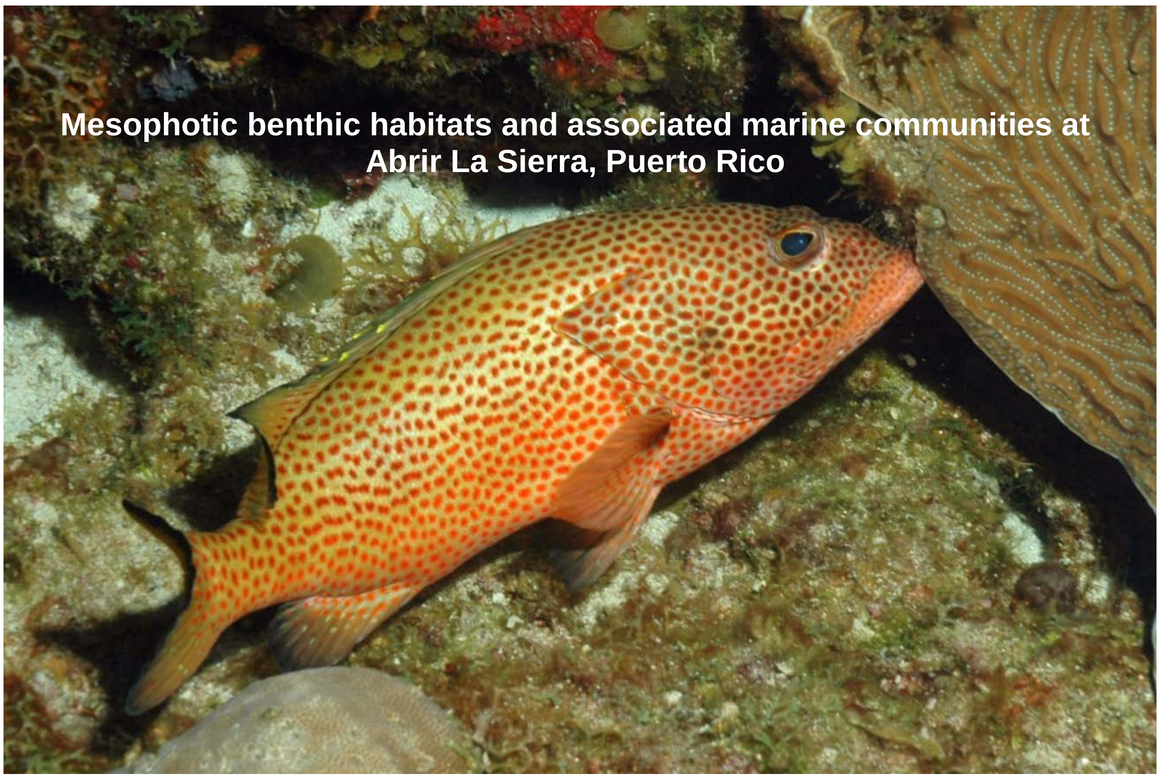
FINAL REPORT

**NOAA CORAL GRANT**

**FNA07NMF4410117**




Jorge R. García-Sais, Ph. D
Roberto L. Castro-Gomez, Jorge Sabater-Clavell,
Rene Esteves, Stacey Williams, Milton Carlo

P. O. Box 3424
Lajas, P. R. 00667
goingdeep49@gmail.com

March, 2010

**Table of Contents**

## Acknowledgements

The authors wish to acknowledge the contribution of Dr. Tim Batista and the crew of the R/V Nancy Foster (NOAA) for the mutibeam bathymetry survey of Abrir la Sierra, with "on-site" collaboration from Reef Survey's staff Rene Esteves and Jorge Sabater. Dr. Jorge Capella assisted with the deployment and data analysis of the ADCP water current study at ALS. This research was supported by a NOAA/CFMC Coral Grant FNA07NMF4410117 awarded under contract to Dr. Jorge R. García Sais. Mrs. Graciela Garcia-Moliner acted as the point of contact from the CFMC for this research. Dr. Ernesto Weill and Dr. David Ballentine helped in the identification of coral and algae, respectively.

# I. EXECUTIVE SUMMARY

This research at Abrir la Sierra (ALS) forms part of an initiative by the Caribbean Fishery Management Council (CFMC) to characterize the benthic habitats and associated fish and shellfish communities present within the Caribbean EEZ, Puerto Rico and the USVI, with particular interest on the corals and fish and shellfish species of commercial value. The main objectives of the study included the preparation of a georeferenced benthic habitat map of the mesophotic zone at ALS within a depth range of 30 – 50 m, along with a quantitative, qualitative and photographic characterization of the predominant sessile-benthic, fish and motile-megabenthic invertebrate communities associated with these mesophotic habitats. Production of the benthic habitat map was based on a series of field observations and habitat classifications of the main reef topographic features by rebreather divers, as suggested from a multi-beam bathymetry footprint produced by the R/V Nancy Foster (NOAA). A total of 62 stations were occupied for direct field verification of benthic habitats, including 47 -10 m long transects for determinations of percent cover by sessile-benthic categories. The same transect array was used to quantify demersal reef fishes and motile megabenthic invertebrates. Determinations of densities of each species per belt-transect were recorded.

ALS is a shelf-edge reef located approximately 23.5 km west off Punta Guaniquilla, Cabo Rojo, on the west coast of Puerto Rico. The main bathymetry features of the mesophotic habitat at ALS within the 30 - 50 m depth range consist of two internal slope walls, a deep outer shelf terrace and an insular slope wall. Such features were considered the main reef physiographic zones at ALS. Mesophotic benthic habitats within these reef zones included: colonized pavement, rhodolith reefs, a small coral reef, and a mostly un-consolidated habitat of scattered rhodoliths and sand. Inner walls of the deep terrace exhibited moderate live coral cover, consistent with the classification of a coral reef habitat down to a maximum depth of approximately 27 - 28 m. Below 30 m, reef substrate was observed to consist mostly of pavement (hard bottom) colonized by algae, sponges and scattered corals that typically declined in abundance and diversity with increasing depth. Boulder star coral, *Montastraea annularis* was the main structural component of the coral reef habitat and was observed to be in good condition. An assemblage of 20 species of scleractinian corals, 10 octocorals, two hydrocorals and 44 sponges were identified from mesophotic habitats at ALS.

Statistically significant differences of benthic community structure were detected between the rhodolith reef (RR) and all other habitats, and between the coral reef (CR) and all other habitats, except the inner wall (IW). Slope habitats at 40 and 50 m (SL 40, SL 50) were different from those at the IW and SL 30. Differences were not statistically significant between IW and the SL 30, and between the SL 40 and SL 50. RR was different from all other habitats by the relatively higher substrate cover by benthic algae and lower cover by scleractinian corals, gorgonians and sponges. Although this habitat was mostly devoid of sessile-benthic invertebrate fauna, it presented the highest density of motile megabenthic invertebrates, particularly queen conch, *Strombus gigas*, as it appears that RR functions as an essential (foraging) habitat for this commercially important invertebrate at ALS. Dissimilarity of sessile-benthic community structure between CR and other habitats at ALS was mostly driven by the relatively higher cover by scleractinian corals, gorgonians, sponges and abiotic substrate categories, and relatively lower cover by cyanobacteria, turf and fleshy algae. IW and SL 30, 40 and 50 are colonized pavement habitats with variations of sessile-benthic community structure driven mostly by cover of scleractinian corals, gorgonians and cyanobacteria. IW exhibited less cover by gorgonians than slope stations. Conversely, IW presented relatively higher cover by scleractinian corals than slope stations. A mostly un-colonized pavement habitat with scattered rhodoliths and sand was observed to be widely distributed within the deep terrace at ALS, but was not quantitatively characterized. This habitat presented a series of small interspersed hard ground promontories with corals and high fish aggregations.

A total of 100 species of reef fishes were identified from mesophotic habitats (30 – 50 m) at ALS during this study. The three main benthic habitats associated with mesophotic reef zones at ALS, (e.g. rhodolith reef, colonized pavement, and scattered rhodolith and sand) exhibited statistically significant differences of fish community structure. Differences were also noted between colonized pavement habitats of different reef zones, such as the top of the insular slope at 30 m and the deepest zone of the insular slope surveyed at 50 m. Differences between these two zones were mostly driven by the higher abundance of bluehead wrasse, *T. bifasciatum* and parrotfishes, *S. aurofrenatum, S. iserti* at 30 m, whereas masked goby, *C. personatus*, sunshine fish, *C. insolata* and bicolor damselfish, *S. partitus* were most prominent at 50 m. Differences of fish community structure between the rhodolith reef and colonized pavement habitats were mostly associated with higher abundance of *C. argi, S. atomarium, S. tabacarius, S. baldwini* and *P. maculatus* at the RR, and higher abundance of *C. personatus, C. insolata, T. bifasciatum, S, iserti* and *S. aurofrenatum* at SL and IW stations.

Red hind and queen conch were observed to be the most prominent species of commercial value within mesophotic habitats (30 – 50 m) at ALS. Red hinds were found distributed along the entire range of mesophotic reef zones and benthic habitats at ALS. Although more geographically extensive studies need to be performed to provide an assessment of its population densities, it appeared that the highest densities of red hinds were present at the top of the insular slope (SL 30), at the rhodolith reef (36 – 40 m) and on the small rock promontories of the scattered rhodolith and sand habitat within the deep terrace. Queen conch were also widely distributed in mesophotic habitats of ALS, but it was particularly evident that their preferred habitat was the rhodolith reef, where they seem to find optimum foraging conditions, perhaps associated to the extensive macroalgal availability. High abundance of queen conch was also noted at the top of the insular slope (30 – 33 m) and at the rhodolith and sand habitat within the deep terrace. Despite the permanent fishing closure of queen conch at ALS, there is still active fishing on the adult population as evidenced by the common findings of recently opened shells at the bottom. Black groupers, ranging in size from 50 – 80 cm were observed at depths of 35 – 50 m at the insular slope, where they seem to be the most prominent demersal predator. Two individuals of the lionfish, *Pterois volitans* were observed at depths between 33 – 40 m within the deep terrace of ALS.

During the mutton snapper (*Lutjanus analis*) spawning aggregation event at ALS in May 2009, water current flow structure was characterized by a swift, highly dominant north-northwest flow that appeared to be topographically steered by the shelf-edge bottom contours. Such water current pattern would transport and disperse fertilized eggs and early larvae towards the west-northwest coast of PR and Mona Passage. Continuous water temperature measurements during this period showed a sharp decline of 1.2 °C during May 16, between 27.5 – 26.3 °C. The sudden decline of water temperature is inferred to be the influence of an internal wave at ALS, a factor which has been suggested to act as a cue for massive spawning by mutton snapper.

