

FINAL REPORT

Mesophotic Benthic Habitats and Associated Reef Communities at Lang Bank, St. Croix, USVI

by:

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I. Executive summary

This research represents an effort towards the characterization of essential fish habitats and associated reef communities from Puerto Rico and the U. S. Virgin Islands sponsored by NMFS thru the Caribbean Fishery Management Council (CFMC). Since 1993, the CFMC has seasonally closed Lang Bank to all bottom tending gear in order to protect spawning aggregations of the red hind, *Epinephelus guttatus*. The main objectives of the study included the production of a georeferenced benthic habitat map of the mesophotic insular shelf and upper slope within the 30 – 50 m depth range, provide a quantitative and qualitative characterization of the sessile-benthic and motile-megabenthic invertebrates and fish populations of the main benthic habitat types and provide a fisheries independent survey of the most important commercially valuable fish and shellfish populations from mesophotic habitats at Lang Bank, located at the eastern tip of St. Croix, USVI.

Five main benthic habitat types were discovered within the 30 – 50 m depth range at Lang Bank, these include a Bank Coral Reef system (BCR), Colonized Pavement (CPV), Colonized Rhodolith Reef (CRR), Spur and Groove Reef (SAG), and Patch Reef (PRF). The BCR habitat occupied an estimated area of 2.0 km², or 32 % of the total area surveyed. It is an impressive continuous formation of scleractinian corals, particularly boulder star coral, *Orbicella franksi* growing at depths of 30 m to at least 50 m (100 – 165') throughout the deep outer shelf basin of Lang Bank with an average live coral cover of 29.0 %. The most extensive habitat surveyed within the 30 – 50 m depth range corresponded to CPV, with a total area of 2.5 km², or 41 % of the total area surveyed. Continuous sections of CPV habitat were found associated with the reef tops of the inner and outer shelf edge, and down the outer shelf insular slope. The SAG was observed to be largely a neritic habitat that extended just to the shallow margin of the mesophotic realm at a depth of 30 m in some of its deepest sections and thus, not properly addressed by this study. It is the habitat where spawning aggregations of red hind (*Epinephelus guttatus*) had been reported. PRFs were mostly found near the boundaries of the BCR at the deep basin walls. These were more common at the inner slope of the outer shelf break and covered a total estimated area of 0.6 km², or 9.3 % of the total area surveyed. CRR habitats were observed mostly down the insular slope of the outer shelf break. A few patches were observed as well near the edges of the deep basin and in small sections of the BCR. The areal extension of CRR habitat was estimated as 0.9 km², or 14.9 % of the surveyed area.

Based on its relatively high composition of live coral cover and high within habitat affinity or similarity, the BCR was statistically different in terms of sessile-benthic community structure to all other mesophotic habitat types at Lang Bank within the 30 – 50 m depth range. The CPV, PRF and CRR benthic habitats were characterized by relatively low affinity (high variability) on the relative composition of substrate categories within stations. High variability within transects was measured for abiotic cover, live corals and octocorals. The CPV and CRR habitats were distributed throughout a wide range of depths (30 – 50 m) and slopes, factors that may have influenced benthic community structure. The sessile-benthic invertebrate community observed from mesophotic habitats at Lang Bank included altogether, a total of 26 spp of hard corals, 10 genera of octocorals, and at least 53 sponge spp.

The reef fish community was comprised by at least 87 spp, distributed into 25 families. The highest densities (42.8 Ind/30 m²) and species richness (70 spp) were surveyed from the BCR. Fish community structure at the BCR was characterized by relatively high within habitat affinity with an average similarity of 31.4 %. Within habitat similarity was strongly influenced by the relatively uniform density of bicolor damselfish (*Stegastes partitus*), blue chromis (*Chromis cyanea*), yellowhead wrasse (*Halichoeres garnoti*) and princess parrotfish (*Scarus taeniopterus*). Statistically significant differences were found between the relative abundances of fishes at the BCR and all other habitats surveyed at Lang Bank. The highest dissimilarity resulted between the BCR and the CRR (colonized rhodolith reef) at 80.8 %. The fish community at the BCR was more specious than the CRR and other habitats surveyed at Lang Bank. The higher densities and species richness at the BCR appear to be associated with the higher benthic habitat complexity

and rugosity. Fish community structure at the CPV, PRF, and CRR habitats were characterized by relatively low affinity (high variability) within sampling stations, influenced by the high variability of reef physiographic conditions in terms of depth, topographic relief and slope.

A total of 283 fish individuals distributed into 22 species and 77 shellfish individuals distributed into two species were included in the fishery independent surveys performed at Lang Bank. The total area surveyed was 13,200 m². Surveys at the CPV and BCR habitats represented approximately 78 % of the total area surveyed. Large groupers and snappers were observed in very low numbers at Lang Bank. It is possible that the high availability of protective structures at the BCR may have influenced underestimates of large grouper/snapper densities and sightings, but CPV and CRR habitats at Lang Bank were mostly devoid of such protective structures. The lack of physical and biological complexity at these habitats may limit the occurrence of large demersal fishes because of the virtual absence of prey items and residential structures. Nurse sharks (*Ginglymostoma cirratum*) were the largest top predators observed from mesophotic habitats at Lang Bank. The lionfish (*Pterois* sp), an invasive fish of potential commercial value as food was the most abundant fish larger than 25 cm. Lionfishes (*Pterois* sp) occurred within the entire mesophotic depth range studied at Lang Bank, but were more common at the upper insular slope (35 – 40m) close to the shelf-edge, and associated with rocky outcrops, crevices and coral heads. Red hinds were observed to be part of the residential fish assemblage at the BCR, SAG and CPV mesophotic habitats of Lang Bank, with higher densities surveyed from the BCR. Densities of red hind at Lang Bank are within the range estimated from visual surveys at other mesophotic habitats within the US Caribbean EEZ. Mutton snapper (*Lutjanus analis*) was the most abundant commercially important snapper observed from mesophotic habitats at Lang Bank. Higher densities were surveyed from the BCR, but were present from all benthic habitats studied. Queen conch (*Strombus gigas*) were observed in very high densities (up to 50 Ind/1000m²), but mostly concentrated on CRR habitats, which have relatively limited distribution within the 30 – 50 m mesophotic depth range in Lang Bank. The size frequency distribution was strongly skewed towards the larger size classes, indicative that mesophotic habitats at Lang Bank, particularly the CRR functions as an important habitat mostly for adult queen conch. Spiny lobsters (*Panulirus argus*) were highly abundant at Lang Bank, particularly at the CPV habitat, where densities of up to 5 Ind/1000m² were surveyed. Spiny lobsters were mostly concentrated at the outer shelf-edge ridge at depths of 33 – 38 m associated with coral heads and crevices in a relatively flat pavement colonized by sponges, gorgonians and isolated coral heads.

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II. Introduction

Lang Bank is a submerged coral reef system located along the eastern shelf of St. Croix, USVI. The easternmost tip, with an extension of approximately 10 km² has been seasonally (December – February) closed to all bottom tending gear (traps, pots, nets and long lines) by the CFMC since 1993 to protect a spawning aggregation of red hind, *Epinephelus guttatus*. The closed fishing area fringes the shelf-edge and includes a deep outer shelf basin with mesophotic terraces and ridges. Prada (2003), under contract by the CFMC produced a benthic habitat map of Land Bank based on visual interpretations of Side Scan Sonar (SSS) imagery and geotiff mosaics of multibeam bathymetry. Soft corals, or gorgonian plains were reported as the dominant benthic habitat type, representing nearly 70% of the total area surveyed. Field verifications of mesophotic habitats were not included in the mapping effort by Prada (2003). Aside from unpublished observations of coral composition at the red hind spawning aggregation site studied by Nemeth et al. (2006, 2007), scientific characterizations of mesophotic benthic habitats and associated sessile-benthic and pelagic communities of Lang Bank were lacking. In addition to research focused on the red hind spawning aggregation, a Seemap fishery survey on the shallow sections of the bank was reported by Tobias et al. (2002).

Research recently completed on Isla Desecheo (García-Sais et al., 2005b), Bajo de Sico (García-Sais et al., 2007), Abrir La Sierra (García-Sais et al., 2010), El Seco-Vieques (García-Sais et al. 2011) and the St. Thomas, USVI Hind Bank Marine Conservation District Reef (Nemeth et al. 2008, Smith et al, 2010) have contributed to the location and mapping of mesophotic reefs with technical support (bathymetry, benthic habitat maps) from NOAA's Biogeography Team

(http://ccma.nos.noaa.gov/products/biogeography/usvi_nps/data.html). The aforementioned studies have demonstrated that mesophotic reef systems function as important residential and foraging habitats, as well as spawning aggregation sites for a variety of commercially important demersal reef fishes that have virtually disappeared from shallow reef systems in Puerto Rico. In addition, coral species that have been severely impacted and are presently vulnerable to bleaching events associated with increasing water temperatures in shallow reefs; such as *Orbicella* (formerly *Montastraea*) *annularis* (complex) have been protected from the bleaching effects in mesophotic reefs

until present (but see Menza, 2007 and Smith et al., 2010). Thus, mesophotic reefs also represent genetic reservoirs for these coral species and associated biota.

This investigation identifies and maps the main benthic habitat types found at Lang Bank within the 30 – 50 m depth range and provides a quantitative and qualitative characterization of the predominant sessile-benthic and fish communities associated to the main benthic habitats. A fishery independent survey of the commercially important fish and shellfish populations, with particular attention to the red hind (*Epinephelus guttatus*) during its seasonal spawning aggregation was also included as part of the quantitative assessment of mesophotic habitats at Lang Bank.

The Caribbean Fishery Management Council (CFMC) subcontracted with Principal Investigator Dr. Jorge R. García-Sais and other personnel to carry out the proposed work herewith. Mrs. Maria A. Irizarry acted as the Fiscal Administrator and Graciela García-Moliner as the study monitor.

III. Research Background

Characterizations of reef habitats and associated sessile-benthic and fish communities at depths between 30 – 100 m (mesophotic) are rare in the Caribbean, and until recently, mostly available from submersible surveys. Colin (1974; 1976) described the taxonomic composition of reef fishes at depths between 90 – 305 m off the coasts of Jamaica, Belize and the Bahamas as a mixed assemblage of shallow reef (< 30 m) and true “deep-reef” species seldom present shallower than 50 m. Colin (1974) argued that the vertical distribution of some reef fish species was more related to local environmental conditions (habitat features) than depth, and noted ontogenetic trends in the vertical distribution of “deep-reef” species, where juvenile stages were typically observed at shallower depths than adults. In Puerto Rico, the Seward Johnson- Sea Link submersible survey (Nelson and Appeldoorn, 1985) provided a qualitative characterization of benthic habitats and associated fishes of the insular slope, encompassing depths between 100 – 1,250 m. Despite observations of a “rich and highly complex” reef fish community associated with the upper insular slope (30 – 100 m), these habitats were left virtually undescribed by the Seward Johnson - Sea Link survey.

Quantitative assessments of reef substrate cover by sessile-benthic communities from mesophotic reef habitats in the Caribbean include the autonomous underwater vehicle (AUV) surveys of the La Parguera shelf-edge (Singh et al., 2004) and the Marine Conservation District (MCD) coral reef system located south of St. Thomas, USVI (Armstrong et al., 2006). Menza et al. (2007) reported on coral taxonomic composition, percent substrate cover, and recent degradation of a mesophotic coral reef system (MSR-1) dominated by *Orbicella* (formerly *Montastraea*) *annularis* (complex) on the outer shelf south of St. John, USVI using video and still camera images dropped from the NOAA R/V Nancy Foster. Smith et al. (2010) also reported on diseased colonies of *O. annularis* at the Hind Bank MCD, USVI. The aforementioned studies identified major differences of sessile-benthic community structure associated with the various mesophotic habitat types and depth gradients, but lack inferences about their reef fish communities. Beets and Friedlander (1997) and Nemeth (2005) conducted quantitative surveys of the red hind (*Epinephelus guttatus*) population within the MCD, a known spawning aggregation site for this species. These studies provided a baseline and an assessment of the effectiveness of the closed fishing regulation for the recovery of the

red hind population within the MCD, but do not include information on fish - habitat associations for other species. A more general description of the fish community at the MCD from AGRRA surveys is available from Nemeth et al. (2008).

The spatial and temporal patterns of migration and movement by red hind during its seasonal spawning aggregation at Lang Bank was studied by Nemeth et al. (2007). The aggregation site was located at the edge of a coral spur that projects into a deeper water basin within outer shelf. The study found that *E. guttatus* migrated 5 – 18 km from an area of about 90 km around St. Croix. Similarities in terms of movement timing, temporal and spatial changes in sex ratios, annual and lunar predictabilities and sexual behavioral responses to environmental cues were similar than those at the Hind Bank, MCD in St. Thomas. With respect to the benthic habitat, Nemeth et al (2007) noted that Lang Bank presented less topographic relief than the MCD at the aggregation site, but that the composition of the reef coral species was similar between sites. Data on coral composition was cited as “unpublished” by Nemeth et al (2007).

As part of the NMFS-CFMC initiative toward the mapping and characterization of mesophotic reef systems in the U.S. Caribbean EEZ, the marine reserve at Isla Desecheo and the seasonally closed reefs at Bajo de Sico and Abrir La Sierra in Mona Passage, El Seco Reef in Vieques, and the Hind Bank Marine Conservation District of St. Thomas, USVI have been recently studied (Garcia-Sais et al, 2005, 2007, 2010; 2011; Nemeth et al, 2008, Smith et al. 2010). Statistically significant differences of sessile-benthic and fish community structure were found between euphotic and mesophotic habitats at Isla Desecheo (Garcia-Sais, 2010). The percent of live coral cover and the relative composition of coral species, sponges and benthic algae exhibited marked variations with depth and/or benthic habitat (Garcia-Sais et al. 2005, Garcia-Sais, 2010). Similar findings were reported for Bajo de Sico and Abrir La Sierra (Garcia-Sais et al., 2007, 2010), where important shifts of sessile-benthic and fish community structure appear to be associated not only with depth, but also with habitat type, slope and rugosity.

The recently studied mesophotic reefs share the presence of large demersal fishes in abundances never previously reported for shallow reefs in Puerto Rico. In general, fish assemblages exhibit marked differences of relative abundance associated with habitat

type and/or depths, high taxonomic connectivity between habitats across depth gradients, and presence of what appears to be a small group of indicator fish species of mesophotic reefs (Garcia-Sais et al., 2007, 2010; Garcia-Sais, 2010). A relevant conclusion from these researches is that mesophotic reefs function as the residential and foraging habitats for a wide spectrum of commercially exploited reef fishes, particularly large groupers and snappers, and also for queen conch. These populations appear to migrate from their mesophotic residential habitats to their spawning aggregation sites in shallower sections of the shelf-edge. Also, the particularly high abundance of post-settlement juveniles of Coneys (*Cephalopholis fulva*), Blue Chromis (*Chromis cyanea*) and Fairy Basslet (*Gramma loreto*) reported for Isla Desecheo, Bajo de Sico and Abrir La Sierra suggests that these mesophotic reefs may function as prime recruitment sites for these and other reef fish populations.

Fishery independent surveys of commercially important fish and shellfish populations from mesophotic habitats within a 30 – 50 m depth range were performed at reef sites within the Puertorrican EEZ, Abrir la Sierra (ALS), Isla Desecheo (Des), and Bajo de Sico (BDS) during the February 2011 thru January 2012 (Garcia-Sais et al. 2012). Fish targets included large groupers (red hind, Nassau, yellowfin, black), snappers (mutton, cubera, dog, schoolmaster, yellowtail), large parrotfish (midnight, blue, rainbow), hogfish, queen triggerfish, lionfish, great barracuda, and sharks. Shellfish targets included spiny lobster and queen conch. Mesophotic benthic habitats at sites surveyed included reef tops, slope walls and rhodolith reefs at ALS; slope walls, patch reefs with colonized pavement and rhodolith reefs at Des; and rock reef promontories and rhodolith reef at BDS. Marked variations in the composition and abundance of several commercially important fish and shellfish populations between sites were noted. Higher abundance of queen conch, large snappers (mutton, dog, cubera) and hogfish were observed from at ALS, as compared to Des and BDS. Given the similarity of benthic habitat types between sites and the habitat plasticity displayed by many fish populations, it is proposed that the sharp differences in population size and species composition of commercially important fish and shellfish populations is related to the recruitment enhancement effect provided by the within shelf connectivity between nursery and mesophotic habitats at ALS, compared to the partial isolation imposed by the oceanic boundary of Mona Passage separating Des and BDS from the PR shelf. Several populations evidenced marked preferences for particular benthic habitats. For example:

more than 90 % of all queen conch from all sites was observed from the rhodolith reef at ALS. Conversely, spiny lobsters, groupers, hogfishes, lionfishes and snappers, with the exception of mutton snapper, were more abundant at the reef top and slope wall habitats than at the rhodolith reef. Queen conch was more abundant during the August – September survey, coinciding with their peak reproductive season at ALS. Couples of queen conchs were observed engaged in copulation and egg masses discovered buried on the rhodolith habitat at depths ranging between 38 – 45 m (125 – 145 ') during the August-September survey.

IV. Study Objectives

- 1) Provide a baseline quantitative and qualitative characterization of the sessile-benthic, motile-megabenthic invertebrate and demersal fish communities associated with the principal mesophotic reef habitats within a depth range of 30 – 50 m at Lang Bank.
- 2) Validate by direct diver observations mesophotic habitats (30 – 50 m) included in the benthic habitat map of Lang Bank prepared by Geophysique GPR International, Inc. (Prada, 2003).
- 3) Analyze relationships between the benthic and fish community structure with physical factors, such as habitat type, and evaluate the function of mesophotic habitats in the life cycle of commercially important reef fish populations
- 4) Provide a fisheries-independent assessment of the abundance and size frequency distributions of commercially important and transitory fish and shellfish (queen conch, spiny lobster) species associated with mesophotic (30 – 50 m) reef habitats at Lang Bank.
- 5) Produce a digital photographic and video album of deep reef communities from Lang Bank.

V. Methods

1.0 Study Site

Lang Bank is a submerged coral reef system located along the eastern shelf of St. Croix, USVI (Figure 1). The easternmost tip, with an extension of approximately 10 km² has been seasonally (December – February) closed to all bottom tending gear (traps, pots, nets and long lines) by the CFMC since 1993 to protect a spawning aggregation of red hind, *Epinephelus guttatus*. The closed fishing area fringes the shelf-edge and includes a deep outer shelf basin with mesophotic terraces and ridges. Prada (2003) produced a benthic habitat map of Land Bank based on visual interpretations of Side Scan Sonar (SSS) imagery and geotiff mosaics of multibeam bathymetry. Soft corals, or gorgonian plains were reported as the dominant benthic habitat type, representing nearly 70% of the total area surveyed. Field verifications of mesophotic habitats were not included in the mapping effort by Prada (2003). Aside from unpublished observations of coral composition at the red hind spawning aggregation site studied by Nemeth et al. (2006, 2007), scientific characterizations of mesophotic benthic habitats and associated sessile-benthic and pelagic communities of Lang Bank are lacking. In addition to research focused on the red hind spawning aggregation, a Seemap fishery survey on the shallow sections of the bank was reported by Tobias et al. (2002).

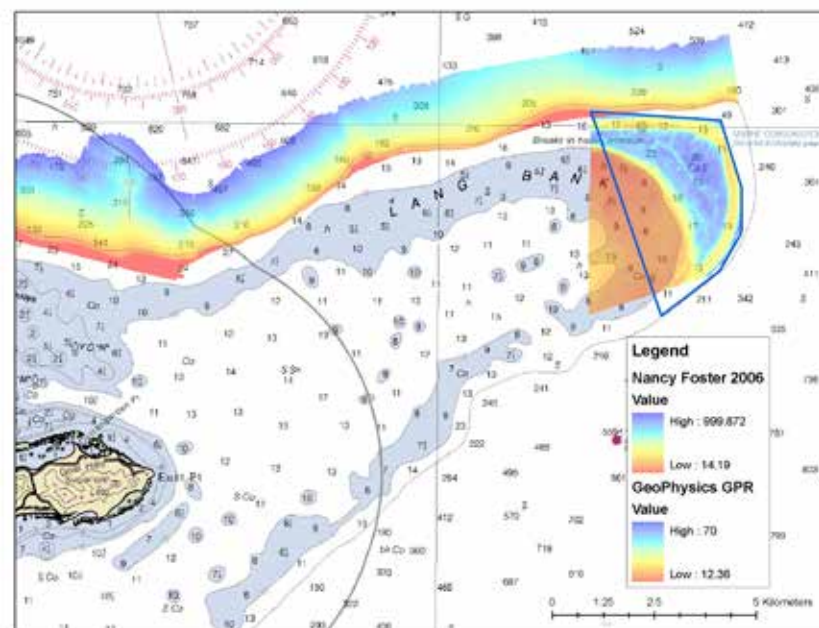


Figure 1. Location of Lang Bank in the east coast of St. Croix with Side Scan Sonar bathymetry data produced by GPR (2003).

2.0 Benthic Habitat Mapping

The side-scan (SSC) bathymetric survey of the southeast coast of St. Croix, USVI prepared by GPR International, Inc. (2003) was used as the main footprint for the selection of sampling stations for characterization of benthic habitats and for preparation of the benthic habitat map. Benthic habitat transitions at Lang Bank were generally characterized by particular topographic features of the seafloor recognized from the SSC bathymetry and derived rugosity values. At least four distinct reef physiographic zones were evident from the bathymetry map: 1) an inner shelf-break and slope at depths between 25 – 40 m; 2) a deep outer shelf basin at depths between 40 – 60+ m; 3) an outer reef top ridge at depth between 30 – 35 m; and 4) the outer shelf-edge and slope (Figure 2).

The reef top ridge and outer shelf-edge and slope were characterized by a series of roughly equidistantly separated sets of 10 depth-stratified station clusters at 30, 40 and 50 m for a total of 30 transects. Due to the existence of several extensive pools deeper than 50 m interspersed within the deep outer basin, a total of 33 sampling stations were selected to provide both geographical coverage and depth characterization to this physiographic zone. A total of nine (9) stations were sampled at 30 m, 13 stations were sampled at 40 m and 11 stations were sampled at 50 m, for a total of 33 transects surveyed within the deep basin. The inner shelf break and slope were sampled at 19 stations haphazardly selected to provide both geographical and depth coverage to this physiographic zone with nine (9) transects at 30m and 10 transects at 40 m. In all, 85 stations were sampled for quantitative biological observations and benthic habitat mapping (Figure 3). The exact station geographic position, depth, habitat type, and additional observations are included as Appendix 1.

3.0 Characterization of Mesophotic Reef Communities

3.1 Sessile-Benthic Community

At each of the 85 sampling stations selected for characterization of the main reef physiographic zones one 20 m line transect was laid over the substrate using a fiberglass tape measure. The initial 10 m were photographed using a Nikon D70 digital camera with an Aquatica housing maintaining a constant distance between the camera and the seafloor. Ten (10) non-

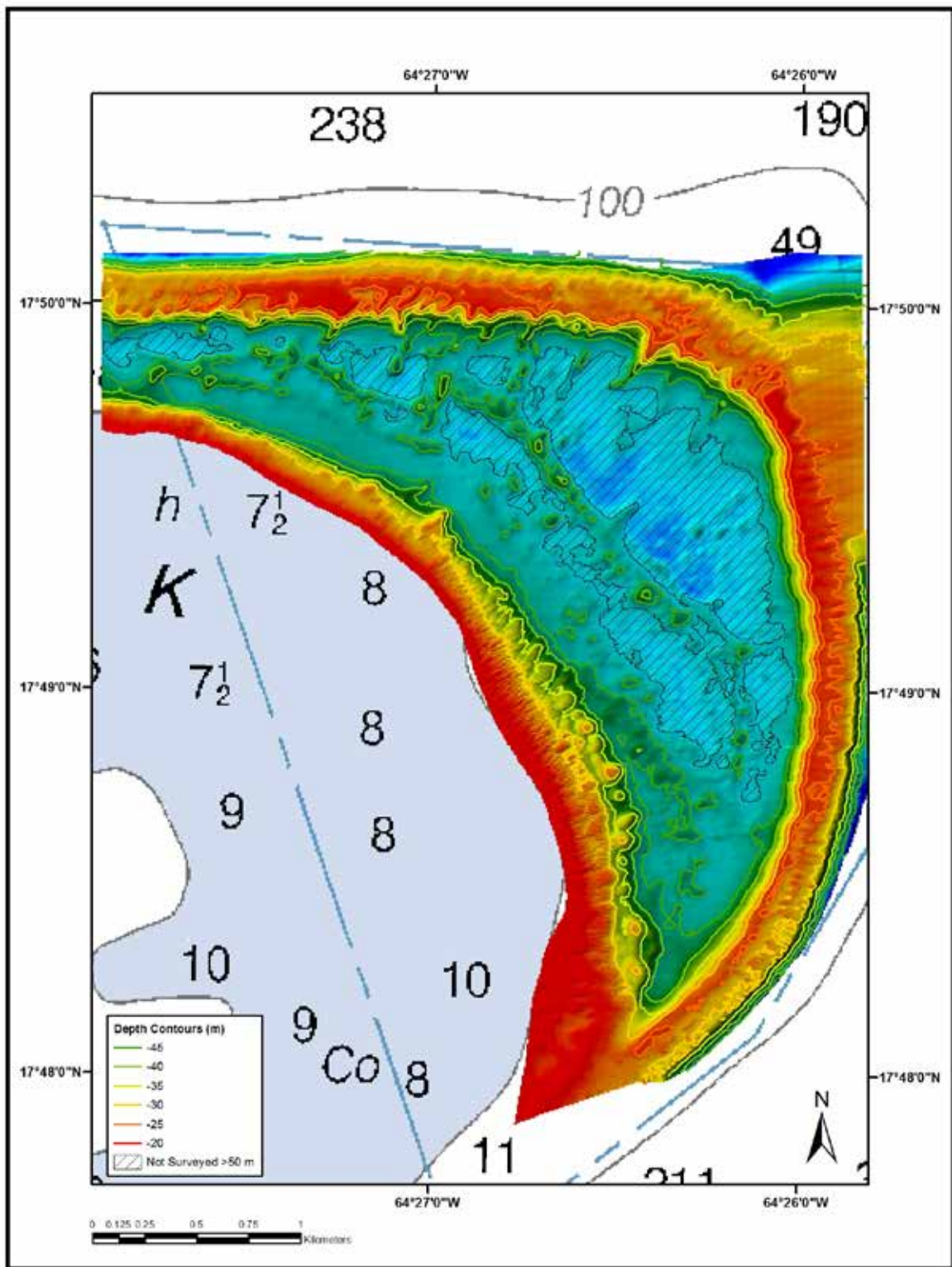


Figure 2. Bathymetry map of Lang Bank showing the main physiographic features. Produced after Prada (2003)

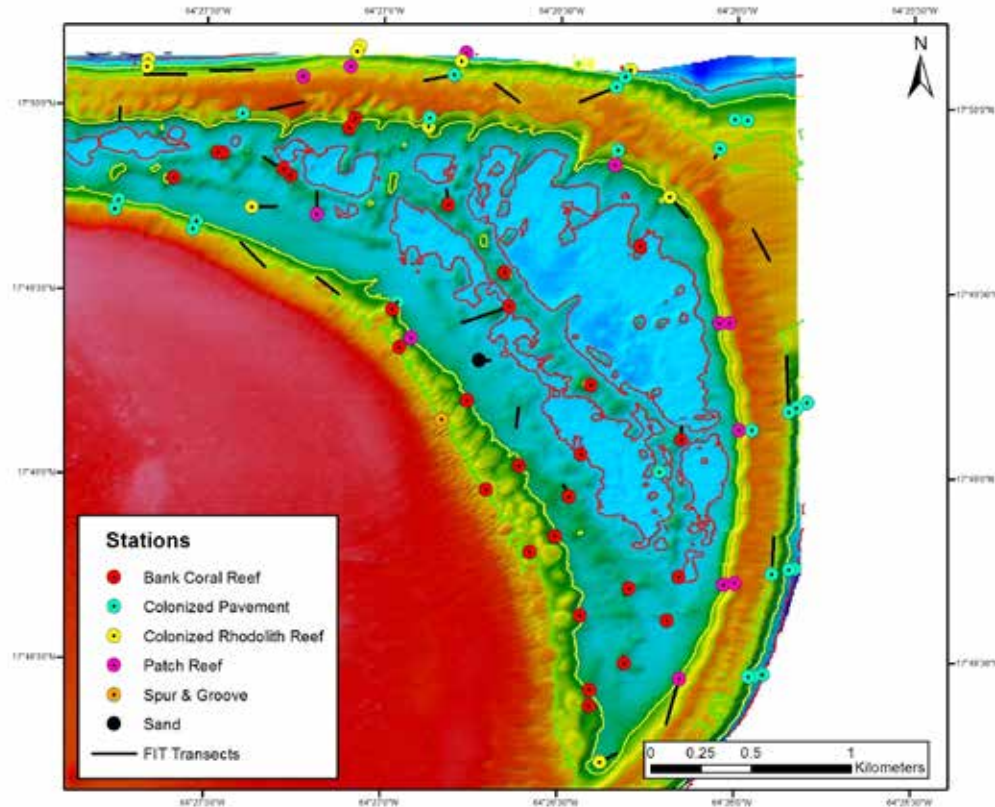


Figure 3. Location of sampling stations at Lang Bank

overlapping digital photos of each transect were obtained, representing each an area of approximately 0.9 m² per frame. Quantitative determinations of reef substrate cover by sessile-benthic categories were accomplished from analyses of 10 digital images (photos) of the habitat substrate per transect. Twenty-five (25) random points were overlaid over each photo image and the proportion of each substrate category over the total number of points determined with the “Coral Point Count with Excel extensions” software (Kohler and Gill, 2006). Panoramic photos and videos of the reef habitats were taken to supplement benthic habitat characterizations.

Substrate classifications included the following:

- **Stony corals** – reported by species and percent substrate cover included stony hydrocorals and scleractinian corals (e.g. *Millepora alcicornis*, *Montastraea cavernosa*.)
- **Octocorals** -(soft corals) reported by species and percent substrate cover, included sea fans, sea whips and encrusting forms, such as *Erythropodium* sp.
- **Sponges** – percent substrate cover reported by species or lowest possible taxon,
- **Zoanthids** – percent substrate cover by species or lowest possible taxon
- **Algal Turf** – percent substrate cover reported for a mixed assemblage of short algae intermixed with other small epibenthic biota forming a mat or carpet over hard substrate
- **Calcareous Algae** – percent substrate cover or lowest possible taxon
- **Coralline Algae** - percent substrate cover or lowest possible taxon
- **Fleshy Algae** – percent substrate cover reported as total fleshy algae, or lowest possible taxon for vertically projected, mostly brown, red and green macroalgae
- **Abiotic Substrate** – percent substrate cover by unconsolidated sediment, bare rock, deep holes, crevices and gaps.

3.2 Characterization of Fishes and Motile Megabenthic Invertebrate

a) Small Demersal Fishes

Demersal (non-cryptic) and territorial reef fish populations and motile megabenthic (> 5 cm) invertebrates (MI) were surveyed from 10 m long by 3 m wide (30 m²) belt-transects centered over the reference line of transects used for sessile-benthic reef characterizations. Locations of transect sampling stations are shown in Figure 2. Each transect was surveyed during 10-12 minutes, subject to the species richness and abundance encountered. The initial two minutes focused on elusive and/or transitory species that could swim away of the “belt-transect” area upon detection of a diver (e.g. snappers, large groupers, hogfish, mackerel, large parrotfishes, etc.). During the next two minutes, the diver swam over the center of the transect counting fishes attracted to divers, such as wrasses and butterflyfishes (e.g. *Thalassoma*, *Halichoeres* spp., *Chaetodon* spp.). Then, fishes that form schooling aggregations at less than 3 meters over the reef (e.g. *Chromis* spp., *Clepticus parrae*, *Bodianus*, etc.) and other transitory species were counted as they entered the belt-transect area. Runs over both sides of transects were performed during the last four-six minutes of the survey area in order to enumerate demersal and territorial fishes (e.g. *Stegastes* spp, *Gramma loreto*, squirrelfishes, etc.) that remain within

the transect area. Fish species observed outside transect areas were reported to supplement the taxonomic assessment, but were not included in density (abundance) determinations.

b) Large demersal and transitory pelagic fishes

Transitory pelagic and other large demersal but elusive fishes that usually represent the commercially important assemblage were quantified along 20 m long x 3 m wide (area: 60 m²) belt-transects. These were extensions of the same 10 m long transects used for benthic invertebrates and small demersal fish assessments. Survey of these transects preceded all other sampling activities in the reef in order to obtain the most accurate information regarding densities of these large fishes in their natural environment. All fishes of commercial value were targeted by this sampling approach, with particular attention to large demersal reef snappers, groupers and hogfish, but also included reef pelagics, such as sharks, mackerels, jacks, barracudas and others present within three (3) meters above the reef substrate. A size estimate of each fish was made in order to provide size frequency data for each species present. Large megabenthic invertebrates of commercial value, such as lobsters and conch were included in the survey.

In addition, a series of 26 drift transects were executed to contribute fishery independent data and supplement taxonomic characterizations and density estimates of the large elusive, commercially important fish and shellfish community. Transect locations (Figure 3) were selected to characterize the main benthic habitat types, including the Bank Coral Reef (BCR), Colonized Pavement (CPV), and Colonized Rhodolith Reef (CRR). Transect width was kept constant at 6 m. The distance varied due to depth, current speed and the presence of queen conch, but generally ranged between 100 – 200 m, to yield transect areas of 600 – 1200 m² per transect.

VI. Results and Discussion

1.0 Benthic Habitat Map

The benthic habitat mapping effort in this study includes a total surface area of 7.5 km², extending 3.7 km from the eastern shelf-edge towards the west and 4.0 km from the southern shelf-edge towards the north. An area of 1.4 km², within the deep basin, with water depths deeper than 50m was not surveyed and thus excluded from the habitat map. As a result of this, the total area mapped was actually 6.1 Km². Five predominant benthic habitat types were observed within the study area at Lang Bank; these include: bank coral reef (BCR), colonized rhodolith reef (CRR), colonized pavement (CPV), spur and groove coral reef (SGR), and patch coral reef (PCR).

1.1 Bank Coral Reef. The bank coral reef habitat is an impressive continuous formation of scleractinian corals growing at depths of 30 m to at least 50 m (100 – 165') throughout the deep outer shelf basin of Lang Bank (Figure 4). The total surface area of the coral reef bank within the study area was estimated as of 1.97 km², or 32 % of the total area surveyed (Table 1). The bank coral reef habitat is largely (almost a biotope) of *Orbicella* (formerly *Montastraea*) *franksi*, a sibling species of *O. annularis* growing as laminar planks of up to 1 m of diameter, supported by pedestals of unknown origin and variable heights. The coral reef system has developed at the inner shelf slope starting at a depth of approximately 30 m and extends down the gradual slope towards the deep section of the basin. The coral reef system, as defined by the contiguous growth of coral colonies creating a topographic anomaly and physical habitat was observed to reach a maximum depth of 52.4 m (173'). It is unknown if isolated coral colonies or smaller “patch reef” formations exist deeper than our diving depth limit of 50 m within the deep basin of Lang Bank.

1.2 Patch Coral Reef

A series of small coral reef patches were observed at 11 dive sites/stations within the study area at Lang Bank, occupying an estimated area of 0.57 km² (Table 1). Patch reefs were mostly found near the boundaries of the bank coral reef at the deep basin walls. These were more common at the inner slope of the outer shelf break (Figure 4), but were also observed at the slope wall of the inner shelf break, near the edge of the outer shelf break, and down the outer shelf slope. Patch reefs associated with the deep basin walls were essentially discontinuous sections of the bank coral reef comprised by variable sets of *Orbicella franksi* colonies growing

together with other reef benthic biota and surrounded by sand. Patch reefs observed at the outer shelf edge and slope were typically found as sponge-coral bioherms associated with substrate anomalies in an otherwise biologically featureless pavement habitat. These patch reefs typically presented a more diverse reef benthic biota and appeared to concentrate fishes and shellfish, particularly spiny lobsters.

Table 1. Areal surface cover for each benthic habitat as represented in the benthic habitat map constructed for Lang Bank, St. Croix, USVI. 2013.

| Benthic Habitat | Area (m ²) | Area (km ²) | % |
|--------------------------|------------------------|-------------------------|------|
| Colonized Pavement | 2,508,593 | 2.51 | 41.2 |
| Bank Coral Reef | 1,970,912 | 1.97 | 32.4 |
| Colonized Rhodolith Reef | 907,452 | 0.91 | 14.9 |
| Patch Coral Reef | 568,978 | 0.57 | 9.3 |
| Sand | 93,379 | 0.09 | 1.5 |
| Spur and Groove Reef | 40,058 | 0.04 | 0.7 |
| Total Area = | 6,089,372 | 6.09 | |
| Not Surveyed (>50 m) | 1422748 | 1.42 | |

1.3 Colonized Pavement.

The colonized pavement habitat is here defined as hard ground substrate of variable topographic relief where corals and/or other reef biota, when present, grow mostly as isolated colonies without forming any complex physical/structural habitat that significantly increases biodiversity relative to adjacent habitats. At Lang Bank, the colonized pavement habitat presented a highly variable benthic composition that appeared to be influenced by slope, depth and water currents. Extensive continuous sections of colonized pavement habitat were found associated with the reef tops of the inner and outer shelf edge, and down the outer shelf insular slope (Figure 4). The total area covered by colonized pavement was estimated as 2.5 km², or

41.2 % of the total study area within the 30 – 50 m depth range (Table 1).

1.4 Colonized Rhodolith Reef

Rhodolith reefs are deposits of crustose coralline algal nodules of variable dimensions and shapes that once stabilized over the bottom undergo a process of biological colonization by fleshy and turf algae, sponges, corals and other encrusting reef biota. Although typically of low relief, rhodolith deposits produce an environment of high microhabitat availability that can serve for establishment of a reef community of high biodiversity relative to adjacent habitats.

Colonized rhodolith reefs were observed at the edges of the northern and southern inner slope and along the deeper sections of the outer shelf slope (Figure 4), occupying a total area of 0.907 km², or 14.9 % of the study area (Table 1).

1.5 Spur and Groove

Spur and groove coral reef formation was observed at only one sampling station near the edge of the inner shelf edge (Figure 4). This station was studied because it was the location of the red hind spawning aggregation. The spur and groove coral reef appears to be a common feature of the shallow sections of the inner shelf edge, particularly along the southern section of the study area in the 20 – 27 m depth range, distributed towards the insular shelf, at the boundary of the mesophotic realm.

1.6 Uncolonized bottom habitats.

Sand patches were observed at the deepest sections of the study area below our diving depth limit of 50 m. This observation was made while diving at the deep boundaries of the bank coral reef, but quantitative assessments of its areal cover are not available.

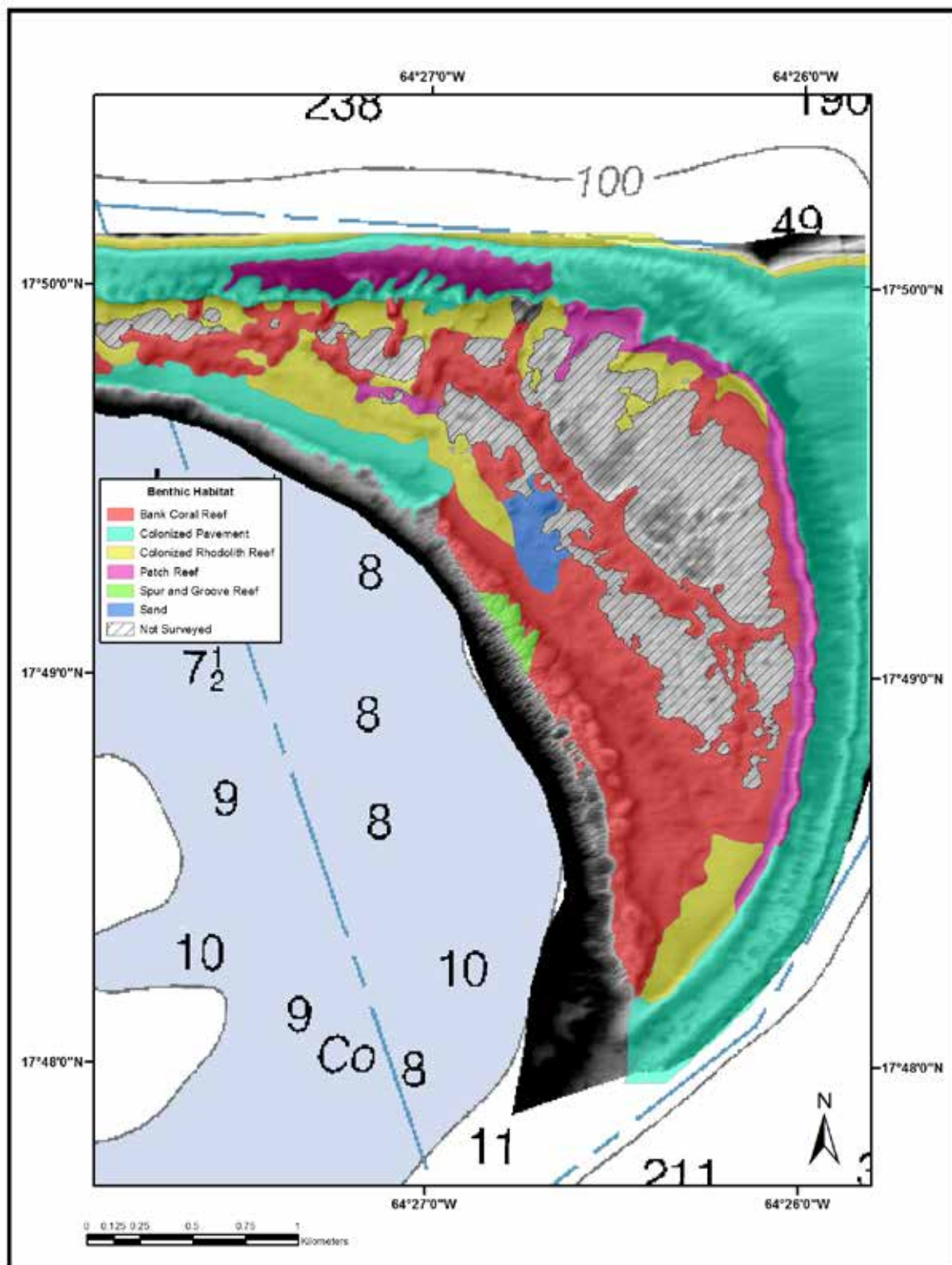


Figure 4. Benthic habitat map of Lang Bank, ST. Croix USVI.

