	-	0.68
	IV	0.23	0.37	0.66	-

Jaccard's community coefficient (JC) was calculated using either all RDS observations (above diagonal, n=176 species) or after excluding species with single observations (below diagonal, n=141 species).

Table 6. Observed cross-shelf distribution patterns of fish species.

Type of Distribution	Habitat Zones	All observations (n = 176)		Species with AI*[1] > 1.0 (n = 94)*[2]		
		No. Species	%	No. Species	%	Example Species
Broad	all zones	35	19.9%	30	31.9%	bluehead, ocean surgeon, french grunt
Wide (three zones)	not zone I	27	15.3%	19	20.2%	brown chromis, yellowhead wrasse
	not zone IV	5	2.8%	3	3.2%	dwarf herring, redlip blenny
	not zone II	4	2.3%	2	2.1%	schoolmaster, yellowtail damselfish
	not zone III	4	2.3%	1	1.1%	dusky squirrelfish
	Subtotal =	40	22.7%	25	26.6%	
Restricted (two zones)	zones III & IV	20	11.4%	14	14.9%	queen parrotfish, blue chromis, spanish hogfish
	zones I & II	16	9.1%	8	8.5%	blackear wrasse, bucktooth parrotfish
	zones II & III	5	2.8%	1	1.1%	flamefish
	zones I & IV	2	1.1%	1	1.1%	smallmouth and spanish grunts
	zones I & III	0	-	0	-	-
	zones II & IV	0	-	0	-	-
	Subtotal =	43	24.4%	24	25.5%	
Narrow (one zone)	zone I	20	11.4%	6	6.4%	night sergeant, glassy sweeper, hairy blenny
	zone IV	18	10.2%	6	6.4%	black durgon, boga, YT & barred hamlets
	zone II	14	8.0%	1	1.1%	green razorfish
	zone III	6	3.4%	2	2.1%	barred cardinalfish, yellowhead jawfish
	Subtotal =	58	33.0%	15	16.0%	
	Total =	176	100.0%	94	100.0%	

*notes: 1. AI is average abundance index.
2. Those species for which the average abundance index (AI) was > 1.0 in at least one habitat zone.

Figure 1. Map of western St. Croix. The Frederiksted Reef and locations of previous studies (as discussed in the text) are shown. The map is re-drawn from Kendall et al. (2001) to show only land (gray) and linear reef (stippled polygons). Abbreviations are as follows: EN = Estate Northside, FP = Frederiksted Pier, HB = Hams Bluff Bay, BB = Butler Bay, SH = Spat Hole, SP = Sandy Point, UTR = Underwater Tracking Range headquarters at Estate Sprat Hall.

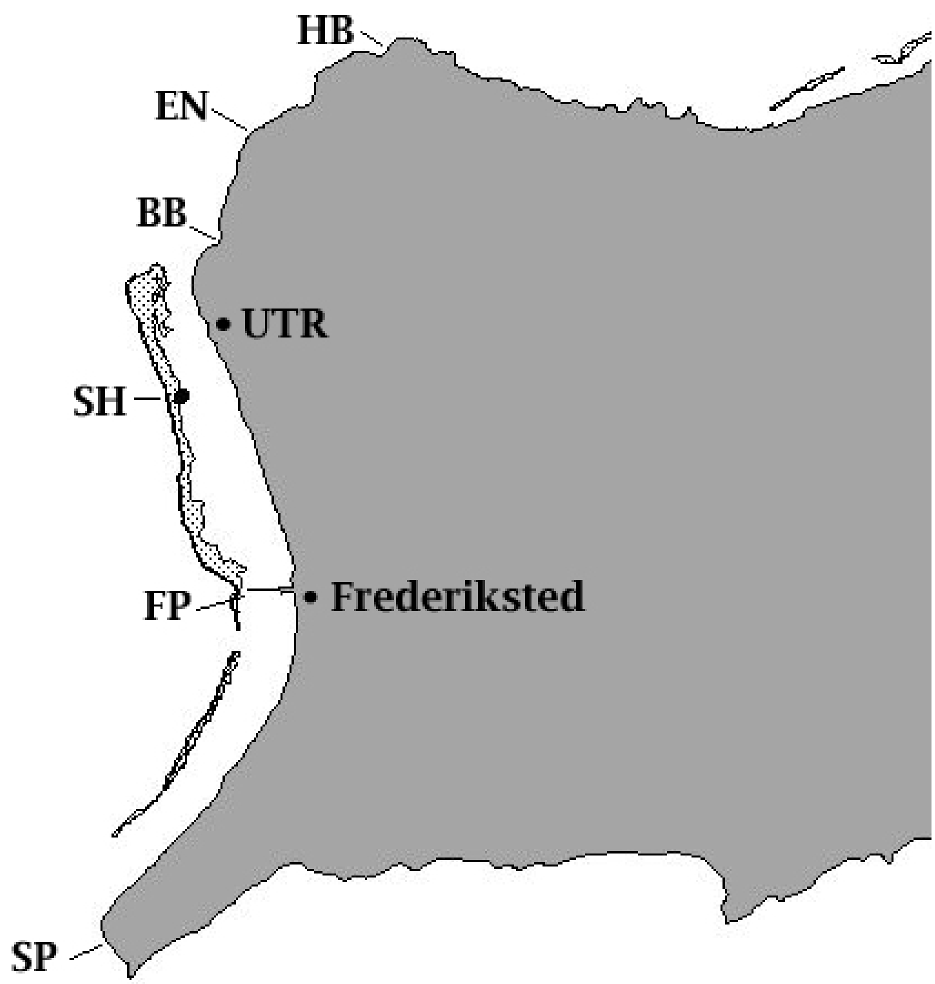


Figure 2. Location of towed-diver transects on aerial photos. The location of 8 transects are shown with solid lines. Partial transects (0 and 9) are shown with dashed lines. Seaward ends of transects were terminated at the 60 foot depth contour. The town of Frederiksted is visible in the lower (southern) part of the photo. Location of the Underwater Tracking Range (UTR) Headquarters and the red crane (RC) at the base of the Frederiksted Cruise Ship Pier are shown for reference purposes. Georeferenced aerial photo mosaic is from Kendall et al. (2001).

Figure 3. Intertidal/shallow subtidal habitat zone (Zone I). **A.** Exposed limestone bedrock creates a rocky intertidal habitat with numerous tidepools. Interspersed among the rocky habitats are beaches of sand and cobble. Photo from transect 2 looking north. **B.** The shallow subtidal zone support a lush macroalgal community. Some species of scleractinian corals are also common in this habitat zone. Photo from transect 2.

A.

B.

Figure 4. Inshore low relief habitat zone (Zone II). **A.** This zone is characterized by limestone pavements covered by turf algae and sediments. In areas, gorgonians are locally abundant. Pictured is a school of bigeye scad, *Selar crumenophthalmus*. Photo from transect 8. **B.** Areas of coral and limestone rubble create patches of habitat structure where fish assemblages are diverse and juvenile fish are abundant. The long-spined sea urchin, *Diadema antillarum,* may also be locally abundant. Photo from transect 5

A.

B.

Figure 5. Transitional/patch reef habitat zone (Zone III). **A**. Patch reefs add to the three dimensional structure of this zone. Numerous fish species are found in association with structures including gunts, parrotfishes and surgeonfishes. Photo from transect 2. **B.** Larger areas of patch reefs form semi-continuous reef structures (transitional reefs) although live coral cover in this zone is typically intermediate between that of zones II and IV. Photo from transect 3.

A.

B.

Figure 6. Reef Crest habitat zone (Zone IV). **A.** The amount of live coral cover is highest in this zone where *Montastraea annularis* predominates and contributes greatly to three dimensional habitat complexity. Photo from transect 7. **B.** Coral diversity is also high in this zone. Many fish species that are characteristic of reef habitats are common in zone IV, such as the rock beauty, *Holacanthus tricolor*, pictured here. Photo from transect 8.

A.

B.

Figure 7. Location of observed habitat zone transition points on NOAA benthic habitat map. Each black circle represents an observed transition point between habitat zones (as defined in this study) along cross-shelf, towed diver transects (straight lines). Colored polygons show habitat types from NOAA maps (Kendall et al. 2001) as follows: land (gray), colonized bedrock (yellow), colonized pavement (orange), sand (white), colonized pavement with sand channels (pink) , scattered coral/rock in unconsolidated sediment (brown), linear reef (red) and unknown/overdepth (blue).