## II.INTRODUCTION

Recent investigations of mesophotic reef systems within the Caribbean EEZ (Garcia-Sais et. al., 2005, 2007, 2009; Nemeth et. al., 2008) have identified the presence of benthic habitats at depths between 30 – 50 m. These habitats serve as recruitment, residential, foraging and spawning aggregation habitats for a wide assemblage of commercially important reef fishes, shellfish and sea turtles. Mesophotic benthic habitats include outer shelf and seamount reef tops, slope walls, deep rock promontories, coral reefs, and algal rhodolith reefs. Significant community structure variations of the sessile-benthic and fish assemblages have been found associated with different benthic habitats and depths (Garcia-Sais et. al., 2005, 2007; García-Sais, 2010). Below 30 m, reef substrate cover by live scleractinian corals declined sharply and branching sponges were the dominant sessile-benthic reef invertebrates at Isla Desecheo. Other relevant transitions of reef community structure within the euphotic-mesophotic depth gradient at Isla Desecheo include the shift of benthic algae from a turf dominated assemblage above 30 m to a *Lobophora variegata* (fleshy algae) dominated environment below. Likewise, lettuce corals, *Agaricia spp*., particularly the *lamarki/grahame* complex dominate the *Montastraea spp*. coral complex below 40 m (Garcia-Sais, 2010). Nemeth et al. (2008) reported that *M. annularis* (complex) was the dominant coral at depths down to 40 m at the MCD reef located off the south coast of St. Thomas.

Sharp contrasts of community structure between mesophotic benthic habitats at Bajo de Sico were observed between reef tops, slope walls and rhodolith reefs. Branching and encrusting sponges were the dominant sessile-benthic invertebrate at all mesophotic habitats, but live scleractinian corals presented higher surface cover at the reef tops, whereas gorgonians, particularly the deep water gorgonian, *Iciligorgia schrammi* and black corals (Antipatharians) were most abundant at the slope walls. Rhodolith reefs, located at depths below 40 m at Isla Desecheo and Bajo de Sico exhibited lower cover by corals and much higher cover by fleshy algae, mostly *L. variegata* than reef tops and slope walls (Garcia-Sais et. al., 2005, 2007; Garcia-Sais, 2010).

Reef fish assemblages have been shown to vary significantly between different benthic habitats and depths studied at Isla Desecheo within a 15 – 50 m euphotic-mesophotic depth gradient (Garcia-Sais, 2010). Fish species richness was positively correlated with live coral cover, but the relationship between total fish abundance and live coral was not significant. Abundance of several numerically dominant fish species varied independently from live coral cover and appeared to be more influenced by depth and/or benthic habitat type. The role of large branching sponges and black corals, such as tube sponges, *Agelas spp*. and bushy black coral, *Antipathes caribbeana* as recruitment habitats for small schooling reef fishes (*Chromis cyanea*, *C. insolata, Clepticus parrae)* was a relevant factor introducing variability to the fish abundance-live coral cover relationship at Bajo de Sico and Isla Desecheo (Garcia-Sais et. al. 2005, 2007; Garcia-Sais, 2010).

A small assemblage of reef fishes that included the cherubfish, *Centropyge argi*, sunshine chromis, *C. insolata,* greenblotch parrotfish, *Sparisoma atomarium*, yellowcheek wrasse, *Halichoeres cyanocephalus*, sargassum triggerfish, *Xanthychthys ringens*, and the longsnout butterflyfish, *Chaetodon aculeatus* were most abundant and/or only present from stations deeper than 30 m at Isla Desecheo and Bajo de Sico, and thus appear to be indicator species of mesophotic habitats (Garcia-Sais et. al. 2005, 2007; Garcia-Sais, 2010). Active search surveys at Isla Desecheo and Bajo de Sico have also shown that mesophotic reefs represent essential habitats for many large, commercially important fish and shellfish. For example, reef tops appear to be the main residential habitat for a healthy population of Nassau groupers, *Epinephelus striatus*, schoolmaster, yellowtail, dog and cubera snappers (*Lutjanus apodus, L. chrysurus, L. jocu*, *L. cyanopterus*), large adult spiny lobsters, *Panulirus argus* and hawksbill turtles, *Eretmochelys imbricata* at Bajo de Sico. Red hinds, *E. guttatus*, and the yellowfin, yellowmouth and black groupers were observed to be common at the slope wall habitats of Bajo de Sico. Deep rhodolith reefs appear to be foraging habitats of the queen triggerfish, *Balistes vetula*, and residential habitats of the red hind and an assemblage of small reef fishes that are commercially important in the aquarium trade, such as *C. argi*, *C. aculeatus*, and the orangeback basslet, *Serranus annularis*.

The high concentration of schooling zooplanktivore fish species associated with mesophotic reefs, such as *C. parrae*, the creole fish, *Paranthias furcifer* and the mackerel scad, *Decapterus macarellus* attract large pelagic reef predators, including the great barracuda, *Sphyraena barracuda*, king and cero mackerels, *Scomberomorus* *cavalla, S. regalis*, sharks, *Sphyrna spp*., *Carcharhinus limbatus*, and large jacks, such as the black jack, *Caranx lugubris*, rainbow runner, *Elagatis bipinnulata* and blue runner, *Carangoides crysos*, among others. Pelagic migratory fish predators, such as the wahoo, *Acanthocybium solandri*, dorado, *Coryphaena hippurus*, blackfin, skipjack and yellowfin tunas, *Thunnus spp*., *Katsuwonus sp*., and marlins, *Makaira nigricans, Isthiophorus albicans, Tetrapturus albidus* also forage upon mid water schooling reef fishes associated with mesophotic reef habitats and their smaller pelagic predators.

This research at Abrir la Sierra (ALS) is part of an initiative by the Caribbean Fishery Management Council (CFMC) and the National Marine Fishery Service (NMFS) to characterize the benthic habitats and associated fish and shellfish communities present within the Caribbean EEZ, Puerto Rico and the USVI, with particular interest on the corals and fish and shellfish species of commercial value.

## III. RESEARCH BACKGROUND

### A. Fish Community Structure

Information regarding the taxonomic composition, depth range and habitat preferences of mesophotic reef fishes (depth: 30 – 150 m) is scarce and mostly available from fishery records, collections of scientific expeditions, submarine surveys, and more recently from direct observations by divers using SCUBA and re-breather diving technologies. Some of the best studied areas in the western Atlantic include the Flower Garden Banks in the northwestern Gulf of Mexico (Bright 1977; Dennis and Bright 1988), Discovery Bay in Jamaica (Colin 1974; Itzkowitz et al. 1991), Tongue-of-the-Ocean in the Bahamas (Colin 1976, Lukens 1981), Isla Desecheo and Bajo de Sico in Puerto Rico (García-Sais et al. 2005, 2007; Ballantine et al., 2008), the Marine Conservation District (MCD) in the south coast of St. Thomas, U. S. Virgin Islands (Nemeth 2005); Pulley Ridge in southwest Florida (Halley et al. 2007), and a series of deep reefs off the northeastern coast of Brazil (Collete and Rutzler 1977; Feitoza et al. 2005). Some of the best studied areas of the Indo-Pacific include the Enewetak Atoll, Marshall Islands (Thresher & Colin 1986); Great Barrier Reef (Cappo et al. 2007); and the northern Red Sea (Brokovich 2008, Brokovich et al. 2008).

The community structure of fishes from mesophotic reefs has been shown to vary in terms of species richness, relative abundance and density at different “reef zones” or benthic habitat types found across depth and light gradients. The number of fish species present per unit area surveyed at both the West and East Flower Garden Banks declined markedly with increasing depth (Dennis and Bright, 1988). Major shifts of the fish community structure were also detected, as the numerically dominant species assemblages varied greatly at the different benthic habitats present across the depth gradient in the Flower Garden Banks. Marked differences in the taxonomic composition and abundance of demersal fishes were reported by Feitoza et al (2005) associated with deep shelf-edge and over-shelf reef habitats off the northern coast of Brazil. Deep flat zones were mostly occupied by small fishes, whereas the larger demersal fishes were associated with the large crevices and ledges present at the slope, or “steep zone”.

In the Caribbean, Garcia-Sais (2010) found marked declines of fish species richness and abundance within belt-transects associated with increasing depth at mesophotic reef habitats of the insular slope, relative to euphotic shelf reef habitats in Isla Desecheo, Puerto Rico. A strong positive correlation was found between live coral cover and fish species richness. Abundance of several numerically dominant species varied independently from live coral cover across the depth gradient, introducing substantial variability into the live coral, depth and total fish abundance relationships. Marked variations of fish taxonomic composition and a decline of species richness and abundance with increasing depth were also noted between the reef top, reef wall and rhodolith reef habitats within a depth range of 30 – 50 m at Bajo de Sico seamount in Mona Passage, Puerto Rico (Garcia-Sais et al. 2007).

The main inference from submersible surveys of insular slope habitats in Caribbean locations, such as the Discovery Bay system in Jamaica (Colin, 1974; Itzkowitz et al., 1991), off the coast of Belize (Colin, 1974), Tongue-of-the-Ocean in Bahamas and Cayman Islands (Colin, 1976; Lukens, 1981), and Puerto Rico and the U. S. Virgin Islands (Nelson and Appeldoorn, 1985) is that the number of fish species and abundance of individuals varies in relation to substrate rugosity, but in general, decreases with increasing depth. 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. The high availability of crevices and escarpments along wall faces promote high relative abundance of species adapted for secretive habitats (e.g. basslets, basses, squirrelfishes and gobies) and the physical continuity of the habitat appears to facilitate penetration of deep water predators into the mesophotic reef system (Colin, 1974). Nelson and Appeldoorn (1985) noted that the most pronounced reduction of fish abundance and species richness across the depth gradient was related to the complete loss of light at approximately 135 m.

At the Enewetak Atoll, Thresher and Colin (1986) found the highest number of fish species at 30 to 60 m depths overlapping the zone of highest coral cover. Deeper reef habitats were characterized by a more abrupt slope (75-$80^0$ at 75-90 m) and a near vertical wall below 120 m, in which the number of species declined monotonically. In the Gulf of Aqaba, Brokovich et al. (2008) found a gradual change in fish community structure correlated with a decline of branching corals with depth. The 30 m depth was found to be a transition zone between shallow and deep reef assemblages and presented the highest number of species. At the Great Barrier Reef, Cappo et al. (2007) also found the 30-35 m isobaths to have the highest number of fish species. They showed species richness to decline below 35 m and towards the shoreline.