2.0 Biological Characterization of Mesophotic Benthic Habitats

2.1 Sessile-benthic community

2.1.1 Colonized Pavement (CPV)

The relative composition by substrate categories from the 26 transects surveyed at the CPV habitat is shown in Figure 5. Species-specific data for all transects surveyed is included as Appendix 1. Benthic algae were the dominant benthic substrate with an overall mean of 61.6% (range: 35.7 - 95.0%). The encrusting fan alga, *Lobophora variegata*, was the main taxonomic component averaging 33.4% or 54.2 % of the benthic algae assemblage (Table 2). Turf algae, which is a mixed assemblage of short filamentous algae growing as a carpet over the substrate was present from almost all sites, averaging a reef substrate cover 24.6 %. Brown fleshy (*Styopodium sp*, *Dictyota sp*), calcareous (*Halimeda sp.*) and crustose coralline algae were also identified from the CPV habitat. Blue-green algae, or cyanobacterial films were observed from 11 out of the 26 transects with a mean of 0.7%. Abiotic substrates, particularly sand, ranked second in terms of percent substrate cover with a mean of 13.8% (range: 0 – 56.3%). Sand pockets within the CPV habitat were colonized by cyanobacteria or rhodoliths.

Sponges, represented by 42 species and averaging a reef substrate cover of 7.1 % were the dominant taxa among sessile-benthic invertebrates of the CPV habitat. The more common sponges present were the barrel sponge, *Xestospongia muta*, and an unknown brown encrusting sponge. The large erect structure of *X. muta* contributed substantially to the topographic complexity of the colonized pavement habitat. Barrel sponges were present at 20 transects, averaging 1.3% of the benthic cover.

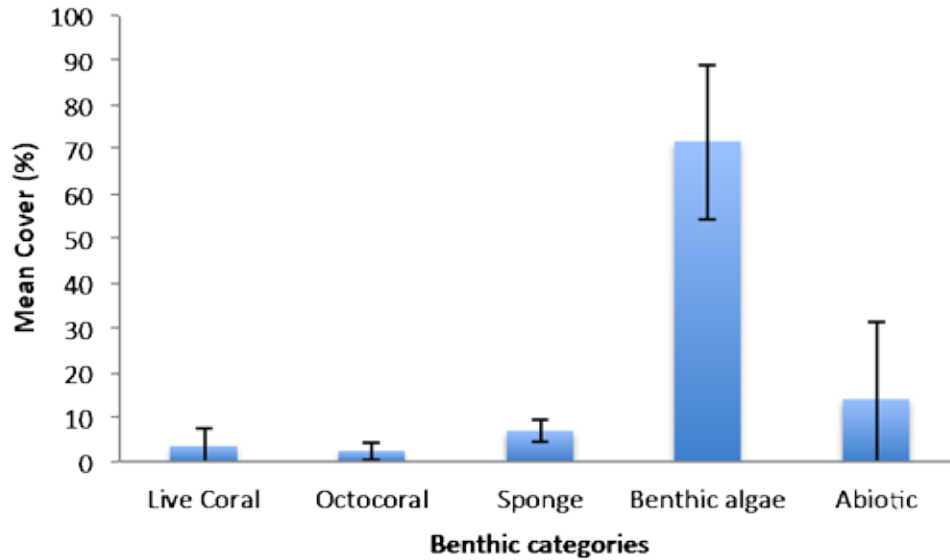


Figure 5. Mean percent composition of substrate categories from a total of 26 transects surveyed at the colonized pavement habitat in Lang Bank, ST. Croix USVI.

Hard corals were represented by a 17 species within transects and averaged a reef substrate cover of 3.64 % (range: 0 – 19.5 %). Boulder star coral, *Orbicella* (formerly *Montastraea*) *franksi*, was the dominant species in terms of substrate cover with a mean of 1.6% and was present in 12 out of the 26 transects surveyed. Lettuce corals (*Agaricia spp*), mustard hill coral (*Porites astreoides*) and massive starlet coral (*Sclerastrea siderea*) were present in at least 10 transects and along with boulder star coral appeared to be the main coral assemblage of the CPV. The corals exhibited mostly encrusting and/or mound shaped growth and typically occurred as small, isolated colonies. At the outer shelf-edge ridge, small to moderate sized coral heads were observed in association with erect and branching sponges, forming sponge-coral bioherms that were particularly important as microhabitats for spiny lobsters (*Panulirus argus*). In other sections of the outer shelf ridge, corals were more abundant within rocky outcrop substrates and in some areas corals were observed growing together, forming biologically complex systems with substantial contributions to the overall structural topographic relief. It can be argued that in many rocky outcrops of the CPV, coral growth significantly increased the value and function of these habitats as protective structures

Table 2. Mean percent cover by substrate categories at the main mesophotic (30–50 m) benthic habitats surveyed by photo transects at Lang Bank, St. Croix, USVI. 2013

| Benthic Habitats | | | | | |
|----------------------------------|--------------------|-----------------|------------------|--------------------------|--------------------------|
| Substrate categories | Colonized Pavement | Bank Coral Reef | Patch Coral Reef | Spur & Groove Coral Reef | Colonized Rhodolith Reef |
| Abiotic | | | | | |
| Dead coral | 0.15 | 0.36 | 1.49 | 1.39 | 0.21 |
| Pavement | 1.39 | | 5.74 | | 0.45 |
| Rhodolith | 0.36 | | 0.88 | | 3.88 |
| Rubble | 1.00 | 0.17 | 3.75 | 0.18 | 1.95 |
| Sand | 11.23 | 3.79 | 24.94 | 3.13 | 25.79 |
| Total abiotic | 14.14 | 4.32 | 36.80 | 4.70 | 32.28 |
| Benthic algae | | | | | |
| Crustose coralline algae | 0.47 | 8.47 | 0.30 | 3.08 | 0.27 |
| <i>Dictyota</i> spp. | 0.78 | 1.40 | 2.00 | 2.95 | 4.50 |
| <i>Halimeda</i> spp. | 0.13 | 0.04 | 0.08 | | 0.19 |
| <i>Lobophora</i> spp. | 33.45 | 29.47 | 30.27 | 15.19 | 37.65 |
| Macroalgae | 2.10 | 1.18 | 4.26 | 2.07 | 1.03 |
| <i>Stypopodium</i> spp. | 0.07 | | | | 0.71 |
| Turf | 24.57 | 19.90 | 12.19 | 40.99 | 10.41 |
| Total benthic algae | 61.57 | 60.47 | 49.09 | 64.28 | 54.76 |
| Cyanobacteria | | | | | |
| | 0.74 | 0.27 | 0.76 | | 0.94 |
| Hard corals | | | | | |
| <i>Agaricia agaricites</i> | 0.08 | 0.04 | 0.08 | 0.17 | |
| <i>Agaricia grahamae</i> | 0.12 | 0.65 | 0.21 | | 0.06 |
| <i>Agaricia lamarcki</i> | 0.21 | 0.42 | 0.28 | | 0.15 |
| <i>Colpophyllia natans</i> | | 0.65 | | 2.33 | |
| Coral spp. | 0.06 | 0.03 | 0.10 | | 0.06 |
| <i>Diploria labyrinthiformis</i> | 0.03 | 0.01 | | | |
| <i>Diploria strigosa</i> | 0.12 | | | | 0.04 |
| <i>Diploria strigosa</i> | | 0.54 | 0.17 | | |
| <i>Eusmilia strigosa</i> | 0.03 | 0.05 | | | |
| <i>Leptoseris cucullata</i> | | 0.04 | | | |
| <i>Madracis decactis</i> | 0.17 | 0.11 | 0.08 | 0.50 | 0.09 |
| <i>Manicina areolata</i> | 0.02 | | | | |
| <i>Meandrina meandrites</i> | 0.08 | 0.03 | | | 0.05 |
| <i>Millepora alcicornis</i> | 0.12 | | 0.11 | 0.17 | |
| <i>Millepora alcicornis</i> | | 0.02 | | | |
| <i>Montastraea cavernosa</i> | 0.22 | 0.42 | 0.11 | 0.67 | |

Benthic Habitats

| Substrate categories | Colonized Pavement | Bank Coral Reef | Patch Coral Reef | Spur & Groove Coral Reef | Colonized Rhodolith Reef |
|----------------------------------|-----------------------|-----------------------|---------------------|--------------------------------|--------------------------------|
| <i>Montastraea faveolata</i> | | 0.06 | | | |
| <i>Mycetophyllia aliciae</i> | 0.02 | 0.05 | 0.15 | 0.19 | |
| <i>Mycetophyllia ferox</i> | | 0.04 | | 0.17 | |
| <i>Orbicella franksi</i> | 1.58 | 23.05 | 0.65 | 15.47 | 0.36 |
| <i>Porites astreoides</i> | 0.42 | 0.81 | 0.46 | 0.43 | 0.09 |
| <i>Porites divaricata</i> | | 0.09 | | | |
| <i>Porites furcata</i> | | 1.68 | 0.12 | 2.88 | |
| <i>Porites porites</i> | | 0.01 | | 0.17 | |
| <i>Siderastrea siderea</i> | 0.35 | 0.17 | 0.17 | 0.50 | 0.11 |
| <i>Stephanocoenia intersepta</i> | 0.02 | 0.04 | 0.04 | | 0.14 |
| Total hard coral | 3.64 | 29.00 | 2.71 | 23.65 | 1.15 |
| Octocorals | | | | | |
| <i>Antillogorgia</i> spp. | 0.11 | 0.04 | 0.26 | | |
| <i>Briareum</i> sp. | | 0.20 | 0.08 | | |
| <i>Erythropodium caribaeorum</i> | 0.09 | 0.39 | | | 0.06 |
| <i>Eunicea</i> spp. | 1.27 | 0.07 | 0.48 | 0.17 | 0.28 |
| <i>Gorgonian</i> spp. | 0.04 | 0.02 | | | |
| <i>Muriceopsis</i> spp. | 0.06 | | | | |
| <i>Plexaura</i> spp. | 0.35 | 0.02 | | 0.34 | 0.04 |
| <i>Plexaurella</i> spp. | 0.07 | 0.02 | | | |
| <i>Pseudoplexaura</i> spp. | 0.45 | 0.02 | 0.08 | 0.17 | 0.04 |
| <i>Pterogorgia</i> spp. | 0.08 | | | | |
| Total octocoral | 2.51 | 0.76 | 0.91 | 0.68 | 0.42 |
| Sponges | | | | | |
| <i>Agelas citrina</i> | 0.10 | | 0.04 | 0.50 | |
| <i>Agelas clathrodes</i> | 0.12 | 0.42 | 0.22 | 0.17 | |
| <i>Agelas conifera</i> | 0.51 | 0.50 | 0.28 | | 0.22 |
| <i>Agelas dispar</i> | | 0.02 | 0.04 | 0.17 | |
| <i>Agelas tubulata</i> | 0.05 | 0.06 | 0.08 | 0.33 | |
| <i>Aiolochoia crassa</i> | 0.08 | 0.20 | 0.12 | 0.17 | 0.19 |
| <i>Amphimedon compressa</i> | 0.06 | 0.05 | 0.08 | | |
| <i>Aplysina archeri</i> | 0.08 | | | | |
| <i>Aplysina cauliformis</i> | 0.46 | 0.07 | 0.38 | | 0.33 |
| <i>Aplysina fistularis</i> | 0.34 | 0.01 | 0.12 | | 0.31 |
| <i>Aplysina insularis</i> | 0.04 | 0.02 | | | |
| <i>Aplysina lacunosa</i> | 0.02 | 0.02 | 0.12 | | 0.04 |
| Black unknown sponge | 0.02 | | 0.07 | | |
| <i>Callyspongia armigera</i> | 0.02 | | | | |
| <i>Callyspongia plicifera</i> | | 0.02 | | | |

Benthic Habitats

| Substrate categories | Colonized Pavement | Bank Coral Reef | Patch Coral Reef | Spur & Groove Coral Reef | Colonized Rhodolith Reef |
|------------------------------------|-------------------------------|--------------------------------|-----------------------------|---|---|
| <i>Chondrilla caribensis</i> | | | 0.11 | | |
| <i>Cinachyrella kuekenthali</i> | 0.24 | 0.02 | 0.04 | | 0.04 |
| <i>Clathria schoenus</i> | 0.02 | 0.08 | 0.04 | 1.52 | 0.05 |
| <i>Cliona aprica</i> | | 0.01 | | | |
| <i>Cliona caribbaea</i> | 0.07 | 0.27 | | 2.17 | 0.04 |
| <i>Cliona delitrix</i> | 0.03 | 0.01 | | | 0.04 |
| <i>Cribrochalina vasculum</i> | 0.02 | | 0.03 | | |
| <i>Ectoplasia ferox</i> | 0.05 | 0.03 | | | |
| <i>Erylus formosus</i> | | 0.02 | | | 0.15 |
| <i>Geodia neptuni</i> | 0.34 | 0.85 | 0.17 | 0.69 | 0.40 |
| <i>Hyrtios cavernosus</i> | 0.14 | 0.20 | 0.12 | | 0.16 |
| <i>Ircinia campana</i> | | | 0.04 | | |
| <i>Ircinia felix</i> | 0.03 | | 0.07 | | |
| <i>Ircinia sp.</i> | | 0.01 | 0.14 | | 0.04 |
| <i>Ircinia spp. brown</i> | 0.03 | | | | |
| <i>Ircinia strobilina</i> | 0.07 | 0.01 | 0.08 | | 0.11 |
| <i>Myrmekioderma gyroderma</i> | 0.02 | | | | |
| <i>Neopetrosia proxima</i> | 0.07 | 0.03 | 0.20 | 0.33 | 0.22 |
| <i>Niphates digitalis</i> | 0.21 | 0.06 | 0.07 | | 0.05 |
| <i>Niphates erecta</i> | 0.02 | | | | |
| <i>Petrosia pellasarca</i> | 0.01 | | 0.33 | | |
| <i>Plakortis angulospiculatus</i> | 0.16 | | 0.08 | | 0.26 |
| <i>Plakortis halichondrioides</i> | 0.19 | | 0.11 | | 0.19 |
| <i>Plakortis spp.</i> | 0.04 | 0.02 | | 0.17 | 0.04 |
| <i>Prosuberites laughlini</i> | 0.34 | 0.03 | 0.11 | | 0.30 |
| <i>Ptilocaulis walpersi</i> | | | | | 0.18 |
| <i>Scopalina ruetzleri</i> | 0.06 | | | 0.17 | 0.08 |
| <i>Smenospongia conulosa</i> | 0.10 | 0.03 | 0.03 | | 0.06 |
| <i>Spheciospongia vesparium</i> | 0.10 | | 0.12 | | |
| <i>Spriastrella coccinea</i> | 0.18 | 0.01 | 0.04 | | 0.23 |
| <i>Suberea sp.</i> | | | 0.03 | | |
| <i>Svenzea zeai</i> | 0.12 | 0.65 | 0.11 | | |
| <i>Topsentia aphirophidites</i> | | | | | 0.04 |
| Unknown sponge | 1.13 | 0.54 | 0.93 | 0.55 | 0.36 |
| <i>Verongula gigantea</i> | 0.03 | 0.01 | 0.03 | | 0.09 |
| <i>Verongula reiswigi</i> | | | 0.04 | | |
| <i>Verongula rigida</i> | 0.13 | 0.01 | 0.39 | | 0.16 |
| <i>Xestospongia muta</i> | 1.27 | 0.06 | 1.23 | | 0.90 |
| Total Sponges | 7.09 | 4.36 | 6.23 | 6.94 | 5.28 |

for fish and invertebrate species, which is more consistent with their classification as small coral reef habitats. Conversely, the CPV habitat present at the insular slope was mostly featureless with very low density of corals and low topographic relief.

Octocorals (soft corals), represented by nine species were present from 22 transects at the CPV. The main octocoral genera observed was *Eunicea* spp., followed by the encrusting soft coral, *Erythropodium caribaeorum*. The larger gorgonians such as the *Antillogorgia* spp. (formerly *Pseudopterogorgia*) also contributed to the reef topographic relief, serving as a physical protective habitat for fishes.

A multidimensional scaling plot of Bray Curtis similarities of community structure within and between the main sessile-benthic habitats surveyed at Lang Bank is shown in Figure 6. Statistical analyses of similarities (ANOSIM) within and dissimilarities between benthic habitats surveyed are included as Appendix 2. The CPV habitat was characterized by relatively low affinity (high variability) on the relative composition of substrate categories within transects surveyed (average: 71.3 %). High variability within transects was measured for basically all substrate categories, but was extreme in the case of abiotic cover (range: 0 – 56.3 %), hard corals (0 – 19.5 %) and octocorals (0 – 7.8 %). The CPV habitat was distributed throughout a wide range of depths (30 – 50 m) and slopes (nearly 0 at the reef top to ca. 45 degrees at the slope) at Lang Bank, which are factors that may influence the structure of benthic communities. Still, high variability was also observed within transects surveyed at similar reef physiographic zones, depths and inclinations within the CPV habitat, rendering the relationships between community structure and depth statistically insignificant (ANOSIM; $p > 0.05$). Community structure dissimilarity between CPV and other benthic habitats surveyed at Lang Bank was highest and statistically significant compared to the bank coral reef (ANOSIM; $p < 0.001$). Substrate cover by hard corals was the main contributor to the differences between the CPV (mean: 3.6 %) and BCR (mean: 29.0 %) habitats (see Appendix 2). Statistically marginal differences (ANOSIM; $p = 0.029$) were also evident between the CPV and colonized rhodolith reef (CRR) habitats. In this case, it was abiotic cover the main contributor to the differences between habitat types.

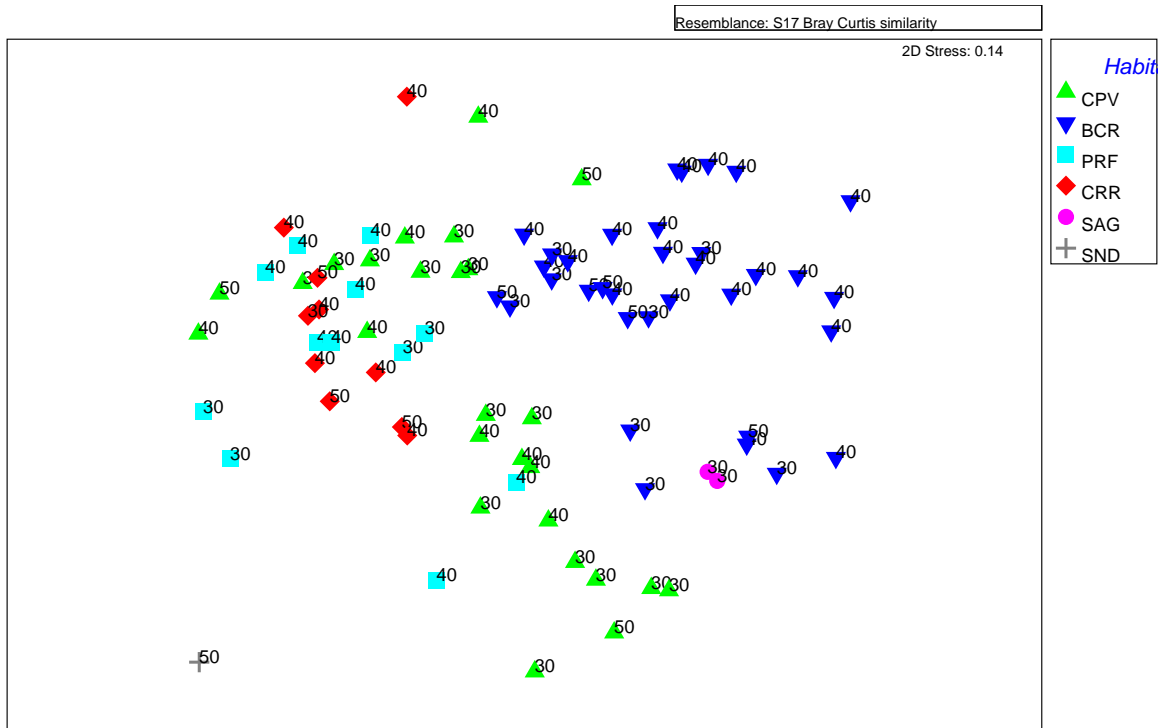
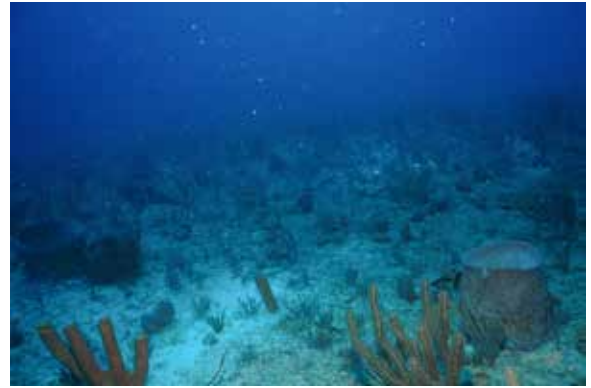


Figure 6. Multidimensional scaling plot (MDS) of Bray Curtis similarities of community structure within and between the main mesophotic (30 – 50 m) sessile-benthic habitats surveyed at Lang Bank, 2013.

Photo Album 1. Colonized Pavement







2.1.2 Bank Coral Reef (BCR)

Live scleractinian coral was the dominant sessile-benthic invertebrate in terms of substrate cover at the bank coral reef habitat (Figure 7) with a total of 23 species present within transects and an average reef substrate cover of 29.0% (range: 10.5 - 55.3%). Transect specific data of percent substrate cover by benthic categories at the BCR habitat are included in Appendix 3. The main reef builder and dominant coral species in terms of substrate cover at the BCR was the boulder star coral, *Orbicella franksi*. The mean cover by *O. franksi* was 23.0 % representing 79.3 % of the total cover by scleractinian corals at the BCR (Table 2). *Orbicella franksi* was observed growing in table-shaped colonies side by side, sometimes overlapping and producing impressive continuous live mesophotic coral reef system resembling those described by Smith et al. (2009) for the MCD Hind Bank in St. Thomas, USVI, and by García-Sais et al. (2011) for El Seco in Vieques, Puerto Rico. Mustard hill and branched finger corals (*Porites astreoides*, *P. furcata*), lettuce corals (*Agaricia grahamae*, *A. lamarki*), Massive starlet coral (*Siderastrea siderea*), and great star coral (*Montastraea cavernosa*) were all present in more than 10 out of the 33 transects surveyed and along with boulder star coral represented the main coral assemblage at the BCR.

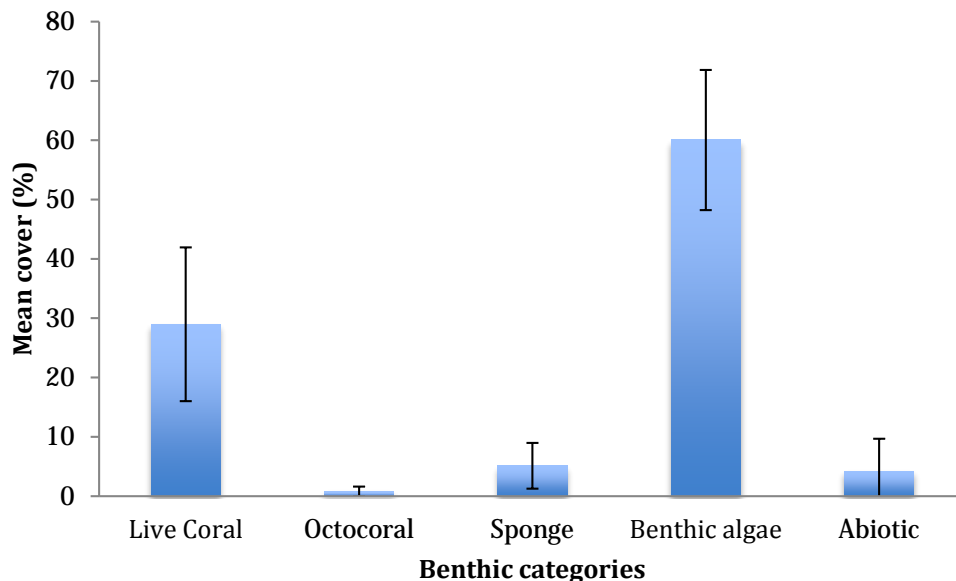


Figure 7. Mean percent composition of substrate categories from a total of 33 transects surveyed at the Bank Coral Reef habitat in Lang Bank, ST. Croix USVI.

Sponges, represented by 33 species had a combined substrate cover of 5.1% (range: 0 – 13.8%) at the BCR (Table 2). The leathery barrel sponge, *Geodia neptuni*, with an average 0.9% (range: 0 – 5.1%) was the dominant species in terms of reef substrate cover and was present in 19 out of the 33 transects surveyed. *Geodia neptuni*, because of its large size (up to > 1.0 m provides protective microhabitat to a wide variety of small fishes and invertebrates and is an important food source for the green turtle (*Chelonia midas*). In addition to *G. neptuni*, *Svenzea zeai*, *Agelas conifera*, *A. clathrodes* and an unidentified brown sponge were present in at least 10 out of the 33 transects surveyed and comprised the main sponge assemblage of the BCR habitat at Lang Bank (Table 2).

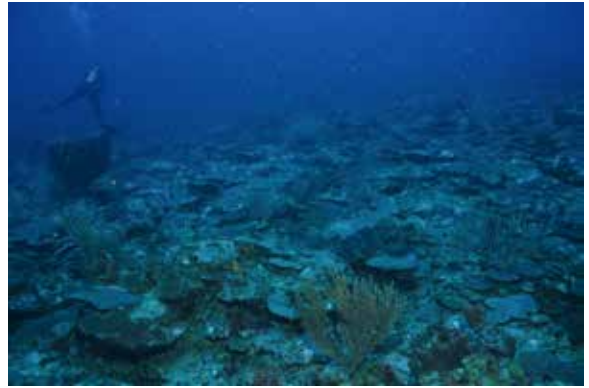
Octocorals (gorgonians) were present but with low substrate cover (mean: 0.8 %) at the BCR (Table 2). Evidently, scleractinian corals exhibiting laminar growth outcompete the vertically projected octocorals. The encrusting type, *Erythropodium caribaeorum* was the dominant species in terms of reef substrate cover (mean: 0.4%) and was observed in 13 transects (Appendix 2). A total of eight gorgonian species were identified from the BCR.

Benthic algae were found in relatively high abundance, with an overall mean of 60.5% (range: 30.7 – 80.9 %). The benthic algal assemblage included fleshy brown algae (Phaeophyta), *Lobophora variegata* and *Dictyota* spp., crustose coralline algae (Rhodophyta), turf (mixed assemblage), and *Halimeda* spp. *Lobophora variegata* was the main component of the benthic algae in terms of reef substrate cover averaging 29.5%% (Table 2). Crustose coralline algae, which acts as a settlement cue for many benthic organisms was present at all BCR stations, averaging 8.5%. Minor components of the sessile-benthic community structure included the overgrowing mat tunicate, *Trididemnum solidum*.

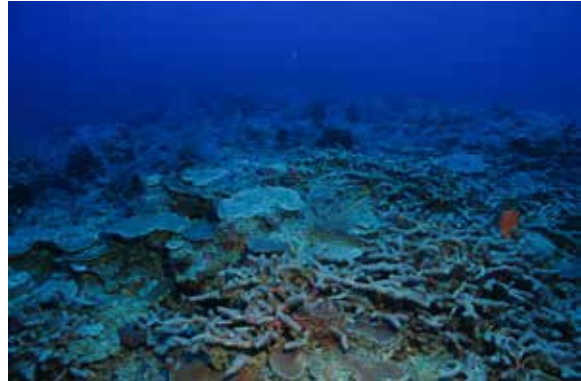
The MDS plot of Bray-Curtis similarities (Figure 6) showed a clear pattern of high within station affinities for the BCR stations, with an average similarity of 78.3% (ANOSIM, see Appendix 2) and separation from other benthic habitat types with exception of the spur and groove reef. Fleshy macroalgae and hard corals were the main contributors to within station similarity at the BCR. Statistically significant differences of sessile-benthic community structure were observed between the BCR and all other benthic habitats except the spur and groove reef formation (ANOSIM, $p < 0.01$). Substrate cover by hard corals and crustose coralline algae were the main factors contributing to community

structure differences between benthic habitats. Differences between the BCR and the PRF were strongly influenced by the higher abiotic cover at the PRF, in addition to the lower cover of hard corals at the PRF compared to the BCR (Appendix 2).

Photo Album 2. Bank Coral Reef







2.1.3 Patch Coral Reef (PCR)

A total of 12 transects were surveyed at the Patch Coral Reef (PCR) habitat in Lang Bank. The mean percent cover by substrate categories is shown in Figure 8. Species-specific data for all transects is included as Appendix 4. Benthic algae were the dominant benthic substrate category with an overall mean of 49.1% (range: 15.0 – 69.3 %). The encrusting fan alga, *Lobophora variegata*, was the main taxonomic component averaging 30.3% or 61.7 % of the benthic algae assemblage (Table 2). Turf algae and brown fleshy macroalgae (including *Dictyota* sp.) were present in at least 11 transects, averaging a combined reef substrate cover of 18.5 %. Red crustose coralline algae were also identified from the PCR habitat. Blue-green algae, or cyanobacterial films were observed from 7 out of the 12 transects with a mean of 0.8%. Abiotic substrates, particularly sand, were prominent in terms of percent substrate cover with a mean of 38.9% (range: 18.9 – 70.0%), the highest among benthic habitats at Lang Bank (Table 2). Live scleractinian corals were present in 11 out of the 12 PCR sites surveyed with a total of 14 species within transects and a mean reef substrate cover of 2.7 % (range: 0 – 6.0%). *Orbicella franksi* and *Porites astreoides* with means of 0.6% and 0.5 % were the dominant coral species in terms of reef substrate cover. Other species that were present in at least 3 stations included *Agaricia lamarcki* (0.3%), *Siderastrea siderea*, *Montastraea cavernosa* and *Mycetophyllia aliciae*.

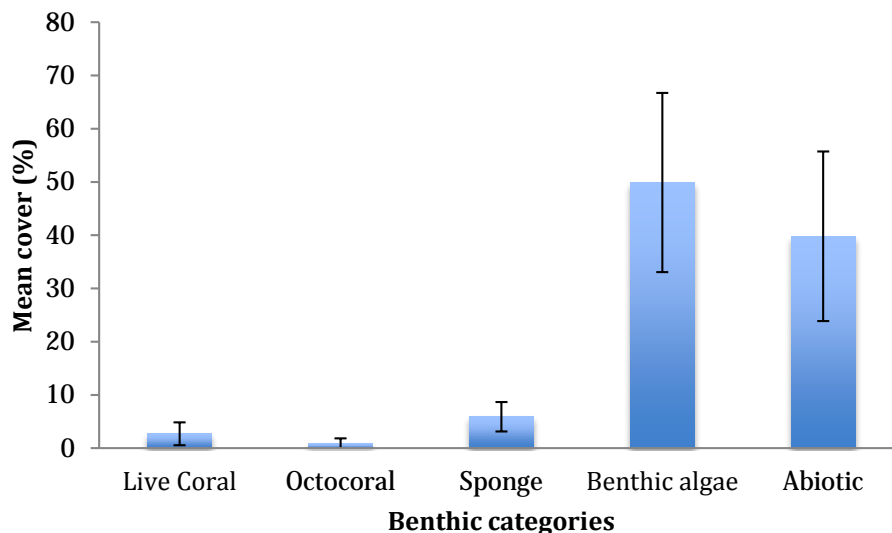


Figure 8. Mean percent composition of substrate categories from a total of 12 transects surveyed at the Patch Coral Reef habitat in Lang Bank, ST. Croix USVI.

Sponges, represented by 37 species and averaging a reef substrate cover of 6.2 % were the dominant taxa among sessile-benthic invertebrates of the PCR habitat. The more common sponges present were the barrel sponge, *Xestospongia muta*, and an unknown brown encrusting sponge. These two species were present in at least 10 out of the 12 transects surveyed at the PCR. Octocorals (gorgonians) were present at eight transects, averaging a reef substrate cover of 0.9% (range: 0 – 3.1%) and. The main octocoral genera observed was *Eunicea* spp., followed by the bushy soft coral, *Antillogorgia* spp. The latter species usually grows in tall, feather-like plumes, and their structure contributes to the reef topographic relief and complexity, serving as a protective habitat for fishes.

Benthic community structure at PRF differed significantly from the BCR and the Spur and Groove (SAG) habitats (Figure 6) (ANOSIM; $p < 0.01$; Appendix 2). Differences were mostly related to the much higher proportion of abiotic cover (mostly sand) at the PRF and the higher substrate cover by live hard corals at the BCR and the SAG. PRF was more similar in terms of benthic community structure to CPV (colonized pavement) and CRR (colonized rhodolith reef) (Figure 6). Similarities between these habitats were largely driven by abiotic, turf algae and macroalgal benthic categories.

Photo Album 3. Patch Coral Reef







2.1.4 Spur & Groove (SAG)

The spur and groove reef formation consisted of parallel ridges (spurs) running perpendicular to the shelf-edge separated by sand channels (grooves) of variable widths. This habitat type was observed to reach mesophotic depths (>30 m) at the deepest end of its distribution at Lang Bank. Because of its largely neritic distribution only three transects were surveyed in the vicinity of the red hind (*Epinephelus guttatus*) spawning aggregation site. The mean composition (% substrate cover) of sessile-benthic substrate categories at the spur and groove habitat is shown in Figure 9. Transect data on percent substrate cover by benthic categories at the SAG habitat are presented in Appendix 5.

Benthic algae were the dominant substrate category with an overall mean of 64.3 % (range: 58.8 – 67.2%). A mixed assemblage of short filamentous algae, known as turf algae was the main component of the benthic algal substrate cover at the SAG averaging 41.0% (Table 2). The encrusting fan alga, *Lobophora variegata*, Y-branched alga, *Dictyota* spp., unidentified macroalgae, and crustose coralline algae were also present at all three transects surveyed. Abiotic substrates, particularly sand, was relatively low in transects, averaging 4.7% (Table 2).

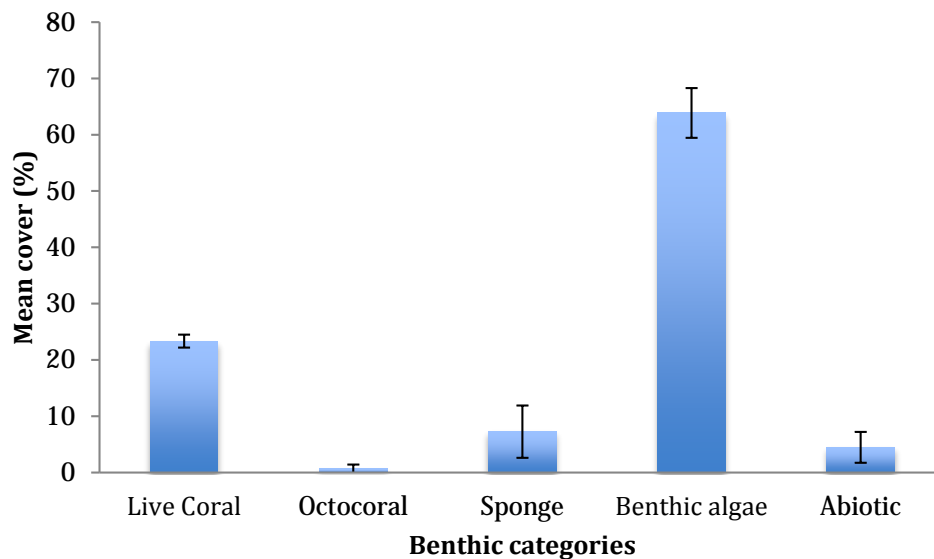


Figure 9. Mean percent composition of substrate categories from a total of 3 transects surveyed at the Spur and Groove Reef habitat in Lang Bank, ST. Croix USVI.

Among sessile-benthic invertebrates, live scleractinian corals were the dominant category, averaging 23.4% of the reef substrate cover and were observed in all transects. A total of 12 species of corals were identified within transects at the spur and groove habitat (Table 2). Boulder star coral, *Orbicella franksi* was the most abundant at the SAG habitat, averaging a reef substrate cover of 15.5 %, or 65.5 % of the total cover by corals. Other common corals present at the SAG habitat were *Porites furcata*, *Colpophyllia natans*, and *Montastraea cavernosa*. *Orbicella franksi* was observed growing in table-shaped laminar colonies, similar to its growth at the BCR. However, many of the *O. franksi* colonies showed old mortality, especially around the border of the colonies.

Sponges were represented within transects by 12 species, with an overall mean reef substrate cover of 6.9 % (range: 2.3 – 11.5 %). Encrusting and lobate sponges were more common at the SAG habitat. *Cliona caribbaea* was the most abundant species. Clioniids are efficient excavators of calcareous material, such as corals. Their function on the reef is important because they are competitors of hard corals for space. Octocorals (soft corals) were represented by only three species with relatively low substrate cover (mean: 0.7%). *Plexaura* spp., *Eunicea* spp. and *Pseudoplexaura* spp. were identified from the SAG habitat.

Transects surveyed at the SAG habitat presented high affinity of benthic community structure with an average similarity of 81.3%, the highest amongst habitats studied at Lang Bank (Appendix 2). Compared to other benthic habitats, the SAG was not significantly different than the BCR habitat (ANOSIM; $p = 0.268$; Figure 6), presenting relatively high similarity throughout all major benthic categories. As in the case of BCR, SAG benthic community was different to CCR (ANOSIM; $p = 0.007$), PRF (ANOSIM; $p = 0.002$) and CPV (ANOSIM; $p = 0.036$). The main contributors to the dissimilarity between the SAG and other benthic habitats (other than BCR) at Lang Bank were the relatively high composition of (live) hard coral and the relatively low cover by abiotic substrates.

2.1.5 Colonized Rhodolith Reef

Colonized rhodolith reef (CRR) habitats occupied a relatively low areal cover (14.9%) within the 30 – 50 m mesophotic realm at Lang Bank. Mostly scattered and lightly colonized rhodolith deposits were observed down the insular slope of the outer shelf break, particularly along the northern section of the insular slope. This habitat consists of crustose algal nodules of variable shapes and sizes deposited over an otherwise flat, relatively homogeneous and gently sloping shelf. The mean substrate cover data for sessile-benthic categories surveyed at 10 stations within the CRR habitat are presented in Figure 10. Benthic algae were the dominant category in terms of substrate cover in most transects with an average of 57.3% (range: 34.9 – 76.0%). Brown fleshy algae, including the encrusting fan alga, *Lobophora variegata*, Y branched alga, *Dictyota sp.* and turf algae were the main components of the benthic algal assemblage. Crustose coralline algae were only present in two transects with a mean cover of 0.3% (Table 2).

Cyanobacteria growing over mostly abiotic substrate and macroalgae were present in five transects, with mean cover ranging from 0.4% to 3.5%. Abiotic substrates ranked second in terms of reef substrate cover at CRR habitat with an average of 31.0 %. Extensive and widespread coralline sand pockets interspersed within the rhodolith

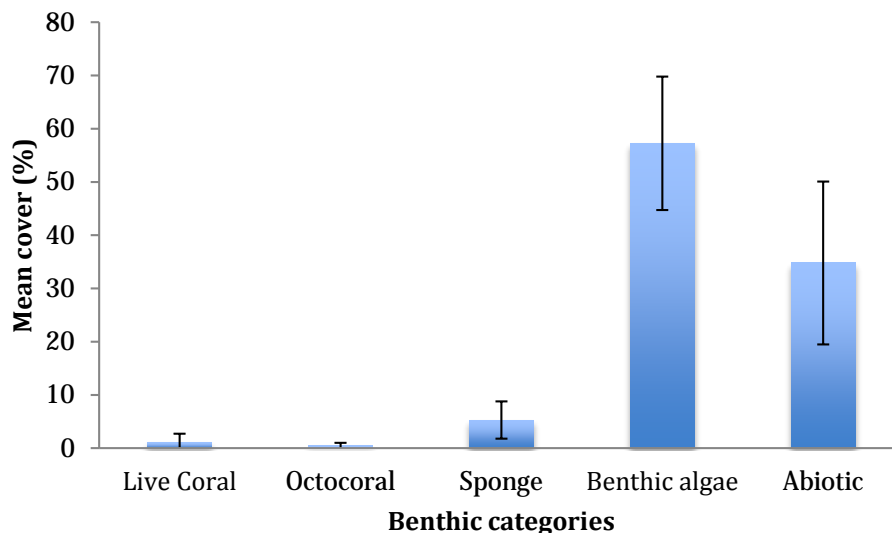


Figure 10. Mean percent composition of substrate categories from a total of 10 transects surveyed at the Colonized Rhodolith Reef habitat in Lang Bank, ST. Croix USVI.

deposits were the main contributor to abiotic cover at the CRR, representing 83.0 % of the total with a mean cover of 25.8 % (range: 0.9 – 46.9 %). Specific transect data is included as Appendix 6.

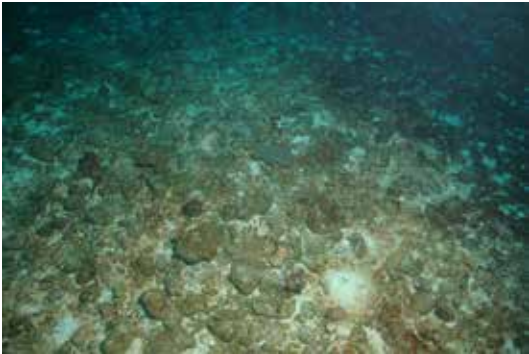
Barrel, branching, and encrusting sponges were present in all 10 transects surveyed at the CRR. A total of 29 species were identified within photo-transects with a mean reef substrate cover of 5.3% (range: 1.5 – 13.8%). The giant barrel sponge, *Xestospongia muta* was the most prominent species, followed by the leathery barrel sponge, *Geodia neptuni* (Table 2). Both barrel sponges were observed in large sizes and contributed to the overall topographic relief and habitat complexity in an otherwise flat, homogeneous and structurally featureless habitat. The larger branching and barrel sponges appeared to be attached to the primary hard ground, not to rhodoliths.