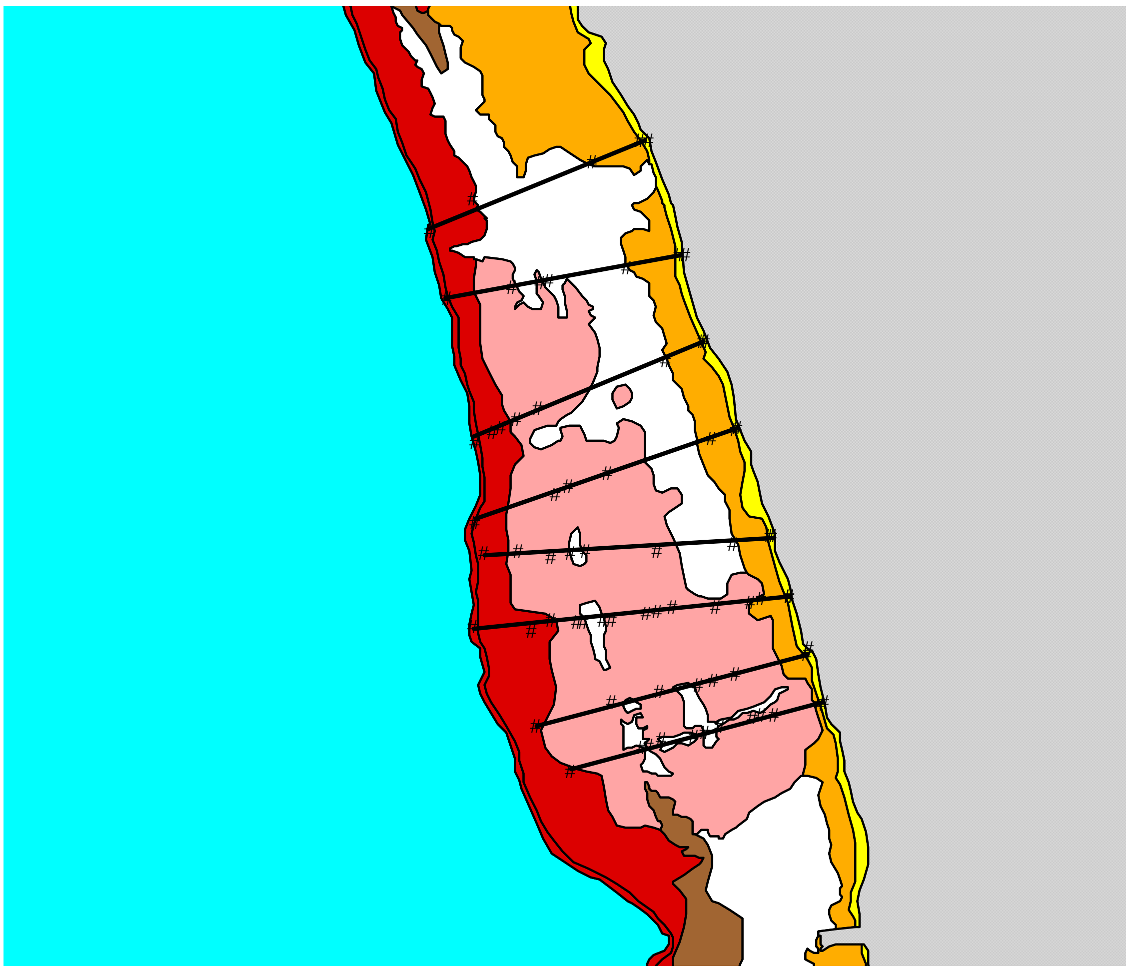


Figure 8. Depth profiles across towed-diver transects. Partial transects (#0 and #9) are not included. Note: scale of y-axis is expanded 10-fold relative to x-axis.

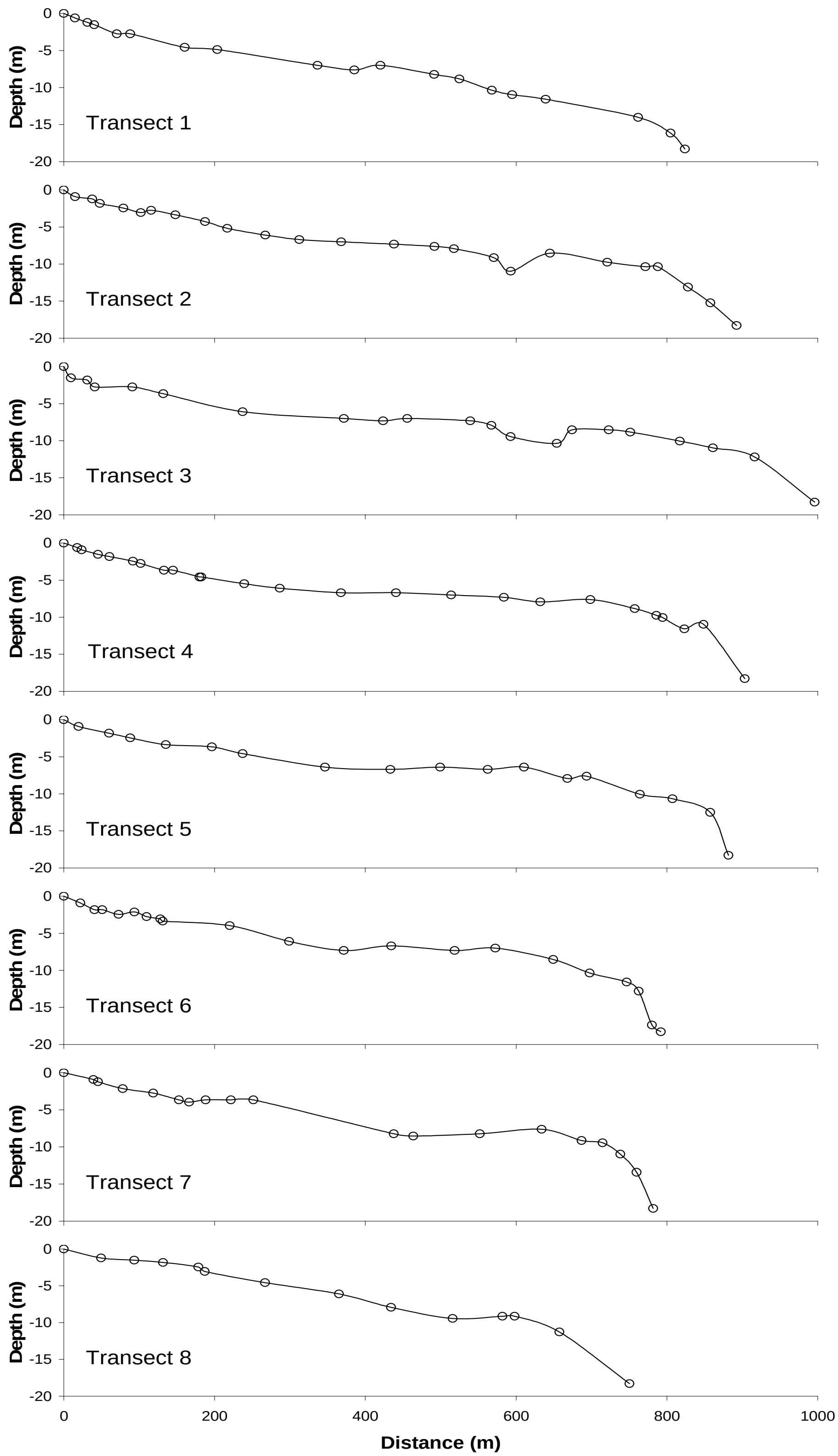


Figure 9. Location of 27 roving diver survey (RDS) sites. Fish surveys were conducted in four different habitat zones (see text). Habitat zones are color coded as follows: zone I (red), zone II (yellow), zone III (black), zone IV (white). See also Appendix 5.

Figure 10. Average fish species richness observed in four habitat zone (n=8 surveys per habitat zone). Richness was calculated from all species observations (gray columns) or after excluding those species which were observed in only one replicate survey from each habitat (white columns). Error bars show +/- one standard deviation.

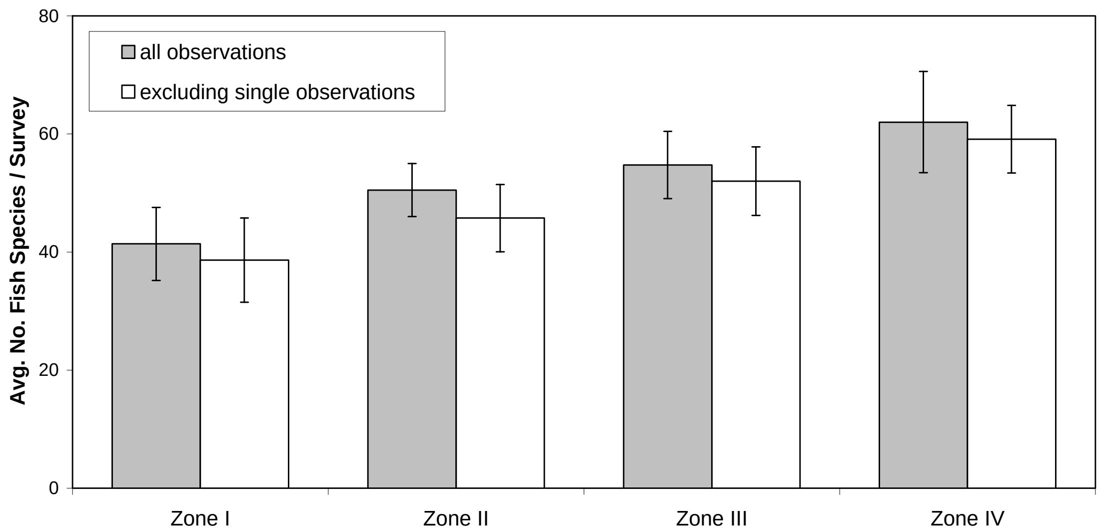


Figure 12. Observed distribution of parrotfish species among habitat zones. The y-axis shows average abundance index (AI; see text) determined from roving diver surveys (error bars=SEM).