There are at present no studies at the community level of the food habits of fishes from mesophotic reefs and thus, inferences of fish trophic interactions from these systems is largely based on studies from Caribbean shallow reefs (Randall, 1967) and direct observations by scientists from submersibles and or diving with SCUBA (Feitoza et al., 2005; Garcia-Sais et al. 2005; 2007). It is evident that planktivores supply most of the energetic demands of mesophotic fish food webs throughout the depth range of 30 – 120 m. About 28 % (22/79) of the fish species listed in Table 1 as common or abundant in mesophotic reefs in the tropical Western Atlantic are known planktivores. Some of the species display highly aggregated (schooling) distributions and seem to account for a significant proportion of the mesophotic reef fish biomass. Despite the diverse and

**Table 1**. Common and abundant fishes reported from mesophotic reef systems in the western Atlantic region. Habitat: SE- Shelf-edge; A/S- Algal-sponge zone; W- Wall; S- Surface; n/d- no data. Sites: 1- PR, 2- Brazil, 3- Bahamas; 4- Jamaica; 5- Belize; 6- Flower Garden Banks; 7- Pulley Ridge. Distribution: TWA- Tropical Western Atlantic; NSA- Northern South America; G/F- Gulf of Mexico and Florida

| Family/*Species* | Reef Habitat | Depth Range (m) | Sites Abundant | Trophic Group |
|---|---|---|---|---|
| Ginglymostomidae | | | | |
| *Ginglymostoma cirratum* | SE, A/S | 30 – 80 | 1, 2, 6 | C |
| Carcharhinidae | | | | |
| *Carcharhinus perezi* | SE, A/S | 30 – 80 | 1 | C |
| *Carcharhinus limbatus* | SE, A/S | 30 – 80 | 1 | C |
| Sphyrnidae | | | | |
| *Sphyrna mokarran* | SE, A/S | 30 – 80 | 1 | C |
| Dasyatidae | | | | |
| *Dasyatis americana* | SE, A/S | 30 – 80 | 1, 2, 6 | C |
| Muraenidae | | | | |
| *Gymnothorax funebris* | SE, A/S | 30 – 80 | 1, 2 | C |
| Belonidae | | | | |
| *Ablennes hians* | S | 0 – 3 | 1, 2 | C |
| *Strongylura timucu* | S | 0 – 3 | 1, 2 | C |
| *Tylosurus crocodilus* | S | 0 – 3 | 1, 2 | C |
| Synodontidae | | | | |
| *Synodus intermedius* | SE, A/S | 30 – 80 | 1, 6 | C |
| *Synodus synodus* | SE, A/S | 30 – 80 | 1, 2 | C |
| Exocoetidae | | | | |
| *Cheilopogon cyanopterus* | S | 0 – 3 | 2 | PL |
| *Cheilopogon melanurus* | S | 0 – 3 | 2 | PL |
| Hemiramphidae | | | | |
| *Hemiramphus brasiliensis* | S | 0 – 3 | 1 | PL |
| Holocentridae | | | | |
| *Holocentrus adscensionis* | SE, A/S | 30 – 80 | 1, 2 | C |
| *Holocentrus marianus* | | 90 – 120 | 3, 4, 5 | C |
| *Holocentrus rufus* | SE, W, A/S | 30 – 100 | 1, 3, 6 | C |
| *Myripristis jacobus* | SE, A/S | 30 – 80 | 1, 2 | C |
| *Sargocentron bullisi* | n/d | 60 – 120 | 7 | C |
| Dactylopteridae | | | | |
| *Dactylopterus volitans* | S | 0 – 1 | 2 | PL |
| Serranidae | | | | |
| *Cephalopholis cruentatus* | SE, W | 100 – 120 | 1, 3, 4, 5, 6 | C |
| *Cephalopholis fulva* | SE, W | 30 – 80 | 1, 2, 3, 7 | C |
| *Epinephelus adscensionis* | SE | 25 – 40 | 6 | C |
| *Epinephelus striatus* | SE, W | 30 – 40 | 1 | C |
| *Epinephelus guttatus* | SE, W | 30 – 50 | 1, 3 | C |
| *Epinephelus morio* | n/d | 60 – 120 | 7 | C |
| *Holanthias martinicensis* | W | 85 – 120 | 6 | C |
| *Hypoplectrus puella* | SE, W | 30 – 70 | 1, 3 | C |

**Table 1.** continued

| | | | | |
|---|---|---|---|---|
| *Liopropoma eukrines* | A/S | 50 - 80 | 6, 7 | C |
| *Liopropoma mowbrayi* | n/d | 100 - 120 | 1, 3, 4, 5 | P |
| *Mycteroperca bonaci* | SE, W | 30 - 80 | 1, 2, 3, 6 | C |
| *Mycteroperca phenax* | n/d | 60 - 120 | 7 | C |
| *Mycteroperca tigris* | SE, W, A/S | 30 - 80 | 1, 6 | C |
| *Mycteroperca venenosa* | SE, W | 30 - 40 | 1, 6 | C |
| *Paranthias furcifer* | SE, W | 30 - 40 | 1, 2, 6 | P |
| *Serranus annularis* | A/S | 50 - 80 | 1, 6 | C |
| *Serranus baldwini* | SE, W | 30 - 70 | 3 | C |
| *Serranus lucipercanus* | SE, W | 100 - 120 | 1, 3, 4, 5 | C |
| *Serranus tabacarius* | SE, W | 100 - 120 | 1 | C |
| *Serranus tortugarum* | SE, W | 100 - 120 | 1 | C |
| *Serranus phoebe* | W | 85 - 120 | 6 | C |
| *Schultzea beta* | SE, W | 100 - 120 | 1, 3, 4, 5 | P |
| Grammidae | | | | |
| *Gramma loreto* | SE, W | 30 - 50 | 1, 3 | PL |
| *Gramma linki* | W, C | 30 - 50 | 1, 3 | PL |
| *Gramma melacara* | | 90 - 120 | 3, 4, 5 | PL |
| *Lipogramma klayi* | n/d | 100 - 120 | 1, 3, 4, 5 | PL |
| Opistognathidae | | | | |
| *Opistognathus aurifrons* | SE, W | 30 - 50 | 1, 2 | PL |
| Apogonidae | | | | |
| *Apogon americanus* | SE, W | 30 - 50 | 2 | PL |
| *Apogon pseudomaculatus* | SE, W | 30 - 50 | 2 | PL |
| Malacanthidae | | | | |
| *Malacanthus plumieri* | SE, SD | 35 - 70 | 1, 2, 7 | C |
| Carangidae | | | | |
| *Carangoides bartholomei* | SE, W | 35 - 70 | 1, 2 | C |
| *Caranx crysos* | SE, W | 30 - 50 | 1, 2 | C |
| *Caranx latus* | SE, W | 30 - 50 | 1 | C |
| *Caranx lugubris* | SE, W | 30 - 50 | 1, 2 | C |
| *Decapterus macarellus* | SE, W | 30 - 50 | 1 | PL |
| *Decapterus tabl* | SE, W | 30 - 50 | 2 | PL |
| *Elagatis bipinnulata* | SE, W | 30 - 50 | 1, 2 | C |
| *Trachinotus goodei* | SE, W | 30 - 40 | 1, 2 | C |
| Lutjanidae | | | | |
| *Lutjanus analis* | SE, W | 35 - 70 | 1, 2 | C |
| *Lutjanus apodus* | SE, W | 30 - 50 | 1, 3, 6 | C |
| *Lutjanus buccanella* | W | 100 - 120 | 1 | C |
| *Lutjanus campechanus* | W | 85 - 120 | 6 | C |
| *Lutjanus jocu* | SE, W | 35 - 70 | 1, 2, 6 | C |
| *Lutjanus vivanus* | n/d | 100 - 120 | 1 | C |
| *Ocyurus chrysurus* | SE, W | 30 - 50 | 1, 3, 6 | C |
| *Rhomboplites aurorubens* | W | 30 - 120 | 1, 6 | C |
| Haemulidae | | | | |
| *Anisotremus surinamensis* | SE, W | 35 - 60 | 2 | C |
| *Haemulon aurolineatum* | SE, W | 35 - 70 | 2 | C |
| *Haemulon parra* | SE, W | 35 - 60 | 2 | C |
| *Haemulon plumieri* | SE, W | 35 - 70 | 2 | C |

**Table 1.** continued

| | | | | |
|---|---|---|---|---|
| *Haemulon striatum* | n/d | 100 - 120 | 3, 4 | C |
| Sparidae | | | | |
| *Calamus pennatula* | | 35 - 70 | 2 | C |
| Mullidae | | | | |
| *Pseudupeneus maculatus* | | 35 - 70 | 2 | C |
| Chaetodontidae | | | | |
| *Chaetodon aculeatus* | SE, W, A/S | 30 - 50 | 1 | P |
| *Chaetodon aya* | A/S | 50 - 120 | 7, 1 | P |
| *Chaetodon guyanensis* | n/d | 100 - 120 | 3, 4, 5 | |
| *Chaetodon ocellatus* | SE, W | 35 - 60 | 2 | C |
| *Chaetodon sedentarius* | n/d | 100 - 120 | 3, 6 | C |
| Pomacanthidae | | | | |
| *Centropyge argi* | A/S | 50 - 80 | 1, 6 | H |
| *Centropyge aurantonotus* | A/S | 50 - 80 | 1, 6 | H |
| *Holacanthus tricolor* | | 100 - 120 | 1, 3, 4, 5, 7 | O |
| *Holacanthus ciliaris* | SE, W | 35 - 70 | 1, 2 | O |
| *Pomacanthus paru* | SE, W | 35 - 80 | 2, 7 | O |
| Cirrhitidae | | | | |
| *Amblycirrhitus pinos* | A/S | 50 - 80 | 1 | C |
| Pomacentridae | | | | |
| *Chromis cyanea* | SE, W, A/S | 30 - 70 | 1, 4 | P |
| *Chromis enchrysurus* | | 100 - 120 | 1, 6 | P |
| *Chromis insolata* | SE, W | 30 - 120 | 1, 4, 5 | P |
| *Chromis multilineata* | SE, W | 30 - 40 | 1, 6 | P |
| *Chromis scotti* | n/d | 100 - 120 | 3, 4, 5 | P |
| *Stegastes partitus* | SE, W, A/S | 30 - 80 | 1, 6, 7 | P |
| *Stegastes pictus* | SE, W | 35 - 70 | 2 | H |
| Labridae | | | | |
| *Bodianus rufus* | SE, W | 35 - 70 | 2, 6 | C |
| *Bodianus pulchelus* | A/S | 50 - 120 | 6, 7 | C |
| *Clepticus parrae* | SE, W | 30 - 50 | 1, 3, 4, 5, 6 | P |
| *Halichoeres dimidiatus* | SE, W | 35 - 70 | 2 | C |
| *Halichoeres garnoti* | SE, W | 30 - 40 | 1 | C |
| *Lachnolaimus maximus* | | 60 - 120 | 7 | C |
| *Thalassoma bifasciatum* | SE, W | 30 - 80 | 1, 6, 7 | P |
| *Thalassoma noronhanum* | SE, W | 35 - 70 | 2 | P |
| Scaridae | | | | |
| *Sparisoma atomarium* | A/S | 50 - 100 | 1, 4, 5 | H |
| *Sparisoma frondosum* | n/d | 30 - 50 | 2 | H |
| Gobiidae | | | | |
| *Coryphopterus glaucofraenum* | SE, W | 30 - 40 | 1 | C |
| *Coryphopterus lipernes* | SE, W, A/S | 30 - 50 | 1 | C |
| *Coryphopterus personatus* | SE, W | 30 - 40 | 1 | C |
| *Coryphopterus thrix* | SE, W | 30 - 50 | 2 | C |
| *Elacatinus figaro* | SE, W | 35 - 70 | 2 | C |
| *Risor ruber* | SE, W | 35 - 70 | 2 | C |
| Microdesmidae | | | | |
| *Ptereleotris randalli* | n/a | 35 - 70 | 2 | Pl |
| Acanthuridae | | | | |

**Table 1.** continued

| | | | | | |
|---|---|---|---|---|---|
| | *Acanthurus chirurgus* | SE, W | 35 - 70 | 2 | H |
| | *Acanthurus coeruleus* | SE, W | 35 - 70 | 2 | H |
| Sphyraenidae | | | | | |
| | *Sphyraena barracuda* | SE, W | 35 - 100 | 1, 2, 3, 4, 5 | C |
| Scombridae | | | | | |
| | *Thunnus albaceres* | S | 0 - 20 | 1 | C |
| | *Thunnus obesus* | S | 0 - 50 | 2 | C |
| Balistidae | | | | | |
| | *Balistes vetula* | SE, W | 35 - 110 | 1, 2, 5 | C |
| | *Canthidermis sufflamen* | WC | 30 - 70 | 1, 2 | C |
| | *Melichthys niger* | WC | 30 - 70 | 1, 2 | C |
| | *Xanthychthys ringens* | SE, W | 30 - 120 | 1, 4 | C |
| Tetraodontidae | | | | | |
| | *Canthigaster rostrata* | SE, W | 30 - 120 | 1, 4 | C |
| Diodontidae | | | | | |
| | *Diodon sp.* | SE, W | 30 - 40 | 2 | C |

abundant assemblage of zooplanktivorous fishes in mesophotic reefs, studies of zooplankton abundance in Isla Desecheo revealed a depauperate macro zooplankton (> 200 um) community in which the only moderately abundant item collected throughout most of the water column over the reef was fish eggs (Rodriguez-Jeréz 2004). High predation pressure by zooplanktivorous fishes, strong dependence upon fish eggs as plankton food, and/or significant roles of demersal zooplankton (under sampled) in mesophotic food webs were some of the explanations (hypotheses) proposed by Rodriguez-Jeréz (2004) to account for the unexpected finding. The shelf-edge is a known spawning site for more than 26 species of reef fishes in the Caribbean (Colin and Clavijo, 1988), including several that spawn daily and others that display massive seasonal spawning aggregations (Sadovy et al., 1994; Matos-Caraballo and Padilla, 2004, Matos-Caraballo et al., 2006). Thus, the relevance of fish eggs in the diet of zooplanktivorous fishes in mesophotic reefs should not be overlooked.