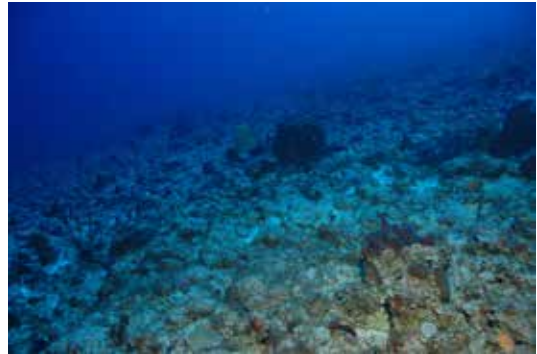
Scleractinian coral richness and cover was low at the CRR, with nine species averaging 1.2% (Table 2). *Orbicella franksi*, a sister species of the boulder star coral, was the most prominent species of the assemblage (mean: 0.4%), followed by lettuce coral, *Agaricia lamarcki* (mean: 0.2%). Scleractinian corals grew mostly attached to the algal nodules and were generally of small to very small sizes, contributing very little to the topographic relief. Octocorals were present in very low abundance and diversity. The overall mean cover of octocoral at rhodolith reefs was 0.4%. *Eunicea* spp. and the encrusting octocoral, *Erythropodium caribaeorum*, were the most prominent octocorals at this habitat.

In terms of sessile-benthic community structure, the CRR habitat exhibited relatively high affinity within transects with an average similarity of 79.7 % (Figure 6; Appendix 2). Similarity within CRR sampling stations was mostly influenced by the consistently high substrate cover of fleshy macroalgae and abiotic categories. Conversely, the highest dissimilarities of the CRR were associated with the BCR and the SAG habitats, where substrate cover by hard corals was relatively high and abiotic cover was relatively low.

Photo Album 4. Colonized Rhodolith Reef







2.2.0 Fish and Shellfish Communities

2.2.1 Colonized Pavement Habitat (CPV)

A total of 50 fish species were identified from the CPV habitat, including 38 within belt-transects (Table 3). Mean fish density was 23.8 Ind/30 m². The combined abundance of seven species represented 73.9 % of the total abundance within transects. The main fish assemblage included (in descending abundance order) the bicolor damselfish (*Stegastes partitus*), Blue and Yellowhead Wrasses (*Thalassoma bifasciatum*, *Halichoeres garnoti*), Blue Chromis (*Chromis cyanea*), Cherubfish (*Centropyge argi*) Princess Parrotfish (*Scarus taeniopterus*) and the doctorfish (*Acanthurus chirurgus*). Species of commercial value included the hogfish (*Lachnolaimus maximus*), mutton snapper (*Lutjanus analis*), yellowfin, Nassau and red hind groupers (*Mycteroperca venenosa*, *Epinephelus striatus*, *E. guttatus*), great barracuda (*Sphyrna barracuda*), lionfish (*Pterois* sp.) and rainbow parrotfish (*Scarus guacamaia*).

The top five fish species in terms of abundance were also the most common within the CPV habitat as they were present in at least 50 % of the transects surveyed (Appendix 7) and along with the Coney (*Epinephelus fulva*) and the squirrelfish (*Holocentrus rufus*) were the main contributors to the within station fish community structure similarity at the CPV habitat. The aforementioned fish assemblage were also the main contributors to dissimilarities with the BCR habitat (Figure 10; Appendix 8). The CPV habitat was characterized by relatively high variability in terms of fish community structure and statistically significant differences (ANOSIM; $p < 0.1$) were only found between the CPV and the BCR habitats (Figure 10). Aside from the sharp differences of community structure associated with the most abundant fish assemblage, differences were also influenced by the absence of hamlet species (*Hypoplectrus* spp) at the CPV habitat and overall lower densities of masked and peppermint gobies (*Coryphopterus personatus*, *C. lipernes*), graysbe (*Epinephelus cruentatus*), Spanish hogfish (*Bodianus rufus*) and black-bar Soldierfish (*Myripristis jacobus*) relative to the BCR habitat (Appendix 8).

Table 3. Mean abundance of fishes identified within belt-transects from the main benthic habitat types at Lang Bank. 2012-13

| SPECIES | Common Name | CPV | BCR | CRR |
|------------------------------------|------------------------|------------|------------|------------|
| <i>Stegastes partitus</i> | Bicolor Damselfish | 6.35 | 4.73 | 9.8 |
| <i>Thalassoma bifasciatum</i> | Bluehead Wrasse | 4.58 | 1.79 | 2.3 |
| <i>Halichoeres garnoti</i> | Yellowhead Wrasse | 2.08 | 1.67 | 1.5 |
| <i>Chromis cyanea</i> | Blue Chromis | 1.62 | 5.70 | 1.1 |
| <i>Centropyge argi</i> | Cherubfish | 1.08 | 0.03 | 2.1 |
| <i>Scarus taeniopterus</i> | Princess Parrotfish | 0.96 | 4.88 | 0.3 |
| <i>Acanthurus chirurgus</i> | Doctorfish | 0.92 | 0.33 | |
| <i>Epinephelus fulva</i> | Coney | 0.69 | 0.21 | 0.6 |
| <i>Haemulon flavolineatum</i> | French Grunt | 0.58 | 0.27 | |
| <i>Scarus iserti</i> | Stripped Parrotfish | 0.50 | 0.70 | |
| <i>Caranx ruber</i> | Bar Jack | 0.50 | | |
| <i>Haemulon melanorum</i> | Cottonwick | 0.46 | 0.06 | 0.4 |
| <i>Holocentrus rufus</i> | Squirrelfish | 0.46 | 0.30 | 0.1 |
| <i>Chromis insolata</i> | Sunshine Chromis | 0.38 | | 0.6 |
| <i>Sparisoma aurofrenatum</i> | Redband Parrotfish | 0.38 | 0.85 | |
| <i>Elacatinus evelynae</i> | Sharknose Goby | 0.27 | 0.73 | |
| <i>Halichoeres maculipinna</i> | Clown Wrasse | 0.23 | | 0.1 |
| <i>Acanthurus coeruleus</i> | Blue Tang | 0.23 | 0.24 | |
| <i>Serranus tigrinus</i> | Harlequin Bass | 0.19 | 0.06 | 0.3 |
| <i>Sparisoma radians</i> | Bucktooth Parrotfish | 0.19 | 0.06 | |
| <i>Coryphopterus lipernes</i> | Peppermint Goby | 0.12 | 3.09 | |
| <i>Acanthurus bahianus</i> | Ocean Surgeon | 0.08 | 0.18 | 0.4 |
| <i>Pomacanthus paru</i> | French Angelfish | 0.08 | 0.03 | 0.3 |
| <i>Canthigaster rostrata</i> | Caribbean Puffer | 0.08 | 0.27 | 0.1 |
| <i>Xanthichthys ringens</i> | Sargassum Triggerfish | 0.08 | 0.03 | 0.1 |
| <i>Chaetodon capistratus</i> | Four-eye Butterflyfish | 0.08 | 0.48 | |
| <i>Paranthias furcifer</i> | Creole Fish | 0.08 | 0.12 | |
| <i>Chaetodon striatus</i> | Banded Butterflyfish | 0.08 | 0.06 | |
| <i>Amblycirrhitus pinos</i> | Redspotted Hawkfish | 0.08 | | |
| <i>Chaetodon sedentarius</i> | Reef Butterflyfish | 0.08 | | |
| <i>Dasyatis americana</i> | Southern Stingray | 0.08 | | |
| <i>Balistes vetula</i> | Queen Triggerfish | 0.04 | X | X |
| <i>Coryphopterus glaucophaenum</i> | Bridled Goby | 0.04 | 0.03 | 0.2 |
| <i>Pomacanthus arcuatus</i> | Gray Angelfish | 0.04 | 0.03 | 0.1 |
| <i>Epinephelus cruentatus</i> | Graysbe | 0.04 | 0.24 | |

| | | | | |
|----------------------------------|-------------------------|------|------|-----|
| <i>Sparisoma viride</i> | Stoplight Parrotfish | 0.04 | 0.24 | |
| <i>Chaetodon aculeatus</i> | Longsnout Butterflyfish | 0.04 | 0.15 | |
| <i>Holacanthus tricolor</i> | Rock Beauty | 0.04 | 0.09 | |
| <i>Sargocentron coruscus</i> | Reef Squirrelfish | 0.04 | | |
| <i>Pterois volitans</i> | Lionfish | | 0.12 | X |
| <i>Serranus tabacarius</i> | Tobacco Fish | | 0.03 | 0.3 |
| <i>Lutjanus buccanella</i> | Blackfin Snapper | | | 0.2 |
| <i>Serranus tortugarum</i> | Chalk Bass | | 0.06 | 0.1 |
| <i>Malacanthus plumieri</i> | Sand Tilefish | | | 0.1 |
| <i>Coryphopterus personatus</i> | Masked Goby | | 6.97 | |
| <i>Clepticus parrae</i> | Creole Wrasse | | 5.52 | |
| <i>Myripristis jacobus</i> | Black-bar Soldierfish | | 0.36 | |
| <i>Hypoplectrus puella</i> | Barred Hamlet | | 0.30 | |
| <i>Gramma loreto</i> | Fairy Basslet | | 0.30 | |
| <i>Melichthys niger</i> | Black Durgon | | 0.27 | |
| <i>Mulloidichthys martinicus</i> | Yellow Goatfish | | 0.27 | |
| <i>Hypoplectrus chlorurus</i> | Yellowtail Hamlet | | 0.24 | |
| <i>Bodianus rufus</i> | Spanish Hogfish | | 0.18 | |
| <i>Flammeo marianus</i> | Longspine Squirrelfish | | 0.12 | |
| <i>Microspathodon chrysurus</i> | Yellowtail Damselfish | | 0.09 | |
| <i>Scarus vetula</i> | Queen Parrotfish | | 0.06 | |
| <i>Haemulon sciurus</i> | Bluestriped Grunt | | 0.03 | |
| <i>Equetus lanceolatus</i> | Jacknife Fish | | 0.03 | |
| <i>Diodon hystrix</i> | Porcupinefish | | 0.03 | |
| <i>Holacanthus ciliaris</i> | Queen Angelfish | | 0.03 | |
| <i>Lutjanus apodus</i> | Schoolmaster Snapper | | 0.03 | |
| <i>Liopropoma rubre</i> | Swissguard Basslet | | 0.03 | |
| <i>Sparisoma atomarium</i> | | | 0.03 | |
| <i>Lachnolaimus maximus</i> | Hogfish | X | X | X |
| <i>Lutjanus analis</i> | Mutton Snapper | X | X | X |
| <i>Lutjanus mahogany</i> | Mahogany Snapper | | X | |
| <i>Epinephelus striatus</i> | Nassau Grouper | X | X | |
| <i>Epinephelus guttatus</i> | Red Hind | | X | X |
| <i>Elagatis bipinnulata</i> | Rainbow Runner | | | X |
| <i>Mycteroperca venenosa</i> | Yellowfin Grouper | X | | X |
| <i>Scarus guacamaia</i> | Rainbow Parrotfish | X | | |
| <i>Sphyaena barracuda</i> | Great Barracuda | X | X | |
| <i>Pterois sp.</i> | Lionfish | X | X | |
| <i>Caranx lugubris</i> | Black Jack | | X | |

| | | | |
|------------------------------------|---------------------|---|---|
| <i>Caranx bartholomaei</i> | Yellow Jack | | X |
| <i>Chromis multilineata</i> | Yellow-edge Chromis | | |
| <i>Coryphopterus glaucofraenum</i> | Bridled Goby | | |
| <i>Haemulon sciurus</i> | Bluestriped Grunt | X | |
| <i>Holacanthus tricolor</i> | Rock Beauty | X | |
| <i>Anisotremus virginicus</i> | Porkfish | X | |
| <i>Malacanthus plumieri</i> | Sand Tilefish | X | |
| <i>Seriola rivoliana</i> | Almaco Jack | X | |
| <i>Scomberomorus regalis</i> | Cero Mackerel | X | |
| <i>Ginglymostoma cirratum</i> | Nurse Shark | X | |
| Invertebrates | | | |
| <i>Panulirus argus</i> | Spiny Lobster | X | X |
| <i>Strombus gigas</i> | Queen Conch | X | X |

| | | | |
|--|--------------|--------------|--------------|
| Mean Abundance (Ind/30 m²) | 23.85 | 42.79 | 21.10 |
|--|--------------|--------------|--------------|

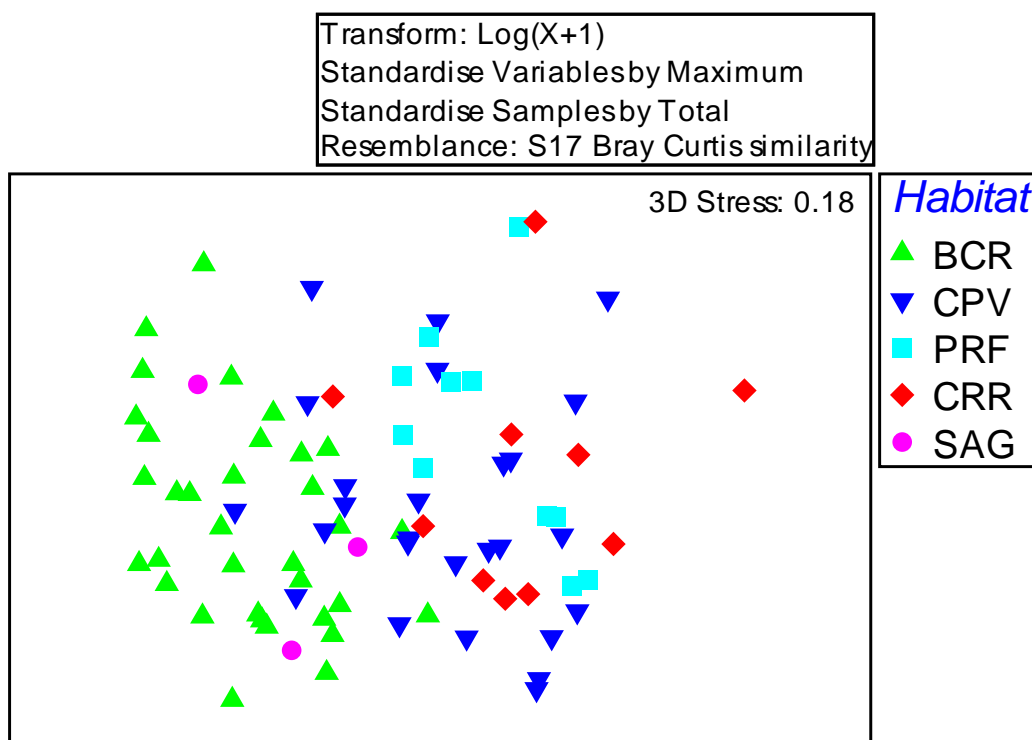


Figure 10. Non-dimensional multi-scaling plot (nMDS) of Bray Curtis similarities of fish community structure at the main benthic habitats of Lang Bank, St. Croix, USVI. 2012-13

A total of 10 spiny lobsters and 13 queen conch individuals were observed at the CPV habitat. Spiny lobsters were mostly observed at the outer shelf-edge ridge associated with small coral heads and aggregated within rocky ledges and crevices. Queen conch were present at the upper section of the insular slope over mostly abiotic substrates at depths within the 30 – 40 m range.

2.2.2 Bank Coral Reef (BCR)

A total of 70 fish species were identified from the BCR habitat at Lang Bank within the 30 – 50 m depth range, including 53 within belt-transects (Table 3). The mean fish density was 42.8 Ind/30 m², the highest among the three main benthic habitats surveyed. The combined abundance of six species represented 72.2 % of the total individuals within transects. The main fish assemblage included (in decreasing rank order of abundance) the masked goby (*Coryphopterus personatus*), blue chromis (*Chromis cyanea*), creole wrasse (*Clepticus parrae*), princess parrotfish (*Scarus taeniopterus*), bicolor damselfish (*Stegastes partitus*) and peppermint goby (*Coryphopterus lipernes*). The masked goby is a small schooling species that was present in small to moderate aggregations of 5 - 50 individuals usually below coral ledges in 12 stations out of the 26 stations surveyed. Likewise, the creole wrasse was also present in aggregations of up to 100 individuals, but was only observed in nine stations within belt-transects at the BCR habitat (Appendix 9). Adult creole wrasses formed streaming aggregations swimming over the reef, whereas juvenile formed combined aggregations with blue chromis within the reef structure. Bluehead and Yellowhead wrasses (*Thalassoma bifasciatum* and *Halichoeres garnoti*) were both present in 23 out of the 26 stations surveyed.

Fish community structure at the BCR was characterized by relatively high within habitat affinity with an average similarity of 31.4 %. Within habitat similarity was strongly influenced by the relatively uniform density of bicolor damselfish, blue chromis, yellowhead wrasse and princess parrotfish across the 26 sampling stations (see Appendix 7). Statistically significant differences (ANOSIM; $p < 0.1$) were found between the relative abundances of the BCR and all other habitats surveyed at Lang Bank, except the SAG (spur and groove), where only a few transects were surveyed (Figure 10). The highest dissimilarity was between the BCR and the CRR (colonized rhodolith reef) at 80.8 %. The fish community at the BCR was more specious than the CRR and

other habitats surveyed at Lang Bank. Thus, the occurrence of these species at the BCR and not at other habitats (e.g. *Hypoplectrus spp.*, *Chaetodon spp.*, *Sparisoma spp.*, *Clepticus parrae*, *Holacanthus spp.*) introduced substantial dissimilarity relative to other habitats. Conversely, the BCR exhibited lower densities and lower relative abundance of species that typically occupy small microhabitats in the CRR and PRF habitats, such as the cherubfish (*Centropyge argi*), bridled goby (*Coryphopterus glaucofraenum*) and the tobacco fish (*Serranus tabacarius*) (see Appendix 7).

Fish species of commercial value at the BCR habitat included the hogfish (*Lachnolaimus maximus*), Mutton and mahogany snappers (*Lutjanus analis*, *L. mahogoni*), lionfish (*Pterois sp.*), Nassau and red hind groupers (*Epinephelus striatus*, *E. guttatus*) and the nurse shark (*Ginglymostoma cirratum*). The latter species appears to be one of the top predators of the BCR habitat. Large pelagic piscivores such as the great barracuda (*Sphyraena barracuda*), Cero Mackerel (*Scomberomorus regalis*) and the almaco jack (*Seriola rivoliana*) were present at the BCR. Adult spiny lobsters (*Panulirus argus*) and queen conch (*Strombus gigas*) were also observed within the 40 – 50 m depth range at the BCR.

2.2.3 Colonized Rhodolith Reef (CRR)

A total of 30 fish species were identified from the CRR habitat, including 22 within belt-transects (Table 2). Mean fish density was 21.1 Ind/30m², the lowest among benthic habitats at Lang Bank. The bicolor damselfish (*Stegastes partitus*) was the numerically dominant species within transects with a mean density of 9.8 Ind/30 m², representative of 46.4 % of the total fish density and was present in all 10 transects. Fish survey data for all transects surveyed at the CRR habitat are included as Appendix 10. The yellowhead and bluehead wrasses and blue chromis were all present in at least five transects and along with the bicolor damselfish comprised the main residential fish assemblage at the CRR. The relatively depauperate fish community at the CRR habitat is related to the virtual absence of protective structures, such as coral reefs, rock outcrops, holes, crevices or ledges.

The CRR provides microhabitats associated with the deposit of crustose algal nodules suited for small fishes, such as bicolor damselfish, cherubfish, and small wrasses and

gobies. Fish community structure tends to increase in CRR habitats in relation to the magnitude of colonization of rhodoliths by hard coral and erect sponges. Higher fish densities and more biodiverse fish communities associated with CRR habitats have been previously reported for Desecheo Island (Garcia-Sais et al., 2005), Bajo de Sico (Garcia-Sais et al., 2007) and Abrir la Sierra (Garcia-Sais et al., 2009), where heavy colonization by corals, sponges and algal growth has been noted. CRR habitats at Lang Bank were observed to be lightly colonized, mostly by fleshy algae and small sponges, with relatively higher substrate cover by abiotic categories, mostly sand.

Fish community structure at the CRR habitat was characterized by low affinity within sampling stations (Figure 10). Average similarity of fish community (26.1 %) was the lowest among benthic habitats studied at Lang Bank. This is different from the pattern previously reported for Desecheo (Des), Bajo de Sico (BDS) and Abrir la Sierra (ALS) (Garcia-Sais et al., 2005, 2007, 2009) where the CRR habitat has been described as one of the most uniform within the mesophotic realm in the 30 – 50 m depth range. At Lang Bank, high variability of the physical habitat was associated with the magnitude of abiotic cover (mostly sand) and colonization by biota contributing topographic relief. Because of the high within station variability, differences of fish community structure with other benthic habitats was only significant relative to the BCR, where the highest cover by corals and lowest cover by abiotic categories was measured. Even though the absolute densities by most of the numerically dominant fish species at the CRR habitat were lower than at the BCR, the relative composition of these species were much higher at the CRR, thereby contributing substantially to between station dissimilarities (see Appendix 7). Important exceptions were the higher absolute densities of cherubfish (*Centropyge argi*), tobacco fish (*Serranus tabacarius*) and blackfin snapper (*Lutjanus buccanella*) at the CRR relative to the BCR. Considering the consistently high prevalence of the cherubfish on CRR habitats from Des, BDS and ALS (Garcia-Sais et al., 2005, 2007, 2009) it can be established that CRR represent a preferred habitat for this species. The tobacco fish tends to hover over mounds of sand and rubble that were more common at the CRR than at the BCR, which may have influenced its higher densities on the former. Occurrence of blackfin snapper at CRR habitats was associated with several rhodolith deposits found down the insular slope at a depth of 50 m. Small schools of this insular slope fish penetrated transect areas rising from deeper sections of the slope, perhaps attracted to diver survey activities.

Several demersal fish species of commercial value were present at the CRR habitat. These included the queen triggerfish (*Balistes vetula*), mutton and blackfin snappers (*Lutjanus analis*, *L. buccanella*), red hind (*Epinephelus guttatus*) and yellowfin grouper (*Mycteroperca venenosa*). Spiny lobsters (*Panulirus argus*) and queen conch (*Strombus gigas*) were observed at the CRR habitat of Lang Bank. An adult, reproductively active queen conch population was reported by Garcia-Sais et al. (2009) from CRR habitats at Abrir La Sierra.

2.3.0 Fishery Independent Surveys

A total of 283 fish individuals distributed into 22 species and 77 shellfish individuals distributed into two species were included in the fishery independent surveys performed at Lang Bank. The total area surveyed was 13, 200 m², including the area covered by the 20 m x 3 m belt-transects and the drift dives performed at each benthic habitat. Surveys at the CPV and BCR habitats represented approximately 78 % of the total area surveyed. The complete list of fish/shellfish species reported per benthic habitat, area surveyed and fish/shellfish size distributions are included as Appendix 11. Only two shellfish species, the spiny lobster (*Panulirus argus*) and the queen conch (*Strombus gigas*), and four species of fish were represented by more than 15 individuals in fishery independent surveys at Lang Bank. Fish species represented by more than 15 individuals included the red hind (*Epinephelus guttatus*), lionfish (*Pterois spp*), mutton snapper (*Lutjanus analis*) and the queen triggerfish (*Balistes vetula*).

Large groupers and snappers were observed in very low numbers at Lang Bank. Only one Nassau and two yellowfin groupers were observed from almost 100 stations surveyed. Cubera and dog snappers (*Lutjanus cyanopterus*, *L. jocu*), previously observed in high densities at El Seco Reef in Vieques and Tourmaline Reef, off Mayaguez (Garcia-Sais et al., 2009, 2011) were rare at Lang Bank. Tiger groupers (*Mycteroperca tigris*), common at El Seco and at BDS (Garcia-Sais et al. 2007, 2009) were not observed at Lang Bank. It is possible that the high availability of protective structures at the BCR may have influenced underestimates of large grouper/snapper densities and sightings, but CPV and CRR habitats at Lang Bank were mostly devoid of such protective structures. The physical habitat of the outer shelf slope and of rhodolith reef deposits within the 30 – 50 m depth range were essentially featureless with respect

to bottom topography and depauperate with regards to biological substrate colonization. The lack of physical and biological complexity at these habitats may limit the occurrence of large demersal fishes because of the virtual absence of prey items and residential structures. Large parrotfishes included two (2) rainbow parrotfishes (*Scarus guacamaia*) observed from the BCR at a depth of 40 m.

Nurse sharks (*Ginglymostoma cirratum*) were the largest top predators observed from mesophotic habitats at Lang Bank, consistent with previous reports for El Seco in Vieques (Garcia-Sais et al., 2010). Nurse sharks were observed from all benthic habitats, but were more common at the BCR. Great barracudas were the only large pelagic reef predator observed to be common from mesophotic habitats at Lang Bank. Also present were low numbers of yellow and bar jacks (*Caranx bartholomaei*, *C. ruber*), blue and rainbow runners (*Carangoides crysos*, *Elagatis bipinnulata*) and almaco jack (*Seriola rivoliana*).

2.3.1 Lionfish (*Pterois* sp.)

The lionfish, an invasive fish of potential commercial value as food was the most abundant fish larger than 25 cm (TL) observed within mesophotic habitats at Lang Bank. It was present in higher densities at the CPV habitat, but was sighted also at the SAG and BCR habitats (Figure 11). Lionfishes were observed solitary, as pairs and aggregated in small schools within crevices, gaps, holes, under ledges and essentially associated with any type of physical structure that could serve as refuge from the prevailing water current at the CPV habitat. Lionfishes occurred within the entire mesophotic depth range studied at Lang Bank, but were more common at the upper insular slope (35 – 40m) close to the shelf-edge and associated with rocky outcrops, crevices and coral heads. Mostly adult individuals were present, with a strong mode at 30 cm, maximum length at 40 cm, and minimum length at 15 cm (Figure 12). Juvenile lionfishes were not observed from any mesophotic habitat. The size-frequency distribution suggests that mostly adult lionfishes inhabit the mesophotic habitats of Lang Bank, but it may also reflect the fact that there has been low recruitment, or recruitment failure during the last couple of years for this species in the eastern St. Croix outer shelf and perhaps elsewhere in the USVI. The present stock appears to be comprised by large adults individuals remaining from a previously successful year class. A progression of lionfish size classes appears to be evident from previous surveys of mesophotic

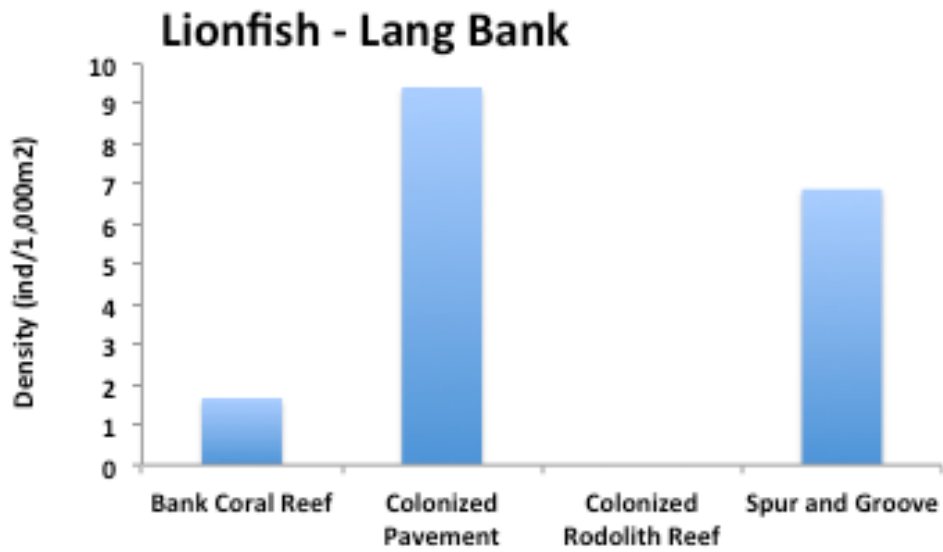


Figure 11. Density distribution of lionfish (*Pterois* sp.) at the various mesophotic benthic habitats surveyed from Lang Bank, St. Croix, USVI. 2012-13

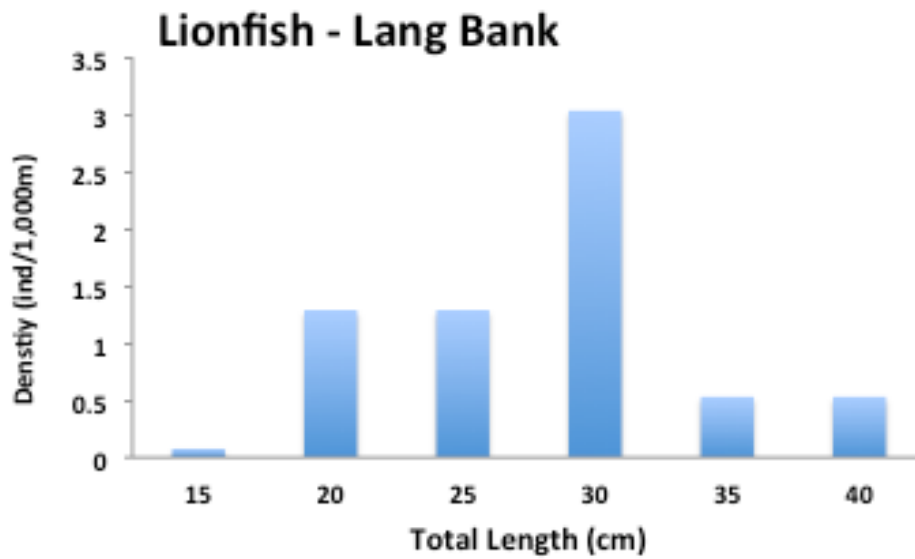


Figure 12. Size frequency distribution of lionfish (*Pterois* sp.) from all mesophotic benthic habitats surveyed at Lang Bank, St. Croix, USVI. 2012-13

habitats at Isla Desecheo (Garcia-Sais et al, 2005), Bajo de Sico (Garcia-Sais et al, 2005) and Abrir la Sierra (Garcia-Sais et al, 2010).

2.3.2 Red hind (*Epinephelus guttatus*)

Red hinds were observed to be part of the residential fish assemblage at the BCR, SAG and CPV mesophotic habitats of Lang Bank, with higher densities surveyed from the BCR (Figure 13). Densities of red hind at Lang Bank are within the range estimated from visual surveys at other mesophotic habitats within the US Caribbean EEZ (Garcia-Sais et al, 2012). The size frequency distribution of red hind was strongly skewed to the larger size classes (Figure 14), suggesting that mostly an adult population was present at mesophotic habitats of Lang Bank. The mode length at 35 cm, stands as the largest among mesophotic habitats previously studied (Garcia-Sais et al, 2012). Maximum size was estimated at 40 cm. Consistent with previous reports of mesophotic habitats, juvenile red hinds in the 10 – 15 cm (TL) size range were observed from the CRR habitat at Lang Bank. It is possible that CRR function as recruitment habitats of red hind.

One day before and during the full moon of February, dives were performed at two different locations where spawning aggregations of red hind had been reported within the SAG coral reef habitat of Lang Bank at depths of 27 – 30 m. At one of these sites, ADCP current meter deployment structures were in place, indicative that this site had been previously monitored, presumably by personnel from the University of the U. S. Virgin Islands. Red hinds were observed from both of these sites, but aggregations were not present. Thus, it is possible that spawning occurred at the previous full moons of December and/or January. The few red hinds observed during February at the SAG habitat were relatively small and appeared to be spent.

2.3.3 Mutton Snapper (*Lutjanus analis*)

Mutton snapper was the most abundant commercially important snapper observed from mesophotic habitats at Lang Bank. Higher densities were surveyed from the BCR, but were present from all benthic habitats studied (Figure 15). Mutton snappers were typically observed in small schools, but large adult solitary specimens were also present. Mutton snapper appeared to be one of the top demersal predators at the CRR habitat,

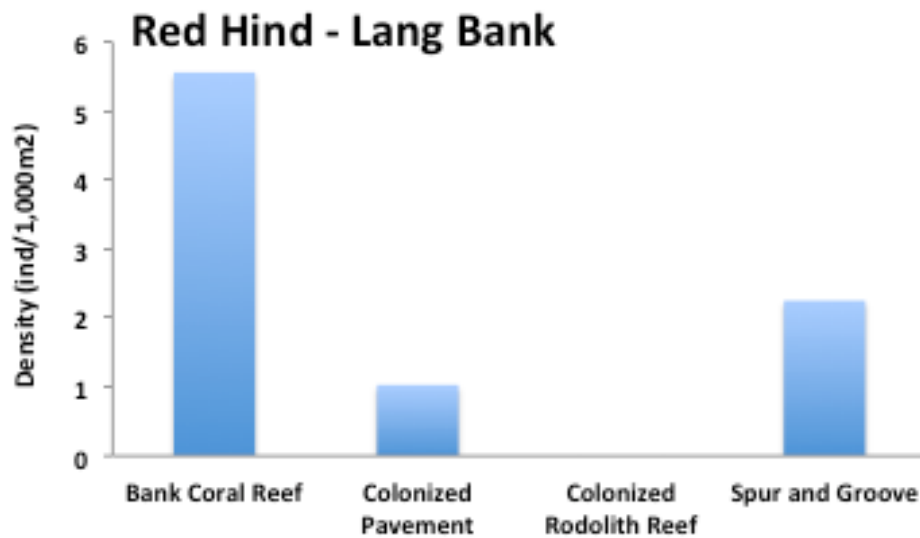


Figure 13. Density distribution of red hind (*Epinephelus guttatus*) at the mesophotic benthic habitats surveyed from Lang Bank, St. Croix, USVI. 2012-13

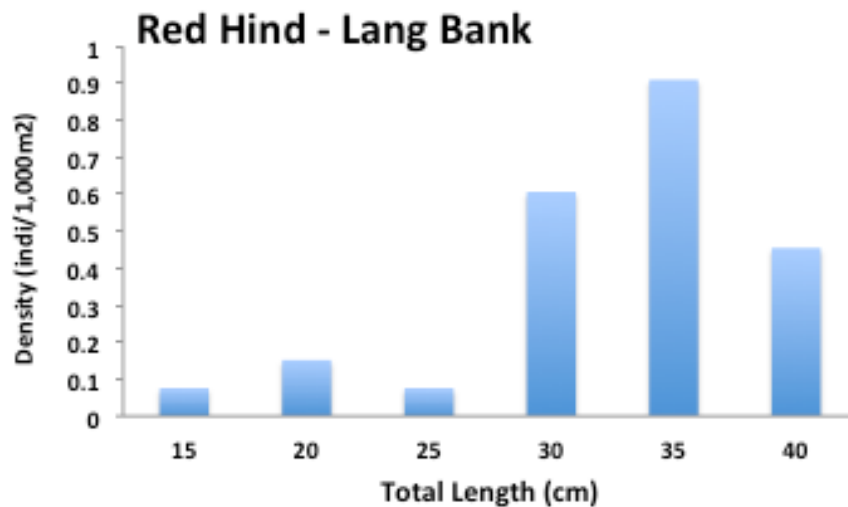


Figure 14. Size frequency distribution of red hind (*Epinephelus guttatus*) from mesophotic habitats surveyed at Lang Bank, St. Croix, USVI. 2012-13

where it may be feeding from small fishes and invertebrates. Compared to other mesophotic habitats surveyed from the US Caribbean EEZ (e.g. Bajo de Sico, Isla Desecheo, Abrir la Sierra, El Seco Reef), densities of mutton snapper at Lang Bank rank as the highest. Healthy mutton snapper populations appear to need direct physical connectivity with coastal-neritic recruitment and nursery habitats. It was present in very low abundance or absent from surveys conducted at oceanic islands, such as Isla Desecheo and Mona, and present at Abrir la Sierra, El Seco and Lang Bank where connectivity with coastal habitats such as seagrass beds and mangroves are available (Garcia-Sais et al, 2012).

The size frequency distribution of mutton snapper from mesophotic habitats at Lang Bank was skewed towards the large, adult size classes (Figure 16). The mode, at 50 cm was well over the length at first reproduction, reported as 41 cm TL (Froese and Pauly, 2005). Juvenile mutton snappers were uncommon from any mesophotic habitat and the minimum size at 30 cm represent specimens that are approaching sexual maturity. Despite being a fish of high commercial value in Puerto Rico, mutton snapper is not regarded as a high value fish in the USVI because it is associated with ciguatera poisoning.

2.3.4 Queen Triggerfish (*Balistes vetula*)

Queen triggerfishes were observed from all mesophotic habitats at Lang Bank, but were observed in higher densities at the CRR (Figure 17). This is consistent with all previous surveys (Garcia-Sais et al., 2012 and references therein) that have established that queen triggerfish is a prominent component of the fish community structure at the CRR habitat, as it occupies one of the top predator roles. Queen triggerfish may be feeding on small benthic invertebrates and small fishes that occupy the small microhabitats present at the CRR. It was observed in lowest densities at the BCR, where it may be outcompeted by larger groupers, snappers and nurse sharks.

The size frequency distribution of queen triggerfish at mesophotic habitats from Lang Bank is indicative that these habitats are largely inhabited by the large adult population. Length at first reproduction of queen triggerfish has been reported at 23 cm (Froese and Pauly, 2005). The size range of queen triggerfish in this survey was from 25 – 50 cm,

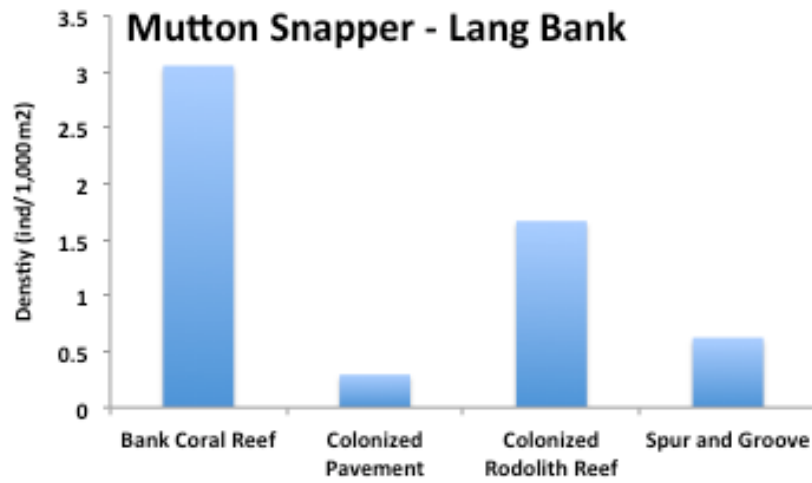


Figure 15. Density distribution of mutton snapper (*Lutjanus analis*) at the mesophotic benthic habitats surveyed from Lang Bank, St. Croix, USVI. 2012-13

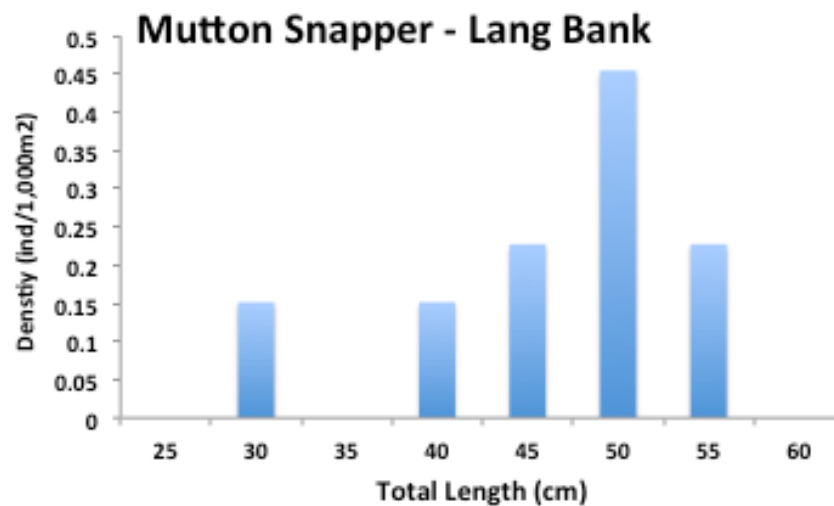


Figure 16. Size frequency distribution of mutton snapper (*Lutjanus analis*) from mesophotic habitats surveyed at Lang Bank, St. Croix, USVI. 2012-13

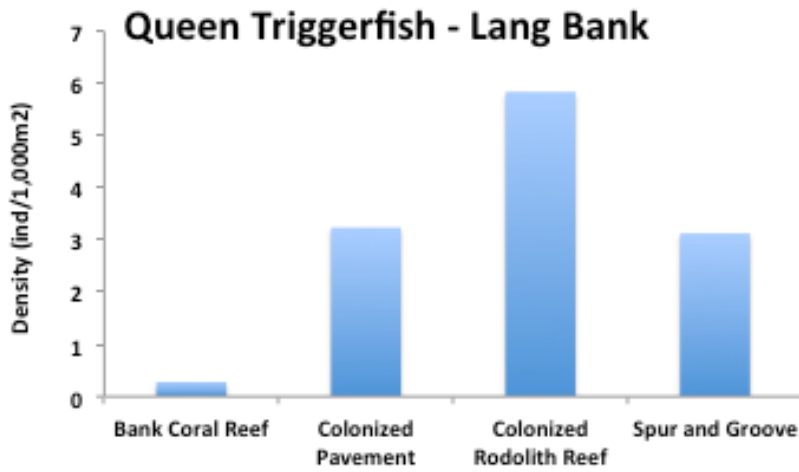


Figure 17. Density distribution of queen triggerfish (*Balistes vetula*) at the mesophotic benthic habitats surveyed from Lang Bank, St. Croix, USVI. 2012-13

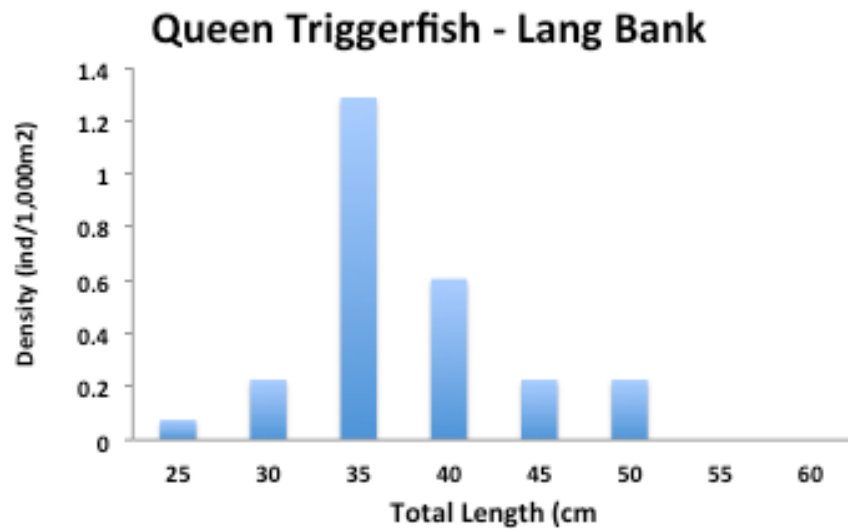


Figure 18. Size frequency distribution of queen triggerfish (*Balistes vetula*) from mesophotic habitats surveyed at Lang Bank, St. Croix, USVI. 2012-13

with a mode at 35 cm (Figure 18). Also, the maximum size reported for this study approached the maximum size reported for queen triggerfish from the Caribbean Antilles at 54 cm (Froese and Pauly, 2005), suggesting that the queen triggerfish population at mesophotic habitats from Lang Bank are not severely overfished.