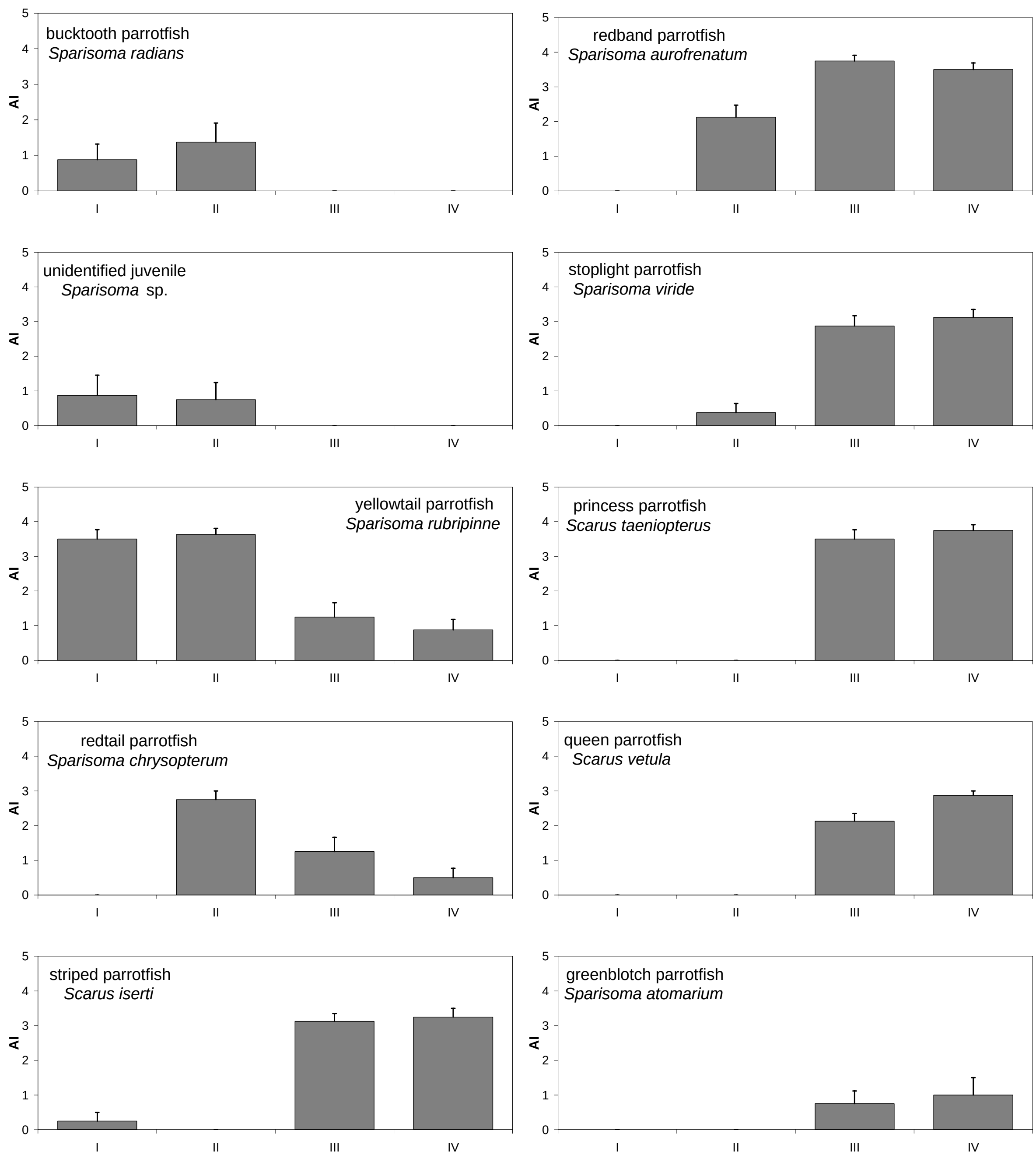
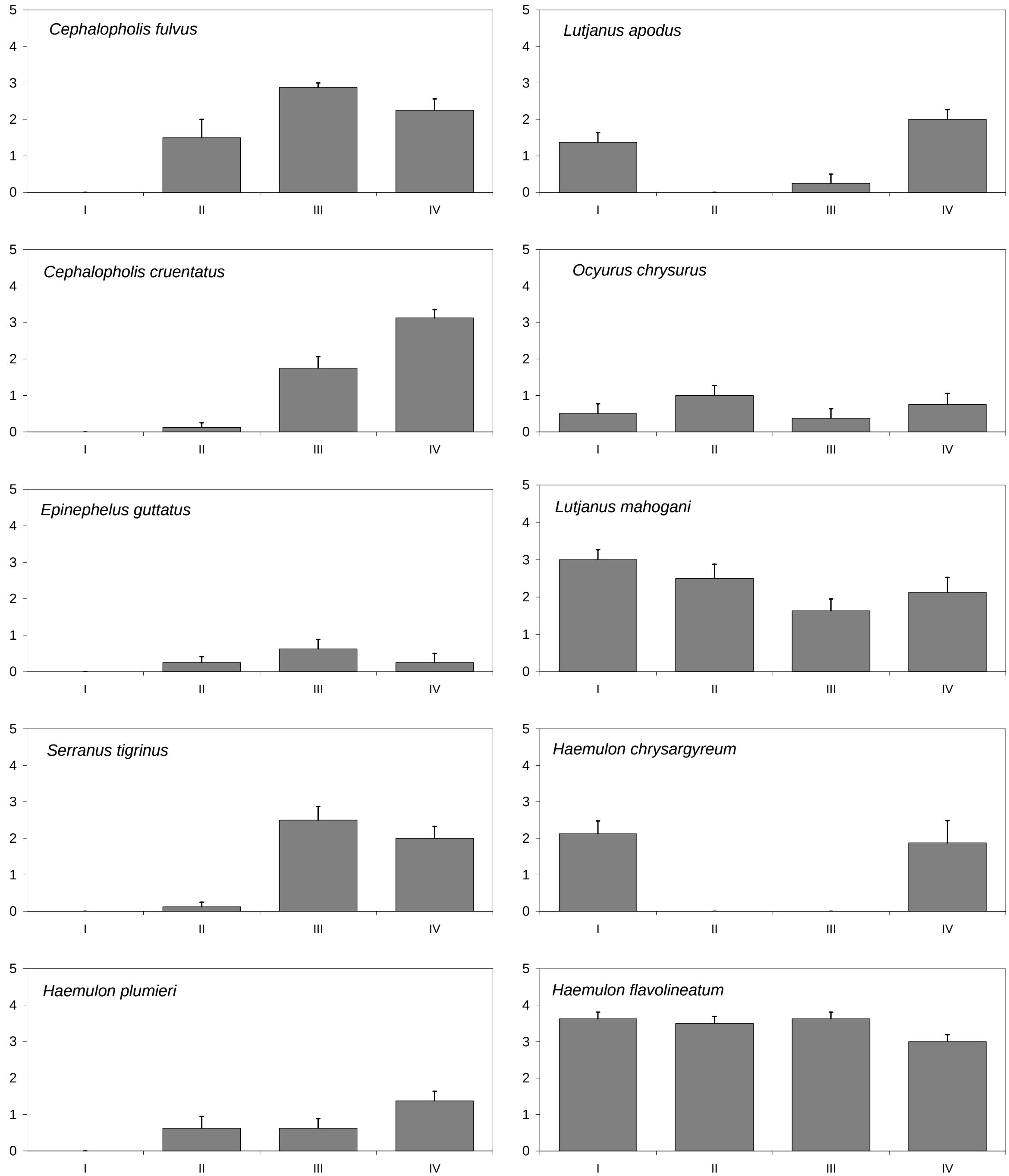


Figure 13. Observed distribution of selected serranid, lutjanid and haemulid species among habitat zones. The y-axis shows average abundance index (AI; see text) determined from roving diver surveys (error bars=SEM).