Another paradigm associated with the community structure of fishes from mesophotic reefs is the scarcity of herbivorous species present, even in reef zones dominated by benthic algae. Only 6 % (5/79) of the fish species listed in Table 1 as very common or abundant in mesophotic reefs from the tropical western Atlantic are known herbivores. This finding was unexpected because quantitative assessments of reef substrate cover by sessile-benthic categories on mesophotic reefs studied from Puerto Rico (Garcia-Sais et al. 2005, 2007: Garcia-Sais, 2010) have shown that benthic algae was the dominant assemblage throughout a depth range between 15 – 50 m. The same assessment applies as well for the extensive "algal-sponge" zone of the Flower Garden Banks reef system (Dennis and Bright, 1988). In the case of Isla Desecheo (Garcia-Sais, 2010) a marked shift in the taxonomic composition of the benthic algae was found. A mixed assemblage of turf algae dominated within the euphotic zone (15 – 25 m), whereas fleshy algae prevailed at mesophotic habitats (30 – 50 m). The encrusting fan-leaf algae, *Lobophora variegata* was the dominant fleshy algae at Isla Desecheo and Bajo de Sico below 35 m. Specific evaluations of the value of this alga as food for fish grazers in mesophotic reefs are lacking, but *L. variegata* is known to serve as food for herbivorous fishes in shallow reefs (Earle, 1972; Colin, 1978). More than 25 species of macroalgae were identified from mesophotic reef habitats within a depth range of 30 – 50 m at Bajo de Sico (Garcia-Sais et al. 2007).

Despite the relatively low number of herbivorous fishes reported for mesophotic reefs, there are several that are very common or abundant. The cherubfish, *C. argi* and the greenblotch parrotfish, *S. atomarium* are prominent over rhodolith habitats (50 – 80 m) in the Flower Garden Banks and Puerto Rico (Dennis and Bright, 1988; Garcia-Sais, 2010). Feitoza et al. (2005) reported six species of parrotfishes (*Sparisoma spp., Cryptostomus sp*.), three doctorfishes (*Acanthurus spp*.) and one damselfish (*Stegastes sp*.) as the main herbivorous fish assemblage of Brazilian reefs studied within a depth range of 35 – 70 m. The paucity of herbivorous fishes associated with slope wall faces in Jamaica, Belize, the Bahamas and Cayman Islands (Colin, 1974, 1976, Itzkowitz et al., 1991, Lukens, 1981) appear to reflect the scarcity of benthic algae in steep mesophotic habitats.

Fish trophic groups changed significantly with depth in the Red Sea and the Enewetak Atoll in the Marshall Islands. Zooplanktivores dominated the deep reef and their relative abundance rose from 50 to almost 100%. A decline in most other trophic groups with depth was noted in Enewetak as well as in the Red Sea, except for piscivores which peaked at 60-75 m in Enewetak, but declined to minimum values at 65 m in the Red Sea. Common zooplanktivores of the deep reef in the Red Sea belonged to the Serranidae, Labridae and Pomacentridae families. Zooplanktivore species of the aforementioned families also dominated the community structure of the deep reefs in Enewetak. In the north Red Sea typical piscivores and benthic invertebrate consumers at the deep reef belonged to the families Serranidae (*Cephalopholis hemistiktos, C. miniata, Epinephelus fasciatus* and *Variola louti*), Scorpaenidae (*Pterois miles*), Tetraodontidae (*Arothron hispidus* and *Canthigaster coronata*) and Lethrinidae (*Lethrinus nebulosus*). Top predators, such as sharks were not observed and barracudas (Sphyraenidae) were observed only in shallow water. Herbivores declined sharply with increasing depth, both in abundance and species richness. At Enewetak they comprised 40% of the population at 30 m, but declined to almost zero at 90 m. Scarids (*Scarus sordidus* and other unidentified species) were common down to 75 m. Herbivorous damselfishes (*Pomacentrus vaiuli* and *Plectroglyphidodon lacrymatus*) were common down to 60 m; Pomacanthidae species such as *Centropyge bispinosus, C. flavicauda* were more common in 30-45 m and *C. heraldi and C. multicolour* were more common between 45-90 m. Acanthurids were seen down to 60-75 m with one herbivorous species reaching 90 m (*Naso lituratus*).

The limited number of surveys, differences in reef fish survey methods, magnitude of survey effort, depth range, as well as the availability of auxiliary fishery and historical data used to document the taxonomic composition of fishes in mesophotic reefs makes the analysis of zoogeographic affinities across the western tropical Atlantic a preliminary exercise. Considering the Flower Garden Banks in the northeastern Gulf of Mexico and the deep reefs off the hump of Brazil as the northern and southern boundaries of the tropical western Atlantic mesophotic reefs distribution, it is evident that there is a high ichthyofaunal similarity between the Caribbean and both distribution boundaries. Of the 148 fish species identified from the Flower Garden Banks (Dennis and Bright 1988) 113, or 76% have been reported for Puerto Rico and the U. S. Virgin Islands (Grana, 2005). Likewise, of the 154 fish species reported for mesophotic reef systems in Brazil (Feitoza et al. 2005) 109, or 71 % have been reported for Puerto Rico and the U. S. Virgin Islands (Grana, 2005). Since a complete record of mesophotic reef fishes is presently unavailable for both the northern Gulf of Mexico and the hump of Brazil, it is only possible here to suggest that there seems to be an effective connectivity throughout the geographic range in the tropical Western Atlantic. From their study of deep reefs off the Brazilian hump, Feitoza et al. (2005) identified only 18 fish species (11.4 % of the total) as endemics of the Brazilian Province, whereas 76.6 % were considered to have Western Atlantic distributions.

The zoogeographic analysis of fish distributions by Feitoza et al. (2005) recognized two main provinces, the Brazilian and the northwestern Atlantic, which appear to be separated by an extensive freshwater lens between the Orinoco and the Amazon Rivers (Rocha, 2003). In the case of mesophotic reef fishes, the freshwater barrier may not be as effective because the low salinity lens declines to less than 2 su below 50 m (Gilbert, 1972; Collete and Rutzler, 1977). Feitoza et al. (2005) proposed that there is a bidirectional dispersal of reef fishes between Brazil and the Caribbean as indicated by the recent reports of a number of species previously considered Brazilian endemics in the southern Caribbean and vice-versa.

### B. Benthic Community Structure

A comprehensive review of previous research on the benthic and pelagic communities associated with mesophotic and deep reef habitats from the Caribbean EEZ, Puerto Rico and the USVI is available from García-Sais et al. (2005). 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) on the outer shelf south of St. Croix, USVI using video and still camera images dropped from the NOAA R/V Nancy Foster. The aforementioned studies identified mayor differences of sessile-benthic community structure associated with the various mesophotic habitat types and depth gradients.

Garcia-Sais et al. (2004) provided a baseline quantitative characterization of the sessile-benthic community from Black Jack Reef, a mesophotic coral reef system in the south coast of Vieques Island. A total of 25 species of scleractinian corals, two antipatharians and one hydrocoral were identified, including 12 within video-transects. Live coral cover averaged 28.8 %. Boulder star coral (*Montastrea annularis*) was the dominant coral species, representing 76 % of the total live coral cover (mean: 21.9 %) at depths between 36 – 40 m. Boulder star coral exhibited a laminar, or flattened growth with closely spaced colonies of moderate size and low relief. Corals grow from a pedestal of unknown origin, creating a large protective habitat underneath the coral. The laminar growth pattern appears to be an adaptation for optimum light utilization and is similar to the one observed at the MCD, south of St. Thomas. Other coral species that presented substrate cover above 1% and that were present in at least four out of five transects surveyed include the mustard hill coral (*Porites astreoides*), graham's sheet coral (*Agaricia grahamae*) and great star coral (*Montastrea cavernosa*). One large colony of the bushy black coral (*Antipathes caribbeana*) was present in the deep terrace of Black Jack Reef. Turf alga was the dominant biological assemblage in terms of substrate cover with 57.4 %. Fleshy (*Lobophora variegata*) and calcareous alga (*Halimeda copiosa*) were also present within transect areas. The combined cover by benthic algae was 64.2 %.

A quantitative survey of the sessile benthic community associated with reef habitats across a 15 – 50 m depth gradient were performed by direct diver observations using rebreathers at Isla Desecheo, Puerto Rico. Statistically significant differences between depths were found for total live coral, total coral species, total benthic algae, total sponges and abiotic cover. Live coral cover was higher at the mid-shelf (20 m) and shelf-edge (25 m) stations, whereas benthic algae and sponges were the dominant sessile-benthic assemblage at mesophotic stations below 25 m. Marked shifts in the community structure of corals and benthic algae were observed across the depth gradient. Star corals, *Montastraea* spp. prevailed down to a maximum depth of 40 m, whereas lettuce corals, *Agaricia* spp, were dominant at 50 m. Turf algae were the dominant assemblage at (euphotic) shelf stations (15, 20, 25 m), but fleshy algae (mostly *L. variegata*) prevailed in terms of reef substrate cover at mesophotic stations (30, 40, 50 m). Sponges were highly prominent at mesophotic depths (> 30 m) (mean surface cover: 17.3 %), growing mostly as large erect and branching forms that produced substantial topographic relief and protective habitat for fishes and invertebrates. In many instances, sponges were observed growing attached to stony corals, forming sponge-coral bioherms of considerable size. One of the most common associations involved brown tube (*Agelas conifera, A. sceptrum*) and row pore sponges (*Aplysina spp*.) with star corals (*M. cavernosa, M. annularis*). A total of 25 scleractinian corals, three hydrocorals and two antipatharian (black coral) species were identified from mesophotic habitats at Isla Desecheo.