2.3.5 Queen Conch (*Strombus gigas*)

Queen conch were mostly concentrated on CRR habitats (Figure 19), which have relatively limited distribution within the 30 – 50 m mesophotic depth range in Lang Bank. Few individuals were also sighted in the CPV and SAG benthic habitats. Mean density of queen conch within the CRR habitat at Lang Bank was of approximately 50 Ind/1000m², which is higher than previously reported for CRR habitats at Abrir la Sierra during peak reproductive season (Garcia-Sais et al., 2012). CRR has been shown to be the preferred habitat of queen conch at mesophotic depths within the 30 – 50 m depth range, and there is evidence that a reproductively active population exists at depths of 40 m at Abrir la Sierra (Garcia-Sais et al., 2012). The deep outer shelf basin of Lang Bank has extensive sections deeper than 50 m and these areas were not surveyed. It is possible that if CRR habitats prevail in these deep sections, queen conch may be found there. Otherwise, the low prevalence of queen conch at other mesophotic habitats other than the CRR appear to constrain their population to a habitat with limited geographical extension within the 30 – 50 m depth range in Lang Bank.

The size frequency distribution of queen conch in mesophotic habitats of Lang Bank is skewed towards the (large) adult size ranges, with a minimum size at 21 cm, a strong mode at 25 cm and maximum length at 27 cm (Figure 20). The size range and mode of queen conch at Lang Bank is similar to that reported for the CRR mesophotic habitat of Abrir la Sierra (Garcia-Sais et al., 2012).

2.3.6 Spiny Lobster (*Panulirus argus*)

A total of 31 spiny lobsters were sighted from mesophotic habitats surveyed at Lang Bank. Densities were highest at the SAG habitat (5 Ind/1000m²), but 71 % of the individuals were observed at the CPV habitat (Figure 21). Spiny lobsters were mostly concentrated at the outer shelf-edge ridge at depths of 33 – 38 m associated with coral heads and crevices in a relatively flat pavement colonized by sponges, gorgonians and

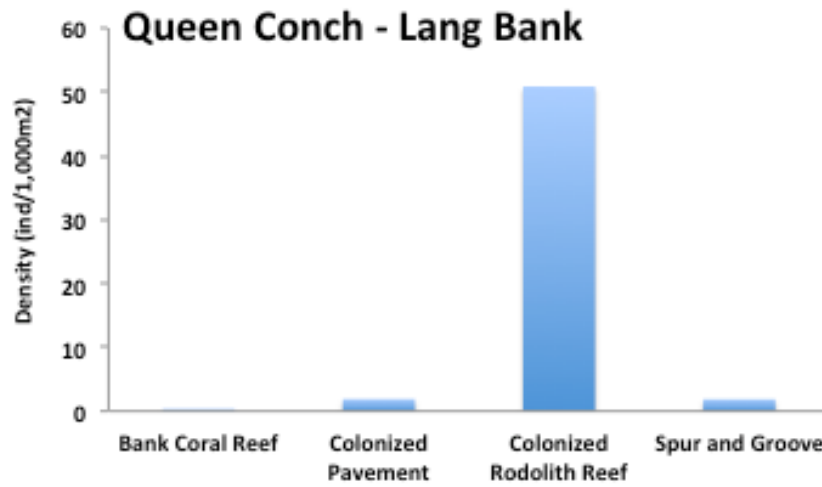


Figure 19. Density distribution of queen conch (*Strombus gigas*) at the mesophotic benthic habitats surveyed from Lang Bank, St. Croix, USVI. 2012-13

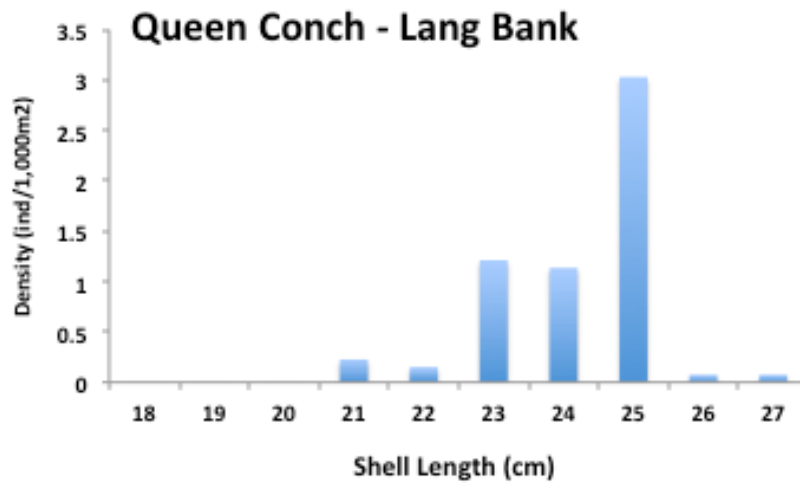


Figure 20. Size frequency distribution of queen conch (*Strombus gigas*) from mesophotic habitats surveyed at Lang Bank, St. Croix, USVI. 2012-13

isolated coral heads. Only a couple of spiny lobsters were present at the CPV of the insular slope at depths below 40m, and none were observed from the CRR. At both of these sites physical protective microhabitats were mostly lacking. Only one spiny lobster was observed at the BCR. It is possible that these were not detected due to their cryptic behavior and the high structural complexity of the BCR system, but high predation pressure by nurse sharks and/or other large predators may be important.

Overall, density of spiny lobsters at Lang Bank was much higher than any other mesophotic reef sites previously studied (Garcia-Sais et al., 2005, 2007, 2010, 2012). Fishing effort at Lang Bank was observed to be relatively low and may be allowing accumulation of spiny lobsters to a higher concentration than at other mesophotic sites with similar benthic habitat types. Only a few dozen fish traps were observed within the entire mesophotic shelf at Lang Bank and diver spear fishermen were not detected. The physical continuity of mesophotic habitats at Lang Bank with nursery habitats of the neritic shelf may be influencing the higher density of adult lobsters compared to other oceanic sites, but more research needs to be addressed to the spiny lobster population dynamics and the role of mesophotic reef habitats in their life cycles.

The size-frequency distribution of spiny lobster from mesophotic habitats of Lang Bank is presented in Figure 22. Mostly large juveniles and adults were present. Cephalothorax length ranged between 16 – 20 cm, with a mode at 18 cm. Several lobster aggregations were detected and mostly comprised by large juveniles and small adults in the 16 – 18 cm size range, whereas solitary specimens were typically adults of moderate and large sizes of up to 20 cm cephalothorax length.

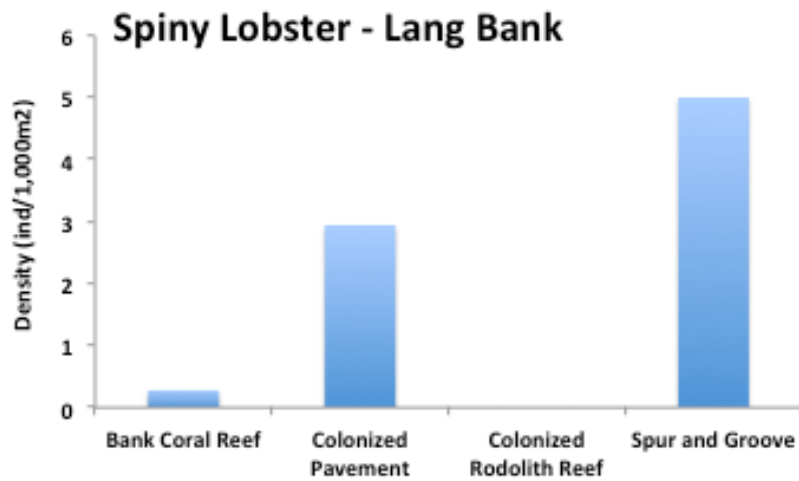


Figure 21. Density distribution of spiny lobster (*Panulirus argus*) at the mesophotic benthic habitats surveyed from Lang Bank, St. Croix, USVI. 2012-13

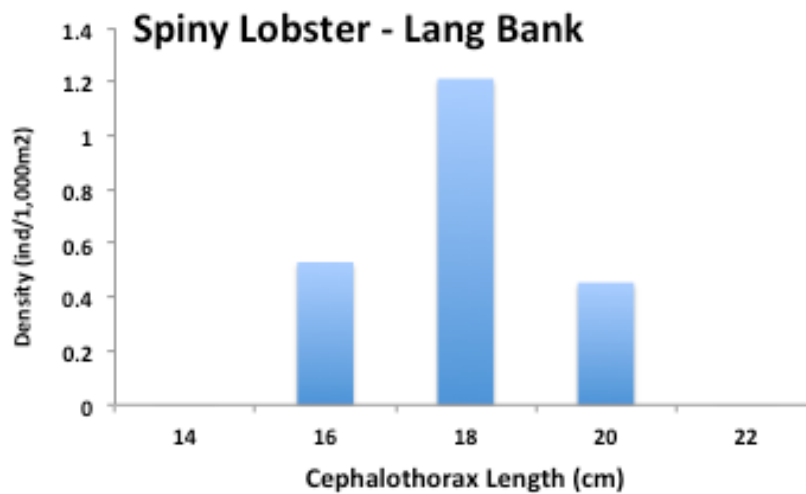


Figure 22. Size frequency distribution of spiny lobster (*Panulirus argus*) from mesophotic habitats surveyed at Lang Bank, St. Croix, USVI. 2012-13

Photo Album 5. Fish and Shellfish Community





VII. Conclusions

Five main benthic habitat types were discovered within the 30 – 50 m depth range at Lang Bank, these include a Bank Coral Reef system (BCR), Colonized Pavement (CPV), Colonized Rhodolith Reef (CRR), Spur and Groove Reef (SAG), and Patch Reef (PRF).

The BCR habitat occupied an estimated area of 1.97 km², or 32 % of the total area surveyed. It is an impressive continuous formation of scleractinian corals, particularly boulder star coral, *Orbicella franksi* growing at depths of 30 m to at least 50 m (100 – 165') throughout the deep outer shelf basin of Lang Bank with an average live coral cover of 29.0 %.

The most extensive habitat surveyed within the 30 – 50 m depth range corresponded to CPV, with a total area of 2.5 km², or 41 % of the total area surveyed. Continuous sections of CPV habitat were found associated with the reef tops of the inner and outer shelf edge, and down the outer shelf insular slope.

The SAG was observed to be largely a neritic habitat that extended just to the shallow margin of the mesophotic realm at a depth of 30 m in some of its deepest sections and thus, not properly addressed by this study. It is the habitat where spawning aggregations of red hind (*Epinephelus guttatus*) had been reported.

PRFs were mostly found near the boundaries of the BCR at the deep basin walls. These were more common at the inner slope of the outer shelf break and covered a total estimated area of 0.57 km², or 9.3 % of the total area surveyed.

CRR habitats were observed mostly down the insular slope of the outer shelf break. A few patches were observed as well near the edges of the deep basin and in small sections of the BCR. The areal extension of CRR habitat was estimated as 0.9 km², or 14.9 % of the surveyed area.

Based on its relatively high composition of live coral cover and high within habitat affinity or similarity, the BCR was statistically different in terms of sessile-benthic community structure to all other mesophotic habitat types at Lang Bank within the 30 – 50 m depth range.

The CPV, PRF and CRR benthic habitats were characterized by relatively low affinity (high variability) on the relative composition of substrate categories within stations. High variability within transects was measured for abiotic cover, live corals and octocorals.

The CPV and CRR habitats were distributed throughout a wide range of depths (30 – 50 m) and slopes, factors that may have influenced benthic community structure.

The sessile-benthic invertebrate community observed from mesophotic habitats at Lang Bank included altogether, a total of 26 spp of hard corals, 10 genera of octocorals, and at least 53 sponge spp. identified.

The reef fish community was comprised by at least 87 spp, distributed into 25 families. The highest densities (42.8 Ind/30 m²) and species richness (70 spp) were surveyed from the BCR.

Fish community structure at the BCR was characterized by relatively high within habitat affinity with an average similarity of 31.4 %. Within habitat similarity was strongly influenced by the relatively uniform density of bicolor damselfish (*Stegastes partitus*), blue chromis (*Chromis cyanea*), yellowhead wrasse (*Halichoeres garnoti*) and princess parrotfish (*Scarus taeniopterus*).

Statistically significant differences were found between the relative abundances of fishes at the BCR and all other habitats surveyed at Lang Bank. The highest dissimilarity resulted between the BCR and the CRR (colonized rhodolith reef) at 80.8 %. The fish community at the BCR was more specious than the CRR and other habitats surveyed at Lang Bank. The higher densities and species richness at the BCR appear to be associated with the higher benthic habitat complexity and rugosity.

Fish community structure at the CPV, PRF, and CRR habitats were characterized by relatively low affinity (high variability) within sampling stations, influenced by the high variability of reef physiographic conditions in terms of depth, topographic relief and slope.

A total of 283 fish individuals distributed into 22 species and 77 shellfish individuals distributed into two species were included in the fishery independent surveys performed at Lang Bank. The total area surveyed was 13, 200 m². Surveys at the CPV and BCR habitats represented approximately 78 % of the total area surveyed.

Large groupers and snappers were observed in very low numbers at Lang Bank. It is possible that the high availability of protective structures at the BCR may have influenced underestimates of large grouper/snapper densities and sightings, but CPV and CRR habitats at Lang Bank were mostly devoid of such protective structures. The lack of physical and biological complexity at these habitats may limit the occurrence of large demersal fishes because of the virtual absence of prey items and residential structures.

Nurse sharks (*Ginglymostoma cirratum*) were the largest top predators observed from mesophotic habitats at Lang Bank. The lionfish (*Pterois sp*), an invasive fish of potential commercial value as food was the most abundant fish larger than 25 cm.

Lionfishes (*Pterois sp*) occurred within the entire mesophotic depth range studied at Lang Bank, but were more common at the upper insular slope (35 – 40m) close to the shelf-edge, and associated with rocky outcrops, crevices and coral heads.

Red hinds were observed to be part of the residential fish assemblage at the BCR, SAG and CPV mesophotic habitats of Lang Bank, with higher densities surveyed from the BCR. Densities of red hind at Lang Bank are within the range estimated from visual surveys at other mesophotic habitats within the US Caribbean EEZ.

Mutton snapper (*Lutjanus analis*) was the most abundant commercially important snapper observed from mesophotic habitats at Lang Bank. Higher densities were surveyed from the BCR, but were present from all benthic habitats studied.

Queen conch (*Strombus gigas*) were observed in very high concentrations (up 50 Ind/1000m²), but mostly concentrated on CRR habitats, which have relatively limited distribution within the 30 – 50 m mesophotic depth range in Lang Bank. The size frequency distribution was strongly skewed towards the larger size classes, indicative

that mesophotic habitats at Lang Bank, particularly the CRR functions as an important habitat for adult queen conch.

Spiny lobsters (*Panulirus argus*) were highly abundant at Lang Bank, particularly at the CPV habitat, where densities of up to 5 Ind/1000m² were surveyed. Spiny lobsters were mostly concentrated at the outer shelf-edge ridge at depths of 33 – 38 m associated with coral heads and crevices in a relatively flat pavement colonized by sponges, gorgonians and isolated coral heads.

VIII. Literature Cited

- Armstrong, R., H. Singh, J. Torres, R. Nemeth, A. Can, C. Roman, R. Justice, L. Riggs, and G. García-Moliner. (2006). Characterizing the deep insular shelf coral reef habitat of the Hind Bank Marine Conservation District (US Virgin Islands) using the SeaBED Autonomous Underwater Vehicle. *Continental Shelf Research* 26: 194-205
- Beets, J. and A. Friedlander. 1997. Evaluation of the spawning aggregation closure for red hind (*Epinephelus guttatus*), St. Thomas, US Virgin Islands. Report to the Caribbean Fishery Management Council, San Juan, P. R., 17 p.
- Colin, P. L. 1974. Observation and collection of deep reef fishes off the coasts of Jamaica and Honduras. *Marine Biology* 24 (1): 29-38
- Colin, P. L. 1976. Observation of deep reef fishes in the Tongue-of-the-Ocean, Bahamas. *Bull. Mar. Sci.* 26: 603-605
- García-Sais, J. R., J. Sabater, R. Esteves and M. Carlo. 2012. Fishery independent survey of commercially exploited fish and shellfish populations from mesophotic reefs within the Puertorrican EEZ. Final Report submitted to the CFMC/NOAA. 88 pp
- García-Sais, JR. 2010. Reef habitats and associated sessile-benthic and fish assemblages across a euphotic-mesophotic depth gradient in Isla Desecheo, Puerto Rico, Coral reefs 29: 277-288.
- García-Sais, J. R., J. Sabater-Clavell, R. Esteves and M. Carlo. 2012. Fishery Independent survey of commercially exploited fish and shellfish populations from mesophotic reefs within the Puertorrican EEZ. Final Report submitted to the CFMC/NOAA. 93 p.
- García-Sais, J. R., J. Sabater-Clavell, R. Esteves, J. Capella and M. Carlo. 2011. Characterization of benthic habitats and associated coral reef communities at El Seco, southeast Vieques, Puerto Rico. Final Report submitted to the CFMC/NOAA. 102 p.
- García-Sais, J. R., R. Castro, J. Sabater, S. Williams and M. Carlo. 2010. Characterization of benthic habitats and associated reef communities at Abrir La Sierra, Puerto Rico. Final Report submitted to the CFMC/NOAA. 115 p.
- García-Sais, J. R., R. Castro, J. Sabater and M. Carlo. 2007. Characterization of benthic habitats and associated reef communities at Bajo de Sico Seamount, Mona Passage, Puerto Rico. Final Report submitted to the CFMC/NOAA. 91 p.

- García-Sais, J. R., R. Castro, J. Sabater and M. Carlo. 2005 b. Inventory and atlas of corals and coral reefs from the U. S. Caribbean EEZ (Puerto Rico and the United States Virgin Islands). Final Report submitted to the CFMC/NOAA. 215 p.
- Menza, C., M. Kendall, C. Rogers, and J. Miller. 2007. A deep reef in deep trouble. *Continental Shelf Research*. 27: 2224-2230.
- Nelson, W. R. and R. S. Appeldoorn. 1985. Cruise Report R/V Seward Johnson. A submersible survey of the continental slope of Puerto Rico and the U. S. Virgin Islands. Report submitted to NOAA, NMFS, SEFC, Mississippi Laboratories. University of Puerto Rico, Department of Marine Sciences. 76 p.
- Nemeth, R. S., T. B. Smith, J. Blondeau, S. Herzlieb, and E. Kadison. 2007. Spatial and temporal patterns of movement and migration at spawning aggregations of red hind, *Epinephelus guttatus*, in the U. S. Virgin Islands. *Environ. Biol. Fishes*, 78: 365-381.
- Nemeth, R. S., T. B. Smith, J. Blondeau, E. Kadison, J. M. Calnan, and J. Gass. 2008. Characterization of deep water reef communities within the Marine Conservation District, St. Thomas, U. S. Virgin Islands. Final Report submitted to the Caribbean Fishery Management Council, (CFMC), San Juan, Puerto Rico.
- Nemeth, R. S., S. Herzlieb, and J. Blondeau. 2006. Comparison of two seasonal closures for protecting red hind spawning aggregations in the U. S. Virgin Islands. *Proc. 10th Int Coral Reef Conf.* 4: 1306-1313
- Nemeth, R. S. 2005. Population characteristics of a recovering US Virgin Islands red hind spawning aggregation following protection. *Mar. Ecol. Progr. Ser.*, 286: 81-97
- Prada, M. 2003. Delineation of benthic habitats from side scan sonar mosaics from the marine conservation district St. Thomas, Lang Bank and mutton snapper closed area in St. Croix, US Virgin Islands. Geophysique GPR International, Inc. Report to the CFMC. San Juan. 19 pp.
- Singh, H., R. Armstrong, F. Gilbes, R. Eustice, C. Roman, O. Pizarro and J. Torres. 2004. Imaging coral I: Imaging coral habitats with the Seabed AUV. *Subsurface Sensing Technologies and Applications*. 5 (1): 25-42
- Smith, T. B., J. Blondeau, R. S. Nemeth, S. J. Pitman, J. M. Calnan, E. Kadison, J. Gass. 2010. Benthic structure and cryptic mortality in a Caribbean mesophotic coral reef bank system, the Hind Bank Marine Conservation District, U.S. Virgin Islands. *Coral Reefs*, 29:
- Tobias, W., Toller, W., Ventura, W. and Rivera, H. 2002. SEAMAP – C USVI. St. Croix fisheries independent trap and line survey. Caribbean/NMFS Cooperative SEAMAP Program. April 1, 2000 – August 31, 2002. NAO7FS0100-1. Division of Fish and Wildlife, Department of Natural Resources, USVI. 12 pp.

IX. Appendices

Appendix 1.

Percent substrate cover by sessile-benthic categories from stations/transects surveyed at the Colonized Pavement Habitat in Lang Bank. 2012-13

| Substrate categories | Spawn 2 | IW48 | IW47 | IW49 | IW50 | DB13-30m | DB13-30m | DB18 | DB15 | 844 | OW77 |
|----------------------|--------------|--------------|--------------|--------------|--------------|--------------|------------|--------------|--------------|--------------|-------------|
| Abiotic | | | | | | | | | | | |
| Sand | 18.22 | 32.57 | 24.29 | 48.72 | 13.64 | 13.73 | 3.45 | 32.89 | 14.23 | 4.88 | 43.87 |
| Pavement | | | 1.5 | | 11.54 | | 3.48 | | 13.52 | 5.78 | 0.4 |
| Rubble | 0.89 | 3.43 | 0.5 | 7.42 | 1.28 | | 0.9 | 6.67 | 0.44 | 0.89 | 2.43 |
| Dead coral | | 1.15 | | 0.11 | 0.33 | | | 1.79 | 0.55 | | |
| Total abiotic | 19.11 | 37.15 | 26.29 | 56.25 | 26.81 | 13.73 | 7.9 | 41.34 | 28.74 | 11.55 | 46.7 |

Rhodolith 7.22

Benthic algae

| | | | | | | | | | | | |
|----------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <i>Lobophora</i> spp. | 64 | 21.71 | 43.51 | 2.24 | 47.41 | 55.29 | 65.05 | 45.78 | 42.59 | 57.25 | 3.85 |
| Turf | 1.78 | 7.43 | 1.5 | 0.67 | 1.2 | 5.58 | 4.57 | 2.22 | 2.67 | 6.22 | |
| Macroalgae | 1.33 | 19.43 | 8.6 | 8.67 | 2.2 | 3.56 | | 4 | 0.44 | 0.44 | 4.8 |
| <i>Dictyota</i> spp. | | 1.14 | 7.58 | 5.42 | 1.52 | | 0.57 | 0.44 | | 0.44 | 1.2 |
| Crustose coralline algae | 1.78 | | 1 | | | 1.56 | 0.57 | | 0.89 | 0.44 | |
| <i>Halimeda</i> spp. | | 1.71 | 0.5 | 0.67 | 0.5 | | | | | | |
| <i>Styopodium</i> spp. | | | | | | | | | | | |
| Total benthic algae | 68.89 | 51.42 | 62.69 | 35.67 | 52.47 | 65.99 | 70.76 | 52.44 | 46.59 | 64.79 | 36.85 |

| | | | | | | | | | | | |
|----------------------|------|------|-----|------|-----|---|------|------|------|------|-----|
| Cyanobacteria | 0.89 | 3.43 | 1.5 | 2.69 | 3.2 | 1 | 2.29 | 0.44 | 1.35 | 1.35 | 1.2 |
|----------------------|------|------|-----|------|-----|---|------|------|------|------|-----|

Hard corals

| | | | | | | | | | | | |
|------------------------------|------|------|-----|--|------|------|------|------|------|------|-----|
| <i>Orbicella franksi</i> | 1.33 | | 1.5 | | | 4.54 | 3.43 | | 4.19 | 2.22 | |
| <i>Porites astreoides</i> | | | | | 0.5 | 1.53 | 0.57 | 0.44 | 2.74 | | 0.4 |
| <i>Siderastrea siderea</i> | 0.44 | 0.57 | | | | 1.5 | | 0.44 | 0.89 | 1.35 | |
| <i>Montastraea cavernosa</i> | 0.89 | | | | 0.53 | | | 0.44 | 0.44 | 0.44 | |
| <i>Agaricia lamarcki</i> | | | | | | | 0.6 | | | | |
| <i>Madracis decactis</i> | | | | | 1.28 | | | | 1.33 | 0.44 | |
| <i>Agaricia grahamae</i> | 0.44 | 1.14 | | | | 0.5 | 0.57 | | | | |
| <i>Millepora alcicornis</i> | | | 0.5 | | | | | 0.89 | | | |
| <i>Diploria strigosa</i> | | | | | | 0.5 | | | | 0.89 | |
| <i>Meandrina meandrites</i> | | | | | | | | | | 0.44 | |

| | | | | | | | | | | | |
|-------------------------------|------|------|-----|------|------|------|------|------|------|------|------|
| Agaricia agaricites | | | | | | | | | | 0.44 | |
| Coral spp. | 0.44 | 0.57 | | | | | | | | | |
| Diploria labyrinthiformis | | | | | | | | | | 0.89 | |
| Eusmilia strigosa | | | | | | | | | | | |
| Mycetophyllia aliciae | | | | | | | | 0.46 | | | |
| Manicina areolata | | | | | | | | | | | |
| Stephanocoenia intersepta | | | | | | | | | | | |
| Total hard coral | 3.56 | 2.29 | 2 | | 2.42 | 8.56 | 5.17 | 2.22 | 9.85 | 7.13 | 0.4 |
| Octocoral | | | | | | | | | | | |
| Eunicea spp. | 0.44 | | | 1.36 | 3.42 | 1.53 | 3.48 | | 2.26 | 0.44 | |
| Pseudoplexaura spp. | | | | | 2.28 | 1.5 | | | 1.78 | 2.28 | |
| Plexaura spp. | 0.89 | 1.14 | | 1.36 | 0.5 | 0.54 | | | | | |
| Antillogorgia spp. | | | | | 0.5 | | | | | | |
| Erythropodium caribaeorum | 0.44 | | 1 | | | 0.54 | | | 0.44 | | |
| Pterogorgia spp. | | | | | 0.5 | | | | | | |
| Plexaurella spp. | 0.44 | | | | | | | | | | |
| Muriceopsis spp. | | | 0.5 | | 0.53 | | | | | | |
| Gorgonian spp. | | | | 0.67 | | | | | | | |
| Total octocoral | 2.22 | 1.14 | 1.5 | 3.39 | 7.83 | 4.18 | 3.48 | | 4.48 | 2.72 | |
| Sponge | | | | | | | | | | | |
| Xestospongia muta | 0.89 | 1.14 | | | 1.5 | 0.5 | 1.71 | 0.89 | | 2.22 | 2.42 |
| Unknown sponge | 0.89 | 0.57 | 0.5 | 1.33 | 2 | 3.16 | 1.14 | 0.44 | 1.81 | | 0.8 |
| Agelas conifera | | | | | | | 2.95 | | 0.46 | 2.67 | |
| Aplysina cauliformis | 0.44 | | | | 1 | | | | | 1.33 | |
| Prosuberites laughlini | | 0.57 | | 0.67 | | | | | | | 0.4 |
| Geodia neptuni | | | | | | 0.5 | 1.14 | 0.44 | | 0.46 | |
| Aplysina fistularis | | | | | 1 | 0.5 | | | | 0.44 | 2.17 |
| Cinachyrella kuekenthali | 1.33 | 0.57 | | | | | | | | | 0.4 |
| Niphates digitalis | | 0.57 | | | | 1.5 | | | | | |
| Plakortis halichondrioides | | | | | 0.5 | | | | 1.8 | 1.33 | 0.4 |
| Spriastrella coccinea | | | | | 1.28 | | | | | | |
| Plakortis angulospiculatus | | | 1 | | | | 1.76 | | 0.44 | | |
| Hyrtios cavernosus | | | | | | | | | | | 0.4 |
| Verongula rigida | | | 2.5 | | | | | | | | |
| Agelas clathrodes | 1.33 | | | | | | | | 0.44 | 0.44 | |
| Svenzea zeai | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---------------------------------|-------------|-------------|-------------|----------|-------------|-------------|--------------|-------------|-------------|--------------|-------------|--|
| <i>Smenospongia conulosa</i> | 0.44 | | | | 0.53 | | | | | | | |
| <i>Spheciospongia vesparium</i> | | | | | | | | | 0.89 | 0.89 | | |
| <i>Agelas citrina</i> | | | | | | | | | | 0.89 | | |
| <i>Aiolochoira crassa</i> | | | | | | | 0.57 | | 0.46 | | | |
| <i>Aplysina archeri</i> | | | 1 | | 0.53 | | | | 0.44 | | | |
| <i>Neopetrosia proxima</i> | | | | | 0.53 | | | | | 0.89 | | |
| <i>Ircinia strobilina</i> | | 0.57 | | | | | | 0.44 | 0.89 | | | |
| <i>Cliona caribbaea</i> | | | | | | 0.5 | | 1.33 | | | | |
| <i>Amphimedon compressa</i> | | | | | | | | | | 0.44 | | |
| <i>Scopalina ruetzleri</i> | | | | | | | | | | | | |
| <i>Agelas tubulata</i> | | | 0.5 | | | | | | | | 0.8 | |
| <i>Ectoplasia ferox</i> | | | | | | | | | | | | |
| <i>Plaktoris</i> spp. | | | 0.53 | | | | 0.57 | | | | | |
| <i>Aplysina insularis</i> | | | | | | | | | | | | |
| <i>Cliona delitrix</i> | | | | | | | | | 0.44 | | | |
| <i>Ircinia felix</i> | | | | | | | | | 0.44 | | | |
| <i>Verongula gigantea</i> | | | | | | | | | | | | |
| <i>Ircinia</i> spp. brown | | | | | | | | | | | | |
| <i>Aplysina lacunosa</i> | | | | | | | 0.57 | | | | | |
| <i>Cribrochalina vasculum</i> | | 0.57 | | | | | | | | | | |
| <i>Callyspongia armigera</i> | | | | | | | | | 0.44 | | | |
| <i>Clathria schoenus</i> | | | | | | | | | | 0.44 | | |
| <i>Myrmekioderma gyroderma</i> | | | | | | | | | | | | |
| Black unknown sponge | | | | | | | | | | | | |
| <i>Niphates erecta</i> | | | | | | | | | | | | |
| <i>Petrosia pellasarca</i> | | | | | | | | | | | | |
| Total sponges | 5.33 | 4.57 | 6.03 | 2 | 8.87 | 6.66 | 10.42 | 3.56 | 8.98 | 12.46 | 7.78 | |

| | | | | | | | | | | | | |
|----------------------|----------------------|------------|--|------------|--|------------|-------------|--|------------|--|------------|-------------|
| Abiotic | | | | | | | | | | | | |
| | Sand | 0.5 | | 0.8 | | 2.4 | 7.27 | | 0.4 | | 3.5 | 6.67 |
| | Pavement | | | | | | | | | | | |
| | Rubble | | | | | | | | | | | 0.44 |
| | Dead coral | | | | | | | | | | | |
| | Total abiotic | 0.5 | | 0.8 | | 2.4 | 7.27 | | 0.4 | | 3.5 | 7.11 |
| | Rhodolith | | | | | 0.8 | | | | | | 1.33 |
| Benthic algae | | | | | | | | | | | | |

| | | | | | | | | | | | |
|----------------------------|-------------|--------------|-------------|-----------|-------------|--------------|-------------|-------------|-----------|-----------|--------------|
| <i>Lobophora</i> spp. | 63 | 75.1 1 | 12 | 24 | 32.8 | 5.55 | 56 | 7 | 58.67 | 48.5 | 1.22 |
| Turf | 5 | 14.6 7 | 7.4 | 71 | 54 | 32.3 6 | 31.6 | 18 | 27.33 | 42.5 | 65.33 |
| Macroalgae | | | | | | 0.73 | | 0.4 | | | |
| <i>Dictyota</i> spp. | | | | | | | | | | 0.5 | |
| Crustose coralline algae | 3.5 | | | | | 0.73 | | | | 0.5 | |
| <i>Halimeda</i> spp. | | | | | | | | | | | |
| <i>Styopodium</i> spp. | | | | | | 0.36 | | | | | |
| Total benthic algae | 71.5 | 89.78 | 82.4 | 95 | 86.8 | 84.73 | 87.6 | 88.4 | 86 | 92 | 75.56 |

Cyanobacteria

Hard corals

| | | | | | | | | | | | |
|----------------------------------|-------------|-------------|----------|------------|------------|--|------------|------------|-------------|------------|-------------|
| <i>Orbicella franksi</i> | 14.5 | 0.44 | 3.2 | | | | | 0.8 | | | |
| <i>Porites astreoides</i> | | | 1.2 | | | | | | | | 0.89 |
| <i>Siderastrea siderea</i> | | | 0.4 | | | | 0.8 | | | | 1.33 |
| <i>Montastraea cavernosa</i> | 1 | | | | 0.4 | | | | | 0.5 | |
| <i>Agaricia lamarcki</i> | 3.5 | | | 0.5 | | | 0.8 | | | | |
| <i>Madracis decactis</i> | | 0.44 | | | | | | | | | |
| <i>Agaricia grahamae</i> | 0.5 | | | | | | | | | | |
| <i>Millepora alcicornis</i> | | | 0.8 | | | | | 0.4 | | | 0.44 |
| <i>Diploria strigosa</i> | | | | | | | 0.8 | | | | |
| <i>Meandrina meandrites</i> | | | | | | | | | | | 1.33 |
| <i>Agaricia agaricites</i> | | 0.44 | | | | | | | | | 0.89 |
| Coral spp. | | | | | | | | | | | |
| <i>Diploria labyrinthiformis</i> | | | | | | | | | | | |
| <i>Eusmilia strigosa</i> | | | 0.4 | | | | | | 0.33 | | |
| <i>Mycetophyllia aliciae</i> | | | | | | | | | | | |
| <i>Manicina areolata</i> | | | | | | | | | | | 0.44 |
| <i>Stephanocoenia intersepta</i> | | | | | 0.4 | | | | | | |
| Total hard coral | 19.5 | 1.33 | 6 | 0.5 | 0.8 | | 2.4 | 1.2 | 0.33 | 0.5 | 5.33 |

Octocoral

| | | | | | | | | | | | |
|----------------------------------|--|--|-----|-----|-----|------|-----|-----|------|-----|------|
| <i>Eunicea</i> spp. | | | 0.4 | | | 1.45 | 3.6 | 0.8 | 3.33 | 0.5 | 0.44 |
| <i>Pseudoplexaura</i> spp. | | | 0.8 | | | | | 0.4 | 1 | | 0.89 |
| <i>Plexaura</i> spp. | | | 0.4 | 0.5 | 0.8 | | | | | | 0.89 |
| <i>Antillogorgia</i> spp. | | | | | | | | | | | 0.44 |
| <i>Erythropodium caribaeorum</i> | | | | | | | | | | | |

| | | | | | | | | | |
|-----------------------------------|----------|------------|------------|-------------|----------|------------|----------|----------|-------------|
| <i>Pterogorgia</i> spp. | | | | 0.4 | | | 0.67 | | 0.44 |
| <i>Plexaurella</i> spp. | | | | | | | | 0.5 | |
| <i>Muriceopsis</i> spp. | | 0.4 | | | | | | | |
| <i>Gorgonian</i> spp. | | | | | 0.4 | | | | |
| Total octocoral | 2 | 0.5 | 1.2 | 1.45 | 4 | 1.2 | 5 | 1 | 3.11 |
| Sponge | | | | | | | | | |
| <i>Xestospongia muta</i> | 4 | 1.6 | 1 | 2.4 | 1.45 | | 0.4 | 2.33 | 0.5 |
| Unknown sponge | 0.89 | 1.6 | | 2 | 1.45 | 0.8 | 4.4 | 0.33 | |
| <i>Agelas conifera</i> | 1.33 | 0.8 | | 0.8 | 0.36 | 0.8 | 0.4 | | |
| <i>Aplysina cauliformis</i> | | 0.4 | 1 | 0.4 | | 0.4 | 0.4 | 0.67 | 0.89 |
| <i>Prosuberites laughlini</i> | | 0.4 | | | | 1.2 | 0.4 | 3.33 | 1 |
| <i>Geodia neptuni</i> | 2 | 0.4 | | 0.4 | 0.36 | 0.8 | | | |
| <i>Aplysina fistularis</i> | 0.89 | | 1 | 0.8 | | | | 0.67 | 0.44 |
| <i>Cinachyrella kuekenthali</i> | 1.33 | | | | | 0.4 | 0.8 | | |
| <i>Niphates digitalis</i> | | 0.4 | 1 | | 0.36 | | 0.4 | | 0.44 |
| <i>Plakortis halichondrioides</i> | | 0.4 | | | | | | | |
| <i>Spirastrella coccinea</i> | | | | 0.4 | | | | 0.67 | 0.5 |
| <i>Plakortis angulospiculatus</i> | | | | | | | 0.4 | | 0.44 |
| <i>Hyrtios cavernosus</i> | 2 | | | | | | | 0.67 | |
| <i>Verongula rigida</i> | | 0.8 | | | | | | | |
| <i>Agelas clathrodes</i> | 0.5 | | | | | | | | 0.44 |
| <i>Svenzea zeai</i> | 2 | 0.4 | | | 0.73 | | | | |
| <i>Smenospongia conulosa</i> | 0.5 | | | | | | 0.8 | | |
| <i>Spheciospongia vesparium</i> | | | | | | | 0.4 | | |
| <i>Agelas citrina</i> | 0.5 | 0.8 | | | 0.36 | | | | |
| <i>Aiolochoira crassa</i> | 0.5 | | | | | | | | 0.44 |
| <i>Aplysina archeri</i> | | | | | | | | | |
| <i>Neopetrosia proxima</i> | 0.5 | | | | | | | | |
| <i>Ircinia strobilina</i> | | | | | | | | | |
| <i>Cliona caribbaea</i> | | | | | | | | | |
| <i>Amphimedon compressa</i> | | 0.4 | | 0.4 | | | | | 0.44 |
| <i>Scopalina ruetzleri</i> | | | | | | | | | |
| <i>Agelas tubulata</i> | | | | | | | | | |
| <i>Ectoplasia ferox</i> | | | | | | 1.2 | | | |
| <i>Plaktoris</i> spp. | | | | | | | | | |
| <i>Aplysina insularis</i> | | | | | | | | 1 | |
| <i>Cliona delitrix</i> | | 0.4 | | | | | | | |
| <i>Ircinia felix</i> | | | | | 0.36 | | | | |
| <i>Verongula gigantea</i> | | | | 0.4 | | | | | |
| <i>Ircinia</i> spp. brown | | | | | 0.73 | | | | |
| <i>Aplysina lacunosa</i> | | | | | | | | | |

| | | | | | | | | | | | |
|--------------------------------|-----------------|------------------|-------------|------------------|------------------|------------------|------------------|------------------|------------------|-------------|--------------|
| <i>Cribrochalina vasculum</i> | | | | | | | | | | | |
| <i>Callyspongia armigera</i> | | | | | | | | | | | |
| <i>Clathria schoenus</i> | | | | | | | | | | | |
| <i>Myrmekioderma gyroderma</i> | | 0.44 | | | | | | | | | |
| Black unknown sponge | | | | | | | | | | | |
| <i>Niphates erecta</i> | | | | | | | | 0.4 | | | |
| <i>Petrosia pellasarca</i> | | | | | | 0.36 | | | | | |
| Total sponges | 8.5 | 8.89 | 8.8 | 4 | 8 | 6.55 | 6 | 8.8 | 8.67 | 3 | 7.56 |
| Substrate categories | DB 4 | OW 51 | OW52 | OW5 3 | OW5 4 | OW5 6 | OW5 7 | OW5 9 | OW6 0 | OW63 | OW55 |
| Abiotic | | | | | | | | | | | |
| Sand | 0.5 | | 0.8 | | 2.4 | 7.27 | | 0.4 | | 3.5 | 6.67 |
| Pavement | | | | | | | | | | | |
| Rubble | | | | | | | | | | | 0.44 |
| Dead coral | | | | | | | | | | | |
| Total abiotic | 0.5 | | 0.8 | | 2.4 | 7.27 | | 0.4 | | 3.5 | 7.11 |
| Rhodolith | | | | | 0.8 | | | | | | 1.33 |
| Benthic algae | | | | | | | | | | | |
| <i>Lobophora</i> spp. | 63 | 75.1 1 | 12 | 24 | 32.8 | 5.55 | 56 | 7 | 58.67 | 48.5 | 1.22 |
| Turf | 5 | 14.6 7 | 7.4 | 71 | 54 | 32.3 6 | 31.6 | 18 | 27.33 | 42.5 | 65.33 |
| Macroalgae | | | | | | 0.73 | | 0.4 | | | |
| <i>Dictyota</i> spp. | | | | | | | | | | 0.5 | |
| Crustose coralline algae | 3.5 | | | | | 0.73 | | | | 0.5 | |
| <i>Halimeda</i> spp. | | | | | | | | | | | |
| <i>Stypopodium</i> spp. | | | | | | 0.36 | | | | | |
| Total benthic algae | 71.5 | 89.78 | 82.4 | 95 | 86.8 | 84.73 | 87.6 | 88.4 | 86 | 92 | 75.56 |
| Cyanobacteria | | | | | | | | | | | |
| Hard corals | | | | | | | | | | | |
| <i>Orbicella franksi</i> | 14.5 | 0.44 | 3.2 | | | | | 0.8 | | | |
| <i>Porites astreoides</i> | | | 1.2 | | | | | | | | 0.89 |
| <i>Siderastrea siderea</i> | | | 0.4 | | | | 0.8 | | | | 1.33 |
| <i>Montastraea cavernosa</i> | 1 | | | | 0.4 | | | | | 0.5 | |
| <i>Agaricia lamarcki</i> | 3.5 | | | 0.5 | | | 0.8 | | | | |
| <i>Madracis decactis</i> | | 0.44 | | | | | | | | | |
| <i>Agaricia grahamae</i> | 0.5 | | | | | | | | | | |

| | | | | | | | | | | |
|----------------------------------|------|------|-----|-----|-----|-----|-----|------|-----|------|
| <i>Millepora alcicornis</i> | | | 0.8 | | | | 0.4 | | | 0.44 |
| <i>Diploria strigosa</i> | | | | | | 0.8 | | | | |
| <i>Meandrina meandrites</i> | | | | | | | | | | 1.33 |
| <i>Agaricia agaricites</i> | 0.44 | | | | | | | | | 0.89 |
| Coral spp. | | | | | | | | | | |
| <i>Diploria labyrinthiformis</i> | | | | | | | | | | |
| <i>Eusmilia strigosa</i> | | | 0.4 | | | | | 0.33 | | |
| <i>Mycetophyllia aliciae</i> | | | | | | | | | | |
| <i>Manicina areolata</i> | | | | | | | | | | 0.44 |
| <i>Stephanocoenia intersepta</i> | | | | | 0.4 | | | | | |
| Total hard coral | 19.5 | 1.33 | 6 | 0.5 | 0.8 | 2.4 | 1.2 | 0.33 | 0.5 | 5.33 |