Appendix 1. Roving Diver Survey (RDS) data from habitat zone I – intertidal/shallow subtidal.

		Site†	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8
		Transect†	T-3	T-5	T-7	T-7	T-8	T-4	T-0/1	T-2
		Date	1/17	1/23	2/24	2/24	3/1	3/12	3/13	3/19
Common Name	Species	RDS No.†	1	2	3	4	5	6	7	8
ocean surgeonfish	*Acanthurus bahianus*		3*	4*	4*	3	4*	5*	4*	4*
doctorfish	*Acanthurus chirurgus*		1*	3*	0	0	0	2*	2*	0
blue tang	*Acanthurus coeruleus*		3*	4*	2*	1	2*	2	2*	3*
hardhead silverside	*Atherinomorus stipes*		0	0	0	0	0	4	5	5
trumpetfish	*Aulostomus maculatus*		0	0	0	0	0	0	1	1
flat needlefish	*Ablennes hians*		0	2	0	0	0	0	0	0
keeltail needlefish	*Platybelone argalus*		0	0	0	0	0	0	2	1
pearl blenny	*Entomacrodus nigricans*		1	2	0	0	0	2	2	2
redlip blenny	*Ophioblennius atlanticus*		3	3	3	0	3	3	3	3
molly miller	*Scartella cristata*		2	2	0	0	0	0	0	0
peacock flounder	*Bothus lunatus*		1	1	0	1	0	1	0	0
blue runner	*Caranx crysos*		2	0	0	0	0	0	0	0
horse-eye jack	*Caranx latus*		2	1	1	0	0	3	0	3
bar jack	*Caranx ruber*		3	0	0	0	0	2	0	2
permit	*Trachinotus falcatus*		0	0	2	2	2	0	1	0
palometa	*Trachinotus goodei*		2	1	0	0	0	1	2	3
banded butterflyfish	*Chaetodon striatus*		0	0	1	0	1	1*	2*	0
redear sardine	*Harengula humeralis*		5	5	0	0	0	5	0	0
dwarf herring	*Jenkinsia lamprotaenia*		5	5	5	0	5	5	5	5
balloonfish	*Diodon holocanthus*		0	0	0	0	1	0	0	0
porcupinefish	*Diodon hystrix*		0	0	0	0	0	1	1	2
Irish pompano	*Diapterus auratus*		0	0	3	0	0	0	0	0
spotfin mojarra	*Eucinostomus argenteus*		0	0	0	0	0	2	0	0
mottled mojarra	*Eucinostomus leyfroi*		0	0	2	0	3	3	3	3
yellowfin majorra	*Gerres cinereus*		0	1	0	0	1	2	0	1
frillfin goby	*Bathygobius soprator*		3	0	0	0	0	2	2	2
nineline goby	*Ginsburgellus novemlineatus*		2	0	0	0	1	2	2	0
greenbanded goby	*Gobiosoma multifasciatum*		2	2	0	0	0	2	1	0
unident. juvenile grunts	*Haemulon* sp.		0	0	2	0	0	0	3	0
black margate	*Anisotremus surinamensis*		0	0	0	0	0	0	0	1
tomtate	*Haemulon aurolineatum*		0	0	0	1	0	0	0	0
caesar grunt	*Haemulon carbonarium*		2*	3*	3*	2*	2*	1*	0	1*
smallmouth grunt	*Haemulon chrysargyreum*		2	3	2	2	3	0	3	2
french grunt	*Haemulon flavolineatum*		3	4	3	3	4	4	4	4
spanish grunt	*Haemulon macrostomus*		0	1	0	0	0	0	0	0
sailors choice	*Haemulon parra*		0	0	0	0	2	0	0	0
bluestriped grunt	*Haemulon sciurus*		0	0	0	0	0	0	0	1
squirrelfish	*Holocentrus adcensionis*		0	0	1	0	0	0	0	0
longspine squirrelfish	*Holocentrus rufus*		0	1	1	0	0	0	0	0
reef squirrelfish	*Sargocentron coruscum*		1	1	1	0	1	0	0	2
dusky squirrelfish	*Sargocentron vexillarium*		2	2	0	0	2	2	3	1
chub	*Kyphosus sectatrix/incisor*		0	0	0	0	0	0	1	3
slippery dick	*Halichoeres bivittatus*		4	5	4	3	5	4	4	5
clown wrasse	*Halichoeres maculipinna*		2	3	3	0	3	3	4	3
blackear wrasse	*Halichoeres poeyi*		2	3	2	2	3	2	2	2
pudding wife	*Halichoeres radiatus*		0	3	2	1	3	2	3	3
bluehead wrasse	*Thalassoma bifasciatum*		4	5	4	3	5	4	4	5
palehead blenny	*Labrisomus gobio*		0	0	0	0	0	2	0	0
hairy blenny	*Labrisomus nuchipinnis*		2	2	1	0	2	2	2	1
goldline blenny	*Malacoctenus aurolineatus*		2	3	2	0	2	2	2	2
dusky blenny	*Malacoctenus gilli*		0	1	0	0	2	2	2	0
saddled blenny	*Malacoctenus triangulatus*		0	1	0	0	0	0	1	1
schoolmaster	*Lutjanus apodus*		2	1*	2*	1	1	0	2*	2
gray snapper	*Lutjanus griseus*		0	0	0	0	0	0	0	1
mahogany snapper	*Lutjanus mahogoni*		2*	4*	3*	2*	4*	3*	3*	3*
yellowtail snapper	*Ocyurus chrysurus*		2*	1*	1*	0	0	0	0	0
orangespotted filefish	*Cantherhines pullus*		0	2	2	0	2	2	2	0

Appendix 1. continued.

Common Name	Species	Site† / Transect† / Date / RDS No.†	R-1 T-3 1/17 1	R-2 T-5 1/23 2	R-3 T-7 2/24 3	R-4 T-7 2/24 4	R-5 T-8 3/1 5	R-6 T-4 3/12 6	R-7 T-0/1 3/13 7	R-8 T-2 3/19 8
slender filefish	*Monacanthus tuckeri*		0	1	1	0	0	0	0	0
white mullet	*Mugil curema*		0	0	0	0	0	0	0	3
yellow goatfish	*Mulloidichthys martinicus*		2*	4*	3*	3*	3*	0	3*	3*
spotted goatfish	*Psuedupeneus maculatus*		0	2*	3*	2*	3*	2*	3*	2*
chain moray	*Echidna catenata*		1	2	0	0	2	0	0	0
spotted moray	*Gymnothorax moringa*		0	0	0	1	0	0	0	0
honeycomb cowfish	*Acanthostracion ploygonia*		1	0	0	0	0	0	0	0
spotted trunkfish	*Lactophrys bicaudalis*		0	1	0	0	0	0	1	0
smooth trunkfish	*Lactophrys triqueter*		0	0	0	0	0	0	0	1
glassy sweeper	*Pempheris schomburgki*		2	2	0	0	2	1	3	4
french angelfish	*Pomacanthus paru*		1*	0	0	0	0	1*	0	0
sergeant major	*Abudefduf saxatilis*		4*	4*	3*	1*	3*	3	4*	3*
night sergeant	*Abudefduf taurus*		2	3	3	2	2	2	4	4
yellowtail damselfish	*Microspathodon chrysurus*		2	0	0	2	0	0	3	0
dusky damselfish	*Stegastes adustus*		3	4	4	2	4	3	4	4
beaugregory	*Stegastes leucostictus*		2	2	2	2	3	2	0	0
unident. juvenile scarids	*Sparisoma* sp.		0	0	4	3	0	0	0	0
striped parrotfish	*Scarus iserti*		0	0	0	0	2	0	0	0
bucktooth parrotfish	*Sparisoma radians*		0	0	3	2	2	0	0	0
yellowtail parrotfish	*Sparisoma rubripinne*		3	4	4*	2	4*	4*	3	3
highhat	*Pareques acuminatus*		0	0	0	0	1	2	0	0
sand drum	*Umbrina coroides*		0	0	0	0	0	3	1	0
spotted scorpionfish	*Scorpaena plumieri*		2	1	1	0	0	2	2	0
greater soapfish	*Rypticus saponaceus*		0	0	0	2	0	0	0	0
great barracuda	*Sphyraena barracuda*		0	0	0	1	0	0	0	0
sand diver	*Synodus intermedius*		0	0	0	0	0	2	0	1
sharpnose puffer	*Canthigaster rostrata*		0	0	0	2	0	0	0	0
bandtail puffer	*Sphoeroides spengleri*		1	0	0	0	1	0	0	0
checkered puffer	*Sphoeroides testudineus*		0	1	0	0	0	0	0	0
Totals (n = 86 taxa)			43	47	38	28	40	46	45	44

Asterisks (*) indicate counts where recruits or juveniles were observed to be more abundant than adults of the same species.
† Refer to Appendix 5.