Mesophotic benthic habitats were recently described from Bajo de Sico (BDS), a submerged seamount in Mona Passage (García-Sais et. al., 2007). Benthic habitats verified to a maximum depth of 50 m include: a reef top and a vertical reef wall associated with rock promontories, colonized pavement and sand channels at the base of promontories, un-colonized gravel and rhodoliths at the reef slope, and a colonized rhodolith reef habitat surrounding the rock promontories at least to a depth of 50 m. Benthic habitats beyond 50 m have not been field verified, but several video images produced by the R/V Nancy Foster detected coral growth down to a maximum depth of 90 m along the deep shelf platform at BDS. From the multi-beam bathymetry survey of the reef produced aboard the R/V Nancy Foster, the total extension of BDS includes a surface area of approximately 11.1, $km^2$ of which only 3.6 % is associated with rock promontories (0.4 $km^2$) and more than 88 % corresponds to the deep shelf platform at depths below 50 m.

The sessile-benthic community at the reef top of BDS was characterized by a highly diverse assemblage comprised by benthic algae (52%), sponges (26%), scleractinian corals (8%), octocorals (5%) and hydrozoans (3%), with an abiotic cover of less than 1.5%. Scleractinian corals were represented at the reef top by 13 species within transects surveyed, with a mean substrate cover of 8.0% and a mean density of almost 20 colonies/$m^2$. Growth of scleractinian corals at the reef top of BDS was characterized by a species rich and numerous assemblage of small, isolated encrusting colonies that contributed minimal topographic relief. Lettuce corals, mostly *Agaricia lamarki* and *A. grahame* were the dominant assemblage in terms of reef substrate cover and density of colonies. *Tubastrea coccinea, Porites astreoides* and *Montastraea cavernosa* were also common at the reef top. Sponges, represented within transects by at least 12 species were the dominant sessile-benthic invertebrate in terms of reef substrate cover (mean: 26%) at the reef top. Due to their large size and abundance, sponges contributed substantially to the reef topographic relief and served as an important habitat for fishes and invertebrates.

The reef wall habitat at BDS was characterized by irregular formations that appear to have been influenced by erosional processes, with deep crevices, undercuts, gaps, ledges and other substrate irregularities. The sessile-benthos of the reef wall habitat resembled the reef top in that it was also highly diverse and taxonomically complex, comprised by sponges (43%), benthic algae (26%), octocorals (14%), scleractinian corals (5.5%), antipatharians (3%) and hydrozoans (2%). Abiotic cover was approximately 4%. Sponges were the most prominent component of the sessile-benthos at the reef wall, with at least 11 species present within transects surveyed and the prevalence of large erect and branching growth forms providing substantial topographic relief and reef substrate complexity. Octocorals (gorgonians), particularly the deep sea fan, *Iciligorgia schrammi* combined with black corals (Antipatharians), mostly the Caribbean bushy coral, *Antipathes caribbeana* to contribute an average reef substrate cover of 17%, adding to the benthic substrate heterogeneity and providing protective habitat for fishes at the reef wall. As in the reef top, scleractinian corals were present as a species rich assemblage of numerous, but small isolated colonies growing encrusted to the hard ground substrate and contributing minimally to the reef topographic relief.

At BDS, the deep platform rhodolith reef, at least down to the maximum surveyed depth of 50 m, appears to be a vast deposit of crustose algal nodules or rhodoliths overgrown by a dense macroalgal carpet, mostly the encrusting fan-leaf alga, *Lobophora variegata*. The sessile-benthic invertebrate community was characterized by relatively low taxonomic diversity, with virtual absence of gorgonians and antipatharians, low substrate cover and species composition by scleractinian corals and a marked decline of cover and species composition by sponges, relative to the reef top and wall habitats. With few exceptions, scleractinian corals and sponges grow attached to rhodoliths, and are therefore not fixed to the bottom. Lettuce corals, *Agaricia spp*. were the dominant scleractinian taxa in terms of reef substrate cover.

## IV. STUDY OBJECTIVES

The main objectives of the study were to:

1) Locate, identify and describe the main reef physiographic zones within mesophotic depths in the range of 30 – 50 m at ALS, validating multi-beam bathymetry data and preliminary benthic habitat classifications produced by the R/V Nancy Foster (NOAA).
2) Produce a digital and geo-referenced benthic map of the ALS mesophotic reef habitats at depths of 30 – 50 m, based on direct diver observations.

3) Provide a quantitative characterization of the percent substrate cover by sessile-benthic categories from the main benthic habitats and reef physiographic zones at ALS within the 30 – 50 m depth range.
4) Perform a taxonomic survey of the predominant benthic assemblages at the main reef physiographic zones and benthic habitats from ALS.
5) Provide a taxonomic survey and a quantitative characterization (density, relative abundance) of the diurnal, non-cryptic fishes and motile, megabenthic invertebrates from the main reef physiographic zones and benthic habitats.
6) Analyze and compare the variations of benthic and pelagic community structure between reef physiographic zones and benthic habitats at ALS
7) Measure water current velocities and directions during May, encompassing the period of mutton snapper, *Lutjanus analis* group spawning aggregation.
8) Produce a digital and video record illustrative of the main reef physiographic zones, benthic habitats and their predominant biological components at ALS.

## V. METHODS

### A. Bathymetry map of Abrir La Sierra

Upon request of the CFMC, a multibeam bathymetry survey of Abrir La Sierra (ALS) was produced by NOAA's Center for Coastal Monitoring and Assessment previous to the start of this grant period (http://ccma.nos.noaa.gov/ecosystems/coral reef/usvi_nps.html). The work was performed under the direction of Dr. Tim Batista aboard NOAA's research vessel (R/V) Nancy Foster with collaboration from representatives from the grantee's research team, Jorge Sabater Clavell and Rene Esteves. Derived parameters of slope and substrate rugosity were also provided. The bathymetry map was incorporated in to Hypack software by our team in order to facilitate navigation over the main reef topographic and physiographic features at ALS. This aided in the selection and execution of dives for construction of a field validated benthic habitat map, and for quantitative and qualitative characterization of communities associated with the main reef physiographic zones and benthic habitats.

The available multibeam bathymetry data was processed in GIS to construct a bathymetry map with two meter interval depth contours within the 30 – 50 m range.

Depth contours were drawn as polygons to allow determinations of area included under each depth strata within the 30 – 50 m range.

B. Benthic habitat map of Abrir La Sierra

Production of the benthic habitat map of ALS was based on a series of field observations and habitat classifications of the main reef topographic features by rebreather divers as suggested from the multi-beam bathymetry map, and from drop-video camera images and preliminary classifications of benthic habitats produced by the R/V Nancy Foster. A total of 62 stations were occupied for direct field verification of benthic habitats. These included a combination of bounce (point) dives at strategic locations, long exploratory drift dives for assessment of commercially important fishes and shellfish, and saturation dives for quantitative biological characterizations. Figure 1 shows the location of field sampling stations at ALS. Exact station geographic positions, depths, habitat, and survey work data is presented in Table 2.

The final benthic habitat map was prepared in Arc-View software with NOAA's Habitat Digitizer extension. Initially, drop-video camera images from the R/V Nancy Foster were reviewed and field validated (Figure 2). Preliminary classifications of benthic habitats by NOAA within the 30 – 50 m depth range included 1) algal plains, 2) scattered algal nodules in sand, 3) pavement, and 4) scattered coral/rock in sand. All benthic field observations, including NOAA's drop-video camera, were plotted in GIS and utilized for the construction of the benthic habitat map. In addition to field verified observations, parameters of slope and rugosity were used to generate polygons of areas consistent with previously verified sites. These areas with similar slope and rugosity characteristics were labeled as being the same habitat until further on site verification.

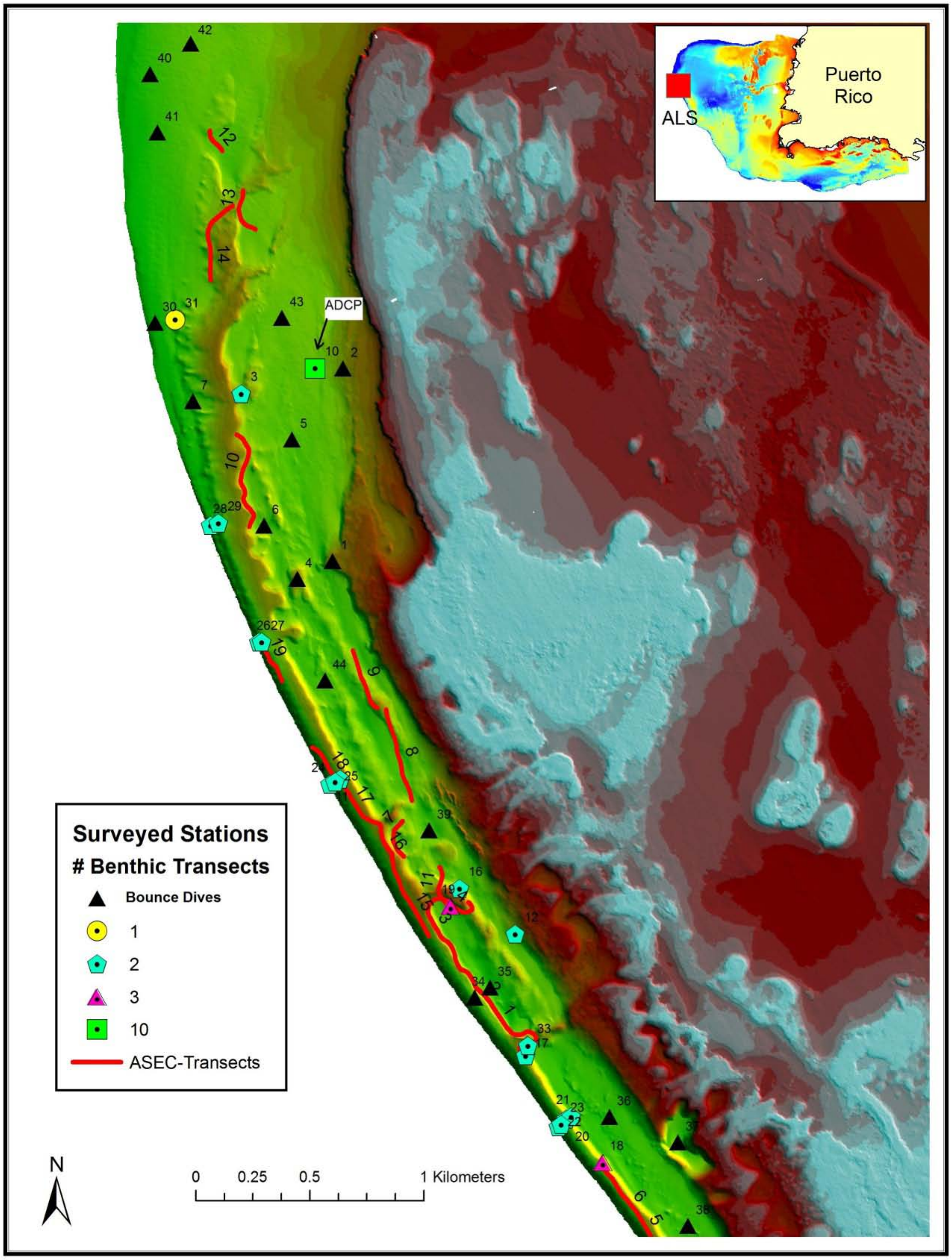
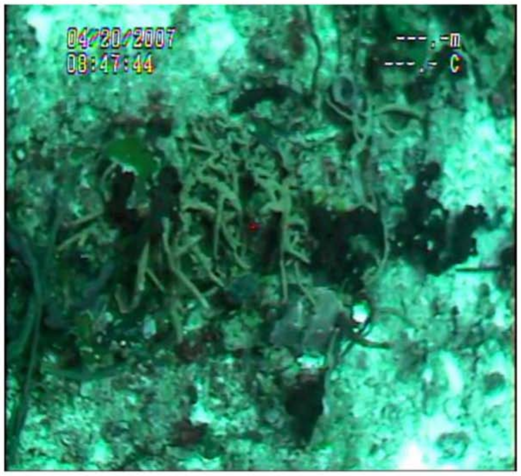
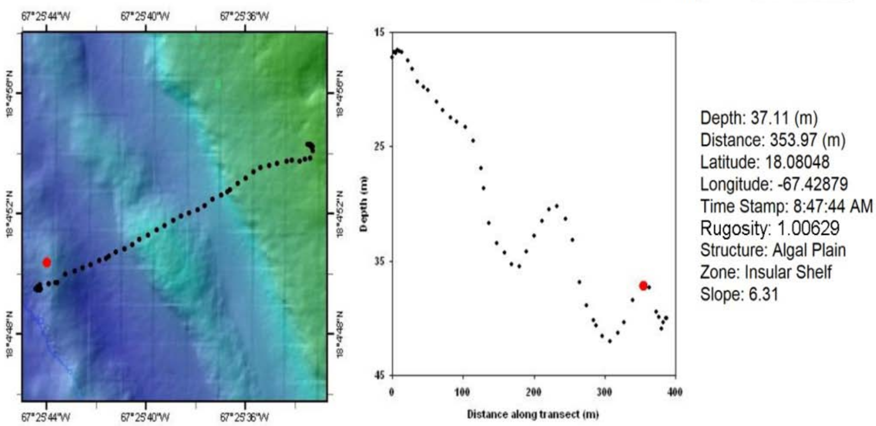