Octocoral

| | | | | | | | | | | | |
|----------------------------------|--|--|----------|------------|------------|-------------|----------|------------|----------|----------|-------------|
| <i>Eunicea</i> spp. | | | 0.4 | | | 1.45 | 3.6 | 0.8 | 3.33 | 0.5 | 0.44 |
| <i>Pseudoplexaura</i> spp. | | | 0.8 | | | | | 0.4 | 1 | | 0.89 |
| <i>Plexaura</i> spp. | | | 0.4 | 0.5 | 0.8 | | | | | | 0.89 |
| <i>Antillogorgia</i> spp. | | | | | | | | | | | 0.44 |
| <i>Erythropodium caribaeorum</i> | | | | | | | | | | | |
| <i>Pterogorgia</i> spp. | | | | | 0.4 | | | | 0.67 | | 0.44 |
| <i>Plexaurella</i> spp. | | | | | | | | | | 0.5 | |
| <i>Muriceopsis</i> spp. | | | 0.4 | | | | | | | | |
| <i>Gorgonian</i> spp. | | | | | | | 0.4 | | | | |
| Total octocoral | | | 2 | 0.5 | 1.2 | 1.45 | 4 | 1.2 | 5 | 1 | 3.11 |

Sponge

| | | | | | | | | | | |
|-----------------------------------|------|-----|---|-----|------|-----|-----|------|-----|------|
| <i>Xestospongia muta</i> | 4 | 1.6 | 1 | 2.4 | 1.45 | | 0.4 | 2.33 | 0.5 | 2.67 |
| Unknown sponge | 0.89 | 1.6 | | 2 | 1.45 | 0.8 | 4.4 | 0.33 | | |
| <i>Agelas conifera</i> | 1.33 | 0.8 | | 0.8 | 0.36 | 0.8 | 0.4 | | | |
| <i>Aplysina cauliformis</i> | | 0.4 | 1 | 0.4 | | 0.4 | 0.4 | 0.67 | | 0.89 |
| <i>Prosuberites laughlini</i> | | 0.4 | | | | 1.2 | 0.4 | 3.33 | 1 | 0.44 |
| <i>Geodia neptuni</i> | 2 | 0.4 | | 0.4 | 0.36 | 0.8 | | | | |
| <i>Aplysina fistularis</i> | 0.89 | | 1 | 0.8 | | | | 0.67 | | 0.44 |
| <i>Cinachyrella kuekenthali</i> | 1.33 | | | | | 0.4 | 0.8 | | | |
| <i>Niphates digitalis</i> | | 0.4 | 1 | | 0.36 | | 0.4 | | | 0.44 |
| <i>Plakortis halichondrioides</i> | | 0.4 | | | | | | | | |
| <i>Spriastrella coccinea</i> | | | | 0.4 | | | | 0.67 | 0.5 | 0.89 |
| <i>Plakortis angulospiculatus</i> | | | | | | | 0.4 | | | 0.44 |
| <i>Hyrtilos cavernosus</i> | 2 | | | | | | | 0.67 | | |

| | | | | | | | | | | | |
|---------------------------------|------------|-------------|------------|----------|----------|-------------|----------|------------|-------------|----------|-------------|
| <i>Verongula rigida</i> | | 0.8 | | | | | | | | | |
| <i>Agelas clathrodes</i> | 0.5 | | | | | | | | | | 0.44 |
| <i>Svenzea zeai</i> | 2 | 0.4 | | | 0.73 | | | | | | |
| <i>Smenospongia conulosa</i> | 0.5 | | | | | | | 0.8 | | | |
| <i>Spheciospongia vesparium</i> | | | | | | | | 0.4 | | | |
| <i>Agelas citrina</i> | 0.5 | 0.8 | | | 0.36 | | | | | | |
| <i>Aiolochoira crassa</i> | 0.5 | | | | | | | | | | 0.44 |
| <i>Aplysina archeri</i> | | | | | | | | | | | |
| <i>Neopetrosia proxima</i> | 0.5 | | | | | | | | | | |
| <i>Ircinia strobilina</i> | | | | | | | | | | | |
| <i>Cliona caribbaea</i> | | | | | | | | | | | |
| <i>Amphimedon compressa</i> | | 0.4 | | 0.4 | | | | | | | 0.44 |
| <i>Scopalina ruetzleri</i> | | | | | | | | | | | |
| <i>Agelas tubulata</i> | | | | | | | | | | | |
| <i>Ectoplasia ferox</i> | | | | | | | 1.2 | | | | |
| <i>Plaktoris</i> spp. | | | | | | | | | | | |
| <i>Aplysina insularis</i> | | | | | | | | | | 1 | |
| <i>Cliona delitrix</i> | | 0.4 | | | | | | | | | |
| <i>Ircinia felix</i> | | | | | 0.36 | | | | | | |
| <i>Verongula gigantea</i> | | | | 0.4 | | | | | | | |
| <i>Ircinia</i> spp. brown | | | | | 0.73 | | | | | | |
| <i>Aplysina lacunosa</i> | | | | | | | | | | | |
| <i>Cribrochalina vasculum</i> | | | | | | | | | | | |
| <i>Callyspongia armigera</i> | | | | | | | | | | | |
| <i>Clathria schoenus</i> | | | | | | | | | | | |
| <i>Myrmekioderma gyroderma</i> | | 0.44 | | | | | | | | | |
| Black unknown sponge | | | | | | | | | | | |
| <i>Niphates erecta</i> | | | | | | | 0.4 | | | | |
| <i>Petrosia pellasarca</i> | | | | | 0.36 | | | | | | |
| Total sponges | 8.5 | 8.89 | 8.8 | 4 | 8 | 6.55 | 6 | 8.8 | 8.67 | 3 | 7.56 |

| Substrate categories | OW58 | OW61 | OW64 | OW67 | Mean |
|----------------------------------|-------------|-------------|-------------|-------------|---------------|
| Abiotic | | | | | |
| Sand | 1.2 | 2 | 3.5 | 13.2 | 11.228 |
| Pavement | | | | | 1.393 |
| Rubble | | | | 0.8 | 1.003 |
| Dead coral | | | | | 0.151 |
| Total abiotic | 1.2 | 2 | 3.5 | 14 | 13.779 |
| Rhodolith | | | | | 0.360 |
| Benthic algae | | | | | |
| <i>Lobophora</i> spp. | 9.2 | 5 | 21 | 2 | 33.451 |
| Turf | 68 | 33.5 | 61.5 | 72.8 | 24.570 |
| Macroalgae | | | | | 2.100 |
| <i>Dictyota</i> spp. | | 1.5 | | | 0.781 |
| Crustose coralline algae | 1.2 | | | | 0.468 |
| <i>Halimeda</i> spp. | | | | | 0.130 |
| <i>Styopodium</i> spp. | | 1.5 | | | 0.072 |
| Total benthic algae | 78.4 | 86.5 | 82.5 | 74.8 | 71.943 |
| Cyanobacteria | | | | | 0.744 |
| Hard corals | | | | | |
| <i>Orbicella franksi</i> | | 4.5 | 0.5 | | 1.583 |
| <i>Porites astreoides</i> | 0.8 | 0.5 | 0.5 | 0.8 | 0.418 |
| <i>Siderastrea siderea</i> | 0.8 | | 0.5 | | 0.347 |
| <i>Montastraea cavernosa</i> | 1.2 | | | | 0.225 |
| <i>Agaricia lamarcki</i> | | | | | 0.208 |
| <i>Madracis decactis</i> | 0.8 | | | | 0.165 |
| <i>Agaricia grahamae</i> | | | | | 0.121 |
| <i>Millepora alcicornis</i> | | | | | 0.117 |
| <i>Diploria strigosa</i> | | | | 0.8 | 0.115 |
| <i>Meandrina meandrites</i> | 0.4 | | | | 0.083 |
| <i>Agaricia agaricites</i> | | | | 0.4 | 0.083 |
| Coral spp. | | | 0.5 | | 0.058 |
| <i>Diploria labyrinthiformis</i> | | | | | 0.034 |
| <i>Eusmilia strigosa</i> | | | | | 0.028 |
| <i>Mycetophyllia aliciae</i> | | | | | 0.018 |
| <i>Manicina areolata</i> | | | | | 0.017 |
| <i>Stephanocoenia intersepta</i> | | | | | 0.015 |
| Total hard coral | 4 | 5 | 2 | 2 | 3.634 |

| | | | | | |
|-----------------------------------|------------|----------|----------|------------|--------------|
| Octocoral | | | | | |
| <i>Eunicea</i> spp. | 3.6 | 1 | 4.5 | 0.4 | 1.267 |
| <i>Pseudoplexaura</i> spp. | 0.4 | | | 0.4 | 0.451 |
| <i>Plexaura</i> spp. | 1.2 | | | 0.8 | 0.347 |
| <i>Antillogorgia</i> spp. | 0.8 | 0.5 | 0.5 | | 0.105 |
| <i>Erythropodium caribaeorum</i> | | | | | 0.093 |
| <i>Pterogorgia</i> spp. | | | | | 0.077 |
| <i>Plexaurella</i> spp. | 0.4 | 0.5 | | | 0.071 |
| <i>Muriceopsis</i> spp. | | | | | 0.055 |
| <i>Gorgonian</i> spp. | | | | | 0.041 |
| Total octocoral | 6.4 | 2 | 5 | 1.6 | 2.515 |
| Sponge | | | | | |
| <i>Xestospongia muta</i> | | 1 | 2 | 2.4 | 1.270 |
| Unknown sponge | 2.4 | 0.5 | | 2.4 | 1.131 |
| <i>Agelas conifera</i> | 2 | | | 0.8 | 0.514 |
| <i>Aplysina cauliformis</i> | 2.4 | | 2.5 | | 0.455 |
| <i>Prosuberites laughlini</i> | | 0.5 | | | 0.343 |
| <i>Geodia neptuni</i> | | 1 | 0.5 | 0.8 | 0.338 |
| <i>Aplysina fistularis</i> | 0.4 | | 0.5 | | 0.339 |
| <i>Cinachyrella kuekenthali</i> | 0.8 | 0.5 | | | 0.236 |
| <i>Niphates digitalis</i> | 0.4 | | | 0.4 | 0.210 |
| <i>Plakortis halichondrioides</i> | 0.4 | | | | 0.186 |
| <i>Spirastrella coccinea</i> | 0.4 | 0.5 | | | 0.178 |
| <i>Plakortis angulospiculatus</i> | | | | | 0.155 |
| <i>Hirtios cavernosus</i> | | | 0.5 | | 0.137 |
| <i>Verongula rigida</i> | | | | | 0.127 |
| <i>Agelas clathrodes</i> | | | | | 0.121 |
| <i>Svenzea zeai</i> | | | | | 0.120 |
| <i>Smenospongia conulosa</i> | 0.4 | | | | 0.103 |
| <i>Spheciospongia vesparium</i> | 0.4 | | | | 0.099 |
| <i>Agelas citrina</i> | | | | | 0.098 |
| <i>Aiolochoia crassa</i> | | | | | 0.076 |
| <i>Aplysina archeri</i> | | | | | 0.076 |
| <i>Neopetrosia proxima</i> | | | | | 0.074 |
| <i>Ircinia strobilina</i> | | | | | 0.073 |
| <i>Cliona caribbaea</i> | | | | | 0.070 |
| <i>Amphimedon compressa</i> | | | | | 0.065 |
| <i>Scopalina ruetzleri</i> | | 0.5 | 1 | | 0.058 |
| <i>Agelas tubulata</i> | | | | | 0.050 |
| <i>Ectoplasia ferox</i> | | | | | 0.046 |
| <i>Plakortis</i> spp. | | | | | 0.042 |

| | | | | | |
|----------------------------------|-----------|------------|----------|------------|--------------|
| <i>Aplysina insularis</i> | | | | | 0.038 |
| <i>Cliona delitrix</i> | | | | | 0.032 |
| <i>Ircinia felix</i> | | | | | 0.031 |
| <i>Verongula gigantea</i> | | | 0.4 | | 0.031 |
| <i>Ircinia</i> spp. <i>brown</i> | | | | | 0.028 |
| <i>Aplysina lacunosa</i> | | | | | 0.022 |
| <i>Cribrochalina vasculum</i> | | | | | 0.022 |
| <i>Callyspongia armigera</i> | | | | | 0.017 |
| <i>Clathria schoenus</i> | | | | | 0.017 |
| <i>Myrmekioderma gyroderma</i> | | | | | 0.017 |
| Black unknown sponge | | | 0.4 | | 0.015 |
| <i>Niphates erecta</i> | | | | | 0.015 |
| <i>Petrosia pallasarca</i> | | | | | 0.014 |
| Total sponges | 10 | 4.5 | 7 | 7.6 | 7.097 |

Appendix 2

Results from Analysis of Similarities (ANOSIM) one-way analysis comparing the sessile-benthic categories among habitats. CPV= colonized pavement, BCR= bank coral reef, PRF= patch coral reef, SAG= spur and groove, and CRR= rhodolith reef.

| Habitat | R Statistic | p value |
|-----------------|--------------|---------|
| CPV, BCR | 0.574 | 0.001 |
| CPV, PRF | 0.093 | 0.077 |
| CPV, SAG | 0.263 | 0.036 |
| CPV, CRR | 0.083 | 0.101 |
| BCR, PRF | 0.798 | 0.001 |
| BCR, SAG | 0.085 | 0.268 |
| BCR, CRR | 0.839 | 0.001 |
| PRF, SAG | 0.808 | 0.002 |
| PRF, CRR | -0.022 | 0.588 |
| SAG, CRR | 0.854 | 0.007 |
| Global R | 0.493 | |

2.2 Results from the SIMPER test. Contributions to similarity percentages by substrate categories within benthic habitats surveyed at Lang Bank, St. Croix, USVI.

| Benthic Habitats | Av.Abund | Av.Sim | Sim/SD | Contrib% | Cum.% |
|---|----------|--------|--------|----------|-------|
| Colonized pavement (Average similarity: 71.3) | | | | | |
| Macroalgae | 6.41 | 27.41 | 2.75 | 38.47 | 38.47 |
| Turf | 4.36 | 13.64 | 1.22 | 19.14 | 57.6 |
| Sponge | 2.62 | 11.84 | 5.18 | 16.62 | 74.23 |
| Abiotic | 2.92 | 7.85 | 0.96 | 11.02 | 85.24 |
| Coral | 1.63 | 5.3 | 1.64 | 7.44 | 92.68 |
| Bank coral reef (Average similarity: 78.3) | | | | | |
| Macroalgae | 5.5 | 21.57 | 3.73 | 27.56 | 27.56 |
| Coral | 5.25 | 20.93 | 4.62 | 26.74 | 54.29 |
| Turf | 4.14 | 14.72 | 3.16 | 18.81 | 73.1 |
| CCA | 2.64 | 8.96 | 2.32 | 11.45 | 84.55 |
| Sponge | 2.08 | 7.1 | 2.14 | 9.07 | 93.62 |
| Patch coral reef (Average similarity: 78.7) | | | | | |
| Abiotic | 6.13 | 27.81 | 5.5 | 35.36 | 35.36 |
| Macroalgae | 5.93 | 25.74 | 3.23 | 32.73 | 68.09 |
| Sponge | 2.37 | 10.33 | 5.25 | 13.14 | 81.23 |
| Turf | 2.77 | 7.65 | 1.32 | 9.73 | 90.96 |

Spur and groove (Average similarity: 81.3)

| | | | | | |
|------------|------|-------|--------|-------|-------|
| Turf | 6.25 | 23.56 | 3.44 | 28.97 | 28.97 |
| Coral | 4.83 | 21.4 | 700.31 | 26.32 | 55.29 |
| Macroalgae | 4.15 | 13.24 | 52.93 | 16.29 | 71.58 |
| Sponge | 2.58 | 8.78 | 2.55 | 10.8 | 82.38 |
| Abiotic | 2.1 | 7.42 | 4.08 | 9.13 | 91.51 |

Rhodolith reef (Average similarity: 79.7)

| | | | | | |
|------------|------|-------|------|-------|-------|
| Macroalgae | 6.76 | 33.41 | 8.83 | 41.92 | 41.92 |
| Abiotic | 5.39 | 24.78 | 3.03 | 31.1 | 73.02 |
| Sponge | 2.2 | 9.6 | 4.42 | 12.05 | 85.07 |
| Turf | 2.7 | 8.47 | 1.19 | 10.63 | 95.7 |

2.3 Results from the SIMPER test. Contributions to dissimilarity percentages by substrate categories between benthic habitats surveyed at Lang Bank, St. Croix, USVI. CPV= colonized pavement, BCR= bank coral reef, PRF= patch coral reef, SAG= spur and groove, and CRR= rhodolith reef.

| Substrate Categories | Av.Abund | Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|-----------|-----------|---------|---------|----------|-------|
| Groups CPV & BCR (Average dissimilarity = 36.3) | | | | | | |
| | Group CPV | Group BCR | | | | |
| Coral | 1.63 | 5.25 | 8.87 | 2.25 | 24.42 | 24.42 |
| Turf | 4.36 | 4.14 | 6.7 | 1.53 | 18.44 | 42.86 |
| Abiotic | 2.92 | 1.57 | 5.73 | 1.24 | 15.79 | 58.66 |
| CCA | 0.4 | 2.64 | 5.49 | 1.71 | 15.13 | 73.79 |
| Macroalgae | 6.41 | 5.5 | 4.89 | 1.42 | 13.48 | 87.27 |
| Octocoral | 1.38 | 0.66 | 2.36 | 1.45 | 6.49 | 93.76 |
| Groups CPV & PRF (Average dissimilarity = 29.6) | | | | | | |
| | Group CPV | Group PRF | | | | |
| Abiotic | 2.92 | 6.13 | 9.03 | 1.57 | 30.52 | 30.52 |
| Turf | 4.36 | 2.77 | 7.96 | 1.32 | 26.9 | 57.42 |
| Macroalgae | 6.41 | 5.93 | 4.84 | 1.24 | 16.34 | 73.76 |
| Coral | 1.63 | 1.46 | 2.52 | 1.28 | 8.53 | 82.29 |
| Octocoral | 1.38 | 0.75 | 2.39 | 1.37 | 8.08 | 90.37 |

Groups BCR & PRF (Average dissimilarity = 39.8)

| | Group BCR | Group PRF | | | | |
|------------|-----------|-----------|-------|------|-------|-------|
| Abiotic | 1.57 | 6.13 | 11.13 | 2.39 | 27.95 | 27.95 |
| Coral | 5.25 | 1.46 | 9.21 | 2.53 | 23.14 | 51.08 |
| Turf | 4.14 | 2.77 | 5.94 | 1.37 | 14.92 | 66.01 |
| CCA | 2.64 | 0.27 | 5.79 | 1.84 | 14.52 | 80.53 |
| Macroalgae | 5.5 | 5.93 | 4.07 | 1.35 | 10.21 | 90.74 |

Groups CPV & SAG (Average dissimilarity = 34.1)

| | Group CPV | Group SAG | | | | |
|------------|-----------|-----------|------|------|-------|-------|
| Coral | 1.63 | 4.83 | 7.71 | 2.99 | 22.65 | 22.65 |
| Turf | 4.36 | 6.25 | 7.37 | 1.53 | 21.66 | 44.3 |
| Macroalgae | 6.41 | 4.15 | 6.84 | 1.6 | 20.09 | 64.4 |
| Abiotic | 2.92 | 2.1 | 4.87 | 1.33 | 14.31 | 78.71 |
| CCA | 0.4 | 1.68 | 3.15 | 1.84 | 9.25 | 87.96 |
| Octocoral | 1.38 | 0.65 | 2.28 | 1.46 | 6.69 | 94.65 |

Groups BCR & SAG (Average dissimilarity = 22.7)

| | Group BCR | Group SAG | | | | |
|------------|-----------|-----------|------|------|-------|-------|
| Turf | 4.14 | 6.25 | 5.75 | 1.52 | 25.36 | 25.36 |
| Macroalgae | 5.5 | 4.15 | 4.85 | 1.52 | 21.37 | 46.73 |
| Abiotic | 1.57 | 2.1 | 3.02 | 1.6 | 13.34 | 60.07 |
| CCA | 2.64 | 1.68 | 2.89 | 1.22 | 12.73 | 72.8 |
| Sponge | 2.08 | 2.58 | 2.42 | 1.44 | 10.68 | 83.48 |
| Coral | 5.25 | 4.83 | 2.38 | 1.4 | 10.49 | 93.97 |

Groups PRF & SAG (Average dissimilarity = 39.4)

| | Group PRF | Group SAG | | | | |
|------------|-----------|-----------|------|------|-------|-------|
| Abiotic | 6.13 | 2.1 | 9.69 | 2.92 | 24.58 | 24.58 |
| Turf | 2.77 | 6.25 | 9.13 | 1.79 | 23.14 | 47.72 |
| Coral | 1.46 | 4.83 | 8.08 | 4.03 | 20.5 | 68.22 |
| Macroalgae | 5.93 | 4.15 | 5.71 | 1.44 | 14.47 | 82.69 |
| CCA | 0.27 | 1.68 | 3.38 | 1.99 | 8.58 | 91.27 |

Groups CPV & CRR (Average dissimilarity = 29.3)

| | Group CPV | Group CRR | | | | |
|------------|-----------|-----------|------|------|-------|-------|
| Abiotic | 2.92 | 5.39 | 8.13 | 1.54 | 27.72 | 27.72 |
| Turf | 4.36 | 2.7 | 7.95 | 1.37 | 27.1 | 54.82 |
| Macroalgae | 6.41 | 6.76 | 4.24 | 1.19 | 14.46 | 69.28 |

| | | | | | | |
|-----------|------|------|------|------|------|-------|
| Coral | 1.63 | 0.85 | 2.87 | 1.29 | 9.78 | 79.06 |
| Octocoral | 1.38 | 0.44 | 2.85 | 1.56 | 9.7 | 88.76 |
| Sponge | 2.62 | 2.2 | 2.05 | 1.48 | 6.97 | 95.73 |

Groups BCR & CRR (Average dissimilarity = 40.1)

| | Group BCR | Group CRR | | | | |
|------------|-----------|-----------|-------|------|-------|-------|
| Coral | 5.25 | 0.85 | 10.94 | 3.08 | 27.28 | 27.28 |
| Abiotic | 1.57 | 5.39 | 9.75 | 2.17 | 24.3 | 51.59 |
| CCA | 2.64 | 0.23 | 6.02 | 1.88 | 15 | 66.59 |
| Turf | 4.14 | 2.7 | 5.66 | 1.35 | 14.11 | 80.7 |
| Macroalgae | 5.5 | 6.76 | 4.03 | 1.21 | 10.04 | 90.73 |

Groups PRF & CRR (Average dissimilarity = 20.8)

| | Group PRF | Group CRR | | | | |
|------------|-----------|-----------|------|------|-------|-------|
| Turf | 2.77 | 2.7 | 5.8 | 1.39 | 27.98 | 27.98 |
| Macroalgae | 5.93 | 6.76 | 4.01 | 1.22 | 19.32 | 47.3 |
| Abiotic | 6.13 | 5.39 | 3.83 | 1.05 | 18.45 | 65.75 |
| Coral | 1.46 | 0.85 | 2.53 | 1.45 | 12.21 | 77.95 |
| Sponge | 2.37 | 2.2 | 1.86 | 1.3 | 8.97 | 86.92 |
| Octocoral | 0.75 | 0.44 | 1.69 | 1.3 | 8.14 | 95.06 |

Groups SAG & CRR (Average dissimilarity = 41.2)

| | Group SAG | Group CRR | | | | |
|------------|-----------|-----------|------|------|-------|-------|
| Coral | 4.83 | 0.85 | 9.76 | 5.84 | 23.68 | 23.68 |
| Turf | 6.25 | 2.7 | 9.03 | 1.75 | 21.89 | 45.56 |
| Abiotic | 2.1 | 5.39 | 8.28 | 2.57 | 20.07 | 65.63 |
| Macroalgae | 4.15 | 6.76 | 6.9 | 1.66 | 16.73 | 82.37 |
| CCA | 1.68 | 0.23 | 3.56 | 2.07 | 8.62 | 90.99 |

Appendix 3.

Percent substrate cover by sessile-benthic categories from stations/transects surveyed at the Bank Coral Reef Habitat in Lang Bank. 2012-13

| BANK CORAL REEF | | Spawn | | | | | | | | | | |
|----------------------|--|-------------|----------|------|-----|------|-------------|-----------|-------------|--------------|-------------|--------------|
| Substrate category | | Site 2 | IW42 | DB26 | 816 | DB28 | DB27 | 819 | DB14-30 | 823 | IW35 | IW35 |
| Abiotic | | | | | | | | | | | | |
| Sand | | 17.5 | 8.44 | | | | 7.48 | 17 | 0.53 | 12.13 | 1.54 | 14.11 |
| Dead coral | | | | | | | 0.39 | | 0.58 | | | |
| Rubble | | | | | | | | | | | 0.5 | |
| Total abiotic | | 17.5 | 8 | | | | 7.87 | 17 | 1.11 | 12.13 | 2.04 | 14.11 |

| | | | | | | | | | | | | |
|----------------------------|--|-----------|-----------|--------------|--------------|--------------|--------------|-----------|--------------|--------------|--------------|-------------|
| Benthic algae | | | | | | | | | | | | |
| <i>Lobophora</i> spp. | | 39.5 | 44.64 | 32.01 | 24 | 41.99 | 53.64 | 35.57 | 30.47 | 40.2 | 36.76 | 26.9 |
| Turf | | 11 | 9.35 | 4.15 | 4 | 5.87 | 6.31 | 8 | 13.54 | 5.93 | 18.01 | 11.78 |
| Crustose coralline algae | | 0.5 | 3.59 | 7.28 | 4 | 6.3 | 1.14 | 6.29 | 8.54 | 4.1 | 10.2 | 11.48 |
| <i>Dictyota</i> spp. | | | 6.31 | 0.91 | 2.67 | 1.78 | | 0.57 | | | 3.09 | 9.14 |
| Macroalgae | | | 3.11 | | | | | 0.57 | | | 1.02 | 7.6 |
| <i>Halimeda</i> spp. | | | | | | | | | | | | |
| Total benthic algae | | 51 | 67 | 44.35 | 34.67 | 55.94 | 61.09 | 51 | 52.55 | 50.23 | 69.08 | 66.9 |

| | | | | | | | | | | | | |
|------------------------------|--|-----|-------|-------|-------|-------|------|-------|-------|-------|-------|-------|
| Cyanobacteria | | | | | 1.33 | 0.45 | 0.57 | | | | 1.09 | |
| Hard corals | | | | | | | | | | | | |
| <i>Orbicella franksi</i> | | 9 | 16.04 | 29.53 | 26 | 31.83 | 10.3 | 15.43 | 33.23 | 16.33 | 23.76 | 14.97 |
| <i>Porites furcata</i> | | 3.5 | | 2.26 | 27.33 | 1.33 | | | | | | |
| <i>Porites astreoides</i> | | 1.5 | 1.81 | 1.33 | | 5.89 | | 1.14 | 3.56 | 0.44 | 1.02 | |
| <i>Colpophyllia natans</i> | | | | | | | | | | 1.89 | | |
| <i>Agaricia grahamae</i> | | 2 | 0.44 | 0.48 | 1.33 | | 1.71 | | 0.5 | 0.93 | 0.53 | |
| <i>Diploria strigosa</i> | | | | 11.19 | | | 2.39 | | 2.5 | | | |
| <i>Agaricia lamarcki</i> | | | | | 0.67 | | 1.17 | 0.57 | | | | |
| <i>Montastraea cavernosa</i> | | | | 0.89 | | 0.93 | 2.3 | 0.57 | 0.53 | | | 0.57 |
| <i>Siderastrea siderea</i> | | 0.5 | 0.44 | 0.44 | | 0.46 | | | | | | 0.57 |

| | | | | | | | | | | | |
|--------------------------------------|-------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <i>Madracis decactis</i> | 1 | | | | | | | | 0.46 | | |
| <i>Porites divaricata</i> | | | | | | | | | | | |
| <i>Montastraea faveolata</i> | | | | | | | | | 1.93 | | |
| <i>Eusmilia strigosa</i> | | | | | | | | | 0.46 | 0.57 | |
| <i>Mycetophyllia aliciae</i> | | | | | | | | | | | |
| <i>Agaricia agaricites</i> | | | | | | | | | | | |
| <i>Leptoseris cucullata</i> | | | 0.48 | | | | | 0.5 | | | |
| <i>Mycetophyllia ferox</i> | | | | | | | | | | | |
| <i>Stephanocoenia intersepta</i> | | | | | | | | | | | |
| <i>Meandrina meandrites</i> | | | | | | | 0.57 | | | | |
| Coral spp. | | | | | | | | | | | |
| <i>Millepora alcicornis</i> | | | | | | 0.57 | | | | | |
| <i>Diploria labyrinthiformis</i> | | | | | | | | | | | |
| <i>Porites porites</i> | | | | | | | | | | | |
| Total hard coral | 17.5 | 18.74 | 46.61 | 55.33 | 40.44 | 18.44 | 18.29 | 40.82 | 22.45 | 25.31 | 16.68 |

Octocoral

| | | | | | | | | | | | |
|--------------------------------------|----------|-------------|--|----------|--|--|-------------|--|-------------|------------|--|
| <i>Erythropodium caribaeorum</i> | 0.5 | 0.93 | | 2 | | | 0.57 | | 0.97 | | |
| <i>Briareum</i> sp. | | 1.33 | | | | | | | 0.48 | 1.5 | |
| <i>Eunicea</i> spp. | 0.5 | | | | | | | | | | |
| <i>Antillogorgia</i> spp. | | | | | | | | | | | |
| <i>Gorgonian</i> spp. | | | | | | | | | | | |
| <i>Plexaura</i> spp. | 0.5 | | | | | | | | | | |
| <i>Plexaurella</i> spp. | 0.5 | | | | | | | | | | |
| <i>Pseudoplexaura</i> spp. | | | | | | | | | | | |
| Total octocoral | 2 | 2.26 | | 2 | | | 0.57 | | 1.45 | 1.5 | |

Sponge

| | | | | | | | | | | | |
|--------------------------|-----|------|------|------|------|------|------|------|------|--|------|
| <i>Geodia neptuni</i> | | | 1.83 | | | 5.14 | 1.71 | 1.5 | 1.78 | | |
| <i>Svenzea zeai</i> | 2.5 | 0.89 | 0.44 | 2 | 0.44 | | 0.57 | 1 | | | |
| Unknown sponge | 0.5 | 0.89 | 2.26 | | 0.44 | 0.6 | 0.57 | 0.5 | 1.37 | | |
| <i>Agelas conifera</i> | 0.5 | 0.44 | 2.74 | 0.67 | 1.39 | 1.14 | 0.57 | | 0.97 | | |
| <i>Agelas clathrodes</i> | 1 | | | | | 0.57 | 0.57 | 0.53 | 4.97 | | 1.14 |

| | | | | | | | | | | |
|-----------------------------------|-----|------|------|------|------|------|------|------|------|------|
| <i>Cliona caribbaea</i> | 2 | | 0.44 | | | 0.57 | | | | |
| <i>Plakortis halichondrioides</i> | 0.5 | 0.89 | 0.46 | | 1.14 | 2.86 | | | | |
| <i>Agelas citrina</i> | | | 0.89 | | | | 0.5 | 1.89 | | |
| <i>Hyrtios cavernosus</i> | | | | | | | | 0.97 | 0.5 | 0.57 |
| <i>Aiolochoira crassa</i> | 1 | | | 0.67 | 0.44 | 0.57 | 1.14 | | | |
| <i>Clathria schoenus</i> | | | | | | | 0.57 | | | 0.62 |
| <i>Spheciospongia vesparium</i> | 0.5 | | | | | 0.57 | | 0.5 | | |
| <i>Plakortis angulospiculatus</i> | | | | | | | 0.57 | | 0.46 | |
| <i>Clathria</i> spp. | | | | | | | | | | |
| <i>Aplysina cauliformis</i> | 0.5 | 0.44 | | | | | | 0.5 | | |
| <i>Xestospongia muta</i> | 0.5 | | | | | 0.57 | | | | 0.57 |
| <i>Niphates digitalis</i> | | | | | | | 0.57 | 0.5 | 0.97 | |
| <i>Agelas tubulata</i> | 1.5 | | | | | | | | | |
| <i>Amphimedon compressa</i> | 0.5 | 0.44 | | | | | 0.57 | | | |
| <i>Neopetrosia proxima</i> | | | | | | 0.57 | 0.57 | | | |
| <i>Prosuberites laughlini</i> | | | | | | | | | 0.5 | |
| <i>Ectoplasia ferox</i> | | | | | | | | | | |
| <i>Smenospongia conulosa</i> | | | | | | | | | | |
| <i>Agelas dispar</i> | | | | | | | | | | |
| <i>Plaktoris</i> spp. | | | | | | 0.6 | | | | |
| <i>Aplysina insularis</i> | | | | | | | 0.57 | | | |
| <i>Aplysina lacunosa</i> | | | | | | 0.57 | | | | |
| <i>Callyspongia plicifera</i> | | | | | | | 0.57 | | | |
| <i>Erylus formosus</i> | | | | | | | 0.57 | | | |
| <i>Cinachyrella kuekenthali</i> | 0.5 | | | | | | | | | |
| <i>Aplysina fistularis</i> | | | | | | | | | | |
| <i>Cliona delitrix</i> | | | | | | | | | | |
| <i>Ircinia</i> spp. brown | | | | | | | | | | |
| <i>Ircinia strobilina</i> | | | | | | | | | | |
| <i>Spriastrella coccinea</i> | | | | | | | | | 0.44 | |
| <i>Verongula gigantea</i> | | | | | | | | | | |
| <i>Verongula rigida</i> | | | | | | | | | | |
| <i>Cliona aprica</i> | | | | | | | | | | |

| | | | | | | | | | | | |
|---------------|----|---|------|------|------|-------|-------|------|-------|---|------|
| Total sponges | 12 | 4 | 9.04 | 3.33 | 2.72 | 12.05 | 13.14 | 5.53 | 13.82 | 1 | 2.91 |
|---------------|----|---|------|------|------|-------|-------|------|-------|---|------|

| Substrate category | IW37 | IW38 | IW39 | IW36 | IW36 | DB2 | DB3 | DB21 | DB21 | DB22 | DB22 |
|----------------------|------|------|------|------|------|-----|------|------|------|------|------|
| Abiotic | | | | | | | | | | | |
| Sand | 3.5 | | 1.14 | 2.22 | | 4 | 13.5 | 0.75 | 0.36 | 0.12 | |
| Dead coral | | 3 | 0.19 | 3.19 | 3.5 | | 0.5 | | | | 0.44 |
| Rubble | | | 0.6 | 3.56 | | | 0.5 | | | | 0.46 |
| Total abiotic | 3.5 | 3 | 1.93 | 8.96 | 3.5 | 4 | 14.5 | 0.75 | 0.36 | 0.12 | 0.93 |

| | | | | | | | | | | | |
|----------------------------|------|------|-------|-------|-------|-------|------|-------|-------|-------|-------|
| Benthic algae | | | | | | | | | | | |
| <i>Lobophora spp.</i> | 35.5 | 37 | 22.81 | 7.98 | 22.17 | 34.32 | 51 | 32.09 | 28.2 | 36.33 | 51.41 |
| Turf | 11 | 20.5 | 20.3 | 56.19 | 48.71 | 22.83 | 16.5 | 8.93 | 12.85 | 4.44 | 7.15 |
| Crustose coralline algae | 6.5 | 10.5 | 9.86 | 1.35 | 1 | 5.35 | 1 | 0.89 | 3.3 | 4 | 4.46 |
| <i>Dictyota spp.</i> | 0.5 | 1 | 2.9 | 1.33 | 2 | 0.46 | 1.5 | 0.89 | 0.36 | | |
| Macroalgae | 1 | | 3.43 | 3.13 | 7 | 4.52 | 1.5 | 0.91 | 0.73 | | |
| <i>Halimeda spp.</i> | | | | | | | | 1.02 | | | |
| Total benthic algae | 54.5 | 69 | 59.3 | 69.98 | 80.88 | 67.48 | 71.5 | 44.73 | 45.44 | 44.77 | 63.02 |

| | | | | | | | | | | | |
|----------------------|--|---|--|--|--|------|---|--|------|------|--|
| Cyanobacteria | | 1 | | | | 0.89 | 2 | | 0.36 | 1.33 | |
|----------------------|--|---|--|--|--|------|---|--|------|------|--|

| | | | | | | | | | | | |
|------------------------------|-----|-----|-------|------|------|-------|-----|-------|-------|-------|-------|
| Hard corals | | | | | | | | | | | |
| <i>Orbicella franksi</i> | 39 | 20 | 33.57 | 8.96 | 8.13 | 17.78 | 7.5 | 44.25 | 37.39 | 22.22 | 18.69 |
| <i>Porites furcata</i> | 0.5 | | 4.07 | | 0.5 | | | | 2.18 | 5.78 | 4.89 |
| <i>Porites astreoides</i> | | 0.5 | | 0.97 | 1 | | 0.5 | | 0.73 | 1.33 | 0.44 |
| <i>Colpophyllia natans</i> | | | | 2.26 | 0.5 | | | | | 13.78 | 2.67 |
| <i>Agaricia grahamae</i> | | | | | | 0.44 | | | 3.64 | 4.89 | 0.46 |
| <i>Diploria strigosa</i> | | | | | 1 | | | | | | |
| <i>Agaricia lamarcki</i> | | | | | | 1.83 | 1.5 | 0.44 | | | |
| <i>Montastraea cavernosa</i> | | | | 0.46 | 0.5 | 1.33 | 1 | | | | |
| <i>Siderastrea siderea</i> | | | | 0.89 | | 0.97 | | | | | 0.44 |
| <i>Madracis decactis</i> | | 0.5 | | | 0.5 | | | | 0.73 | | |
| <i>Porites divaricata</i> | | | | | | | | 1.78 | | | |

| | | | | | | | | | | | |
|--------------------------------------|------|------|-------|-------|-------|-------|------|-------|-------|----|-------|
| <i>Montastraea faveolata</i> | | | | | | | | | | | |
| <i>Eusmilia strigosa</i> | | | | | | 0.5 | | | | | |
| <i>Mycetophyllia aliciae</i> | | 1.5 | | | | | | | | | |
| <i>Agaricia agaricites</i> | | | | | | | | | | | |
| <i>Leptoseris cucullata</i> | | | | | | | | | 0.36 | | |
| <i>Mycetophyllia ferox</i> | | | | | | | | | | | |
| <i>Stephanocoenia intersepta</i> | | | | | | | | | | | |
| <i>Meandrina meandrites</i> | | | | | 0.44 | | | | | | |
| <i>Coral spp.</i> | | | | | | | | | | | |
| <i>Millepora alcicornis</i> | | | | | | | | | | | |
| <i>Diploria labyrinthiformis</i> | | | | | | | | | | | |
| <i>Porites porites</i> | | | | | | | | | 0.44 | | |
| Total hard coral | 39.5 | 22.5 | 37.64 | 13.99 | 12.63 | 22.36 | 10.5 | 46.91 | 45.03 | 48 | 27.59 |