Appendix 2. Roving Diver Survey (RDS) data from habitat zone II - inshore low relief.

		Site†	R-9	R-10	R-11	R-11	R-12	R-13	R-14	R-15
		Transect†	T-3	T-1	T-7	T-7	T4	T8-9	T-8	T-6
		Date	1/16	1/30	2/24	2/24	3/18	3/25	3/27	4/2
Common Name	Species	RDS No.†	1	2	3	4	5	6	7	8
ocean surgeonfish	*Acanthurus bahianus*		4*	4	4	3	5*	5*	5*	5*
doctorfish	*Acanthurus chirurgus*		2	0	2	3*	2	2	3	3*
blue tang	*Acanthurus coeruleus*		4*	2	2	3	3	3	3	2
flamefish	*Apogon maculatus*		2	2	2	0	2	3	2	3
hardhead silverside	*Atherinomorus stipes*		0	0	0	0	0	0	0	4
trumpetfish	*Aulostomus maculatus*		1	0	0	0	0	0	0	1
queen triggerfish	*Balistes vetula*		0	0	0	1	0	0	0	0
flat needlefish	*Ablennes hians*		2	0	0	0	0	0	0	0
redlip blenny	*Ophioblennius atlanticus*		0	2	0	2	3	3	2	0
peacock flounder	*Bothus lunatus*		0	0	1	0	1	1	2	2
eyed flounder	*Bothus ocellatus*		1	0	0	0	0	0	0	0
blue runner	*Caranx crysos*		0	1	0	0	0	0	1	0
horse-eye jack	*Caranx latus*		2	0	0	0	0	0	0	0
bar jack	*Caranx ruber*		3	1	0	0	2	2	3	2
bigeye scad	*Selar Crumenophthalmus*		0	0	0	0	0	0	5	0
mackerel scad	*Decapterus macarellus*		0	0	0	3	0	0	0	0
spinyhead blenny	*Acanthemblemaria spinosa*		0	2	0	0	2	2	2	0
sailfin blenny	*Emblemaria pandonis*		0	2	0	0	0	0	0	0
foureye butterflyfish	*Chaetodon capistratus*		2	2	2	0	2	2	0	2
spotfin butterflyfish	*Chaetodon ocellatus*		0	0	1	0	1	0	0	1
banded butterflyfish	*Chaetodon striatus*		2	0	2	0	2*	2	3*	2*
redear sardine	*Harengula humeralis*		5	0	0	0	0	0	0	0
dwarf herring	*Jenkinsia lamprotaenia*		0	0	0	0	4	0	0	0
brown garden eel	*Heteroconger longissimus*		0	0	0	3	0	0	0	0
southern stingray	*Dasyatis americana*		1	0	0	0	0	0	0	0
balloonfish	*Diodon holocanthus*		1	0	0	0	0	0	0	0
porcupinefish	*Diodon hystrix*		0	0	0	0	0	1	1	0
bluespotted cornetfish	*Fistularia tabacaria*		1	0	0	0	0	1	0	0
mottled mojarra	*Eucinostomus leyfroi*		0	0	0	0	0	0	2	0
yellowfin majorra	*Gerres cinereus*		0	0	0	0	2	0	3	2
bridled goby	*Coryphopterus glaucofrenatum*		4	2	2	0	3	3	2	3
goldspot goby	*Gnatholepis thompsoni*		4	3	3	0	4	3	3	3
unident. juvenile grunts	*Haemulon* sp.		0	3	3	0	3	2	3	2
caesar grunt	*Haemulon carbonarium*		0	1	3	2	2*	3	1	3
french grunt	*Haemulon flavolineatum*		3	3	3	3	4	4	4	4
cottonwick	*Haemulon melanurum*		1	0	0	0	0	0	0	0
white grunt	*Haemulon plumieri*		2	0	2	1	0	0	0	0
bluestriped grunt	*Haemulon sciurus*		1	0	2	0	2	2	0	2
ballyhoo	*Hemiramphus brasiliensis*		0	0	0	0	0	3	0	0
squirrelfish	*Holocentrus adcensionis*		2	1	3	2	2	3	3	3
longspine squirrelfish	*Holocentrus rufus*		0	0	0	0	2	0	0	0
blackbar soldierfish	*Myripristis jacobus*		0	0	0	0	0	1	0	2
reef squirrelfish	*Sargocentron coruscum*		0	1	0	0	0	2	1	2
dusky squirrelfish	*Sargocentron vexillarium*		0	0	0	0	0	1	0	0
slippery dick	*Halichoeres bivittatus*		5	5	5	4	5	5	5	5
yellowhead wrasse	*Halichoeres garnoti*		0	0	0	0	0	0	0	1
clown wrasse	*Halichoeres maculipinna*		2	2	2	0	3	4	3	3
blackear wrasse	*Halichoeres poeyi*		2	2	2	0	3	3	2	2
pudding wife	*Halichoeres radiatus*		2	0	2	2	2	2	2	3
bluehead wrasse	*Thalassoma bifasciatum*		4	5	4	4	5	5	5	5
rosy razorfish	*Xyrichtys martinicus*		0	0	1	0	0	0	0	0
green razorfish	*Xyrichtys splendens*		2	0	2	1	3	2	2	2
goldline blenny	*Malacoctenus aurolineatus*		0	0	0	0	0	1	0	0
dusky blenny	*Malacoctenus gilli*		0	2	0	0	0	0	0	0
rosy blenny	*Malacoctenus macropus*		1	2	1	0	0	0	0	0
saddled blenny	*Malacoctenus triangulatus*		1	2	3	2	2	3	4	2
mahogany snapper	*Lutjanus mahogoni*		2*	0	3*	3*	3	3*	3	3*

Appendix 2. continued.

Common Name	Species	Site† Transect† Date RDS No. †	R-9 T-3 1/16 1	R-10 T-1 1/30 2	R-11 T-7 2/24 3	R-11 T-7 2/24 4	R-12 T4 3/18 5	R-13 T8-9 3/25 6	R-14 T-8 3/27 7	R-15 T-6 4/2 8
lane snapper	*Lutjanus synagris*		0	0	0	2	0	0	0	0
yellowtail snapper	*Ocyurus chrysurus*		0	1*	1*	2*	2*	0	1*	1*
sand tilefish	*Malacanthus plumieri*		2	0	0	1	2	3	2	2
whitespotted filefish	*Cantherhines macrocerus*		0	0	1	1	0	0	1	0
orangespotted filefish	*Cantherhines pullus*		0	0	2	1	2	1	2	2
slender filefish	*Monacanthus tuckeri*		0	0	1	0	0	0	1	0
yellow goatfish	*Mulloidichthys martinicus*		3	3	3	3	2	2	3	2
spotted goatfish	*Psuedupeneus maculatus*		2	1*	3	3	3*	3*	2	3*
chain moray	*Echidna catenata*		0	0	0	0	1	0	0	0
goldentail moray	*Gymnothorax miliaris*		0	0	0	1	0	2	0	0
spotted moray	*Gymnothorax moringa*		0	1	0	0	1	1	0	0
sharptail eel	*Myrichthys breviceps*		1	1	0	1	0	0	1	1
unident. jawfish	*Opistognathus sp.*		2	1	1	0	2	0	0	1
honeycomb cowfish	*Acanthostracion ploygonia*		0	0	0	2	0	0	0	0
spotted trunkfish	*Lactophrys bicaudalis*		0	0	0	0	0	0	1	0
trunkfish	*Lactophrys trigonus*		0	0	0	1	0	0	0	0
smooth trunkfish	*Lactophrys triqueter*		2	0	2	0	0	2	0	1
queen angelfish	*Holacanthus ciliaris*		0	1*	1*	0	0	1*	1*	0
french angelfish	*Pomacanthus paru*		1*	2*	2*	2*	3*	2*	2*	2*
sergeant major	*Abudefduf saxatilis*		3	2	2	3	3	3	3	2
brown chromis	*Chromis multilineata*		0	0	0	1	2	3	3	0
dusky damselfish	*Stegastes adustus*		4	3	2	3	3	3	3	3
longfin damselfish	*Stegastes diencaeus*		0	0	0	0	0	2	2	0
beaugregory	*Stegastes leucostictus*		4	3	3	2	3	2	3	3
bicolor damselfish	*Stegastes partitus*		4	4	4	4	5	5	5	5
threespot damselfish	*Stegastes planifrons*		0	0	0	2	0	0	0	0
unident. juvenile scarids	*Sparisoma sp.*		0	3	0	0	0	0	0	3
redband parrotfish	*Sparisoma aurofrenatum*		2	0	3	2	2	3	2	3
redtail parrotfish	*Sparisoma chrysopterum*		3	3	2	2	2	3	4	3
bucktooth parrotfish	*Sparisoma radians*		0	0	0	2	3	0	3	3
yellowtail parrotfish	*Sparisoma rubripinne*		3	4	4	4	3	4	3	4
stoplight parrotfish	*Sparisoma viride*		0	0	0	0	1	2	0	0
highhat	*Pareques acuminatus*		0	1	2	0	1	0	1	2
cero mackerel	*Scomberomorus regalis*		0	0	0	0	0	0	1	0
spotted scorpionfish	*Scorpaena plumieri*		0	2	2	2	2	0	2	2
reef scorpionfish	*Scorpaenodes caribbaeus*		0	1	0	0	0	0	0	0
graysby	*Cephalopholis cruentatus*		0	0	1	0	0	0	0	0
coney	*Cephalopholis fulvus*		1	0	2	0	0	3	3	3
red hind	*Epinephelus guttatus*		1	0	1	0	0	0	0	0
greater soapfish	*Rypticus saponaceus*		1	0	1	2	0	1	0	2
lantern bass	*Serranus baldwini*		0	2	0	0	0	2	1	0
tobacco fish	*Serranus tabacarius*		0	0	0	1	0	0	0	0
harlequin bass	*Serranus tigrinus*		0	0	1	0	0	0	0	0
saucereye porgy	*Calamus calamus*		0	0	0	0	0	0	1	0
great barracuda	*Sphyraena barracuda*		0	0	0	0	0	0	1	0
sand diver	*Synodus intermedius*		0	2	0	1	0	0	0	1
sharpnose puffer	*Canthigaster rostrata*		2	2	0	2	0	0	0	2
bandtail puffer	*Sphoeroides spengleri*		0	0	1	0	0	0	0	0
checkered puffer	*Sphoeroides testudineus*		0	1	0	0	0	0	0	0
Totals (n = 106 taxa)			49	45	51	44	50	54	57	54