**Figure 1**. Location of field sampling stations at Abrir la Sierra.




| Bio Cover Type | Cover Percent |
|---|---|
| Live hard coral (Stony Corals, Hydrocorals) | Rare (1%-10%) |
| Live soft coral (Gorgonians, Black Coral) | Absent (0%) |
| Sponge | Sparse (11%-50%) |
| Seagrass | Absent (0%) |
| Macroalgae | Rare (1%-10%) |
| Coralline algae | Rare (1%-10%) |
| Turf/Filamentous algae | Patchy (51%-90%) |
| Sessile cnidarians, segmented worms and crinoids | Absent (0%) |
| Uncolonized Substrate | Rare (1%-10%) |
| Unknown | Absent (0%) |




Transcect # 200751
43 of 50

**Figure 2**. Transverse section of drop-camera survey by NOAA from the R/V Nancy Foster used in selection of sampling stations for biological characterization of mesophotic habitats at Abrir La Sierra.

Ref. http://ccma.nos.noaa.gov/ecosystems/coral reef/usvi_nps.html

## C. ADCP Water Current Measurements

Water current velocities and directions from depths between 2.1 m and 35.4 m were measured at ALS using an Acoustic Doppler Current Profiler (ADCP) during a 5 week period between May 2 and June 2, 2008. Geographic coordinates, depths and other statistics of the ADCP deployment (ALS-1) are presented in Table 3. The ADCP configuration data is included in Table 4.

**Table 2.** List of stations surveyed at Abrir la Sierra with information on location, depth, habitat type and multi-beam derived parameters. (B) bounce dive; (T) line and belt-transect.

| Station | Survey | Latitude | Longitude | Depth | Zone / Habitat | Rugosity | Slope |
|---|---|---|---|---|---|---|---|
| 1 | B | 18.0864 | -67.4294 | 28.2 | Slope 30 | 1.001 | 3.011 |
| 2 | B | 18.094 | -67.429 | 29.6 | Slope 30 | 1.001 | 2.814 |
| 3 | T | 18.093 | -67.433 | 29.3 | Slope 30 | 1.003 | 2.703 |
| 4 | B | 18.0857 | -67.4308 | 30.0 | Coral Reef | 1.000 | 1.676 |
| 5 | B | 18.0912 | -67.431 | 40.0 | Inner Wall | 1.000 | 1.337 |
| 6 | B | 18.0878 | -67.4321 | 41.0 | Inner Wall | 1.002 | 3.394 |
| 7 | B | 18.0927 | -67.4349 | 38.8 | Inner Wall | 1.008 | 5.749 |
| 10 / ADCP | T | 18.094 | -67.4301 | 35.8 | Rhodolith Reef | 1.000 | 0.730 |
| 11 | T | 18.0778 | -67.4291 | 31.8 | Slope 30 | 1.027 | 13.140 |
| 12 | T | 18.0717 | -67.4222 | 28.6 | Slope 30 | 1.031 | 8.367 |
| 16 | T | 18.0735 | -67.4244 | 33.9 | Inner Wall | 1.087 | 22.714 |
| 17 | T | 18.0669 | -67.4218 | 30.8 | Inner Wall | 1.028 | 11.870 |
| 18 | T | 18.0627 | -67.4188 | 32.6 | Slope 30 | 1.002 | 2.831 |
| 19 | T | 18.0728 | -67.4248 | 37.1 | Inner Wall | 1.020 | 11.348 |
| 20 | T | 18.0644 | -67.4202 | 33.2 | Slope 30 | 1.002 | 3.815 |
| 21 | T | 18.0645 | -67.42 | 41.1 | Inner Wall | 1.159 | 30.237 |
| 22 | T | 18.0641 | -67.4205 | 49.2 | Slope 50 | 1.199 | 32.885 |
| 23 | T | 18.0642 | -67.4204 | 40.9 | Slope 40 | 1.167 | 30.598 |
| 24 | T | 18.0776 | -67.4295 | 51.7 | Slope 50 | 1.208 | 33.978 |
| 25 | T | 18.0777 | -67.4293 | 40.2 | Slope 40 | 1.102 | 24.639 |
| 26 | T | 18.0832 | -67.4323 | 50.8 | Slope 50 | 1.148 | 33.548 |
| 27 | T | 18.0832 | -67.4322 | 40.7 | Slope 40 | 1.104 | 24.995 |
| 28 | T | 18.0878 | -67.4342 | 50.0 | Slope 50 | 1.069 | 19.468 |
| 29 | T | 18.0879 | -67.4339 | 40.0 | Slope 40 | 1.062 | 21.385 |
| 30 | T | 18.0958 | -67.4364 | 50.0 | Rhodolith Reef | 1.006 | 6.368 |
| 31 | T | 18.0959 | -67.4356 | 40.0 | Slope 40 | 1.017 | 10.261 |
| 33 | T | 18.0673 | -67.4217 | 33.0 | Coral Reef | 1.011 | 8.190 |
| 34 | B | 18.0692 | -67.4238 | 34.9 | Slope 40 | 1.011 | 8.325 |
| 35 | B | 18.0696 | -67.4232 | 48.0 | Rhodolith Reef | 1.001 | 2.676 |
| 36 | B | 18.0645 | -67.4185 | 45.9 | Scattered algal nodules | 1.003 | 4.697 |
| 37 | B | 18.0635 | -67.4158 | 45.0 | Scattered algal nodules | 1.009 | 7.486 |
| 38 | B | 18.0602 | -67.4154 | 43.6 | Scattered algal nodules | 1.003 | 2.344 |
| 39 | B | 18.0758 | -67.4256 | 42.9 | Rhodolith Reef | 1.002 | 2.946 |
| 40 | B | 18.1056 | -67.4366 | 45.2 | Rhodolith Reef | 1.002 | 3.118 |
| 41 | B | 18.1033 | -67.4363 | 45.0 | Rhodolith Reef | 1.003 | 4.148 |
| 42 | B | 18.1068 | -67.435 | 38.4 | Rhodolith Reef | 1.000 | 0.591 |
| 43 | B | 18.096 | -67.4314 | 36.5 | Scattered algal nodules | 1.000 | 1.510 |
| 44 | B | 18.0817 | -67.4297 | 41.3 | Scattered algal nodules | 1.001 | 2.248 |

**Table 3**. ADCP deployment at Abrir la Sierra during the mutton snapper spawning aggregation, May – June, 2008. Depth in meters (feet) relative to MLLW.

| | | | | | **Bottom** | **Xducer** | **6% Xducer** |
|---|---|---|---|---|---|---|---|
| **Event** | **Start** | **End** | **Lat (N)** | **Lon (W)** | **Depth** | **Depth** | **Depth** |
| *ALS-1* | 02-May-08 | 02-Jun-08 | 18° 05.'N | 67° 26.'W | 35.4 (116) | 35.1 (115) | 2.11 (6.9) |
| | | | | | | | |

**Table 4**: Sentinel ADCP configuration.

| | |
|---|---|
| Bin size | 1.0 m (3.28 ft) |
| Currents and tide sampling interval | 30 minutes |
| Pings per sampling interval | 300 |
| Standard deviation (ADCP only) | 0.35 cm/s |
| Distance to center of deepest bin | 2.12 m (6.95ft) |

The ADCP was bottom mounted on a rhodolith reef habitat at a depth of 35.4 m near buoy 6, on the northern section of ALS (Figure 1). The RDI Sentinel ADCP has a beam angle of 20°, which restricts useful data to depths greater than 6% (= 1 - cos (20°)) of the transducer depth (Xducer depth in Table 3). Considering these limitations, at a bottom depth of 34.5 m the 600 kHz ADCP provided usable data in the depth range of 3 – 34 m (bin center depths). The ADCP was configured to sample 40 bins, 34 of which were below the 6% depth level indicative of good velocity data.

D. <u>Characterization of sessile-benthic and pelagic communities associated with Habitats/Zones at Abrir la Sierra</u>

The field sampling program for quantitative and qualitative assessment of the predominant sessile-benthic and pelagic communities at ALS consisted of 23 trips to the study site. A total of 47 -10 m long (ea) transects for determinations of percent cover by sessile-benthic categories were surveyed. The same transect array was used to quantify demersal reef fishes and motile megabenthic invertebrates within the 47 – 10 m long x 3 m wide belt-transects. Determinations of densities of each species per belt-transect were recorded. In addition, 20 – 250 m long x 3 m wide transects were run as Active Search Surveys (ASEC) for fishery-independent assessments of commercially important fish (groupers, snappers, hogfish) and shellfish (conch and lobster) populations. Figure 1 shows the location of sampling stations for mesophotic reef community surveys including benthic transects and ASEC transect surveys.