Octocorals

| | | | | | | | | | | | |
|--------------------------------------|-----|-----|------|------|-----|--|--|------|-----|--|------|
| <i>Erythropodium caribaeorum</i> | | | | 0.44 | | | | 2.26 | 2.2 | | 0.89 |
| <i>Briareum sp.</i> | | | 0.57 | 0.46 | | | | | | | |
| <i>Eunicea spp.</i> | | 0.5 | | 0.44 | | | | | | | |
| <i>Antillogorgia spp.</i> | | | | | | | | | | | |
| <i>Gorgonian spp.</i> | 0.5 | | | | | | | | | | |
| <i>Plexaura spp.</i> | | | | | | | | | | | |
| <i>Plexaurella spp.</i> | | | | | | | | | | | |
| <i>Pseudoplexaura spp.</i> | | | | | 0.5 | | | | | | |
| Total octocoral | 0.5 | 0.5 | 0.57 | 1.35 | 0.5 | | | 2.26 | 2.2 | | 0.89 |

Sponges

| | | | | | | | | | | | |
|--------------------------|---|-----|-----|------|-----|------|-----|------|------|------|------|
| <i>Geodia neptuni</i> | 1 | 0.5 | | | 1.5 | 1.33 | | 2.22 | 2.21 | 1.33 | |
| <i>Svenzea zeai</i> | | | | | | 1.78 | 0.5 | | 0.73 | 1.33 | 0.89 |
| <i>Unknown sponge</i> | | | | 0.44 | | 0.44 | 0.5 | | 0.74 | | 0.44 |
| <i>Agelas conifera</i> | | | | 0.44 | | | | 0.44 | 0.38 | 0.89 | 0.89 |
| <i>Agelas clathrodes</i> | | | | 0.89 | | | 0.5 | | 0.73 | | |
| <i>Cliona caribbaea</i> | | 0.5 | 0.6 | | | | | 2.22 | | | |

| | | | | | | | |
|-----------------------------------|-----|-----|------|-----|------|------|------|
| <i>Plakortis halichondrioides</i> | | | 0.44 | | 0.46 | | 0.97 |
| <i>Agelas citrina</i> | | | 1.33 | 0.5 | | | 0.44 |
| <i>Hyrrios cavernosus</i> | 0.5 | 0.5 | | | | | 3.56 |
| <i>Aiolochoiria crassa</i> | | | | | | 0.36 | 0.44 |
| <i>Clathria schoenus</i> | | 0.5 | 1.78 | | | 0.36 | |
| <i>Spheciospongia vesparium</i> | | | | | | | |
| <i>Plakortis angulospiculatus</i> | | | | | | | 0.89 |
| <i>Clathria spp.</i> | 0.5 | 2 | | | | | |
| <i>Aplysina cauliformis</i> | | | | | | 0.44 | |
| <i>Xestospongia muta</i> | | | | | | 0.44 | |
| <i>Niphates digitalis</i> | | | | | | | |
| <i>Agelas tubulata</i> | | | | 0.5 | | | |
| <i>Amphimedon compressa</i> | | | | | | | |
| <i>Neopetrosia proxima</i> | | | | | | | |
| <i>Prosuberites laughlini</i> | | | | | | 0.44 | |
| <i>Ectoplasia ferox</i> | | | | | | | |
| <i>Smenospongia conulosa</i> | | | | | | | 0.44 |
| <i>Agelas dispar</i> | | | | | | 0.73 | |
| <i>Plaktoris spp.</i> | | | | | | | |
| <i>Aplysina insularis</i> | | | | | | | |
| <i>Aplysina lacunosa</i> | | | | | | | |
| <i>Callyspongia plicifera</i> | | | | | | | |
| <i>Erylus formosus</i> | | | | | | | |
| <i>Cinachyrella kuekenthali</i> | | | | | | | |
| <i>Aplysina fistularis</i> | | | | | | 0.44 | |
| <i>Cliona delitrix</i> | | | 0.44 | | | | |
| <i>Ircinia spp. brown</i> | | | | | | | |
| <i>Ircinia strobilina</i> | | | | | | | |
| <i>Spriastrella coccinea</i> | | | | | | | |
| <i>Verongula gigantea</i> | | | | | | | |
| <i>Verongula rigida</i> | | | | | | | 0.44 |

Cliona aprica

0.36

| | | | | | | | | | | | |
|---------------|---|---|-----|------|-----|------|-----|------|------|------|-----|
| Total sponges | 2 | 4 | 0.6 | 5.78 | 2.5 | 5.33 | 1.5 | 5.35 | 6.61 | 5.78 | 7.6 |
|---------------|---|---|-----|------|-----|------|-----|------|------|------|-----|

| Substrate category | IW31 | IW32 | IW33 | IW34 | WP878 | DB6 | LB2 | LB10 | LB8 | LB6 | LB7 | Mean |
|------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| Abiotic | | | | | | | | | | | | |
| Sand | | | 4 | | 8.46 | 0.89 | | 3.81 | | 3.65 | | 3.792 |
| Dead coral | | | | | | | | | | | | 0.357 |
| Rubble | | | | | | | | | | | | 0.170 |
| Total abiotic | | | 4 | | 8.46 | 0.89 | | 3.81 | | 3.65 | | 4.307 |
| Benthic algae | | | | | | | | | | | | |
| <i>Lobophora</i> spp. | 6.22 | 7.56 | 9.33 | 7.56 | 38.85 | 56.17 | 11.64 | 23.17 | 22.27 | 9.89 | 15.31 | 29.468 |
| Turf | 53.33 | 58.22 | 52 | 49.33 | 15.59 | 18.72 | 20.4 | 15.88 | 12.19 | 18.08 | 15.63 | 19.900 |
| Crustose coralline algae | 12 | 7.11 | 8.89 | 7.56 | 6.3 | 5.43 | 32.35 | 25.67 | 24.17 | 25.94 | 12.48 | 8.471 |
| <i>Dictyota</i> spp. | | 2.22 | 0.89 | 6.67 | | | | 0.73 | | 0.36 | | 1.402 |
| Macroalgae | 0.44 | 0.89 | 0.89 | 2.22 | | | | | | | | 1.181 |
| <i>Halimeda</i> spp. | | | 0.44 | | | | | | | | | 0.044 |
| Total benthic algae | 72 | 76 | 72.44 | 73.33 | 60.74 | 80.31 | 64.39 | 65.46 | 58.63 | 54.28 | 43.43 | 60.467 |
| Cyanobacteria | | | | | | | | | | | | 0.273 |
| Hard corals | | | | | | | | | | | | |
| <i>Orbicella franksi</i> | 23.56 | 17.33 | 19.56 | 14.22 | 14.31 | 6.69 | 27 | 29.34 | 40.2 | 39.53 | 44.93 | 23.048 |
| <i>Porites furcata</i> | | | | 1.33 | | | | | 0.57 | 1.09 | | 1.677 |
| <i>Porites astreoides</i> | 0.44 | 1.33 | 0.89 | 0.44 | 0.44 | | 0.5 | | | | 0.44 | 0.807 |
| <i>Colpophyllia natans</i> | | | | | | | | | | | 0.44 | 0.653 |
| <i>Agaricia grahamae</i> | | | | | 1.33 | 0.44 | 1.64 | | | 0.73 | | 0.651 |
| <i>Diploria strigosa</i> | | | | | | | | | 0.62 | | | 0.536 |
| <i>Agaricia lamarcki</i> | 0.44 | | | | | 2.78 | 1 | | | | 3.56 | 0.423 |
| <i>Montastraea cavernosa</i> | 0.44 | | | | 1.33 | 2.22 | 0.5 | 0.36 | | | | 0.422 |

| | | | | | | | | | | | | | |
|----------------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|-------------|--------------|--------------|-------------|--|---------------|
| <i>Siderastrea siderea</i> | 0.44 | | | 0.44 | | | | | | | | | 0.169 |
| <i>Madracis decactis</i> | | 0.44 | | | | | | | | | | | 0.110 |
| <i>Porites divaricata</i> | | | | 1.33 | | | | | | | | | 0.094 |
| <i>Montastraea faveolata</i> | | | | | | | | | | | | | 0.058 |
| <i>Eusmilia strigosa</i> | | | | | | | | | | | | | 0.046 |
| <i>Mycetophyllia aliciae</i> | | | | | | | | | | | | | 0.045 |
| <i>Agaricia agaricites</i> | | | 0.44 | 0.44 | 0.46 | | | | | | | | 0.041 |
| <i>Leptoseris cucullata</i> | | | | | | | | | | | | | 0.041 |
| <i>Mycetophyllia ferox</i> | | | | | | | | | | 1.33 | | | 0.040 |
| <i>Stephanocoenia intersepta</i> | | | | | 1.33 | | | | | | | | 0.040 |
| <i>Meandrina meandrites</i> | | | | | | | | | | | | | 0.031 |
| Coral spp. | | | 0.44 | | | 0.44 | | | | | | | 0.027 |
| <i>Millepora alcornis</i> | | | | | | | | | | | | | 0.017 |
| <i>Diploria labyrinthiformis</i> | | | | 0.44 | | | | | | | | | 0.013 |
| <i>Porites porites</i> | | | | | | | | | | | | | 0.013 |
| Total hard coral | 25.33 | 19.11 | 21.33 | 18.67 | 19.22 | 12.57 | 30.64 | 29.7 | 41.39 | 41.35 | 50.7 | | 29.008 |
| Octocoral | | | | | | | | | | | | | |
| <i>Erythropodium caribaeorum</i> | 0.89 | | | | | | 0.5 | | | 0.36 | 0.46 | | 0.393 |
| <i>Briareum</i> spp. | | 0.89 | | 1.33 | | | | | | | | | 0.199 |
| <i>Eunicea</i> spp. | | 0.44 | 0.44 | | | | | | | | | | 0.070 |
| <i>Antillogorgia</i> spp. | | | | 1.33 | | | | | | | | | 0.040 |
| <i>Gorgonian</i> spp. | | | | | | | | | | | | | 0.015 |
| <i>Plexaura</i> spp. | | | | | | | | | | | | | 0.015 |
| <i>Plexaurella</i> spp. | | | | | | | | | | | | | 0.015 |
| <i>Pseudoplexaura</i> spp. | | | | | | | | | | | | | 0.015 |
| Total octocoral | 0.89 | 1.33 | 0.44 | 2.67 | | | 0.5 | | | 0.36 | 0.46 | | 0.764 |
| Sponge | | | | | | | | | | | | | |
| <i>Geodia neptuni</i> | | 0.89 | | 0.89 | | 0.44 | 1 | 0.74 | | 0.36 | 1.78 | | 0.853 |

| | | | | | | | | | |
|-----------------------------------|------|------|------|------|------|------|------|------|-------|
| <i>Svenzea zeai</i> | 0.44 | 0.44 | | 5.78 | 1.78 | | | | 0.652 |
| Unknown sponge | 0.44 | 0.44 | 0.44 | 0.44 | 3.56 | 2 | | 0.97 | 0.545 |
| <i>Agelas conifera</i> | | 1.78 | | 1.78 | 0.44 | 0.5 | | 0.44 | 0.497 |
| <i>Agelas clathrodes</i> | | | | 1.78 | | | | 1.33 | 0.425 |
| <i>Cliona caribbaea</i> | 0.89 | | | | | 0.5 | | 1.33 | 0.274 |
| <i>Plakortis halichondrioides</i> | | | | | | | | | 0.234 |
| <i>Agelas citrina</i> | | | | 0.44 | 0.89 | | | | 0.208 |
| <i>Hyrtilis cavernosus</i> | | | | | | | | | 0.200 |
| <i>Aiolochoira crassa</i> | | | | 0.46 | | 0.57 | 0.36 | | 0.196 |
| <i>Clathria schoenus</i> | | | | | | | | | 0.116 |
| <i>Spheciospongia vesparium</i> | | | | 1.78 | | | | | 0.102 |
| <i>Plakortis angulospiculatus</i> | | | | 0.44 | 0.44 | | | | 0.085 |
| <i>Clathria</i> spp. | | | | | | | | | 0.076 |
| <i>Aplysina cauliformis</i> | | | | 0.44 | | | | | 0.070 |
| <i>Xestospongia muta</i> | | | | | | | | | 0.063 |
| <i>Niphates digitalis</i> | | | | | | | | | 0.062 |
| <i>Agelas tubulata</i> | | | | | | | | | 0.061 |
| <i>Amphimedon compressa</i> | | | | | | | | | 0.046 |
| <i>Neopetrosia proxima</i> | | | | | | | | | 0.035 |
| <i>Prosuberites laughlini</i> | | | | | | | | | 0.028 |
| <i>Ectoplasia ferox</i> | 0.44 | | 0.44 | | | | | | 0.027 |
| <i>Smenospongia conulosa</i> | | | | 0.44 | | | | | 0.027 |
| <i>Agelas dispar</i> | | | | | | | | | 0.022 |
| <i>Plakortis</i> spp. | | | | | | | | | 0.018 |
| <i>Aplysina insularis</i> | | | | | | | | | 0.017 |
| <i>Aplysina lacunosa</i> | | | | | | | | | 0.017 |
| <i>Callyspongia plicifera</i> | | | | | | | | | 0.017 |
| <i>Erylus formosus</i> | | | | | | | | | 0.017 |
| <i>Cinachyrella kuekenthali</i> | | | | | | | | | 0.015 |
| <i>Aplysina fistularis</i> | | | | | | | | | 0.013 |

| | | | | | | | | | | | | |
|--|-------------|-------------|-------------|-------------|--------------|-------------|-------------|-------------|--|-------------|-------------|--------------|
| <i>Cliona delitrix</i> | | | | | | | | | | | | 0.013 |
| <i>Ircinia</i> spp. <i>brown</i> | | | 0.44 | | | | | | | | | 0.013 |
| <i>Ircinia strobilina</i> | | | | | 0.44 | | | | | | | 0.013 |
| <i>Spriastrella</i> <i>coccinea</i> | | | | | | | | | | | | 0.013 |
| <i>Verongula</i> <i>gigantea</i> | | | | | 0.44 | | | | | | | 0.013 |
| <i>Verongula rigida</i> | | | | | | | | | | | | 0.013 |
| <i>Cliona aprica</i> | | | | | | | | | | | | 0.011 |
| Total sponges | 1.78 | 3.56 | 1.78 | 5.33 | 11.57 | 6.22 | 4.57 | 1.11 | | 0.36 | 5.86 | 5.113 |

Appendix 4.

Percent substrate cover by sessile-benthic categories from stations/transects surveyed at the Patch Coral Reef Habitat in Lang Bank. 2012-13

| Substrate category | IW41 | DB19 | DB19 | DB18 | DB1 | DB1 | 844 | OW70 | 846 | DB20 | OW65 | LB4 | Mean |
|------------------------------|-------------|--------------|--------------|--------------|-------------|-------------|--------------|-----------|-----------|-------------|-------------|--------------|---------------|
| Abiotic | | | | | | | | | | | | | |
| Sand | 3 | 22.22 | 23.11 | 34.86 | 27.5 | 21.6 | 33.78 | 28 | 25.6 | 25 | 36.4 | 18.19 | 24.938 |
| Pavement | | | | | | | | 32.5 | 36.4 | | | | 5.742 |
| Rubble | 2 | 1.67 | 4.44 | 8.57 | 4.5 | 2.4 | 6.22 | 9.5 | 1.2 | 4.5 | | | 3.750 |
| Dead coral | | 3.12 | 0.89 | 1.72 | 2.5 | | 4.9 | | 4.8 | | | | 1.494 |
| Total abiotic | 32 | 36.1 | 28.45 | 45.15 | 34.5 | 24 | 44.9 | 70 | 68 | 29.5 | 36.4 | 18.19 | 38.933 |
| Rhodolith | | | | | | | | | | 2.5 | 8 | | 0.875 |
| Benthic algae | | | | | | | | | | | | | |
| <i>Lobophora variegata</i> | 24.5 | 49.78 | 35.56 | 45.71 | 47.5 | 43.2 | 36.89 | 1 | 16 | 6 | 34.8 | 22.28 | 30.268 |
| Turf | 0.5 | 0.89 | 12.89 | 2.29 | 5 | 11.6 | 5.33 | 3.5 | | 51 | 7.6 | 45.63 | 12.186 |
| Macroalgae | 19.5 | 6.22 | 7.11 | 1.71 | 4 | 5.2 | 0.44 | 1 | 0.4 | 1.5 | 4 | | 4.257 |
| <i>Dictyota</i> spp. | 9.5 | 0.44 | 2.22 | 0.57 | 0.5 | 1.6 | 3.11 | 0.5 | 1.6 | 3 | 0.4 | 0.5 | 1.995 |
| Crustose coralline algae | 1.5 | | | 0.57 | | | | | | | | 1.53 | 0.300 |
| <i>Styopodium</i> spp. | | | | | | | | | | 1.2 | | | 0.100 |
| <i>Halimeda</i> spp. | 1 | | | | | | | | | | | | 0.083 |
| Total benthic algae | 56.5 | 57.33 | 57.78 | 50.85 | 57 | 61.6 | 45.77 | 15 | 18 | 61.5 | 48 | 69.29 | 49.885 |
| | | | | | | | | | | | | | |
| Cyanobacteria | 1 | 1.33 | 1.78 | 1.14 | 0.5 | 1.2 | 2.22 | | | | | | 0.764 |
| Hard corals | | | | | | | | | | | | | |
| <i>Orbicella franksi</i> | 2 | 0.89 | | | 1 | 2 | | 0.5 | 0.4 | 0.5 | | 0.5 | 0.649 |
| <i>Porites astreoides</i> | | 0.44 | 0.44 | | | 1.2 | | 0.5 | 2.4 | | | 0.5 | 0.457 |
| <i>Agaricia lamarcki</i> | | 0.89 | 0.44 | | 1.5 | | | | | | | 0.5 | 0.278 |
| <i>Agaricia grahamae</i> | 1.5 | | | | 0.5 | | | | | | | 0.5 | 0.208 |
| <i>Siderastrea siderea</i> | | | | | | 0.4 | 0.44 | | 1.2 | | | | 0.170 |
| <i>Diploria strigosa</i> | 2 | | | | | | | | | | | | 0.167 |
| <i>Mycetophyllia aliciae</i> | | 0.44 | | | 1 | 0.4 | | | | | | | 0.153 |
| <i>Porites furcata</i> | | | 0.89 | | | | | 0.5 | | | | | 0.116 |

| | | | | | | | | | | | | | |
|-----------------------------------|-----|------|------|------|-----|-----|------|-----|-----|-----|-----|------|-------|
| <i>Montastraea cavernosa</i> | 0.5 | 0.44 | | | | | | | 0.4 | | | | 0.112 |
| <i>Millepora alcicornis</i> | | | | | | | 0.5 | 0.8 | | | | | 0.108 |
| Coral spp. | | | | 0.8 | | | | | | 0.4 | | | 0.100 |
| <i>Agaricia agaricites</i> | | | | | | | | 0.4 | | | 0.5 | | 0.075 |
| <i>Madracis decactis</i> | | | | | | | 0.5 | 0.4 | | | | | 0.075 |
| <i>Stephanocoenia intersepta</i> | | | 0.44 | | | | | | | | | | 0.037 |
| Total hard coral | 6 | 3.11 | 2.22 | | 4 | 4.8 | 0.44 | 2.5 | 6 | 0.5 | 0.4 | 2.5 | 2.706 |
| | | | | | | | | | | | | | |
| Octocoral | | | | | | | | | | | | | |
| <i>Eunicea</i> spp. | 1 | | 2.22 | | | 0.8 | 0.44 | | 0.8 | | | 0.53 | 0.483 |
| <i>Antillologorgia</i> spp. | | | 0.89 | | | 0.4 | | 0.5 | 0.8 | 0.5 | | | 0.258 |
| <i>Briareum</i> sp. | | | | | | | | | | | | 1 | 0.083 |
| <i>Pseudoplexaura</i> spp. | 0.5 | | | | | | | | | 0.5 | | | 0.083 |
| Total octocoral | 1.5 | | 3.11 | | | 1.2 | 0.44 | 0.5 | 1.6 | 1 | | 1.53 | 0.907 |
| | | | | | | | | | | | | | |
| Sponge | | | | | | | | | | | | | |
| <i>Xestospongia muta</i> | | 0.89 | 0.44 | | 3 | 1.2 | 0.44 | 3.5 | 0.4 | 1 | 2.4 | 1.5 | 1.231 |
| Unknown sponge | 0.5 | 0.44 | 0.89 | 0.57 | 0.5 | 1.2 | | 2 | 0.4 | 1 | 1.2 | 2.5 | 0.933 |
| <i>Verongula rigida</i> | | | 0.44 | 0.57 | | | 0.44 | 2 | 1.2 | | | | 0.388 |
| <i>Aplysina cauliformis</i> | | | | | | 1.2 | 0.89 | 0.5 | 1.6 | | 0.4 | | 0.383 |
| <i>Agelas conifera</i> | 0.5 | | | | | 0.8 | | | | | | 2 | 0.275 |
| <i>Agelas clathrodes</i> | | 0.44 | | | | 1.2 | 0.44 | 0.5 | | | | | 0.215 |
| <i>Neopetrosia proxima</i> | 0.5 | | | 0.57 | | | 0.44 | 0.5 | 0.4 | | | | 0.201 |
| <i>Geodia neptuni</i> | | | 0.44 | 1.14 | | | 0.44 | | | | | | 0.168 |
| <i>Ircinia</i> spp. brown | | | | | | | | 0.5 | 0.4 | | 0.8 | | 0.142 |
| <i>Aplysina fistularis</i> | | | | | | | 0.44 | | | 1 | | | 0.120 |
| <i>Aiolochoia crassa</i> | | | | | | | | | 0.4 | 0.5 | | 0.5 | 0.117 |
| <i>Aplysina lacunosa</i> | | | | | | | | 1 | 0.4 | | | | 0.117 |
| <i>Hyrtios cavernosus</i> | | | | | | 0.4 | | | | 1 | | | 0.117 |
| <i>Spheciospongia vesparium</i> | | | | | | 0.4 | | 1 | | | | | 0.117 |
| <i>Plakortis halichondrioides</i> | | | 0.44 | | | | | | 0.4 | | | 0.5 | 0.112 |
| <i>Chondrilla caribensis</i> | | | 1.33 | | | | | | | | | | 0.111 |

| | | | | | | | | | | | | | |
|-----------------------------------|----------|-------------|-------------|-------------|----------|------------|-------------|-----------|------------|----------|------------|------------|--------------|
| <i>Svenzea zeai</i> | | | | | | | 0.89 | | | | 0.4 | | 0.108 |
| <i>Prosuberites laughlini</i> | | 0.44 | | | | | 0.44 | | | | 0.4 | | 0.107 |
| <i>Agelas tubulata</i> | 0.5 | | | | 0.5 | | | | | | | | 0.083 |
| <i>Plakortis angulospiculatus</i> | 1 | | | | | | | | | | | | 0.083 |
| <i>Amphimedon compressa</i> | | 0.44 | | | | | | | | | | 0.5 | 0.078 |
| <i>Ircinia strobilina</i> | | | | | | | 0.44 | | | | | 0.5 | 0.078 |
| <i>Ircinia felix</i> | | | | | | | 0.89 | | | | | | 0.074 |
| Brown encrusting sponge | | | | | | 0.4 | | | 0.4 | | | | 0.067 |
| <i>Niphates digitalis</i> | | | | | | 0.4 | | | | | 0.4 | | 0.067 |
| <i>Cinachyrella kuekenthali</i> | | | | | | | | | | | | 0.5 | 0.042 |
| <i>Ircinia campana</i> | | | | | | | | | | 0.5 | | | 0.042 |
| <i>Spriastrella coccinea</i> | | | | | | | | 0.5 | | | | | 0.042 |
| <i>Agelas citrina</i> | | 0.44 | | | | | | | | | | | 0.037 |
| <i>Agelas dispar</i> | | 0.44 | | | | | | | | | | | 0.037 |
| <i>Clathria schoenus</i> | | 0.44 | | | | | | | | | | | 0.037 |
| <i>Verongula reisiwigi</i> | | 0.44 | | | | | | | | | | | 0.037 |
| <i>Cribrochalina vasculum</i> | | | | | | | | | 0.4 | | | | 0.033 |
| <i>Smenospongia conulosa</i> | | | | | | | | | | | 0.4 | | 0.033 |
| <i>Suberea</i> sp. | | | | | | | | | | | 0.4 | | 0.033 |
| <i>Verongula gigantea</i> | | | | | | | | | | | 0.4 | | 0.033 |
| Total sponges | 3 | 2.22 | 6.22 | 2.86 | 4 | 7.2 | 6.22 | 12 | 6.4 | 5 | 7.2 | 8.5 | 5.902 |

Appendix 5.

Percent substrate cover by sessile-benthic categories from stations/transects surveyed at the Spur and Groove Habitat in Lang Bank. 2012-13

| Substrate category | IW39 | IW40 | IW40 | Mean |
|----------------------|-------------|-------------|----------|------------|
| Abiotic | | | | |
| Sand | 7.43 | 1.47 | 0.5 | 3.13 |
| Dead coral | 0.14 | 2.53 | 1.5 | 1.39 |
| Rubble | | 0.53 | | 0.18 |
| Total abiotic | 7.57 | 4.52 | 2 | 4.7 |

| | | | | |
|----------------------------|--------------|--------------|-----------|--------------|
| Benthic algae | | | | |
| Turf | 19.2 | 48.77 | 55 | 40.99 |
| <i>Lobophora variegata</i> | 35.58 | 4.5 | 5.5 | 15.19 |
| Crustose coralline algae | 5.71 | 1.52 | 2 | 3.08 |
| <i>Dictyota</i> spp. | 2.86 | 3.5 | 2.5 | 2.95 |
| Macroalgae | 4.7 | 0.5 | 1 | 2.07 |
| Total benthic algae | 67.24 | 58.79 | 66 | 64.01 |

| | | | | |
|------------------------------|--------------|--------------|-------------|--------------|
| Hard corals | | | | |
| <i>Orbicella franksi</i> | 22.33 | 12.58 | 11.5 | 15.47 |
| <i>Porites furcata</i> | | 4.63 | 4 | 2.88 |
| <i>Colpophyllia natans</i> | | 4 | 3 | 2.33 |
| <i>Montastraea cavernosa</i> | | 1 | 1 | 0.67 |
| <i>Madracis decactis</i> | | 1 | 0.5 | 0.5 |
| <i>Siderastrea siderea</i> | | | 1.5 | 0.5 |
| <i>Porites astreoides</i> | | 1.28 | | 0.43 |
| <i>Mycetophyllia aliciae</i> | 0.57 | | | 0.19 |
| <i>Agaricia agaricites</i> | | | 0.5 | 0.17 |
| <i>Millepora alcicornis</i> | | | 0.5 | 0.17 |
| <i>Mycetophyllia ferox</i> | | 0.5 | | 0.17 |
| <i>Porites porites</i> | | 0.5 | | 0.17 |
| Total hard coral | 22.95 | 24.67 | 22.5 | 23.37 |

| | | | | |
|----------------------------|--|-------------|------------|-------------|
| Octocoral | | | | |
| <i>Plexaura</i> spp. | | 0.53 | 0.5 | 0.34 |
| <i>Eunicea</i> spp. | | | 0.5 | 0.17 |
| <i>Pseudoplexaura</i> spp. | | | 0.5 | 0.17 |
| Total octocoral | | 0.53 | 1.5 | 0.68 |

Sponge

| | | | | |
|----------------------------|-------------|-------------|----------|-------------|
| <i>Cliona caribbaea</i> | | 3 | 3.5 | 2.17 |
| <i>Clathria schoenus</i> | 0.57 | 3 | 1 | 1.52 |
| <i>Geodia neptuni</i> | 0.57 | 1.5 | | 0.69 |
| Unknown sponge | 1.14 | | 0.5 | 0.55 |
| <i>Agelas citrina</i> | | 0.5 | 1 | 0.5 |
| <i>Agelas tubulata</i> | | | 1 | 0.33 |
| <i>Neopetrosia proxima</i> | | 0.5 | 0.5 | 0.33 |
| <i>Petrosia pallasarca</i> | | 1 | | 0.33 |
| <i>Agelas clathrodes</i> | | 0.5 | | 0.17 |
| <i>Agelas dispar</i> | | 0.5 | | 0.17 |
| <i>Aiolochoira crassa</i> | | | 0.5 | 0.17 |
| <i>Plaktoris</i> spp. | | 0.5 | | 0.17 |
| <i>Scopalina ruetzleri</i> | | 0.5 | | 0.17 |
| Total sponges | 2.29 | 11.5 | 8 | 7.26 |

Appendix 6.

Percent substrate cover by sessile-benthic categories from stations/transects surveyed at the Colonized Rhodolith Reef Habitat in Lang Bank. 2012-13

| COLONIZED RHODOLITH REEF | | | | | | | | | | | |
|----------------------------------|--------------|-------------|--------------|-------------|--------------|--------------|--------------|-------------|-------------|--------------|--------------|
| Substrate category | DB1 | DB1 | OW68 | OW68 | OW76 | OW62 | OW66 | DB17 | LB9 | LB15 | Mean |
| Abiotic | | | | | | | | | | | |
| Sand | 34.65 | 28.5 | 3.95 | 0.89 | 46.86 | 21.78 | 24.36 | 23.6 | 34 | 39.27 | 25.79 |
| Rubble | 1.9 | 11 | | | 4 | 1.78 | | 0.8 | | | 1.95 |
| Pavement | | | | 2.22 | 2.29 | | | | | | 0.45 |
| Dead coral | 0.42 | | 0.57 | | 1.15 | | | | | | 0.21 |
| Total abiotic | 36.15 | 39.5 | 31.52 | 3.11 | 54.3 | 23.56 | 24.36 | 24.4 | 34 | 39.27 | 31.02 |
| Rhodolith | | | | | | 1.33 | 8 | 1.6 | 18 | 9.82 | 3.88 |
| Benthic algae | | | | | | | | | | | |
| <i>Lobophora variegata</i> | 45.27 | 33.5 | 43.1 | 76 | 3.29 | 29.78 | 29.45 | 45.6 | 36.5 | 34 | 37.65 |
| Turf | 1 | 4.5 | 1.14 | | 1.71 | 26.22 | 27.64 | 17.6 | 9 | 15.27 | 10.41 |
| <i>Dictyota</i> spp. | 6.2 | 9 | 12.19 | | 1.71 | 3.11 | 4.73 | 7.6 | 0.5 | | 4.5 |
| Macroalgae | 3.5 | 3 | 1.74 | | | 1.33 | 0.73 | | | | 1.03 |
| <i>Styopodium</i> spp. | | | | | | 7.11 | | | | | 0.71 |
| Crustose coralline algae | 1.52 | | | | 1.14 | | | | | | 0.27 |
| <i>Halimeda</i> spp. | 1.4 | 0.5 | | | | | | | | | 0.19 |
| Total benthic algae | 58.35 | 50.5 | 58.17 | 76 | 34.85 | 67.56 | 62.55 | 70.8 | 46 | 48.36 | 57.31 |
| | | | | | | | | | | | |
| Cyanobacteria | 2 | 3.5 | 2.88 | 0.44 | 0.57 | | | | | | 0.94 |
| Hard corals | | | | | | | | | | | |
| <i>Orbicella franksi</i> | | 0.5 | | 1.78 | 0.57 | | | 0.4 | | 0.36 | 0.36 |
| <i>Agaricia lamarcki</i> | | | 1.14 | | | | 0.36 | | | | 0.15 |
| <i>Stephanocoenia intersepta</i> | | | | 0.89 | | | | | 0.5 | | 0.14 |
| <i>Siderastrea siderea</i> | | | | | 1.14 | | | | | | 0.11 |
| <i>Madracis decactis</i> | | | | 0.89 | | | | | | | 0.09 |
| <i>Porites astreoides</i> | | | | 0.89 | | | | | | | 0.09 |
| <i>Agaricia grahamae</i> | | | | | 0.57 | | | | | | 0.06 |
| Coral spp. | | | | | 0.57 | | | | | | 0.06 |
| <i>Meandrina meandrites</i> | | 0.5 | | | | | | | | | 0.05 |
| <i>Diploria strigosa</i> | | | | 0.44 | | | | | | | 0.04 |
| Total hard coral | 1 | 1.14 | 4.89 | 2.86 | 0.36 | 0.4 | 0.5 | 0.36 | 0.36 | 0.36 | 1.15 |
| | | | | | | | | | | | |
| Octocoral | | | | | | | | | | | |

| | | | | | | | | | | | |
|-----------------------------------|------------|------------|-------------|--------------|-------------|-------------|-------------|------------|------------|-------------|-------------|
| <i>Eunicea</i> spp. | | | 0.57 | 1.78 | | 0.44 | | | | | 0.28 |
| <i>Erythropodium caribaeorum</i> | | | | | 0.57 | | | | | | 0.06 |
| <i>Pseudoplexaura</i> spp. | | | | | | 0.44 | | | | | 0.04 |
| <i>Plexaura</i> spp. | | | | | | | 0.36 | | | | 0.04 |
| Total octocoral | | | 0.57 | 1.78 | 0.57 | 0.89 | 0.36 | | | | 0.42 |
| Sponge | | | | | | | | | | | |
| <i>Xestospongia muta</i> | | 0.5 | 1.14 | 1.78 | 1.14 | 2.22 | 2.18 | | | | 0.9 |
| <i>Geodia neptuni</i> | 0.5 | 0.5 | | 0.44 | | | | 1.6 | 1 | | 0.4 |
| Unknown sponge | 0.5 | | 0.57 | 0.44 | | 1.33 | | 0.8 | | | 0.36 |
| <i>Aplysina cauliformis</i> | | 0.5 | | | 1.14 | 1.33 | 0.36 | | | | 0.33 |
| <i>Aplysina fistularis</i> | | 1 | | 0.89 | | 0.44 | | | | 0.73 | 0.31 |
| <i>Prosuberites laughlini</i> | 1 | 0.5 | 0.57 | 0.89 | | | | | | | 0.3 |
| <i>Plakortis angulospiculatus</i> | 0.5 | 0.5 | 0.57 | | 0.57 | 0.44 | | | | | 0.26 |
| <i>Spriastrella coccinea</i> | | | | 1.33 | 0.57 | | | | | 0.36 | 0.23 |
| <i>Neopetrosia proxima</i> | | | | 2.22 | | | | | | | 0.22 |
| <i>Agelas conifera</i> | | | | 0.89 | | 0.44 | 0.36 | | 0.5 | | 0.22 |
| <i>Plakortis halichondrioides</i> | 0.5 | | | 0.44 | 0.57 | | 0.36 | | | | 0.19 |
| <i>Aiolochoira crassa</i> | | | 1.14 | | | | | | | 0.73 | 0.19 |
| <i>Ptilocaulis walpersi</i> | | | | 1.78 | | | | | | | 0.18 |
| <i>Hyrtios cavernosus</i> | | 0.5 | | | 1.14 | | | | | | 0.16 |
| <i>Verongula rigida</i> | 0.5 | | | | 1.14 | | | | | | 0.16 |
| <i>Erylus formosus</i> | | | 0.57 | 0.89 | | | | | | | 0.15 |
| <i>Ircinia strobilina</i> | | 0.5 | | | 0.57 | | | | | | 0.11 |
| <i>Verongula gigantea</i> | | | 0.57 | | | | 0.36 | | | | 0.09 |
| <i>Scopalina ruetzleri</i> | | | | | | | 0.36 | 0.4 | | | 0.08 |
| <i>Smenospongia conulosa</i> | | | 0.57 | | | | | | | | 0.06 |
| <i>Clathria schoenus</i> | | 0.5 | | | | | | | | | 0.05 |
| <i>Niphates digitalis</i> | | 0.5 | | | | | | | | | 0.05 |
| <i>Cinachyrella kuekenthali</i> | | | | 0.44 | | | | | | | 0.04 |
| <i>Cliona caribbaea</i> | | | | 0.44 | | | | | | | 0.04 |
| <i>Cliona delitrix</i> | | | | 0.44 | | | | | | | 0.04 |
| <i>Ircinia</i> spp. brown | | | | | | 0.44 | | | | | 0.04 |
| <i>Plakortis</i> spp. | | | | 0.44 | | | | | | | 0.04 |
| <i>Aplysina lacunosa</i> | | | | | | | | | | 0.36 | 0.04 |
| <i>Topsentia ophiraphidites</i> | | | | | | | 0.36 | | | | 0.04 |
| Total sponges | 3.5 | 5.5 | 5.71 | 13.78 | 6.86 | 6.67 | 4.36 | 2.8 | 1.5 | 2.18 | 5.29 |

Appendix 7

Results from Analysis of Similarities (ANOSIM) one-way analysis comparing the structure of fish communities among habitats. CPV= colonized pavement, BCR= bank coral reef, PRF= patch coral reef, SAG= spur and groove, and CRR= rhodolith reef.