Asterisks (*) indicate counts where recruits or juveniles were observed to be more abundant than adults of the same species.
† Refer to Appendix 5.

Appendix 3. Roving Diver Survey (RDS) data from habitat zone III – transitional/patch reef.

		Site†	R-16	R-17	R-18	R-18	R-19	R-20	R-21	R-21
		Transect†	T-1	T-3	T-2	T-2	T-5	T-4	T-7	T-7
		Date	4/22	1/17	3/9	3/9	4/11	4/13	4/15	4/15
Common Name	Species	RDS No.†	1	2	3	4	5	6	7	8
ocean surgeonfish	*Acanthurus bahianus*		4	5	3	4	4	5	4	3
doctorfish	*Acanthurus chirurgus*		2	3	0	0	0	0	0	2
blue tang	*Acanthurus coeruleus*		4	4	3	3	4	4	3	3
barred cardinalfish	*Apogon binotatus*		3	0	2	0	0	3	3	0
flamefish	*Apogon maculatus*		0	0	0	0	0	0	0	2
trumpetfish	*Aulostomus maculatus*		2	2	0	0	0	0	0	0
queen triggerfish	*Balistes vetula*		0	2	0	0	0	1	0	0
redlip blenny	*Ophioblennius atlanticus*		2	3	0	0	2	2	0	0
bar jack	*Caranx ruber*		0	3	2	3	2	2	2	2
mackerel scad	*Decapterus macarellus*		0	0	3	0	0	0	0	0
spinyhead blenny	*Acanthemblemaria spinosa*		2	2	0	0	2	2	2	0
foureye butterflyfish	*Chaetodon capistratus*		3	3	2	3	3	2	3	3
spotfin butterflyfish	*Chaetodon ocellatus*		2	0	1	0	0	0	0	0
banded butterflyfish	*Chaetodon striatus*		2	2	2	2	2	1	2	2
redspotted hawkfish	*Amblycirrhitus pinos*		0	1	1	0	0	1	0	0
dwarf herring	*Jenkinsia lamprotaenia*		0	5	0	0	0	0	0	0
brown garden eel	*Heteroconger longissimus*		3	0	0	0	0	0	3	0
southern stingray	*Dasyatis americana*		0	1	0	0	0	0	0	0
web burrfish	*Chilomycterus antillarum*		0	0	1	1	0	0	0	0
balloonfish	*Diodon holocanthus*		0	0	0	0	0	1	1	0
nurse shark	*Ginglymostoma cirratum*		0	0	0	0	0	0	0	1
bridled goby	*Coryphopterus glaucofrenatum*		4	3	4	3	4	4	3	3
peppermint goby	*Coryphopterus lipernes*		0	0	1	0	0	0	0	0
masked/glass goby	*Coryphopterus personatus/hyalinus*		3	0	3	2	0	3	3	4
sharknose goby	*Elacatinus evelynae*		2	0	2	0	3	2	2	2
goldspot goby	*Gnatholepis thompsoni*		4	3	4	0	3	3	3	2
shortstripe goby	*Gobiosoma chancei*		0	0	2	0	0	0	0	0
broadstripe goby	*Gobiosoma prochilos*		0	0	0	1	0	0	0	0
fairy basslet	*Gramma loreto*		2	0	2	0	0	2	0	2
caesar grunt	*Haemulon carbonarium*		2	3	1	2	2	0	1	0
french grunt	*Haemulon flavolineatum*		4	4	4	3	4	4	3	3
white grunt	*Haemulon plumieri*		0	2	0	1	0	0	1	1
bluestriped grunt	*Haemulon sciurus*		2	2	2	0	0	2	2	0
ballyhoo	*Hemiramphus brasiliensis*		0	3	0	0	0	0	0	0
squirrelfish	*Holocentrus adcensionis*		2	3	0	0	0	0	2	2
longspine squirrelfish	*Holocentrus rufus*		2	0	2	2	2	2	2	0
blackbar soldierfish	*Myripristis jacobus*		2	0	0	0	0	2	2	0
longjaw squirrelfish	*Neoniphon marianus*		2	0	0	2	0	0	0	2
spanish hogfish	*Bodianus rufus*		2	1	3	2	0	2	2	1
creole wrasse	*Clepticus parrae*		3	0	4	3	0	0	0	0
slippery dick	*Halichoeres bivittatus*		4	3	4	3	5	5	4	4
yellowhead wrasse	*Halichoeres garnoti*		4	0	5	4	4	4	4	3
clown wrasse	*Halichoeres maculipinna*		3	0	0	3	3	3	2	2
rainbow wrasse	*Halichoeres pictus*		2	0	0	1	3	2	2	0
pudding wife	*Halichoeres radiatus*		1	2	0	2	0	0	0	0
bluehead wrasse	*Thalassoma bifasciatum*		5	5	5	4	5	5	4	4
rosy blenny	*Malacoctenus macropus*		0	1	0	0	0	0	0	0
saddled blenny	*Malacoctenus triangulatus*		0	3	0	0	0	0	0	0
mutton snapper	*Lutjanus analis*		0	0	0	0	0	0	1	0
schoolmaster	*Lutjanus apodus*		2	0	0	0	0	0	0	0
gray snapper	*Lutjanus griseus*		0	0	0	0	0	1	0	0
mahogany snapper	*Lutjanus mahogoni*		3	0	1	2	2	2	1	2
yellowtail snapper	*Ocyurus chrysurus*		0	0	0	0	0	0	2	1
sand tilefish	*Malacanthus plumieri*		2	0	2	3	2	2	2	3
whitespotted filefish	*Cantherhines macrocerus*		1	1	0	0	0	1	0	0
orangespotted filefish	*Cantherhines pullus*		1	1	2	1	1	0	0	0
yellow goatfish	*Mulloidichthys martinicus*		3	3	2	2	2	2	0	0

Appendix 3. continued.