Quantitative assessments of the predominant sessile-benthic and pelagic communities were performed at the main reef physiographic zones down to a maximum depth of 50 m. The mesophotic reef physiographic zones and benthic habitats studied included:

1) insular slope at 30 m (SL 30) - 10 transects. Sta. 3, 11, 12, 18 and 20
2) insular slope at 40 m (SL 40) - 10 transects. Sta. 21, 23, 25, 27 and 29
3) insular slope at 50 m (SL 50) - 8 transects. Sta. 22, 24, 26, and 28
4) inner wall of the deep terrace (IW) at 30 – 40 m - 7 transects. Sta. 16, 17, and 19
5) rhodolith reef habitat of the deep terrace (RR) at 36 m - 10 transects. Sta. 10
6) coral reef habitat of the deep terrace (CR) at 33 m - 2 transects. Sta. 33

## 1.0. Sessile-benthic community characterizations

Sessile-benthic communities were quantitatively described in terms of percent cover by substrate categories along 10-meter long transects. A total of ten non-overlapping digital images (still photos) from each transect were analyzed using the Coral Point Count software v.3.2. A template of 25 random points was overlaid on each image and the substrate categories under each point identified. The cumulative number of points over each substrate category in the ten images analyzed per transect was divided by the total number of points overlaid per transect (e.g. 25 points per image x 10 images = 250 points per transect) and reported as the percent reef substrate cover for that transect. The total number of scleractinian, octocorallian, hydrozoan and antipatharian colonies present in all images analyzed were identified to the lowest possible taxon and enumerated for determination of coral colony density (in colonies per square meter). The reef substrate area encompassed in still images ranged between 0.85 and 1.1 $m^2$.

Sessile-benthic reef categories included in the photographic image analysis included the following:

1) Scleractinian corals – percent cover and density of colonies per transect reported by species. Both hermatypic (e.g. *Montastraea cavernosa*) and ahermatypic (e.g. *Tubastrea coccinea*) taxa included.

2) Octocorals - (soft corals) percent cover and density of colonies per transect reported by species; or lowest identifiable taxon; includes vertically projected colonies, such as *Iciligorgia schrammi* and encrusting colonies, such as *Erythropodium caribaeorum*.

3) Antipatharians – (black corals), percent cover and density of colonies per transect reported to the lowest identifiable taxon.

4) Hydrocorals – (fire and lace corals), percent cover and density of colonies per transect reported by species; or lowest identifiable taxon; includes vertically projected colonies, such as *Stylaster roseus,* and encrusting colonies, such as *Millepora spp*.

5) Sponges – percent cover reported by species, or lowest possible taxon.

6) Algal Turf – percent cover reported by assemblage, consisting of mixed populations of short articulate coralline red, and brown macroalgae, intermixed with other small epibenthic biota forming a mat or carpet over hard substrate.

7) Calcareous Algae – reported as species (*Halimeda sp*.) total calcareous algae, or lowest possible taxon.

8) Fleshy Algae – vertically projected, mostly brown, red and green macroalgae reported as total fleshy algae, or lowest possible taxon (e.g. *Lobophora variegata*).

9) Cyanobacteria – blue green algal mats.

10) Abiotic Substrates – includes unconsolidated sediment, bare rock, deep holes and gaps.

Common names and coral taxonomy followed Veron (2000) and Humann and Deloach (2003).

**2.0. Characterization of Fishes and Motile Megabenthic Invertebrates**

Belt-transects for estimation of densities of demersal (non-cryptic) reef fish populations and motile megabenthic invertebrates were centered along the reference line of transects used for sessile-benthic reef characterizations. Thus, a total of 47 transects were surveyed in characterization of fish and motile megabenthic invertebrates associated with benthic habitats of the slope wall (SL) at 30, 40 and 50 m; and with the inner walls (IW), coral reef (CR) and rhodolith reef (RR) habitats of the deep outer terrace. A detailed description of the survey protocol for fish enumerations within belt-transects is presented in García-Sais et al. (2005).

Large, elusive fishes and shellfish populations (spiny lobsters and queen conch) were visually surveyed by a series of down current drift dives executed by a pair of rebreather divers producing belt-transects of approximately 200 m long by 6 m wide (1,200 $m^2$) each. A total of 20 drift belt-transects were performed at depths between 30 – 50 m. The point of origin was predetermined from the multi-beam bathymetry map. Survey start points were loaded in Hypack software and a marker buoy with a lead at the bottom was deployed upon arrival. Divers went down by the marker and carried the lead weight during the drift dive to allow tracking by the boat GPS. The marker float was pulled three times by the divers to signal the end of the transect swath. The start and finish positions were annotated and each distance covered calculated by Hypack. Target species included nassau, black, yellowfin, and red hind groupers, dog, mutton and cubera snappers, sharks, large pelagic species, spiny lobsters, and queen conch. Common names of reef fishes were taken from Humann and Deloach (2006).

### E. Data Analysis

Patterns of sessile-benthic and ichthyofaunal similarities between reef physiographic zones and benthic habitats were examined using a non-metric multidimensional scaling (MDS) procedure on the data of percent substrate cover by benthic categories and fish abundance from replicate transects at each depth. Both transformation log (x + 1) and double standardization of the data was performed to smooth effects of numerically dominant species with highly aggregated spatial distributions. Data ordination was based on Bray-Curtis Euclidean distances. ANOSIM and SIMPER routines in the PRIMER statistical package were used to analyze similarities of benthic and fish community structure between reef physiographic zones and benthic habitats, and to identify relevant species contributions to similarity/dissimilarity percentages within and between habitats.

## VI. RESULTS

### A. Bathymetry

ALS is a shelf-edge reef located approximately 23.5 km west off Punta Guaniquilla, Cabo Rojo, on the west coast of Puerto Rico. The insular shelf that leads to ALS is an extensive platform of pavement, sand and coral reef habitats that stands as the largest continuous neritic terrace of the Puerto Rican insular shelf. The bathymetry profile of the study area at ALS on the northern edge features a shallow shelf-edge at approximately 15 m (8 fathoms) and a gradual drop down the insular slope to a depth of 63 m, where the slope rises to a relatively wide terrace (Figure 3). Throughout most of the center and southern sections, the bathymetry at ALS exhibits a primary drop-off from the insular shelf at depths between 20 – 22 m (11 – 12 fathoms). This primary drop-off leads to an outer shelf terrace submerged at depths from 30 - 50 m, extending offshore approximately 0.3 - 0.5 km. In some sections of the outer shelf terrace, the seafloor rises to relatively narrow ridges of variable vertical and horizontal dimensions, with the deeper pools reaching a maximum depth of 50 m. A continuous ridge that rises from the deep outer shelf terrace to depths of 27 – 33 m fringes the shelf-edge, except at the northern edge of ALS. The drop-off at the shelf-edge is typically abrupt, particularly along the southern section. Thus, the main bathymetry features of the mesophotic habitat at ALS within the 30-50 m depth range consist of a series of at least two internal slope walls, a deep outer shelf terrace and an outer wall insular slope.

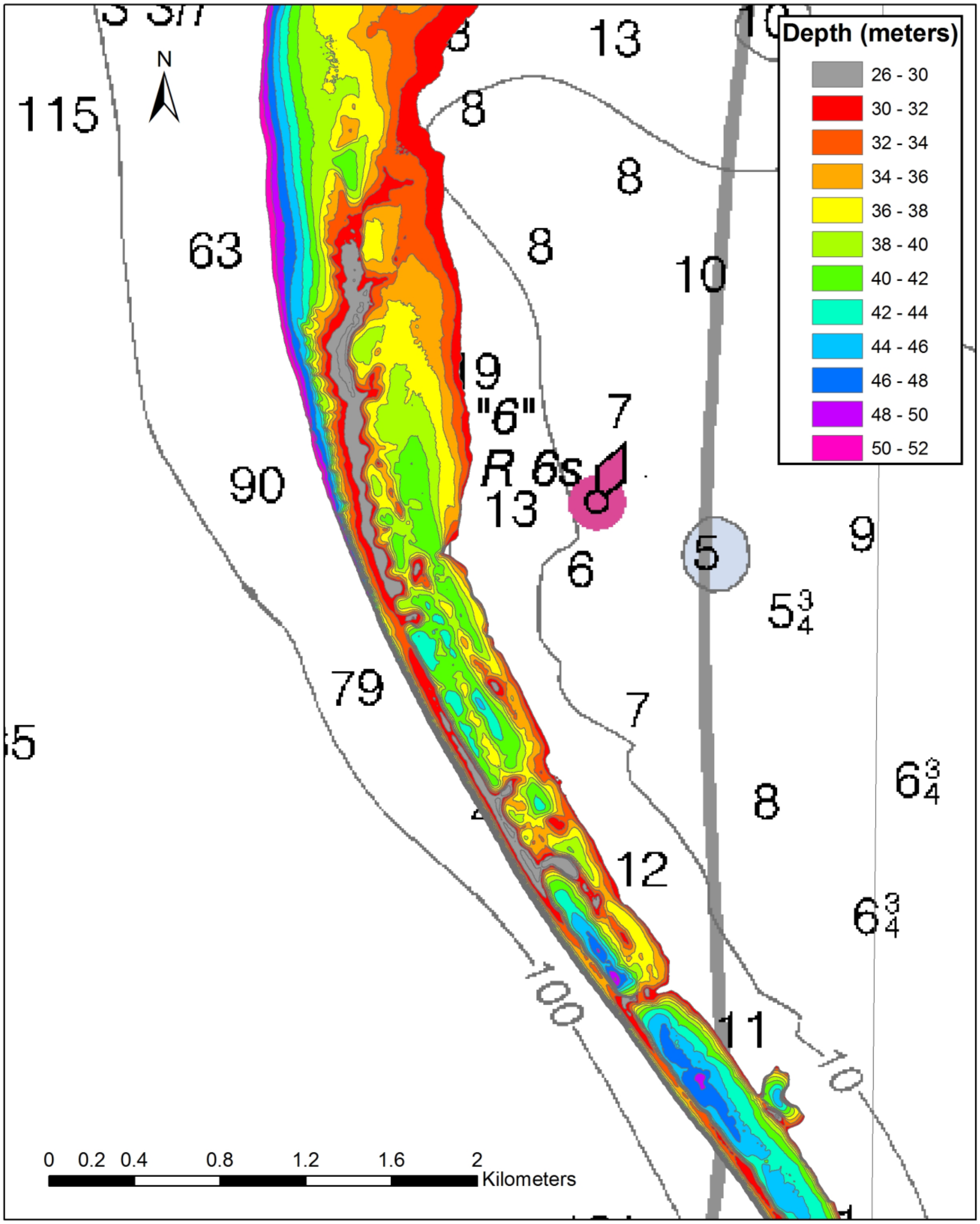



**Figure 3**. Bathymetry of the mesophotic study area at Abrir La Sierra. Source data: http://ccma.nos.noaa.gov/ecosystems/coral reef/usvi_nps.html

http://ccma.nos.noaa.gov/ecosystems/coral reef/usvi_nps.html

B. Water Currents

The May-June, 2008 ADCP deployment at ALS targeted the seasonal spawning aggregation of mutton snapper (*Lutjanus analis*) that has been reported to occur close to the shelf-edge, near Buoy 6 (Figure 1). Current velocities and direction profiles were analyzed to gain insights as to the possible trajectories of fertilized eggs and early larval stages of mutton snapper.