Global Test

Sample statistic (Global R): 0.301

Significance level of sample statistic: 0.1%

Number of permutations: 999 (Random sample from a large number)

Number of permuted statistics greater than or equal to Global R: 0

Pairwise Tests

| Groups | R Statistic | Significance Level % | Possible Permutations | Actual Permutations | Number >= Observed |
|----------|----------------|-------------------------|--------------------------|------------------------|-----------------------|
| BCR, CPV | 0.319 | 0.1 | Very large | 999 | 0 |
| BCR, PRF | 0.545 | 0.1 | Very large | 999 | 0 |
| BCR, CRR | 0.594 | 0.1 | Very large | 999 | 0 |
| BCR, SAG | 0.071 | 30.7 | 7770 | 999 | 306 |
| CPV, PRF | -0.016 | 55.2 | 854992152 | 999 | 551 |
| CPV, CRR | 0.102 | 12.1 | 254186856 | 999 | 120 |
| CPV, SAG | 0.088 | 29.2 | 3654 | 999 | 291 |
| PRF, CRR | 0.019 | 34.1 | 352716 | 999 | 340 |
| PRF, SAG | 0.437 | 2.7 | 364 | 364 | 10 |
| CRR, SAG | 0.232 | 14.7 | 286 | 286 | 42 |

Group BCR

Average similarity: 31.37

| Species | Av.Abund | Av.Sim | Sim/SD | Contrib% | Cum.% |
|--------------------------|----------|--------|--------|----------|-------|
| Stegastes partitus | 6.65 | 4.82 | 1.82 | 15.37 | 15.37 |
| Chromis cyanea | 6.34 | 4.33 | 1.57 | 13.81 | 29.17 |
| Halichoeres garnoti | 6.54 | 4.27 | 1.43 | 13.61 | 42.78 |
| Scarus taeniopterus | 5.46 | 3.39 | 1.26 | 10.81 | 53.58 |
| Sparisoma aurofrenatum | 4.60 | 2.11 | 0.71 | 6.72 | 60.31 |
| Thalassoma bifasciatum | 4.16 | 1.96 | 0.83 | 6.24 | 66.54 |
| Hypoplectrus puella | 4.65 | 1.23 | 0.35 | 3.94 | 70.48 |
| Chaetodon capistratus | 3.75 | 0.87 | 0.35 | 2.78 | 73.26 |
| Epinephelus cruentatus | 2.76 | 0.65 | 0.32 | 2.08 | 75.34 |
| Coryphopterus personatus | 2.76 | 0.65 | 0.34 | 2.06 | 77.41 |
| Epinephelus guttatus | 2.53 | 0.64 | 0.32 | 2.06 | 79.46 |
| Acanthurus coeruleus | 2.16 | 0.60 | 0.39 | 1.91 | 81.37 |
| Coryphopterus lipernes | 2.50 | 0.59 | 0.34 | 1.89 | 83.26 |
| Hypoplectrus chlorurus | 2.93 | 0.47 | 0.22 | 1.49 | 84.74 |
| Holocentrus rufus | 2.11 | 0.46 | 0.26 | 1.46 | 86.20 |
| Acanthurus chirurgus | 1.68 | 0.45 | 0.36 | 1.43 | 87.63 |
| Myripristis jacobus | 2.04 | 0.39 | 0.25 | 1.24 | 88.87 |
| Gramma loreto | 1.80 | 0.37 | 0.28 | 1.18 | 90.05 |

Group CPV

Average similarity: 28.35

| Species | Av.Abund | Av.Sim | Sim/SD | Contrib% | Cum.% |
|------------------------|----------|--------|--------|----------|-------|
| Stegastes partitus | 11.90 | 8.24 | 2.16 | 29.07 | 29.07 |
| Thalassoma bifasciatum | 11.25 | 5.74 | 0.92 | 20.25 | 49.32 |
| Halichoeres garnoti | 8.79 | 4.21 | 0.77 | 14.87 | 64.18 |

| | | | | | |
|------------------------|------|------|------|------|-------|
| Epinephelus fulva | 5.64 | 2.26 | 0.58 | 7.96 | 72.15 |
| Chromis cyanea | 4.71 | 1.74 | 0.57 | 6.15 | 78.30 |
| Holocentrus rufus | 6.31 | 0.99 | 0.23 | 3.50 | 81.80 |
| Sparisoma aurofrenatum | 3.00 | 0.87 | 0.38 | 3.06 | 84.86 |
| Acanthurus chirurgus | 2.80 | 0.75 | 0.34 | 2.65 | 87.51 |
| Acanthurus coeruleus | 2.36 | 0.56 | 0.33 | 1.97 | 89.48 |
| Scarus taeniopterus | 2.17 | 0.52 | 0.33 | 1.85 | 91.33 |

Group PRF

Average similarity: 31.36

| Species | Av.Abund | Av.Sim | Sim/SD | Contrib% | Cum.% |
|-------------------------|----------|--------|--------|----------|-------|
| Stegastes partitus | 11.85 | 9.32 | 1.96 | 29.71 | 29.71 |
| Halichoeres garnoti | 10.77 | 6.55 | 1.51 | 20.88 | 50.59 |
| Thalassoma bifasciatum | 8.10 | 4.05 | 0.89 | 12.93 | 63.51 |
| Epinephelus guttatus | 6.73 | 1.78 | 0.46 | 5.69 | 69.20 |
| Balistes vetula | 5.15 | 1.75 | 0.59 | 5.58 | 74.78 |
| Serranus tigrinus | 4.80 | 1.61 | 0.46 | 5.15 | 79.93 |
| Epinephelus fulva | 4.24 | 1.51 | 0.46 | 4.82 | 84.75 |
| Xanthichthys ringens | 5.28 | 0.89 | 0.23 | 2.84 | 87.59 |
| Haemulon melanorum | 2.85 | 0.71 | 0.33 | 2.27 | 89.86 |
| Halichoeres maculipinna | 3.97 | 0.60 | 0.24 | 1.90 | 91.76 |

Group CRR

Average similarity: 26.13

| Species | Av.Abund | Av.Sim | Sim/SD | Contrib% | Cum.% |
|------------------------|----------|--------|--------|----------|-------|
| Stegastes partitus | 15.44 | 13.16 | 3.32 | 50.35 | 50.35 |
| Halichoeres garnoti | 9.33 | 5.39 | 0.91 | 20.63 | 70.99 |
| Thalassoma bifasciatum | 5.76 | 1.84 | 0.49 | 7.03 | 78.02 |
| Chromis cyanea | 4.59 | 1.59 | 0.49 | 6.10 | 84.11 |
| Centropyge argi | 5.34 | 0.99 | 0.25 | 3.78 | 87.90 |
| Epinephelus fulva | 4.42 | 0.64 | 0.25 | 2.47 | 90.36 |

Group SAG

Average similarity: 30.32

| Species | Av.Abund | Av.Sim | Sim/SD | Contrib% | Cum.% |
|------------------------|----------|--------|--------|----------|-------|
| Chromis cyanea | 10.54 | 6.89 | 1.52 | 22.73 | 22.73 |
| Stegastes partitus | 7.04 | 6.46 | 7.45 | 21.31 | 44.05 |
| Sparisoma aurofrenatum | 8.16 | 6.15 | 14.92 | 20.29 | 64.34 |
| Scarus taeniopterus | 5.35 | 3.93 | 3.48 | 12.97 | 77.31 |
| Halichoeres garnoti | 6.18 | 2.90 | 0.58 | 9.55 | 86.86 |
| Thalassoma bifasciatum | 6.30 | 2.21 | 0.58 | 7.30 | 94.16 |

Groups BCR & CPV

Average dissimilarity = 76.22

| Species | Group BCR | Group CPV | Av.Diss | Diss/SD | Contrib% | Cum.% |
|------------------------|-----------|-----------|---------|---------|----------|-------|
| | Av.Abund | Av.Abund | | | | |
| Thalassoma bifasciatum | 4.16 | 11.25 | 4.82 | 1.14 | 6.33 | 6.33 |
| Halichoeres garnoti | 6.54 | 8.79 | 3.68 | 1.36 | 4.83 | 11.16 |
| Holocentrus rufus | 2.11 | 6.31 | 3.60 | 0.62 | 4.72 | 15.89 |
| Stegastes partitus | 6.65 | 11.90 | 3.32 | 1.03 | 4.36 | 20.24 |
| Epinephelus fulva | 1.46 | 5.64 | 2.84 | 1.02 | 3.72 | 23.96 |
| Chromis cyanea | 6.34 | 4.71 | 2.73 | 1.45 | 3.58 | 27.54 |
| Scarus taeniopterus | 5.46 | 2.17 | 2.40 | 1.30 | 3.15 | 30.69 |
| Sparisoma aurofrenatum | 4.60 | 3.00 | 2.37 | 1.19 | 3.11 | 33.80 |
| Hypoplectrus puella | 4.65 | 0.00 | 2.33 | 0.68 | 3.05 | 36.85 |
| Chaetodon capistratus | 3.75 | 0.92 | 2.05 | 0.67 | 2.69 | 39.54 |
| Epinephelus guttatus | 2.53 | 2.42 | 1.84 | 0.88 | 2.42 | 41.96 |
| Gobiosoma evelynae | 2.07 | 2.09 | 1.76 | 0.64 | 2.31 | 44.26 |

| | | | | | | |
|---------------------------|------|------|------|------|------|-------|
| Acanthurus chirurgus | 1.68 | 2.80 | 1.68 | 0.95 | 2.20 | 46.46 |
| Acanthurus coeruleus | 2.16 | 2.36 | 1.64 | 0.93 | 2.15 | 48.61 |
| Serranus tigrinus | 0.83 | 2.59 | 1.61 | 0.37 | 2.12 | 50.73 |
| Hypoplectrus chlorurus | 2.93 | 0.00 | 1.46 | 0.50 | 1.92 | 52.64 |
| Epinephelus cruentatus | 2.76 | 0.21 | 1.42 | 0.65 | 1.86 | 54.50 |
| Coryphopterus personatus | 2.76 | 0.17 | 1.41 | 0.64 | 1.85 | 56.35 |
| Centropyge argi | 0.10 | 2.69 | 1.38 | 0.37 | 1.81 | 58.15 |
| Pterois volitans | 1.21 | 1.84 | 1.34 | 0.56 | 1.76 | 59.92 |
| Haemulon melanorum | 0.20 | 2.48 | 1.28 | 0.59 | 1.69 | 61.60 |
| Coryphopterus lipernes | 2.50 | 0.15 | 1.27 | 0.64 | 1.67 | 63.27 |
| Acanthurus bahianus | 1.83 | 0.90 | 1.23 | 0.61 | 1.61 | 64.88 |
| Chaetodon aculeatus | 1.69 | 0.91 | 1.19 | 0.51 | 1.56 | 66.44 |
| Canthigaster rostrata | 1.88 | 0.60 | 1.11 | 0.60 | 1.46 | 67.90 |
| Sparisoma viride | 1.58 | 0.74 | 1.10 | 0.48 | 1.44 | 69.34 |
| Myripristis jacobus | 2.04 | 0.00 | 1.02 | 0.55 | 1.34 | 70.68 |
| Grama loreto | 1.80 | 0.31 | 0.99 | 0.61 | 1.30 | 71.98 |
| Clepticus parrae | 1.57 | 0.44 | 0.95 | 0.57 | 1.24 | 73.22 |
| Sphyraena barracuda | 0.79 | 1.18 | 0.93 | 0.36 | 1.23 | 74.44 |
| Holacanthus tricolor | 1.52 | 0.36 | 0.89 | 0.45 | 1.17 | 75.62 |
| Scarus iserti | 0.82 | 1.11 | 0.89 | 0.44 | 1.16 | 76.78 |
| Chaetodon sedentarius | 0.00 | 1.71 | 0.85 | 0.33 | 1.12 | 77.90 |
| Chromis insolata | 0.00 | 1.67 | 0.83 | 0.28 | 1.10 | 78.99 |
| Balistes vetula | 0.36 | 1.43 | 0.83 | 0.46 | 1.08 | 80.08 |
| Haemulon flavolineatum | 0.81 | 0.83 | 0.75 | 0.50 | 0.99 | 81.07 |
| Lutjanus analis | 0.76 | 0.66 | 0.65 | 0.46 | 0.85 | 81.92 |
| Ginglymostoma cirratum | 0.29 | 1.05 | 0.65 | 0.32 | 0.85 | 82.77 |
| Bodianus rufus | 1.27 | 0.00 | 0.64 | 0.39 | 0.83 | 83.61 |
| Caranx ruber | 0.00 | 1.24 | 0.62 | 0.23 | 0.82 | 84.42 |
| Xanthichthys ringens | 0.00 | 1.24 | 0.62 | 0.29 | 0.81 | 85.23 |
| Amblycirrhitus pinos | 0.00 | 1.23 | 0.62 | 0.26 | 0.81 | 86.04 |
| Lutjanus apodus | 1.19 | 0.00 | 0.60 | 0.36 | 0.78 | 86.82 |
| Chaetodon striatus | 0.46 | 0.68 | 0.55 | 0.26 | 0.73 | 87.55 |
| Sparisoma radians | 0.44 | 0.71 | 0.54 | 0.37 | 0.71 | 88.26 |
| Lachnolaimus maximus | 0.00 | 1.05 | 0.53 | 0.29 | 0.69 | 88.95 |
| Holacanthus ciliaris | 1.00 | 0.00 | 0.50 | 0.31 | 0.65 | 89.61 |
| Mulloidichthys martinicus | 0.86 | 0.00 | 0.43 | 0.37 | 0.56 | 90.17 |

Groups BCR & PRF

Average dissimilarity = 78.97

| Species | Group BCR | Group PRF | Av.Diss | Diss/SD | | |
|-------------------------|----------------------|-------------------|---------|---------|------|-------|
| | Av.Abund Contrib% | Av.Abund Cum.% | | | | |
| Epinephelus guttatus | 2.53 | 6.73 | 3.51 | 0.85 | 4.45 | 4.45 |
| Halichoeres garnoti | 6.54 | 10.77 | 3.46 | 1.16 | 4.38 | 8.83 |
| Thalassoma bifasciatum | 4.16 | 8.10 | 3.43 | 1.30 | 4.34 | 13.16 |
| Stegastes partitus | 6.65 | 11.85 | 3.29 | 1.74 | 4.16 | 17.33 |
| Xanthichthys ringens | 0.00 | 5.28 | 2.64 | 0.60 | 3.34 | 20.67 |
| Chromis cyanea | 6.34 | 1.72 | 2.60 | 1.48 | 3.30 | 23.97 |
| Balistes vetula | 0.36 | 5.15 | 2.56 | 0.86 | 3.24 | 27.21 |
| Serranus tigrinus | 0.83 | 4.80 | 2.46 | 0.91 | 3.12 | 30.33 |
| Scarus taeniopterus | 5.46 | 1.54 | 2.37 | 1.27 | 3.00 | 33.33 |
| Hypoplectrus puella | 4.65 | 0.00 | 2.33 | 0.68 | 2.95 | 36.27 |
| Sparisoma aurofrenatum | 4.60 | 0.00 | 2.30 | 1.05 | 2.91 | 39.18 |
| Epinephelus fulva | 1.46 | 4.24 | 2.24 | 1.00 | 2.84 | 42.02 |
| Halichoeres maculipinna | 0.00 | 3.97 | 1.98 | 0.57 | 2.51 | 44.53 |
| Chaetodon capistratus | 3.75 | 0.00 | 1.88 | 0.60 | 2.37 | 46.91 |
| Centropyge argi | 0.10 | 3.34 | 1.69 | 0.51 | 2.14 | 49.05 |
| Pterois volitans | 1.21 | 2.71 | 1.67 | 0.66 | 2.11 | 51.17 |
| Holocentrus rufus | 2.11 | 2.28 | 1.65 | 0.83 | 2.08 | 53.25 |
| Epinephelus cruentatus | 2.76 | 0.97 | 1.63 | 0.70 | 2.07 | 55.32 |
| Acanthurus coeruleus | 2.16 | 1.46 | 1.61 | 0.70 | 2.04 | 57.36 |

| | | | | | | |
|-----------------------------|------|------|------|------|------|-------|
| Hypoplectrus chlorurus | 2.93 | 0.00 | 1.46 | 0.50 | 1.85 | 59.21 |
| Haemulon melanorum | 0.20 | 2.85 | 1.45 | 0.76 | 1.84 | 61.05 |
| Acanthurus chirurgus | 1.68 | 1.82 | 1.44 | 0.80 | 1.83 | 62.88 |
| Coryphopterus personatus | 2.76 | 0.00 | 1.38 | 0.62 | 1.74 | 64.62 |
| Acanthurus bahianus | 1.83 | 1.18 | 1.34 | 0.62 | 1.69 | 66.31 |
| Coryphopterus lipernes | 2.50 | 0.00 | 1.25 | 0.62 | 1.58 | 67.90 |
| Canthigaster rostrata | 1.88 | 0.74 | 1.16 | 0.61 | 1.47 | 69.36 |
| Lachnolaimus maximus | 0.00 | 2.26 | 1.13 | 0.47 | 1.43 | 70.80 |
| Mycteroperca venenosa | 0.00 | 2.26 | 1.13 | 0.47 | 1.43 | 72.23 |
| Pomacanthus arcuatus | 0.35 | 1.86 | 1.07 | 0.36 | 1.36 | 73.59 |
| Gobiosoma evelynae | 2.07 | 0.00 | 1.04 | 0.48 | 1.31 | 74.90 |
| Myripristis jacobus | 2.04 | 0.00 | 1.02 | 0.55 | 1.29 | 76.20 |
| Paranthias furcifer | 0.46 | 1.68 | 0.99 | 0.55 | 1.25 | 77.44 |
| Chromis multilineata | 0.40 | 1.54 | 0.93 | 0.36 | 1.18 | 78.63 |
| Grama loreto | 1.80 | 0.00 | 0.90 | 0.58 | 1.14 | 79.76 |
| Chaetodon aculeatus | 1.69 | 0.00 | 0.84 | 0.44 | 1.07 | 80.83 |
| Sparisoma viride | 1.58 | 0.00 | 0.79 | 0.47 | 1.00 | 81.83 |
| Clepticus parrae | 1.57 | 0.00 | 0.78 | 0.53 | 0.99 | 82.82 |
| Lutjanus analis | 0.76 | 0.92 | 0.77 | 0.47 | 0.98 | 83.80 |
| Amblycirrhitis pinos | 0.00 | 1.54 | 0.77 | 0.32 | 0.97 | 84.78 |
| Holacanthus tricolor | 1.52 | 0.00 | 0.76 | 0.40 | 0.96 | 85.74 |
| Pomacanthus paru | 0.83 | 0.74 | 0.71 | 0.47 | 0.90 | 86.64 |
| Ginglymostoma cirratum | 0.29 | 1.14 | 0.69 | 0.36 | 0.87 | 87.51 |
| Coryphopterus glaucophaenum | 0.00 | 1.34 | 0.67 | 0.32 | 0.85 | 88.36 |
| Bodianus rufus | 1.27 | 0.00 | 0.64 | 0.39 | 0.81 | 89.17 |
| Lutjanus apodus | 1.19 | 0.00 | 0.60 | 0.36 | 0.75 | 89.92 |
| Serranus tabacarius | 0.25 | 0.97 | 0.59 | 0.36 | 0.74 | 90.66 |

Groups CPV & PRF

Average dissimilarity = 71.23

| Species | Group CPV Av.Abund Contrib% | Group PRF Av.Abund Cum. % | Av.Diss | Diss/SD | | |
|-------------------------|-----------------------------------|---------------------------------|---------|---------|------|-------|
| Thalassoma bifasciatum | 11.25 | 8.10 | 4.68 | 1.18 | 6.57 | 6.57 |
| Halichoeres garnoti | 8.79 | 10.77 | 4.31 | 1.31 | 6.06 | 12.63 |
| Holocentrus rufus | 6.31 | 2.28 | 3.64 | 0.63 | 5.11 | 17.74 |
| Epinephelus guttatus | 2.42 | 6.73 | 3.52 | 0.84 | 4.94 | 22.68 |
| Serranus tigrinus | 2.59 | 4.80 | 3.16 | 0.75 | 4.44 | 27.12 |
| Stegastes partitus | 11.90 | 11.85 | 3.12 | 1.14 | 4.38 | 31.49 |
| Epinephelus fulva | 5.64 | 4.24 | 2.95 | 1.17 | 4.14 | 35.63 |
| Xanthichthys ringens | 1.24 | 5.28 | 2.93 | 0.66 | 4.12 | 39.75 |
| Balistes vetula | 1.43 | 5.15 | 2.69 | 0.90 | 3.77 | 43.53 |
| Centropyge argi | 2.69 | 3.34 | 2.63 | 0.61 | 3.69 | 47.22 |
| Chromis cyanea | 4.71 | 1.72 | 2.34 | 1.01 | 3.28 | 50.50 |
| Halichoeres maculipinna | 0.57 | 3.97 | 2.11 | 0.63 | 2.97 | 53.47 |
| Haemulon melanorum | 2.48 | 2.85 | 1.98 | 0.89 | 2.78 | 56.24 |
| Pterois volitans | 1.84 | 2.71 | 1.94 | 0.65 | 2.73 | 58.97 |
| Acanthurus chirurgus | 2.80 | 1.82 | 1.82 | 0.83 | 2.55 | 61.52 |
| Acanthurus coeruleus | 2.36 | 1.46 | 1.69 | 0.69 | 2.38 | 63.90 |
| Sparisoma aurofrenatum | 3.00 | 0.00 | 1.50 | 0.73 | 2.11 | 66.01 |
| Lachnolaimus maximus | 1.05 | 2.26 | 1.49 | 0.55 | 2.09 | 68.09 |
| Scarus taeniopterus | 2.17 | 1.54 | 1.39 | 0.86 | 1.95 | 70.04 |
| Chromis insolata | 1.67 | 1.13 | 1.31 | 0.41 | 1.84 | 71.88 |
| Amblycirrhitis pinos | 1.23 | 1.54 | 1.30 | 0.41 | 1.82 | 73.70 |
| Mycteroperca venenosa | 0.00 | 2.26 | 1.13 | 0.47 | 1.59 | 75.29 |
| Pomacanthus arcuatus | 0.43 | 1.86 | 1.11 | 0.37 | 1.55 | 76.84 |
| Gobiosoma evelynae | 2.09 | 0.00 | 1.05 | 0.43 | 1.47 | 78.31 |
| Ginglymostoma cirratum | 1.05 | 1.14 | 1.02 | 0.42 | 1.43 | 79.74 |
| Paranthias furcifer | 0.37 | 1.68 | 0.96 | 0.54 | 1.35 | 81.08 |
| Acanthurus bahianus | 0.90 | 1.18 | 0.95 | 0.43 | 1.34 | 82.43 |
| Chaetodon sedentarius | 1.71 | 0.00 | 0.85 | 0.33 | 1.20 | 83.62 |

| | | | | | | |
|-----------------------------|------|------|------|------|------|-------|
| Coryphopterus glaucophaenum | 0.41 | 1.34 | 0.84 | 0.37 | 1.18 | 84.80 |
| Chromis multilineata | 0.00 | 1.54 | 0.77 | 0.32 | 1.08 | 85.88 |
| Lutjanus analis | 0.66 | 0.92 | 0.73 | 0.43 | 1.02 | 86.90 |
| Caranx ruber | 1.24 | 0.00 | 0.62 | 0.23 | 0.87 | 87.78 |
| Canthigaster rostrata | 0.60 | 0.74 | 0.61 | 0.43 | 0.86 | 88.64 |
| Sphyræna barracuda | 1.18 | 0.00 | 0.59 | 0.27 | 0.83 | 89.47 |
| Epinephelus cruentatus | 0.21 | 0.97 | 0.57 | 0.36 | 0.80 | 90.27 |

Groups BCR & CRR

Average dissimilarity = 80.78

| Species | Group BCR Av.Abund Contrib% | Group CRR Av.Abund Cum.% | Av.Diss | Diss/SD | | |
|-----------------------------|-----------------------------------|--------------------------------|---------|---------|------|-------|
| Stegastes partitus | 6.65 | 15.44 | 4.49 | 1.93 | 5.56 | 5.56 |
| Halichoeres garnoti | 6.54 | 9.33 | 3.48 | 1.63 | 4.31 | 9.87 |
| Thalassoma bifasciatum | 4.16 | 5.76 | 3.08 | 1.23 | 3.81 | 13.68 |
| Chromis cyanea | 6.34 | 4.59 | 2.69 | 1.57 | 3.33 | 17.01 |
| Centropyge argi | 0.10 | 5.34 | 2.69 | 0.64 | 3.33 | 20.35 |
| Epinephelus fulva | 1.46 | 4.42 | 2.52 | 0.71 | 3.12 | 23.47 |
| Scarus taeniopterus | 5.46 | 1.11 | 2.52 | 1.35 | 3.12 | 26.59 |
| Serranus tabacarius | 0.25 | 4.67 | 2.41 | 0.51 | 2.98 | 29.57 |
| Hypoplectrus puella | 4.65 | 0.00 | 2.33 | 0.68 | 2.88 | 32.45 |
| Sparisoma aurofrenatum | 4.60 | 0.49 | 2.25 | 1.07 | 2.79 | 35.24 |
| Pomacanthus paru | 0.83 | 3.74 | 2.12 | 0.57 | 2.62 | 37.86 |
| Epinephelus guttatus | 2.53 | 1.78 | 1.91 | 0.70 | 2.36 | 40.22 |
| Chaetodon capistratus | 3.75 | 0.00 | 1.88 | 0.60 | 2.32 | 42.54 |
| Pomacanthus arcuatus | 0.35 | 3.53 | 1.87 | 0.52 | 2.32 | 44.86 |
| Serranus tortugarum | 0.24 | 3.36 | 1.75 | 0.51 | 2.17 | 47.02 |
| Lutjanus buccanella | 0.00 | 3.42 | 1.71 | 0.49 | 2.12 | 49.14 |
| Holocentrus rufus | 2.11 | 2.05 | 1.66 | 0.77 | 2.06 | 51.20 |
| Coryphopterus glaucophaenum | 0.00 | 3.15 | 1.57 | 0.33 | 1.95 | 53.15 |
| Malacanthus plumieri | 0.24 | 2.92 | 1.55 | 0.36 | 1.92 | 55.07 |
| Lutjanus analis | 0.76 | 2.62 | 1.54 | 0.60 | 1.90 | 56.98 |
| Acanthurus chirurgus | 1.68 | 1.68 | 1.51 | 0.64 | 1.87 | 58.85 |
| Hypoplectrus chlorurus | 2.93 | 0.00 | 1.46 | 0.50 | 1.81 | 60.66 |
| Epinephelus cruentatus | 2.76 | 0.00 | 1.38 | 0.62 | 1.71 | 62.37 |
| Haemulon melanorum | 0.20 | 2.63 | 1.38 | 0.47 | 1.71 | 64.07 |
| Coryphopterus personatus | 2.76 | 0.00 | 1.38 | 0.62 | 1.71 | 65.78 |
| Chromis insolata | 0.00 | 2.63 | 1.31 | 0.45 | 1.63 | 67.41 |
| Grama loreto | 1.80 | 1.15 | 1.29 | 0.66 | 1.60 | 69.00 |
| Coryphopterus lipernes | 2.50 | 0.00 | 1.25 | 0.62 | 1.55 | 70.55 |
| Acanthurus bahianus | 1.83 | 0.98 | 1.24 | 0.64 | 1.53 | 72.08 |
| Gobiosoma evelynae | 2.07 | 0.56 | 1.19 | 0.56 | 1.48 | 73.56 |
| Balistes vetula | 0.36 | 1.93 | 1.11 | 0.39 | 1.37 | 74.93 |
| Holocentrus adscensionis | 0.00 | 2.17 | 1.08 | 0.33 | 1.34 | 76.27 |
| Acanthurus coeruleus | 2.16 | 0.00 | 1.08 | 0.69 | 1.34 | 77.61 |
| Elagatis bipinnulata | 0.00 | 2.09 | 1.05 | 0.33 | 1.29 | 78.90 |
| Myripristis jacobus | 2.04 | 0.00 | 1.02 | 0.55 | 1.26 | 80.17 |
| Serranus tigrinus | 0.83 | 1.37 | 1.01 | 0.45 | 1.26 | 81.42 |
| Canthigaster rostrata | 1.88 | 0.00 | 0.94 | 0.53 | 1.16 | 82.59 |
| Chaetodon aculeatus | 1.69 | 0.00 | 0.84 | 0.44 | 1.04 | 83.63 |
| Sparisoma viride | 1.58 | 0.00 | 0.79 | 0.47 | 0.98 | 84.61 |
| Clepticus parrae | 1.57 | 0.00 | 0.78 | 0.53 | 0.97 | 85.58 |
| Holacanthus tricolor | 1.52 | 0.00 | 0.76 | 0.40 | 0.94 | 86.52 |
| Paranthias furcifer | 0.46 | 1.15 | 0.76 | 0.43 | 0.94 | 87.46 |
| Seriola rivoliana | 0.37 | 1.15 | 0.72 | 0.38 | 0.89 | 88.35 |
| Xanthichthys ringens | 0.00 | 1.44 | 0.72 | 0.33 | 0.89 | 89.25 |
| Halichoeres maculipinna | 0.00 | 1.36 | 0.68 | 0.33 | 0.84 | 90.09 |

Groups CPV & CRR

Average dissimilarity = 74.16

| Species | Group CPV Av.Abund Contrib% | Group CRR Av.Abund Cum.% | Av.Diss | Diss/SD | | |
|-----------------------------|-----------------------------------|--------------------------------|---------|---------|------|-------|
| Thalassoma bifasciatum | 11.25 | 5.76 | 4.94 | 1.15 | 6.66 | 6.66 |
| Halichoeres garnoti | 8.79 | 9.33 | 4.11 | 1.30 | 5.54 | 12.20 |
| Holocentrus rufus | 6.31 | 2.05 | 3.64 | 0.62 | 4.91 | 17.11 |
| Stegastes partitus | 11.90 | 15.44 | 3.60 | 1.48 | 4.86 | 21.97 |
| Epinephelus fulva | 5.64 | 4.42 | 3.55 | 1.07 | 4.79 | 26.75 |
| Centropyge argi | 2.69 | 5.34 | 3.43 | 0.73 | 4.62 | 31.37 |
| Chromis cyanea | 4.71 | 4.59 | 2.81 | 1.18 | 3.78 | 35.16 |
| Serranus tabacarius | 0.00 | 4.67 | 2.33 | 0.49 | 3.15 | 38.31 |
| Haemulon melanorum | 2.48 | 2.63 | 2.13 | 0.70 | 2.87 | 41.18 |
| Acanthurus chirurgus | 2.80 | 1.68 | 1.96 | 0.75 | 2.64 | 43.82 |
| Chromis insolata | 1.67 | 2.63 | 1.95 | 0.53 | 2.63 | 46.45 |
| Lutjanus buccanella | 0.65 | 3.42 | 1.91 | 0.53 | 2.58 | 49.03 |
| Pomacanthus arcuatus | 0.43 | 3.53 | 1.89 | 0.53 | 2.56 | 51.59 |
| Pomacanthus paru | 0.00 | 3.74 | 1.87 | 0.48 | 2.52 | 54.11 |
| Epinephelus guttatus | 2.42 | 1.78 | 1.86 | 0.66 | 2.51 | 56.62 |
| Serranus tigrinus | 2.59 | 1.37 | 1.83 | 0.41 | 2.47 | 59.09 |
| Coryphopterus glaucophaenum | 0.41 | 3.15 | 1.74 | 0.37 | 2.34 | 61.43 |
| Serranus tortugarum | 0.00 | 3.36 | 1.68 | 0.49 | 2.26 | 63.70 |
| Malacanthus plumieri | 0.36 | 2.92 | 1.60 | 0.37 | 2.16 | 65.86 |
| Sparisoma aurofrenatum | 3.00 | 0.49 | 1.56 | 0.79 | 2.11 | 67.97 |
| Balistes vetula | 1.43 | 1.93 | 1.54 | 0.50 | 2.08 | 70.04 |
| Lutjanus analis | 0.66 | 2.62 | 1.51 | 0.57 | 2.03 | 72.07 |
| Scarus taeniopterus | 2.17 | 1.11 | 1.33 | 0.79 | 1.79 | 73.86 |
| Xanthichthys ringens | 1.24 | 1.44 | 1.23 | 0.44 | 1.66 | 75.52 |
| Gobiosoma evelynae | 2.09 | 0.56 | 1.21 | 0.51 | 1.63 | 77.15 |
| Elagatis bipinnulata | 0.35 | 2.09 | 1.18 | 0.37 | 1.60 | 78.75 |
| Acanthurus coeruleus | 2.36 | 0.00 | 1.18 | 0.64 | 1.59 | 80.34 |
| Holocentrus adscensionis | 0.00 | 2.17 | 1.08 | 0.33 | 1.46 | 81.80 |
| Pterois volitans | 1.84 | 0.00 | 0.92 | 0.39 | 1.24 | 83.04 |
| Halichoeres maculipinna | 0.57 | 1.36 | 0.91 | 0.43 | 1.22 | 84.26 |
| Acanthurus bahianus | 0.90 | 0.98 | 0.86 | 0.44 | 1.17 | 85.43 |
| Chaetodon sedentarius | 1.71 | 0.00 | 0.85 | 0.33 | 1.15 | 86.58 |
| Paranthias furcifer | 0.37 | 1.15 | 0.72 | 0.42 | 0.97 | 87.55 |
| Grama loreto | 0.31 | 1.15 | 0.70 | 0.39 | 0.94 | 88.49 |
| Caranx ruber | 1.24 | 0.00 | 0.62 | 0.23 | 0.84 | 89.33 |
| Amblycirrhitis pinos | 1.23 | 0.00 | 0.62 | 0.26 | 0.83 | 90.16 |

Groups PRF & CRR

Average dissimilarity = 71.92

| Species | Group PRF Av.Abund Contrib% | Group CRR Av.Abund Cum.% | Av.Diss | Diss/SD | | |
|-----------------------------|-----------------------------------|--------------------------------|---------|---------|------|-------|
| Halichoeres garnoti | 10.77 | 9.33 | 3.93 | 1.34 | 5.47 | 5.47 |
| Thalassoma bifasciatum | 8.10 | 5.76 | 3.82 | 1.31 | 5.31 | 10.78 |
| Epinephelus guttatus | 6.73 | 1.78 | 3.70 | 0.81 | 5.14 | 15.92 |
| Centropyge argi | 3.34 | 5.34 | 3.48 | 0.81 | 4.83 | 20.75 |
| Epinephelus fulva | 4.24 | 4.42 | 3.15 | 0.99 | 4.38 | 25.14 |
| Balistes vetula | 5.15 | 1.93 | 3.04 | 0.91 | 4.23 | 29.37 |
| Xanthichthys ringens | 5.28 | 1.44 | 2.97 | 0.68 | 4.13 | 33.50 |
| Stegastes partitus | 11.85 | 15.44 | 2.75 | 1.29 | 3.82 | 37.32 |
| Serranus tabacarius | 0.97 | 4.67 | 2.62 | 0.56 | 3.65 | 40.97 |
| Serranus tigrinus | 4.80 | 1.37 | 2.61 | 0.92 | 3.63 | 44.59 |
| Pomacanthus arcuatus | 1.86 | 3.53 | 2.38 | 0.58 | 3.31 | 47.90 |
| Halichoeres maculipinna | 3.97 | 1.36 | 2.33 | 0.66 | 3.24 | 51.15 |
| Chromis cyanea | 1.72 | 4.59 | 2.32 | 1.10 | 3.23 | 54.37 |
| Haemulon melanorum | 2.85 | 2.63 | 2.22 | 0.79 | 3.09 | 57.46 |
| Coryphopterus glaucophaenum | 1.34 | 3.15 | 2.11 | 0.44 | 2.94 | 60.39 |

| | | | | | | |
|--------------------------|------|------|------|------|------|-------|
| Pomacanthus paru | 0.74 | 3.74 | 2.09 | 0.55 | 2.91 | 63.31 |
| Lutjanus buccanella | 0.00 | 3.42 | 1.71 | 0.49 | 2.38 | 65.68 |
| Holocentrus rufus | 2.28 | 2.05 | 1.71 | 0.77 | 2.38 | 68.06 |
| Chromis insolata | 1.13 | 2.63 | 1.70 | 0.55 | 2.36 | 70.42 |
| Serranus tortugarum | 0.00 | 3.36 | 1.68 | 0.49 | 2.33 | 72.76 |
| Lutjanus analis | 0.92 | 2.62 | 1.58 | 0.58 | 2.20 | 74.96 |
| Acanthurus chirurgus | 1.82 | 1.68 | 1.57 | 0.56 | 2.18 | 77.14 |
| Malacanthus plumieri | 0.00 | 2.92 | 1.46 | 0.33 | 2.03 | 79.16 |
| Pterois volitans | 2.71 | 0.00 | 1.36 | 0.52 | 1.89 | 81.05 |
| Paranthias furcifer | 1.68 | 1.15 | 1.24 | 0.57 | 1.73 | 82.78 |
| Lachnolaimus maximus | 2.26 | 0.00 | 1.13 | 0.47 | 1.57 | 84.35 |
| Mycteroperca venenosa | 2.26 | 0.00 | 1.13 | 0.47 | 1.57 | 85.93 |
| Holocentrus adscensionis | 0.00 | 2.17 | 1.08 | 0.33 | 1.51 | 87.43 |
| Scarus taeniopterus | 1.54 | 1.11 | 1.08 | 0.77 | 1.50 | 88.93 |
| Elagatis bipinnulata | 0.00 | 2.09 | 1.05 | 0.33 | 1.45 | 90.39 |

Groups BCR & SAG

Average dissimilarity = 68.78

| Species | Group BCR Av.Abund | Group SAG Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---------------------------|-----------------------|-----------------------|---------|---------|----------|-------|
| Hypoplectrus puella | 4.65 | 9.23 | 5.39 | 0.97 | 7.84 | 7.84 |
| Chaetodon aculeatus | 1.69 | 5.82 | 3.19 | 0.83 | 4.64 | 12.48 |
| Chromis cyanea | 6.34 | 10.54 | 3.06 | 1.63 | 4.44 | 16.92 |
| Holacanthus tricolor | 1.52 | 5.13 | 2.82 | 0.81 | 4.10 | 21.02 |
| Thalassoma bifasciatum | 4.16 | 6.30 | 2.76 | 1.38 | 4.01 | 25.03 |
| Sparisoma aurofrenatum | 4.60 | 8.16 | 2.57 | 1.45 | 3.74 | 28.77 |
| Halichoeres garnoti | 6.54 | 6.18 | 2.43 | 1.45 | 3.54 | 32.31 |
| Acanthurus chirurgus | 1.68 | 4.92 | 2.23 | 1.30 | 3.24 | 35.55 |
| Chaetodon capistratus | 3.75 | 0.00 | 1.88 | 0.60 | 2.73 | 38.28 |
| Epinephelus cruentatus | 2.76 | 1.82 | 1.70 | 0.87 | 2.48 | 40.75 |
| Epinephelus fulva | 1.46 | 2.57 | 1.58 | 0.83 | 2.30 | 43.06 |
| Scarus taeniopterus | 5.46 | 5.35 | 1.58 | 1.14 | 2.29 | 45.35 |
| Equetus lanceolatus | 0.33 | 2.89 | 1.52 | 0.72 | 2.21 | 47.56 |
| Holocentrus rufus | 2.11 | 1.82 | 1.48 | 0.90 | 2.15 | 49.72 |
| Hypoplectrus chlorurus | 2.93 | 0.00 | 1.46 | 0.50 | 2.13 | 51.84 |
| Apogon maculatus | 0.00 | 2.89 | 1.44 | 0.70 | 2.10 | 53.94 |
| Halichoeres cyanocephalus | 0.00 | 2.89 | 1.44 | 0.70 | 2.10 | 56.04 |
| Hypoplectrus unicolor | 0.00 | 2.89 | 1.44 | 0.70 | 2.10 | 58.14 |
| Lactophrys trigonus | 0.00 | 2.89 | 1.44 | 0.70 | 2.10 | 60.24 |
| Sparisoma radians | 0.44 | 2.57 | 1.39 | 0.74 | 2.02 | 62.26 |
| Coryphopterus personatus | 2.76 | 0.00 | 1.38 | 0.62 | 2.00 | 64.26 |
| Sparisoma viride | 1.58 | 1.82 | 1.34 | 0.81 | 1.95 | 66.21 |
| Stegastes partitus | 6.65 | 7.04 | 1.30 | 1.30 | 1.90 | 68.11 |
| Epinephelus guttatus | 2.53 | 0.00 | 1.27 | 0.66 | 1.84 | 69.95 |
| Coryphopterus lipernes | 2.50 | 0.00 | 1.25 | 0.61 | 1.82 | 71.77 |
| Serranus tigrinus | 0.83 | 1.82 | 1.16 | 0.76 | 1.69 | 73.46 |
| Chaetodon striatus | 0.46 | 1.82 | 1.09 | 0.66 | 1.58 | 75.04 |
| Acanthurus coeruleus | 2.16 | 0.00 | 1.08 | 0.69 | 1.57 | 76.61 |
| Gobiosoma evelynae | 2.07 | 0.00 | 1.04 | 0.48 | 1.51 | 78.12 |
| Melichthys niger | 0.77 | 1.62 | 1.03 | 0.70 | 1.50 | 79.62 |
| Myripristis jacobus | 2.04 | 0.00 | 1.02 | 0.55 | 1.49 | 81.11 |
| Canthigaster rostrata | 1.88 | 0.00 | 0.94 | 0.52 | 1.37 | 82.47 |
| Acanthurus bahianus | 1.83 | 0.00 | 0.91 | 0.53 | 1.33 | 83.80 |
| Grama loreto | 1.80 | 0.00 | 0.90 | 0.57 | 1.31 | 85.11 |
| Mulloidichthys martinicus | 0.86 | 1.03 | 0.80 | 0.72 | 1.16 | 86.27 |
| Clepticus parrae | 1.57 | 0.00 | 0.78 | 0.53 | 1.14 | 87.41 |
| Bodianus rufus | 1.27 | 0.00 | 0.64 | 0.39 | 0.93 | 88.33 |
| Pterois volitans | 1.21 | 0.00 | 0.61 | 0.44 | 0.88 | 89.22 |
| Lutjanus apodus | 1.19 | 0.00 | 0.60 | 0.35 | 0.87 | 90.08 |

Groups CPV & SAG

Average dissimilarity = 73.20

| Species | Group CPV Av.Abund | Group SAG Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---------------------------|-----------------------|-----------------------|---------|---------|----------|-------|
| Hypoplectrus puella | 0.00 | 9.23 | 4.61 | 0.70 | 6.30 | 6.30 |
| Thalassoma bifasciatum | 11.25 | 6.30 | 4.55 | 1.13 | 6.22 | 12.52 |
| Chromis cyanea | 4.71 | 10.54 | 3.90 | 1.62 | 5.33 | 17.85 |
| Halichoeres garnoti | 8.79 | 6.18 | 3.68 | 1.23 | 5.03 | 22.89 |
| Holocentrus rufus | 6.31 | 1.82 | 3.51 | 0.60 | 4.79 | 27.68 |
| Sparisoma aurofrenatum | 3.00 | 8.16 | 3.07 | 1.70 | 4.19 | 31.87 |
| Chaetodon aculeatus | 0.91 | 5.82 | 3.06 | 0.75 | 4.18 | 36.05 |
| Stegastes partitus | 11.90 | 7.04 | 2.90 | 0.93 | 3.96 | 40.02 |
| Epinephelus fulva | 5.64 | 2.57 | 2.81 | 1.08 | 3.84 | 43.85 |
| Holacanthus tricolor | 0.36 | 5.13 | 2.63 | 0.73 | 3.59 | 47.44 |
| Acanthurus chirurgus | 2.80 | 4.92 | 2.35 | 1.26 | 3.20 | 50.65 |
| Scarus taeniopterus | 2.17 | 5.35 | 2.19 | 1.92 | 3.00 | 53.64 |
| Serranus tigrinus | 2.59 | 1.82 | 2.00 | 0.49 | 2.73 | 56.37 |
| Apogon maculatus | 0.00 | 2.89 | 1.44 | 0.70 | 1.97 | 58.34 |
| Equetus lanceolatus | 0.00 | 2.89 | 1.44 | 0.70 | 1.97 | 60.31 |
| Halichoeres cyanocephalus | 0.00 | 2.89 | 1.44 | 0.70 | 1.97 | 62.29 |
| Hypoplectrus unicolor | 0.00 | 2.89 | 1.44 | 0.70 | 1.97 | 64.26 |
| Lactophrys trigonus | 0.00 | 2.89 | 1.44 | 0.70 | 1.97 | 66.23 |
| Sparisoma radians | 0.71 | 2.57 | 1.44 | 0.75 | 1.96 | 68.20 |
| Centropyge argi | 2.69 | 0.00 | 1.35 | 0.35 | 1.84 | 70.04 |
| Haemulon melanorum | 2.48 | 0.00 | 1.24 | 0.55 | 1.69 | 71.73 |
| Epinephelus guttatus | 2.42 | 0.00 | 1.21 | 0.59 | 1.66 | 73.38 |
| Sparisoma viride | 0.74 | 1.82 | 1.21 | 0.61 | 1.65 | 75.03 |
| Chaetodon striatus | 0.68 | 1.82 | 1.18 | 0.63 | 1.61 | 76.65 |
| Acanthurus coeruleus | 2.36 | 0.00 | 1.18 | 0.64 | 1.61 | 78.26 |
| Gobiosoma evelynae | 2.09 | 0.00 | 1.05 | 0.43 | 1.43 | 79.69 |
| Epinephelus cruentatus | 0.21 | 1.82 | 0.95 | 0.72 | 1.29 | 80.98 |
| Pterois volitans | 1.84 | 0.00 | 0.92 | 0.39 | 1.25 | 82.23 |
| Chaetodon sedentarius | 1.71 | 0.00 | 0.85 | 0.33 | 1.17 | 83.40 |
| Chromis insolata | 1.67 | 0.00 | 0.83 | 0.28 | 1.14 | 84.54 |
| Melichthys niger | 0.00 | 1.62 | 0.81 | 0.70 | 1.11 | 85.65 |
| Balistes vetula | 1.43 | 0.00 | 0.72 | 0.40 | 0.98 | 86.63 |
| Caranx ruber | 1.24 | 0.00 | 0.62 | 0.23 | 0.85 | 87.48 |
| Xanthichthys ringens | 1.24 | 0.00 | 0.62 | 0.29 | 0.85 | 88.32 |
| Amblycirrhitis pinos | 1.23 | 0.00 | 0.62 | 0.26 | 0.84 | 89.16 |
| Sphyaena barracuda | 1.18 | 0.00 | 0.59 | 0.27 | 0.81 | 89.97 |
| Scarus iserti | 1.11 | 0.00 | 0.56 | 0.30 | 0.76 | 90.73 |