		Site†	R-16	R-17	R-18	R-18	R-19	R-20	R-21	R-21
		Transect†	T-1	T-3	T-2	T-2	T-5	T-4	T-7	T-7
		Date	4/22	1/17	3/9	3/9	4/11	4/13	4/15	4/15
Common Name	Species	RDS No. †	1	2	3	4	5	6	7	8
spotted goatfish	*Psuedupeneus maculatus*		0	2	2	2	2	2	2	1
spotted moray	*Gymnothorax moringa*		0	0	0	0	1	0	0	0
yellowhead jawfish	*Opistognathus aurifrons*		2	0	2	0	2	2	2	0
honeycomb cowfish	*Acanthostracion ploygonia*		0	0	0	0	0	1	0	0
spotted trunkfish	*Lactophrys bicaudalis*		1	0	0	1	1	1	0	1
smooth trunkfish	*Lactophrys triqueter*		0	2	1	2	0	1	1	2
queen angelfish	*Holacanthus ciliaris*		0	2*	0	0	0	1*	0	1*
rock beauty	*Holacanthus tricolor*		2	0	2	2	2	0	2	1
french angelfish	*Pomacanthus paru*		2*	2*	1*	2*	0	0	0	0
sergeant major	*Abudefduf saxatilis*		3	4	0	2	0	0	0	0
blue chromis	*Chromis cyanea*		5	0	5	4	4	3	3	4
brown chromis	*Chromis multilineata*		5	3	3	4	3	2	4	4
yellowtail damselfish	*Microspathodon chrysurus*		0	1	0	0	0	0	0	0
dusky damselfish	*Stegastes adustus*		0	0	1	3	1	0	0	0
longfin damselfish	*Stegastes diencaeus*		3	2	4	3	3	4	3	1
beaugregory	*Stegastes leucostictus*		2	3	3	1	1	2	2	1
bicolor damselfish	*Stegastes partitus*		5	5	5	5	5	5	5	4
threespot damselfish	*Stegastes planifrons*		3	0	2	3	2	2	3	3
cocoa damselfish	*Stegastes variabilis*		0	0	0	0	0	1	0	0
bluelip parrotfish	*Cryptotomus roseus*		0	0	2	0	0	0	0	0
striped parrotfish	*Scarus iserti*		3	2	4	3	3	4	3	3
princess parrotfish	*Scarus taeniopterus*		4	2	4	3	4	4	4	3
queen parrotfish	*Scarus vetula*		3	1	3	2	2	2	2	2
greenblotch parrotfish	*Sparisoma atomarium*		2	0	0	0	2	2	0	0
redband parrotfish	*Sparisoma aurofrenatum*		4	4	4	3	4	4	4	3
redtail parrotfish	*Sparisoma chrysopterum*		2	3	0	0	2	0	2	1
yellowtail parrotfish	*Sparisoma rubripinne*		2	3	0	1	0	2	2	0
stoplight parrotfish	*Sparisoma viride*		3	1	4	3	3	3	3	3
highhat	*Pareques acuminatus*		0	1	0	0	0	0	0	0
spotted drum	*Equetus punctatus*		0	0	0	1	0	1	0	0
cero mackerel	*Scomberomorus regalis*		0	2	0	0	0	0	1	0
spotted scorpionfish	*Scorpaena plumieri*		1	1	0	0	0	0	0	0
graysby	*Cephalopholis cruentatus*		2	0	3	2	2	2	2	1
coney	*Cephalopholis fulvus*		3	3	3	2	3	3	3	3
red hind	*Epinephelus guttatus*		0	1	0	0	1	2	0	1
black hamlet	*Hypoplectrus nigricans*		1	0	1	1	2	1	2	1
butter hamlet	*Hypoplectrus unicolor*		0	0	0	0	1	1	0	0
greater soapfish	*Rypticus saponaceus*		0	0	0	0	1	0	0	0
lantern bass	*Serranus baldwini*		0	1	0	0	0	1	0	0
tobacco fish	*Serranus tabacarius*		2	1	0	0	0	0	0	0
harlequin bass	*Serranus tigrinus*		3	0	3	3	3	3	3	2
great barracuda	*Sphyraena barracuda*		0	0	0	0	0	1	0	0
sand diver	*Synodus intermedius*		2	0	0	1	0	1	0	0
sharpnose puffer	*Canthigaster rostrata*		2	3	2	2	0	2	2	2
bandtail puffer	*Sphoeroides spengleri*		0	1	0	2	0	0	0	2
Totals (n = 102 taxa)			64	56	53	53	48	62	53	49

Asterisks (*) indicate counts where recruits or juveniles were observed to be more abundant than adults of the same species.
† Refer to Appendix 5.

Appendix 4. Roving Diver Survey (RDS) data from habitat zone IV – reef crest.

		Site†	R-22	R-23	R-24	R-23	R-25	R-26	R-26	R-27
		Transect†	T4	T-8	T3	T-8	T-7	T-5	T-5	T-1
		Date	3/3	3/22	3/3	3/22	4/6	4/15	4/15	4/21
Common Name	Species	RDS No. †	1	2	3	4	5	6	7	8
ocean surgeonfish	*Acanthurus bahianus*		3	4	3	3	4	3	3	3
doctorfish	*Acanthurus chirurgus*		0	0	0	0	2	2	2	4
blue tang	*Acanthurus coeruleus*		3	4	3	3	3	3	3	4
trumpetfish	*Aulostomus maculatus*		2	2	0	2	2	2	2	2
queen triggerfish	*Balistes vetula*		1	0	0	0	0	0	0	0
black durgon	*Melichthys niger*		2	3	3	2	2	2	2	0
peacock flounder	*Bothus lunatus*		0	0	0	0	0	0	1	0
bar jack	*Caranx ruber*		2	2	2	2	2	3	2	3
mackerel scad	*Decapterus macarellus*		0	3	0	0	0	3	0	0
spinyhead blenny	*Acanthemblemaria spinosa*		0	2	0	0	0	0	0	2
longsnout butterflyfish	*Chaetodon aculeatus*		1	2	1	1	2	1	2	0
foureye butterflyfish	*Chaetodon capistratus*		2	3	3	3	3	2	3	3
reef butterflyfish	*Chaetodon sedentarius*		0	0	0	0	0	0	1	0
banded butterflyfish	*Chaetodon striatus*		2	2	3	0	2	0	2	2
redspotted hawkfish	*Amblycirrhitus pinos*		0	0	0	0	1	0	0	0
brown garden eel	*Heteroconger longissimus*		0	4	0	4	0	0	0	4
southern stingray	*Dasyatis americana*		0	1	0	2	0	0	0	0
web burrfish	*Chilomycterus antillarum*		0	0	0	0	0	0	1	0
balloonfish	*Diodon holocanthus*		0	1	1	0	0	0	0	0
porcupinefish	*Diodon hystrix*		0	1	0	0	1	0	0	1
yellowfin majorra	*Gerres cinereus*		0	1	0	1	0	0	0	0
bridled goby	*Coryphopterus glaucofrenatum*		3	3	2	3	0	3	3	3
peppermint goby	*Coryphopterus lipernes*		0	2	0	2	4	2	0	2
masked/glass goby	*Coryphopterus personatus/hyalinus*		5	5	0	4	5	5	5	5
cleaning goby	*Elacatinus genie*		0	0	0	0	2	0	0	0
sharknose goby	*Elacatinus evelynae*		2	3	0	0	2	2	0	2
goldspot goby	*Gnatholepis thompsoni*		3	3	0	0	0	2	2	3
shortstripe goby	*Gobiosoma chancei*		0	0	0	0	0	0	0	1
fairy basslet	*Gramma loreto*		2	3	0	3	0	3	2	3
porkfish	*Anisotremus virginicus*		0	0	0	0	0	0	0	1
caesar grunt	*Haemulon carbonarium*		1	2	2	0	1	2	2	2
smallmouth grunt	*Haemulon chrysargyreum*		4	2	4	2	0	0	0	3
french grunt	*Haemulon flavolineatum*		3	3	3	3	2	3	3	4
spanish grunt	*Haemulon macrostomus*		0	0	0	0	0	1	0	0
white grunt	*Haemulon plumieri*		2	2	1	0	1	1	2	2
bluestriped grunt	*Haemulon sciurus*		1	2	0	2	1	1	0	2
squirrelfish	*Holocentrus adcensionis*		0	1	0	0	0	0	0	1
longspine squirrelfish	*Holocentrus rufus*		2	3	3	3	0	2	2	2
blackbar soldierfish	*Myripristis jacobus*		3	3	3	3	3	3	2	2
longjaw squirrelfish	*Neoniphon marianus*		2	2	3	0	2	2	0	2
cardinal soldierfish	*Plectrypops retrospinis*		0	1	0	0	0	0	0	0
dusky squirrelfish	*Sargocentron vexillarium*		2	0	0	0	0	0	0	0
boga	*Inermia vittata*		0	0	0	0	3	4	4	0
spanish hogfish	*Bodianus rufus*		2	3	3	3	2	2	2	2
creole wrasse	*Clepticus parrae*		4	5	4	4	5	5	5	5
slippery dick	*Halichoeres bivittatus*		0	0	0	0	0	0	0	2
yellowhead wrasse	*Halichoeres garnoti*		4	4	4	3	3	4	3	4
clown wrasse	*Halichoeres maculipinna*		0	0	0	2	0	2	0	2
rainbow wrasse	*Halichoeres pictus*		2	2	0	0	0	2	0	0
pudding wife	*Halichoeres radiatus*		0	1	0	0	0	0	0	0
bluehead wrasse	*Thalassoma bifasciatum*		3	5	5	4	5	5	5	5
schoolmaster	*Lutjanus apodus*		2	2	1	2	3	1	2	3
gray snapper	*Lutjanus griseus*		2	0	0	0	0	0	0	0
mahogany snapper	*Lutjanus mahogoni*		1	3	0	3	3	2	2	3
yellowtail snapper	*Ocyurus chrysurus*		1	0	2	2	0	1	0	0
sand tilefish	*Malacanthus plumieri*		1	2	1	2	0	0	0	2
scrawled filefish	*Aluterus scripta*		0	0	0	0	0	1	0	1

Appendix 4. continued.