Groups PRF & SAG

Average dissimilarity = 78.54

| Species | Group PRF Av.Abund | Group SAG Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|------------------------|-----------------------|-----------------------|---------|---------|----------|-------|
| Hypoplectrus puella | 0.00 | 9.23 | 4.61 | 0.70 | 5.88 | 5.88 |
| Chromis cyanea | 1.72 | 10.54 | 4.51 | 1.84 | 5.75 | 11.62 |
| Sparisoma aurofrenatum | 0.00 | 8.16 | 4.08 | 3.00 | 5.19 | 16.81 |
| Halichoeres garnoti | 10.77 | 6.18 | 3.64 | 1.17 | 4.64 | 21.45 |
| Thalassoma bifasciatum | 8.10 | 6.30 | 3.37 | 1.31 | 4.30 | 25.74 |
| Epinephelus guttatus | 6.73 | 0.00 | 3.36 | 0.72 | 4.28 | 30.03 |
| Stegastes partitus | 11.85 | 7.04 | 3.05 | 2.27 | 3.88 | 33.91 |
| Chaetodon aculeatus | 0.00 | 5.82 | 2.91 | 0.70 | 3.71 | 37.61 |
| Xanthichthys ringens | 5.28 | 0.00 | 2.64 | 0.59 | 3.36 | 40.97 |
| Balistes vetula | 5.15 | 0.00 | 2.58 | 0.83 | 3.28 | 44.26 |
| Holacanthus tricolor | 0.00 | 5.13 | 2.57 | 0.70 | 3.27 | 47.52 |
| Acanthurus chirurgus | 1.82 | 4.92 | 2.49 | 1.28 | 3.18 | 50.70 |
| Serranus tigrinus | 4.80 | 1.82 | 2.49 | 1.06 | 3.16 | 53.86 |
| Epinephelus fulva | 4.24 | 2.57 | 2.25 | 1.04 | 2.87 | 56.73 |
| Scarus taeniopterus | 1.54 | 5.35 | 2.17 | 1.90 | 2.77 | 59.50 |

| | | | | | | |
|---------------------------|------|------|------|------|------|-------|
| Halichoeres maculipinna | 3.97 | 0.00 | 1.98 | 0.56 | 2.53 | 62.03 |
| Centropyge argi | 3.34 | 0.00 | 1.67 | 0.49 | 2.13 | 64.15 |
| Holocentrus rufus | 2.28 | 1.82 | 1.55 | 0.92 | 1.98 | 66.13 |
| Apogon maculatus | 0.00 | 2.89 | 1.44 | 0.70 | 1.84 | 67.97 |
| Equetus lanceolatus | 0.00 | 2.89 | 1.44 | 0.70 | 1.84 | 69.81 |
| Halichoeres cyanocephalus | 0.00 | 2.89 | 1.44 | 0.70 | 1.84 | 71.65 |
| Hypoplectrus unicolor | 0.00 | 2.89 | 1.44 | 0.70 | 1.84 | 73.49 |
| Lactophrys trigonus | 0.00 | 2.89 | 1.44 | 0.70 | 1.84 | 75.32 |
| Haemulon melanorum | 2.85 | 0.00 | 1.42 | 0.71 | 1.81 | 77.14 |
| Pterois volitans | 2.71 | 0.00 | 1.36 | 0.51 | 1.73 | 78.86 |
| Sparisoma radians | 0.00 | 2.57 | 1.28 | 0.70 | 1.63 | 80.50 |
| Epinephelus cruentatus | 0.97 | 1.82 | 1.23 | 0.74 | 1.57 | 82.06 |
| Lachnolaimus maximus | 2.26 | 0.00 | 1.13 | 0.46 | 1.44 | 83.50 |
| Mycteroperca venenosa | 2.26 | 0.00 | 1.13 | 0.46 | 1.44 | 84.94 |
| Pomacanthus arcuatus | 1.86 | 0.00 | 0.93 | 0.31 | 1.19 | 86.13 |
| Chaetodon striatus | 0.00 | 1.82 | 0.91 | 0.70 | 1.16 | 87.29 |
| Sparisoma viride | 0.00 | 1.82 | 0.91 | 0.70 | 1.16 | 88.45 |
| Paranthias furcifer | 1.68 | 0.00 | 0.84 | 0.46 | 1.07 | 89.52 |
| Melichthys niger | 0.00 | 1.62 | 0.81 | 0.70 | 1.03 | 90.55 |

Groups CRR & SAG

Average dissimilarity = 79.02

| Species | Group CRR Av.Abund Contrib% | Group SAG Av.Abund Cum.% | Av.Diss | Diss/SD | | |
|-----------------------------|-----------------------------------|--------------------------------|---------|---------|------|-------|
| Hypoplectrus puella | 0.00 | 9.23 | 4.61 | 0.70 | 5.84 | 5.84 |
| Stegastes partitus | 15.44 | 7.04 | 4.20 | 2.09 | 5.32 | 11.16 |
| Sparisoma aurofrenatum | 0.49 | 8.16 | 3.83 | 2.46 | 4.85 | 16.00 |
| Chromis cyanea | 4.59 | 10.54 | 3.82 | 1.54 | 4.83 | 20.83 |
| Halichoeres garnoti | 9.33 | 6.18 | 3.43 | 1.32 | 4.34 | 25.17 |
| Thalassoma bifasciatum | 5.76 | 6.30 | 3.32 | 1.31 | 4.21 | 29.38 |
| Chaetodon aculeatus | 0.00 | 5.82 | 2.91 | 0.70 | 3.68 | 33.06 |
| Acanthurus chirurgus | 1.68 | 4.92 | 2.81 | 1.26 | 3.55 | 36.61 |
| Epinephelus fulva | 4.42 | 2.57 | 2.74 | 0.81 | 3.47 | 40.08 |
| Centropyge argi | 5.34 | 0.00 | 2.67 | 0.62 | 3.38 | 43.46 |
| Holacanthus tricolor | 0.00 | 5.13 | 2.57 | 0.70 | 3.25 | 46.71 |
| Scarus taeniopterus | 1.11 | 5.35 | 2.36 | 2.16 | 2.98 | 49.69 |
| Serranus tabacarius | 4.67 | 0.00 | 2.33 | 0.48 | 2.95 | 52.64 |
| Pomacanthus paru | 3.74 | 0.00 | 1.87 | 0.48 | 2.37 | 55.01 |
| Pomacanthus arcuatus | 3.53 | 0.00 | 1.77 | 0.48 | 2.24 | 57.25 |
| Lutjanus buccanella | 3.42 | 0.00 | 1.71 | 0.48 | 2.16 | 59.41 |
| Serranus tortugarum | 3.36 | 0.00 | 1.68 | 0.48 | 2.12 | 61.53 |
| Coryphopterus glaucophaenum | 3.15 | 0.00 | 1.57 | 0.33 | 1.99 | 63.53 |
| Holocentrus rufus | 2.05 | 1.82 | 1.57 | 0.83 | 1.99 | 65.52 |
| Malacanthus plumieri | 2.92 | 0.00 | 1.46 | 0.33 | 1.85 | 67.36 |
| Apogon maculatus | 0.00 | 2.89 | 1.44 | 0.70 | 1.83 | 69.19 |
| Equetus lanceolatus | 0.00 | 2.89 | 1.44 | 0.70 | 1.83 | 71.02 |
| Halichoeres cyanocephalus | 0.00 | 2.89 | 1.44 | 0.70 | 1.83 | 72.85 |
| Hypoplectrus unicolor | 0.00 | 2.89 | 1.44 | 0.70 | 1.83 | 74.67 |
| Lactophrys trigonus | 0.00 | 2.89 | 1.44 | 0.70 | 1.83 | 76.50 |
| Serranus tigrinus | 1.37 | 1.82 | 1.41 | 0.70 | 1.79 | 78.29 |
| Haemulon melanorum | 2.63 | 0.00 | 1.32 | 0.44 | 1.67 | 79.96 |
| Chromis insolata | 2.63 | 0.00 | 1.31 | 0.44 | 1.66 | 81.62 |
| Lutjanus analis | 2.62 | 0.00 | 1.31 | 0.49 | 1.66 | 83.28 |
| Sparisoma radians | 0.00 | 2.57 | 1.28 | 0.70 | 1.62 | 84.90 |
| Holocentrus addensioensis | 2.17 | 0.00 | 1.08 | 0.33 | 1.37 | 86.27 |
| Elagatis bipinnulata | 2.09 | 0.00 | 1.05 | 0.33 | 1.32 | 87.60 |
| Balistes vetula | 1.93 | 0.00 | 0.97 | 0.33 | 1.22 | 88.82 |
| Chaetodon striatus | 0.00 | 1.82 | 0.91 | 0.70 | 1.15 | 89.97 |
| Epinephelus cruentatus | 0.00 | 1.82 | 0.91 | 0.70 | 1.15 | 91.12 |

Appendix 8

Densities of fish species surveyed from belt-transects at the CPV habitat in Lang Bank, 2012-13.

| Stations | SPA W | IW4 8 | IW4 7 | IW4 9 | IW5 0 | DB1 3 | DB1 3 | DB1 8 | DB1 5 | 84 4 | OW7 7 | DB 4 |
|-------------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|----------|---------|
| Depth (ft) | 135 | 137 | 100 | 135 | 100 | 100 | 100 | 100 | 116 | 100 | 156 | 165 |
| Species | | | | | | | | | | | | |
| <i>Stegastes partitus</i> | 8 | 6 | 18 | 5 | 1 | 15 | 9 | 7 | 9 | 16 | 7 | 5 |
| <i>Thalassoma bifasciatum</i> | 5 | 4 | 0 | 0 | 0 | 1 | 8 | 17 | 3 | 14 | 0 | 1 |
| <i>Scarus taeniopterus</i> | 1 | 2 | 0 | 0 | 0 | 1 | 6 | 0 | 3 | 4 | 0 | 38 |
| <i>Chromis cyanea</i> | 0 | 3 | 0 | 1 | 0 | 3 | 1 | 3 | 2 | 0 | 0 | 8 |
| <i>Halichoeres garnoti</i> | 1 | 2 | 4 | 0 | 0 | 3 | 5 | 0 | 0 | 0 | 0 | 4 |
| <i>Centropyge argi</i> | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Clepticus parrae</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| <i>Acanthurus chirurgus</i> | 0 | 0 | 2 | 5 | 0 | 2 | 3 | 0 | 1 | 2 | 0 | 0 |
| <i>Epinephelus fulva</i> | 0 | 0 | 1 | 1 | 0 | 3 | 1 | 0 | 0 | 3 | 2 | 0 |
| <i>Sparisoma aurofrenatum</i> | 0 | 1 | 0 | 1 | 0 | 2 | 1 | 2 | 2 | 1 | 0 | 4 |
| <i>Haemulon flavolineatum</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 |
| <i>Scarus iserti</i> | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Cottonwick</i> | 0 | 3 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 |
| <i>Caranx ruber</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Holocentrus rufus</i> | 0 | 0 | 1 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| <i>Acanthurus coeruleus</i> | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 2 | 1 | 0 | 0 | 0 |
| <i>Chromis insolata</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Gobiosoma evelynae</i> | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| <i>Halichoeres maculipinna</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Sparisoma radians</i> | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| <i>Serranus tigrinus</i> | 0 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Coryphopterus lipernes</i> | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Acanthurus bahianus</i> | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| <i>Chaetodon aculeatus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| <i>Chaetodon capistratus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| <i>Chaetodon sedentarius</i> | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Chaetodon striatus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Coryphopterus personatus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Dasyatis americana</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Amblycirrhitus pinos</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Canthigaster rostrata</i> | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| <i>Paranthias furcifer</i> | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| <i>Xanthichthys ringens</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| <i>Acanthostracion quadricornis</i> | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | |
|------------------------------------|----|----|----|----|---|----|----|----|----|----|----|----|
| <i>Canthidermis sufflamen</i> | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Coryphopterus glaucophaenum</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| <i>Epinephelus cruentatus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Gramma loreto</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Holacanthus tricolor</i> | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Malacanthus plumieri</i> | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Pomacanthus arcuatus</i> | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Sargocentron coruscus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| <i>Sparisoma atomarium</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| <i>Sparisoma viride</i> | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Individuals | 18 | 23 | 32 | 27 | 3 | 37 | 40 | 32 | 37 | 45 | 12 | 86 |
| Total Species | 7 | 9 | 10 | 12 | 3 | 13 | 13 | 6 | 13 | 9 | 5 | 8 |

| Stations | OW51 | OW52 | OW53 | OW53 | OW56 | OW57 | OW63 | OW59 | OW60 | OW55 |
|--------------------------------|------|------|------|------|------|------|------|------|------|------|
| Depth (ft) | 135 | 100 | 155 | 135 | 135 | 155 | 135 | 165 | 135 | 110 |
| Species | | | | | | | | | | |
| <i>Stegastes partitus</i> | 4 | 6 | 4 | 7 | 3 | 2 | 6 | 2 | 0 | 6 |
| <i>Thalassoma bifasciatum</i> | 5 | 12 | 2 | 1 | 0 | 3 | 3 | 7 | 8 | 0 |
| <i>Scarus taeniopterus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Chromis cyanea</i> | 0 | 4 | 0 | 2 | 6 | 0 | 4 | 7 | 0 | 1 |
| <i>Halichoeres garnoti</i> | 0 | 1 | 2 | 0 | 4 | 3 | 3 | 2 | 0 | 5 |
| <i>Centropyge argi</i> | 0 | 0 | 0 | 5 | 16 | 0 | 4 | 0 | 0 | 0 |
| <i>Clepticus parrae</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Acanthurus chirurgus</i> | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| <i>Epinephelus fulva</i> | 1 | 1 | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 0 |
| <i>Sparisoma aurofrenatum</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Haemulon flavolineatum</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Scarus iserti</i> | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Cottonwick</i> | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| <i>Caranx ruber</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| <i>Holocentrus rufus</i> | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 |
| <i>Acanthurus coeruleus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| <i>Chromis insolata</i> | 0 | 0 | 2 | 0 | 8 | 0 | 0 | 0 | 0 | 0 |
| <i>Gobiosoma evelynae</i> | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| <i>Halichoeres maculipinna</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Sparisoma radians</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Serranus tigrinus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Coryphopterus lipernes</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Acanthurus bahianus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Chaetodon aculeatus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Chaetodon capistratus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | |
|-------------------------------------|----|----|----|----|----|----|----|----|----|----|
| <i>Chaetodon sedentarius</i> | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| <i>Chaetodon striatus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| <i>Coryphopterus personatus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Dasyatis americana</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| <i>Amblycirrhitus pinos</i> | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| <i>Canthigaster rostrata</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Paranthias furcifer</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Xanthichthys ringens</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Acanthostracion quadricornis</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Canthidermis sufflamen</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Coryphopterus glaucophaenum</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Epinephelus cruentatus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Gramma loreto</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Holacanthus tricolor</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Malacanthus plumieri</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Pomacanthus arcuatus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Sargocentron coruscus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Sparisoma atomarium</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Sparisoma viride</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Individuals | 12 | 34 | 10 | 15 | 41 | 13 | 22 | 20 | 10 | 17 |
| Total Species | 4 | 6 | 4 | 4 | 7 | 8 | 7 | 6 | 3 | 6 |

| Stations | OW58 | OW64 | OW67 | lb3 | |
|-------------------------------|-------------|-------------|-------------|------------|--------------|
| Depth (ft) | 110 | 135 | 100 | 135 | MEANS |
| Species | | | | | |
| <i>Stegastes partitus</i> | 8 | 5 | 10 | 2 | 6.6 |
| <i>Thalassoma bifasciatum</i> | 14 | 11 | 14 | 3 | 5.2 |
| <i>Scarus taeniopterus</i> | 7 | 0 | 0 | 5 | 2.6 |
| <i>Chromis cyanea</i> | 7 | 0 | 0 | 6 | 2.2 |
| <i>Halichoeres garnoti</i> | 6 | 4 | 1 | 6 | 2.2 |
| <i>Centropyge argi</i> | 1 | 0 | 0 | 0 | 1.0 |
| <i>Clepticus parrae</i> | 0 | 0 | 0 | 0 | 1.0 |
| <i>Acanthurus chirurgus</i> | 3 | 0 | 3 | 0 | 0.8 |
| <i>Epinephelus fulva</i> | 3 | 0 | 1 | 1 | 0.8 |
| <i>Sparisoma aurofrenatum</i> | 2 | 0 | 2 | 0 | 0.7 |
| <i>Haemulon flavolineatum</i> | 0 | 0 | 4 | 0 | 0.6 |

| | | | | | |
|------------------------------------|---|----|---|---|-------------|
| <i>Scarus iserti</i> | 0 | 0 | 0 | 2 | 0.6 |
| <i>Cottonwick</i> | 0 | 0 | 0 | 0 | 0.5 |
| <i>Caranx ruber</i> | 0 | 12 | 0 | 0 | 0.5 |
| <i>Holocentrus rufus</i> | 0 | 0 | 0 | 0 | 0.4 |
| <i>Acanthurus coeruleus</i> | 2 | 0 | 0 | 0 | 0.4 |
| <i>Chromis insolata</i> | 0 | 0 | 0 | 0 | 0.4 |
| <i>Gobiosoma evelynae</i> | 1 | 1 | 0 | 0 | 0.2 |
| <i>Halichoeres maculipinna</i> | 4 | 0 | 1 | 0 | 0.2 |
| <i>Sparisoma radians</i> | 3 | 0 | 0 | 0 | 0.2 |
| <i>Serranus tigrinus</i> | 0 | 0 | 0 | 0 | 0.2 |
| <i>Coryphopterus lipernes</i> | 0 | 0 | 0 | 0 | 0.1 |
| <i>Acanthurus bahianus</i> | 0 | 0 | 0 | 0 | 0.1 |
| <i>Chaetodon aculeatus</i> | 0 | 0 | 0 | 2 | 0.1 |
| <i>Chaetodon capistratus</i> | 1 | 0 | 1 | 0 | 0.1 |
| <i>Chaetodon sedentarius</i> | 0 | 0 | 0 | 0 | 0.1 |
| <i>Chaetodon striatus</i> | 0 | 0 | 0 | 0 | 0.1 |
| <i>Coryphopterus personatus</i> | 0 | 0 | 0 | 2 | 0.1 |
| <i>Dasyatis americana</i> | 0 | 0 | 0 | 0 | 0.1 |
| <i>Amblycirrhitus pinos</i> | 1 | 0 | 0 | 0 | 0.1 |
| <i>Canthigaster rostrata</i> | 0 | 0 | 0 | 0 | 0.1 |
| <i>Paranthias furcifer</i> | 0 | 0 | 1 | 0 | 0.1 |
| <i>Xanthichthys ringens</i> | 0 | 0 | 0 | 0 | 0.1 |
| <i>Acanthostracion quadricomis</i> | 0 | 0 | 0 | 0 | 0.04 |
| <i>Canthidermis sufflamen</i> | 0 | 0 | 0 | 0 | 0.04 |
| <i>Coryphopterus glaucophaenum</i> | 0 | 0 | 0 | 0 | 0.04 |
| <i>Epinephelus cruentatus</i> | 1 | 0 | 0 | 0 | 0.04 |
| <i>Gramma loreto</i> | 0 | 0 | 0 | 1 | 0.04 |
| <i>Holacanthus tricolor</i> | 0 | 0 | 0 | 0 | 0.04 |
| <i>Malacanthus plumieri</i> | 0 | 0 | 0 | 0 | 0.04 |
| <i>Pomacanthus arcuatus</i> | 0 | 0 | 0 | 0 | 0.04 |
| <i>Sargocentron coruscus</i> | 0 | 0 | 0 | 0 | 0.04 |
| <i>Sparisoma atomarium</i> | 0 | 0 | 0 | 0 | 0.04 |
| <i>Sparisoma viride</i> | 0 | 0 | 0 | 0 | 0.04 |

| | | | | | |
|--------------------------|----|----|----|----|-------------|
| Total Individuals | 64 | 33 | 38 | 30 | 28.9 |
| Total Species | 16 | 5 | 10 | 10 | 7.8 |

Appendix 9

Densities of fish species surveyed from belt-transects at the BCR habitat in Lang Bank, 2012-13.

| Stations | SPAW | IW42 | DB26 | 816 | DB28 | DB27 | 819 | DB14 | 823 | IW35 | IW35 | IW37 | IW38 | IW39 |
|----------------------------------|------|------|------|-----|------|------|-----|------|-----|------|------|------|------|------|
| Depth (ft) | 100 | 100 | 142 | 140 | 135 | 135 | 132 | 100 | 100 | 135 | 140 | 132 | 115 | 130 |
| Species | | | | | | | | | | | | | | |
| <i>Coryphopterus personatus</i> | 0 | 0 | 0 | 11 | 2 | 14 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Chromis cyanea</i> | 5 | 2 | 11 | 11 | 2 | 8 | 10 | 5 | 10 | 1 | 1 | 3 | 2 | 0 |
| <i>Clepticus parrae</i> | 0 | 0 | 4 | 2 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Stegastes partitus</i> | 10 | 5 | 10 | 4 | 8 | 1 | 8 | 5 | 8 | 1 | 5 | 1 | 3 | 0 |
| <i>Scarus taeniopterus</i> | 1 | 0 | 6 | 4 | 4 | 5 | 10 | 5 | 9 | 5 | 3 | 6 | 3 | 1 |
| <i>Coryphopterus lipernes</i> | 0 | 0 | 0 | 0 | 3 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Thalassoma bifasciatum</i> | 3 | 0 | 1 | 0 | 1 | 2 | 3 | 0 | 15 | 1 | 0 | 1 | 4 | 0 |
| <i>Halichoeres garnoti</i> | 3 | 1 | 0 | 3 | 1 | 1 | 5 | 2 | 1 | 1 | 1 | 1 | 1 | 2 |
| <i>Sparisoma aurofrenatum</i> | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 3 | 2 | 1 | 1 | 1 |
| <i>Scarus iserti</i> | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Gobiosoma evelynae</i> | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| <i>Chaetodon capistratus</i> | 0 | 2 | 0 | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| <i>Grama loreto</i> | 0 | 1 | 1 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Acanthurus chirurgus</i> | 0 | 1 | 1 | 1 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| <i>Acanthurus coeruleus</i> | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| <i>Myripristis jacobus</i> | 0 | 0 | 2 | 1 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Hypoplectrus puella</i> | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| <i>Melichthys niger</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Haemulon flavolineatum</i> | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 4 | 1 | 0 | 0 | 0 | 0 |
| <i>Epinephelus cruentatus</i> | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| <i>Mulloidichthys martinicus</i> | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| <i>Canthigaster rostrata</i> | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| <i>Holocentrus rufus</i> | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| <i>Acanthurus bahianus</i> | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | |
|---------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|
| <i>Sparisoma viride</i> | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| <i>Hypoplectrus chlorurus</i> | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| <i>Bodianus rufus</i> | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| <i>Chaetodon aculeatus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| <i>Epinephelus fulva</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| <i>Flammeo marianus</i> | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Holacanthus tricolor</i> | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Paranthias furcifer</i> | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Pomacanthus paru</i> | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Microspathodon chrysurus</i> | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Holacanthus ciliaris</i> | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Chaetodon striatus</i> | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Serranus tortugarum</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Scarus vetula</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Cottonwick</i> | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Serranus tigrinus</i> | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Anisotremus virginicus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Caranx crysos</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Caranx lugubris</i> | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Centropyge argi</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Chromis multilineata</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Diodon histrix</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Equetus lanceolatus</i> | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Haemulon sciurus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Lutjanus mahogany</i> | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Liopropoma rubre</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Malacanthus plumieri</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Pomacanthus arcuatus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| <i>Seriola rivoliana</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Serranus tabacarius</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Individuals | 29 | 29 | 42 | 42 | 40 | 43 | 64 | 26 | 51 | 18 | 14 | 16 | 16 | 9 |
| Total Species | 11 | 17 | 14 | 12 | 21 | 13 | 15 | 12 | 10 | 12 | 7 | 9 | 8 | 8 |

| Stations | IW36 | IW36 | DB2 | DB3 | DB21 | DB21 | DB22 | DB22 | IW33 | IW34 | DB7 | DB6 | Ib2 | Ib10 |
|----------------------------------|------|------|-----|-----|------|------|------|------|------|------|-----|-----|-----|------|
| Depth (ft) | 100 | 100 | 165 | 165 | 135 | 131 | 135 | 135 | 135 | 135 | 155 | 165 | 150 | 151 |
| Species | | | | | | | | | | | | | | |
| <i>Coryphopterus personatus</i> | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 44 | 6 | 0 | 0 | 1 | 36 |
| <i>Chromis cyanea</i> | 1 | 8 | 4 | 3 | 16 | 10 | 2 | 9 | 4 | 1 | 12 | 4 | 0 | 3 |
| <i>Clepticus parrae</i> | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 1 | 0 | 7 |
| <i>Stegastes partitus</i> | 4 | 6 | 5 | 4 | 2 | 2 | 6 | 6 | 3 | 5 | 0 | 5 | 2 | 3 |
| <i>Scarus taeniopterus</i> | 2 | 0 | 6 | 6 | 5 | 2 | 5 | 5 | 0 | 6 | 0 | 4 | 11 | 0 |
| <i>Coryphopterus lipernes</i> | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 30 | 10 | 0 | 5 | 0 | 7 |
| <i>Thalassoma bifasciatum</i> | 5 | 5 | 0 | 0 | 1 | 3 | 2 | 2 | 0 | 1 | 0 | 1 | 1 | 2 |
| <i>Halichoeres garnoti</i> | 1 | 1 | 2 | 1 | 1 | 0 | 3 | 5 | 2 | 1 | 2 | 1 | 1 | 3 |
| <i>Sparisoma aurofrenatum</i> | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 1 | 0 | 1 | 1 | 2 |
| <i>Scarus iserti</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 1 | 0 | 0 |
| <i>Gobiosoma evelynae</i> | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 2 |
| <i>Chaetodon capistratus</i> | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| <i>Grama loreto</i> | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| <i>Acanthurus chirurgus</i> | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| <i>Acanthurus coeruleus</i> | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| <i>Myripristis jacobus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| <i>Hypoplectrus puella</i> | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| <i>Melichthys niger</i> | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Haemulon flavolineatum</i> | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Epinephelus cruentatus</i> | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| <i>Mulloidichthys martinicus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| <i>Canthigaster rostrata</i> | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| <i>Holocentrus rufus</i> | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 2 |
| <i>Acanthurus bahianus</i> | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| <i>Sparisoma viride</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| <i>Hypoplectrus chlorurus</i> | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Bodianus rufus</i> | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| <i>Chaetodon aculeatus</i> | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| <i>Epinephelus fulva</i> | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| <i>Flammeo marianus</i> | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| <i>Holacanthus tricolor</i> | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| <i>Paranthias furcifer</i> | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Pomacanthus paru</i> | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Microspathodon chrysurus</i> | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Holacanthus ciliaris</i> | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Chaetodon striatus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | | |
|-------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|-----------|-----------|-----------|
| <i>Serranus tortugarum</i> | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Scarus vetula</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| <i>Cottonwick</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| <i>Serranus tigrinus</i> | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Anisotremus virginicus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Caranx crysos</i> | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Caranx lugubris</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Centropyge argi</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| <i>Chromis multilineata</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Diodon histrix</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Equetus lanceolatus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Haemulon sciurus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Lutjanus mahogany</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Liopropoma rubre</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| <i>Malacanthus plumieri</i> | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Pomacanthus arcuatus</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Seriola rivoliana</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <i>Serranus tabacarius</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Total Individuals | 16 | 29 | 39 | 26 | 32 | 23 | 22 | 33 | 90 | 42 | 141 | 30 | 20 | 81 |
| Total Species | 8 | 13 | 15 | 16 | 10 | 10 | 9 | 11 | 7 | 15 | 12 | 16 | 8 | 18 |

| Stations | lb8 | lb7 | lb6 | IW31 | IW32 | |
|---------------------------------|------------|------------|------------|-------------|-------------|--------------|
| Depth (ft) | 150 | 145 | 140 | 138 | 110 | |
| Species | | | | | | MEANS |
| <i>Coryphopterus personatus</i> | 30 | 18 | 0 | 48 | 0 | 7.0 |
| <i>Chromis cyanea</i> | 2 | 10 | 0 | 7 | 25 | 5.8 |
| <i>Clepticus parrae</i> | 2 | 6 | 30 | 0 | 0 | 4.8 |
| <i>Stegastes partitus</i> | 4 | 9 | 8 | 1 | 8 | 4.6 |
| <i>Scarus taeniopterus</i> | 1 | 0 | 2 | 8 | 6 | 4.0 |
| <i>Coryphopterus lipernes</i> | 0 | 11 | 0 | 14 | 9 | 3.1 |
| <i>Thalassoma bifasciatum</i> | 2 | 1 | 3 | 3 | 1 | 1.9 |
| <i>Halichoeres garnoti</i> | 1 | 0 | 0 | 3 | 3 | 1.6 |
| <i>Sparisoma aurofrenatum</i> | 0 | 1 | 1 | 2 | 0 | 0.8 |
| <i>Scarus iserti</i> | 2 | 0 | 0 | 0 | 0 | 0.7 |
| <i>Gobiosoma evelynae</i> | 0 | 0 | 0 | 4 | 4 | 0.7 |
| <i>Chaetodon capistratus</i> | 1 | 1 | 2 | 0 | 0 | 0.5 |
| <i>Grama loreto</i> | 0 | 0 | 0 | 1 | 1 | 0.4 |
| <i>Acanthurus chirurgus</i> | 1 | 0 | 0 | 0 | 1 | 0.4 |
| <i>Acanthurus coeruleus</i> | 0 | 1 | 0 | 1 | 1 | 0.4 |
| <i>Myripristis jacobus</i> | 0 | 0 | 2 | 0 | 0 | 0.4 |
| <i>Hypoplectrus puella</i> | 0 | 1 | 0 | 1 | 0 | 0.4 |

| | | | | | | |
|----------------------------------|-----------|-----------|-----------|-----------|-----------|-------------|
| <i>Melichthys niger</i> | 0 | 0 | 8 | 0 | 1 | 0.3 |
| <i>Haemulon flavolineatum</i> | 0 | 0 | 0 | 0 | 0 | 0.3 |
| <i>Epinephelus cruentatus</i> | 0 | 1 | 0 | 1 | 0 | 0.3 |
| <i>Mulloidichthys martinicus</i> | 0 | 0 | 0 | 1 | 0 | 0.3 |
| <i>Canthigaster rostrata</i> | 0 | 2 | 0 | 2 | 1 | 0.3 |
| <i>Holocentrus rufus</i> | 0 | 1 | 0 | 0 | 0 | 0.3 |
| <i>Acanthurus bahianus</i> | 0 | 0 | 0 | 0 | 1 | 0.3 |
| <i>Sparisoma viride</i> | 0 | 0 | 0 | 0 | 0 | 0.2 |
| <i>Hypoplectrus chlorurus</i> | 0 | 0 | 1 | 1 | 0 | 0.2 |
| <i>Bodianus rufus</i> | 0 | 0 | 0 | 0 | 0 | 0.2 |
| <i>Chaetodon aculeatus</i> | 0 | 1 | 0 | 0 | 0 | 0.2 |
| <i>Epinephelus fulva</i> | 0 | 0 | 0 | 0 | 0 | 0.2 |
| <i>Flammeo marianus</i> | 0 | 0 | 0 | 0 | 0 | 0.2 |
| <i>Holacanthus tricolor</i> | 0 | 0 | 0 | 0 | 0 | 0.2 |
| <i>Paranthias furcifer</i> | 0 | 0 | 0 | 0 | 0 | 0.1 |
| <i>Pomacanthus paru</i> | 0 | 0 | 0 | 0 | 0 | 0.1 |
| <i>Microspathodon chrysurus</i> | 0 | 0 | 0 | 0 | 0 | 0.1 |
| <i>Holacanthus ciliaris</i> | 0 | 0 | 0 | 0 | 0 | 0.1 |
| <i>Chaetodon striatus</i> | 0 | 0 | 0 | 0 | 0 | 0.1 |
| <i>Serranus tortugarum</i> | 0 | 0 | 0 | 0 | 0 | 0.1 |
| <i>Scarus vetula</i> | 0 | 0 | 0 | 0 | 0 | 0.1 |
| <i>Cottonwick</i> | 0 | 0 | 0 | 0 | 0 | 0.1 |
| <i>Serranus tigrinus</i> | 0 | 0 | 0 | 0 | 0 | 0.1 |
| <i>Anisotremus virginicus</i> | 0 | 0 | 0 | 0 | 0 | 0.03 |
| <i>Caranx crysos</i> | 0 | 0 | 0 | 0 | 0 | 0.03 |
| <i>Caranx lugubris</i> | 0 | 0 | 0 | 0 | 0 | 0.03 |
| <i>Centropyge argi</i> | 0 | 0 | 0 | 0 | 0 | 0.03 |
| <i>Chromis multilineata</i> | 0 | 0 | 0 | 0 | 0 | 0.03 |
| <i>Diodon histrix</i> | 0 | 0 | 0 | 0 | 0 | 0.03 |
| <i>Equetus lanceolatus</i> | 0 | 0 | 0 | 0 | 0 | 0.03 |
| <i>Haemulon sciurus</i> | 1 | 0 | 0 | 0 | 0 | 0.03 |
| <i>Lutjanus mahogany</i> | 0 | 0 | 0 | 0 | 0 | 0.03 |
| <i>Liopropoma rubre</i> | 0 | 0 | 0 | 0 | 0 | 0.03 |
| <i>Malacanthus plumieri</i> | 0 | 0 | 0 | 0 | 0 | 0.03 |
| <i>Pomacanthus arcuatus</i> | 0 | 0 | 0 | 0 | 0 | 0.03 |
| <i>Seriola rivoliana</i> | 0 | 0 | 0 | 0 | 0 | 0.03 |
| <i>Serranus tabacarius</i> | 0 | 0 | 0 | 0 | 0 | 0.03 |
| Total Individuals | 47 | 64 | 57 | 98 | 62 | 42.2 |
| Total Species | 11 | 14 | 9 | 16 | 13 | 12.1 |

Appendix 10

Densities of fish species surveyed from belt-transects at the CRR habitat in Lang Bank, 2012-13.

| Stations | OW68 | OW68 | OW76 | DB15 | OW62 | OW66 | DB17 | Ib9 | Ib15 | OW76 | |
|------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|-----------|-------------|
| Depth (ft) | 165 | 130 | 100 | 131 | 165 | 135 | 135 | 145 | 160 | 140 | |
| Species | | | | | | | | | | | MEANS |
| <i>Stegastes partitus</i> | 14 | 16 | 7 | 11 | 12 | 5 | 6 | 4 | 3 | 9 | 8.7 |
| <i>Centropyge argi</i> | 0 | 4 | 0 | 0 | 12 | 5 | 0 | 0 | 0 | 0 | 2.1 |
| <i>Halichoeres garnoti</i> | 4 | 2 | 0 | 2 | 3 | 1 | 1 | 0 | 0 | 6 | 1.9 |
| <i>Chromis cyanea</i> | 5 | 1 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 8 | 1.8 |
| <i>Thalassoma bifasciatum</i> | 5 | 4 | 4 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 1.8 |
| <i>Scarus taeniopterus</i> | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0.8 |
| <i>Paranthias furcifer</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0.6 |
| <i>Chromis insolata</i> | 5 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0.6 |
| <i>Haemulon melanorum</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0.4 |
| <i>Pomacanthus paru</i> | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0.4 |
| <i>Epinephelus fulva</i> | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0.4 |
| <i>Acanthurus chirurgus</i> | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0.3 |
| <i>Grama loreto</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0.3 |
| <i>Holocentrus rufus</i> | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0.3 |
| <i>Serranus tabacarius</i> | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0.3 |
| <i>Acanthurus bahianus</i> | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 |
| <i>Coryphopterus glaucophaenum</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0.2 |
| <i>Pomacanthus arcuatus</i> | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 |
| <i>Serranus tortugarum</i> | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0.2 |
| <i>Gobiosoma evelynae</i> | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |
| <i>Halichoeres maculipinna</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0.1 |
| <i>Holocentrus adensionis</i> | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |
| <i>Malacanthus plumieri</i> | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.1 |
| <i>Serranus tigrinus</i> | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |
| <i>Sparisoma aurofrenatum</i> | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.1 |
| <i>Xanthichthys ringens</i> | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |
| Total Individuals | 33 | 28 | 26 | 20 | 30 | 17 | 12 | 10 | 7 | 39 | 22.2 |
| Total Species | 5 | 6 | 10 | 7 | 5 | 5 | 6 | 5 | 3 | 9 | 6.1 |

Appendix 11.

Size-frequency distribution of fish and shellfish species of commercial value from mesophotic (30-50 m) benthic habitats surveyed at Lang Bank, St. Croix, USVI during 2012-13

| Lang Bank 2/22/2013 - 10/5/2013 | | | | |
|------------------------------------|-----------------|--------------------|--------------------------|-----------------|
| | Bank Coral Reef | Colonized Pavement | Colonized Rhodolith Reef | Spur and Groove |
| | 135-165ft | 100-165ft | 135-165ft | 100-115ft |
| Area (m2) | 3,600 | 6,800 | 1,200 | 1,600 |
| Distance (m) | 900 | 1700 | 300 | 400 |
| Species Name | | | | |
| <i>Epinephelus guttatus</i> | 2 - 20cm | 1 - 15cm | | 2 - 27cm |
| | 1 - 25cm | 2 - 27cm | | 1 - 30cm |
| | 4 - 30cm | 1 - 33cm | | |
| | 5 - 33cm | 1 - 35cm | | |
| | 4 - 35cm | 1 - 40cm | | |
| | 3 - 38cm | 1 - 43cm | | |
| | 1 - 40cm | | | |
| <i>Pterois volitans</i> | 3 - 25cm | 15 - 20cm | | 1 - 15cm |
| | 3 - 30cm | 10 - 25cm | | 2 - 20cm |
| | 4 - 40cm | 4 - 27cm | | 4 - 25cm |
| | 3 - 43cm | 28 - 30cm | | 5 - 30cm |
| | | 2 - 33cm | | |
| | | 5 - 35cm | | |
| <i>Lutjanus analis</i> | 2 - 30cm | 1 - 45cm | 2 - 50cm | 1 - 55cm |
| | 2 - 40cm | 1 - 50cm | | |
| | 2 - 45cm | | | |
| | 3 - 50cm | | | |
| | 2 - 55cm | | | |
| <i>Lutjanus apodus</i> | 1 - 20cm | 1 - 25cm | | 1 - 35cm |
| | 1 - 30cm | 2 - 38cm | | |
| | 1 - 35cm | 1 - 40cm | | |
| | 1 - 38cm | | | |
| | 1 - 40cm | | | |
| | 1 - 60cm | | | |
| <i>Lachnolaimus maximus</i> | 1 - 60cm | 1 - 76cm | | 1 - 48cm |

| | | | | |
|--------------------------------------|-----------|---|----------------------------------|----------------------------------|
| | 1 - 71cm | | | 1 - 60cm |
| <i>Balistes vetula</i> | 1 - 35cm | 1 - 25cm 3 - 30cm 2 - 33cm 12 - 35cm 2 - 40cm 1 - 45cm | 3 - 38cm 1 - 45cm 3 - 50cm | 1 - 36cm 3 - 38cm 1 - 43cm |
| <i>Mycteroperca venenosa</i> | 1 - 25cm | 1 - 91cm | | |
| <i>Panulirus argus</i> | 1 - 20cm | 5 - 15cm 4 - 17cm 11 - 20cm 2 - 23cm | | 5 - 25cm 3 - 30cm |
| <i>Ginglymostoma cirratum</i> | 1 - 140cm | 1 - 155cm 1 - 185cm 2 - 200cm | 1 - 186cm | 1 - 90cm 1 - 200cm |
| <i>Seriola rivoliana</i> | 1 - 30cm | 1 - 30cm 1 - 35cm | | |
| <i>Sparisoma guacamaia</i> | | 2 - 76cm | | |
| <i>Caranx lugubris</i> | | 2 - 38cm | | |
| <i>Caranx bartholomaei</i> | | 3 - 30cm 4 - 35cm | | |
| <i>Caranx ruber</i> | | 50 - 25cm | | |
| <i>Elagatis bipinnulata</i> | | 1 - 50cm | | |
| <i>Epinephelus striatus</i> | | 1 - 71cm | | |
| <i>Lutjanus cyanopterus</i> | | 1 - 100cm | | |
| <i>Lutjanus jocu</i> | | | | 1 - 40cm |

| | | |
|---|--|---|
| <i>Ocyurus chrysurus</i> | 1 - 38cm | 1 - 35cm |
| <i>Acanthostracion quadricomis</i> | 2 - 15cm | |
| <i>Caranx crysos</i> | 2 - 40cm 1 - 45cm | |
| <i>Sphyraena barracuda</i> | 1 - 30cm 3 - 40cm 2 - 50cm 1 - 60cm 2 - 71cm 2 - 76cm 1 - 91cm | 1 - 55cm 1 - 76cm |
| <i>Strombus gigas</i> | | 16 - 23cm 15 - 24cm 12 - 25cm 3 - 21cm |
| <i>Caranx latus</i> | | 2 - 60cm |

Appendix 12.

Length-density distribution of the numerically prominent fish and shellfish species surveyed from mesophotic (30 – 50 m) habitats at Lang Bank. 2012-13.

| Length (cm) | <i>Strombus gigas</i> N=46 | <i>Panulirus argus</i> N=31 | <i>Epinephelus guttatus</i> N=30 | <i>Pterois spp.</i> N=89 | <i>Lutjanus analis</i> N=16 | <i>Balistes vetula</i> N=31 |
|------------------------|---|--|---|---|--|--|
| 10 | | | 0.0758 | | | |
| 15 | | 0.7576 | 0.1515 | 0.0758 | | |
| 17 | | 0.3030 | | | | |
| 20 | | 1.1364 | 0.0758 | 1.2879 | | |
| 21 | 0.2273 | | | | | |
| 22 | 0.1515 | | | | | |
| 23 | 1.2121 | 0.1515 | | | | |
| 24 | 1.1364 | | | | | |
| 25 | 3.0303 | | 0.6061 | 1.2879 | | 0.0758 |
| 26 | 0.0758 | | | | | |
| 27 | 0.0758 | | | | | |

| | | | | |
|----|--------|--------|--------|--------|
| 30 | 0.9091 | 3.0303 | 0.1515 | 0.2273 |
| 35 | 0.4545 | 0.5303 | | 1.2879 |
| 40 | | 0.5303 | 0.1515 | 0.6061 |
| 45 | | | 0.2273 | 0.2273 |
| 50 | | | 0.4545 | 0.2273 |
| 55 | | | 0.2273 | |