Common Name	Species	Site† / Transect† / Date / RDS No.†	R-22 T4 3/3 1	R-23 T-8 3/22 2	R-24 T3 3/3 3	R-23 T-8 3/22 4	R-25 T-7 4/6 5	R-26 T-5 4/15 6	R-26 T-5 4/15 7	R-27 T-1 4/21 8
whitespotted filefish	*Cantherhines macrocerus*		1	1	0	2	2	0	0	1
orangespotted filefish	*Cantherhines pullus*		1	0	0	0	1	0	0	1
yellow goatfish	*Mulloidichthys martinicus*		3	4	3	3	3	2	3	4
spotted goatfish	*Psuedupeneus maculatus*		1	2	2	0	1	2	1	0
spotted moray	*Gymnothorax moringa*		0	1	0	0	0	0	0	0
honeycomb cowfish	*Acanthostracion ploygonia*		1	1	1	2	2	0	0	1
spotted trunkfish	*Lactophrys bicaudalis*		0	0	0	1	1	0	2	1
smooth trunkfish	*Lactophrys triqueter*		0	1	2	2	1	1	2	0
queen angelfish	*Holacanthus ciliaris*		0	0	1	0	0	0	0	0
rock beauty	*Holacanthus tricolor*		1	2	2	0	2	2	0	0
french angelfish	*Pomacanthus paru*		1*	0	0	0	1	0	2	0
sergeant major	*Abudefduf saxatilis*		3	2	3	0	3	3	0	4
blue chromis	*Chromis cyanea*		4	5	5	5	5	5	4	4
brown chromis	*Chromis multilineata*		4	5	4	4	4	5	4	5
yellowtail damselfish	*Microspathodon chrysurus*		1	2	0	0	0	0	2	0
dusky damselfish	*Stegastes adustus*		0	0	3	0	3	0	3	2
longfin damselfish	*Stegastes diencaeus*		3	3	3	2	0	3	3	3
beaugregory	*Stegastes leucostictus*		2	2	3	2	0	2	3	3
bicolor damselfish	*Stegastes partitus*		4	5	5	5	5	5	4	5
threespot damselfish	*Stegastes planifrons*		3	5	4	4	4	4	4	4
cocoa damselfish	*Stegastes variabilis*		2	0	0	0	1	0	0	0
glasseye snapper	*Heteropriacanthus cruentatus*		2	2	0	1	0	1	0	2
bigeye	*Priacanthus arenatus*		0	0	0	0	1	0	1	0
striped parrotfish	*Scarus iserti*		3	4	3	2	4	3	3	4
princess parrotfish	*Scarus taeniopterus*		3	4	4	3	4	4	4	4
queen parrotfish	*Scarus vetula*		3	3	3	3	3	2	3	3
greenblotch parrotfish	*Sparisoma atomarium*		0	0	0	0	2	3	3	0
redband parrotfish	*Sparisoma aurofrenatum*		4	4	3	3	3	4	3	4
redtail parrotfish	*Sparisoma chrysopterum*		0	0	0	0	1	1	0	2
yellowtail parrotfish	*Sparisoma rubripinne*		0	1	1	1	0	2	0	2
stoplight parrotfish	*Sparisoma viride*		4	3	3	2	3	4	3	3
spotted drum	*Equetus punctatus*		1	1	2	0	0	2	0	0
reef croaker	*Odontoscion dentex*		0	0	0	1	0	0	0	0
cero mackerel	*Scomberomorus regalis*		1	0	2	0	2	0	2	0
spotted scorpionfish	*Scorpaena plumieri*		0	1	0	0	0	0	0	0
graysby	*Cephalopholis cruentatus*		3	4	4	2	3	3	3	3
coney	*Cephalopholis fulvus*		2	3	3	3	1	3	1	2
rock hind	*Epinephelus adcensionis*		0	1	0	1	0	0	0	1
red hind	*Epinephelus guttatus*		0	0	2	0	0	0	0	0
yellowtail hamlet	*Hypoplectrus chlorurus*		2	0	0	2	1	2	2	0
shy hamlet	*Hypoplectrus guttavarius*		0	0	0	0	1	0	0	0
indigo hamlet	*Hypoplectrus indigo*		0	0	0	0	1	0	0	0
black hamlet	*Hypoplectrus nigricans*		1	2	0	1	0	0	0	2
barred hamlet	*Hypoplectrus puella*		2	2	3	2	2	2	2	2
butter hamlet	*Hypoplectrus unicolor*		0	1	1	0	1	0	2	1
peppermint basslet	*Liopropoma rubre*		1	0	0	1	0	0	0	0
tobacco fish	*Serranus tabacarius*		1	0	0	0	0	0	0	0
harlequin bass	*Serranus tigrinus*		2	3	3	2	0	2	2	2
great barracuda	*Sphyraena barracuda*		0	1	0	0	0	0	0	0
southern sennet	*Sphyraena picudilla*		2	0	0	0	0	0	0	0
sand diver	*Synodus intermedius*		2	2	2	0	0	0	1	2
sharpnose puffer	*Canthigaster rostrata*		2	0	2	2	2	3	4	3
bandtail puffer	*Sphoeroides spengleri*		0	0	0	0	0	1	0	0
Totals (n = 110 taxa)			68	73	53	56	61	62	57	67

Asterisks (*) indicate counts where recruits or juveniles were observed to be more abundant than adults of the same species.
† Refer to Appendix 5.

Appendix 5. GPS coordinates of RDS fish survey sites.

	Position (Degrees)		
Name	Latitude, N	Longitude, W	Description
R-1	17° 43.397’	64° 53.158’	RDS Site 1 at Transect 3, Zone 1
R-2	17° 43.545’	64° 53.205’	RDS Site 2 at Transect 5, Zone I
R-3	17° 44.065’	64° 53.379’	RDS Site 3 at Transect 7, Zone I
R-4	17° 43.956’	64° 53.362’	RDS Site 4 at Transect 7, Zone I
R-5	17° 44.183’	64° 53.417’	RDS Site 5 at Transect 8, Zone I
R-6	17° 43.620’	64° 53.233’	RDS Site 6 at Transect 4, Zone I
R-7	17° 43.167’	64° 53.077’	RDS Site 7 at Transect 1, Zone I
R-8	17° 43.293’	64° 53.116’	RDS Site 8 at Transect 2, Zone I
R-9	17° 43.362’	64° 53.178’	RDS Site 9 at Transect 3, Zone II
R-10	17° 43.238’	64° 53.145’	RDS Site 10 at Transect 1, Zone II
R-11	17° 43.993’	64° 53.446’	RDS Site 11 at Transect 7, Zone II (2 surveys)
R-12	17° 43.574’	64° 53.279’	RDS Site 12 at Transect 4, Zone II
R-13	17° 44.244’	64° 53.512’	RDS Site 13 at Transect 8, Zone II
R-14	17° 44.165’	64° 53.462’	RDS Site 14 at Transect 8, Zone II
R-15	17° 43.810’	64° 53.352’	RDS Site 15 at Transect 6, Zone II
R-16	17° 43.180’	64° 53.289’	RDS Site 16 at Transect 1, Zone III
R-17	17° 43.287’	64° 53.302’	RDS Site 17 at Transect 3, Zone III
R-18	17° 43.307’	64° 53.358’	RDS Site 18 at Transect 2, Zone III (2 surveys)
R-19	17° 43.639’	64° 53.496’	RDS Site 19 at Transect 5, Zone III
R-20	17° 43.504’	64° 53.492’	RDS Site 20 at Transect 4, Zone III
R-21	17° 43.958’	64° 53.563’	RDS Site 21 at Transect 7, Zone III (2 surveys)
R-22	17° 43.515’	64° 53.648’	RDS Site 22 at Transect 4, Zone IV
R-23	17° 44.049’	64° 53.715’	RDS Site 23 at Transect 8, Zone IV (2 surveys)
R-24	17° 43.256’	64° 53.625’	RDS Site 24 at Transect 3, Zone IV
R-25	17° 43.858’	64° 53.749’	RDS Site 25 at Transect 7, Zone IV
R-26	17° 43.642’	64° 53.688’	RDS Site 26 at Transect 5, Zone IV (2 surveys)
R-27	17° 43.208’	64° 53.416’	RDS Site 2 at Transect 1, Zone IV