The water current flow structure was characterized by a highly dominant north-northwest flow that appears to be topographically steered by the shelf-edge bottom contours (Figure 4). The flow direction and velocities is typical of the water current pattern that has been previously recorded from this site (Capella, unpublished). The velocity profile time series was characterized by a dominant semi-diurnal tidal component superimposed on a much weaker diurnal, and lower frequency flows. This pattern is typical of the north and west coasts of Puerto Rico. The average magnitude of the flow in the near-surface layer, as represented by the scalar mean speed and by the 50$^{th}$ percentile speed was in the order of 30 cm/s (Figure 5). Maximum near-surface speeds in excess of 100 cm/s were measured. The magnitude of the observed flow at this site is the second highest observed by the Sentinel ADCP in Puerto Rico, following those measured at El Bajo de Sico seamount (Garcia-Sais et al., 2007). The northward, topographically steered (along isobath) flow is consistent with data obtained in 1997-1998 at a site further north, west of Mayaguez, using AANDERAA RCM9s in a taut wire mooring (Capella, unpublished). The flow pattern measured during May - June at ALS was consistent towards the north, with few and relatively weak tidal reversals. Biological particles, such as fish eggs and early larval stages carried by the subsurface flow would tend to be advected northwards, while the drift of free-floating particles at the surface might be influenced by easterly and southeasterly winds. Therefore, dispersal of fertilized eggs and larvae would seed the west coast of PR and Mona Passage. Water current flow at this location is consistent with the similar strong northward flow observed at Bajo de Sico (Garcia-Sais et al., 2007).

Continuous water temperature measurements during this period showed a sharp decline of 1.2 °C during May 16, between 27.5 – 26.3 °C (Figure 6). The sudden decline of water temperature observed may be associated with the arrival of an internal wave at ALS, a factor which has been suggested to act as a cue for massive spawning by mutton snapper (Esteves, 2005).

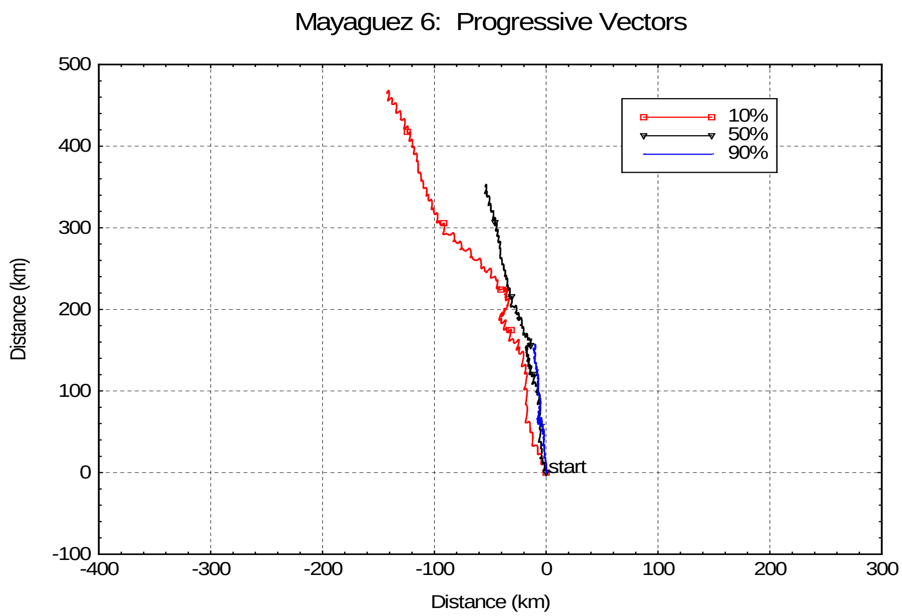



**Figure 4**. Progressive vectors of water current direction at ALS from the start date of May 2 to the finish date of June 2, 2008.

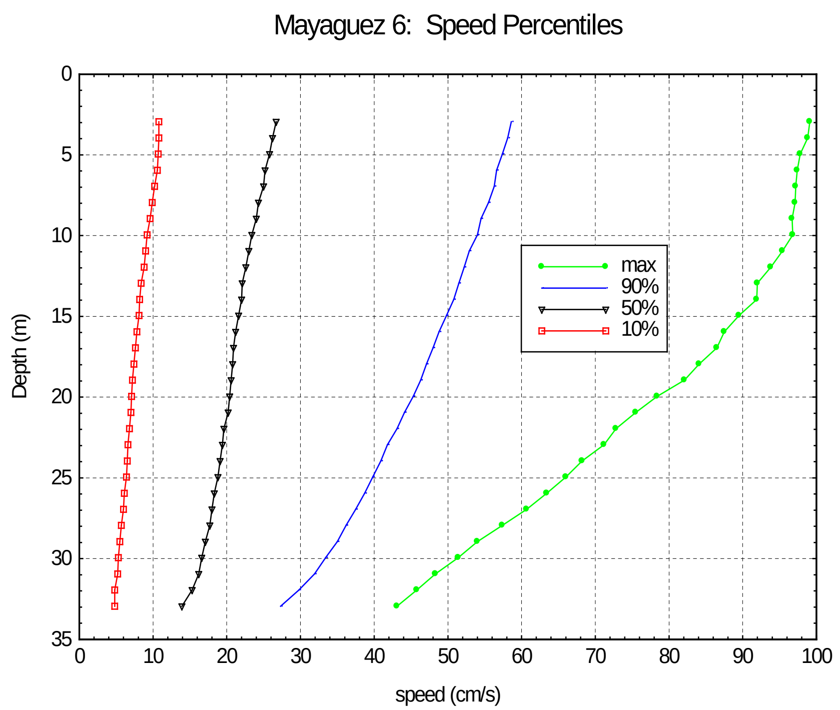



**Figure 5**. ADCP water current velocity profiles from Abrir la Sierra during the deployment period from May 2 – June 2, 2008.

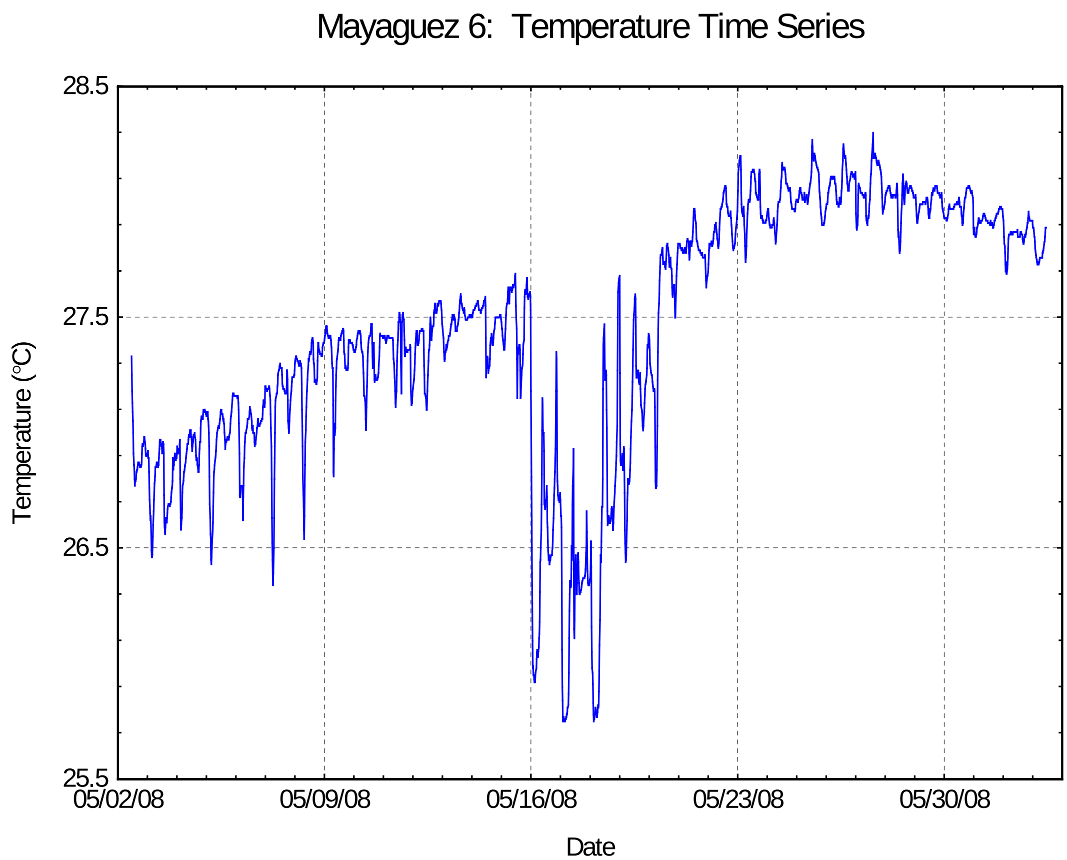



**Figure 6**. Water temperature records from Abrir la Sierra during the mutton snapper spawning aggregation (May 2 – June 2, 2008).

C. Benthic Habitat Map

Mesophotic (> 30 m) benthic habitats at ALS were found associated with a deep outer shelf terrace separated by two inner walls, and a shelf-edge outer slope wall that represents the upper section of the insular slope. Benthic habitats associated with the deep outer terrace included colonized pavement, rhodolith reefs, a very small section of coral reef, and scattered rhodoliths and sand. Inner walls exhibited moderate live coral cover, consistent with the classification of a coral reef habitat down to a maximum depth of approximately 27 - 28 m. Below 30 m, reef substrate was observed to consist mostly of pavement (hard bottom) colonized by algae, sponges and scattered corals that typically declined in abundance and diversity with increasing depth.

Benthic habitats distributed within the horizontal, or gently sloping profile of the deep terrace included sections of unconsolidated sandy bottoms with scattered rhodoliths, (scattered rhodolith and sand) and areas of extensive deposits of algal rhodoliths (rhodolith reefs) with minimal abiotic cover. One relatively small coral reef habitat was discovered at depths between 30 – 33 m associated with a protected cove within the outer shelf terrace habitat at ALS (Figure 7). Boulder star coral, *Montastraea annularis* was the main structural reef component and was observed to be in good condition. Gorgonians were prominent and contributed substantially to the benthic habitat complexity. Scattered hard ground promontories rising from the bottom one or two meters, with a maximum diameter of about 10 meters were observed in some sections of the otherwise unconsolidated sandy bottom at the deep terrace. These promontories were typically colonized by sponges, gorgonians and corals, in contrast with the mostly un-colonized condition of the surrounding sandy habitat with scattered rhodoliths.

Extensive rhodolith deposits, here classified as rhodolith reefs were found distributed at depths varying between 35 – 50 meters within the outer shelf deep terrace at ALS. This habitat was initially classified by NOAA as an algal plain, and was previously described for Isla Desecheo and Bajo de Sico by García-Sais et al (2005; 2007) as an algal rhodolith reef. Rhodoliths were covered by a dense mat of fleshy algae, particularly the encrusting fan alga, *Lobophora variegata*. Erect and branching sponges were common and represented the main benthic feature providing topographic relief and protective habitat. Rhodolith nodules served as attachment substrates for sponges and isolated, mostly laminar scleractinian corals.

At a depth of approximately 42 - 45 m the seafloor at the deep terrace begins to rise again up a steep slope reaching a reef top that runs north-south as a narrow ridge at depths between 27 – 34 m. The benthic habitat at the insular slope wall within the 30 – 50 m range studied was observed to be mostly pavement (hard ground) colonized by turf and fleshy algae, sponges and scattered corals growing as encrusting and massive isolated colonies. Corals did not contribute substantial topographic relief and were not observed to form structurally or biologically complex reef systems.

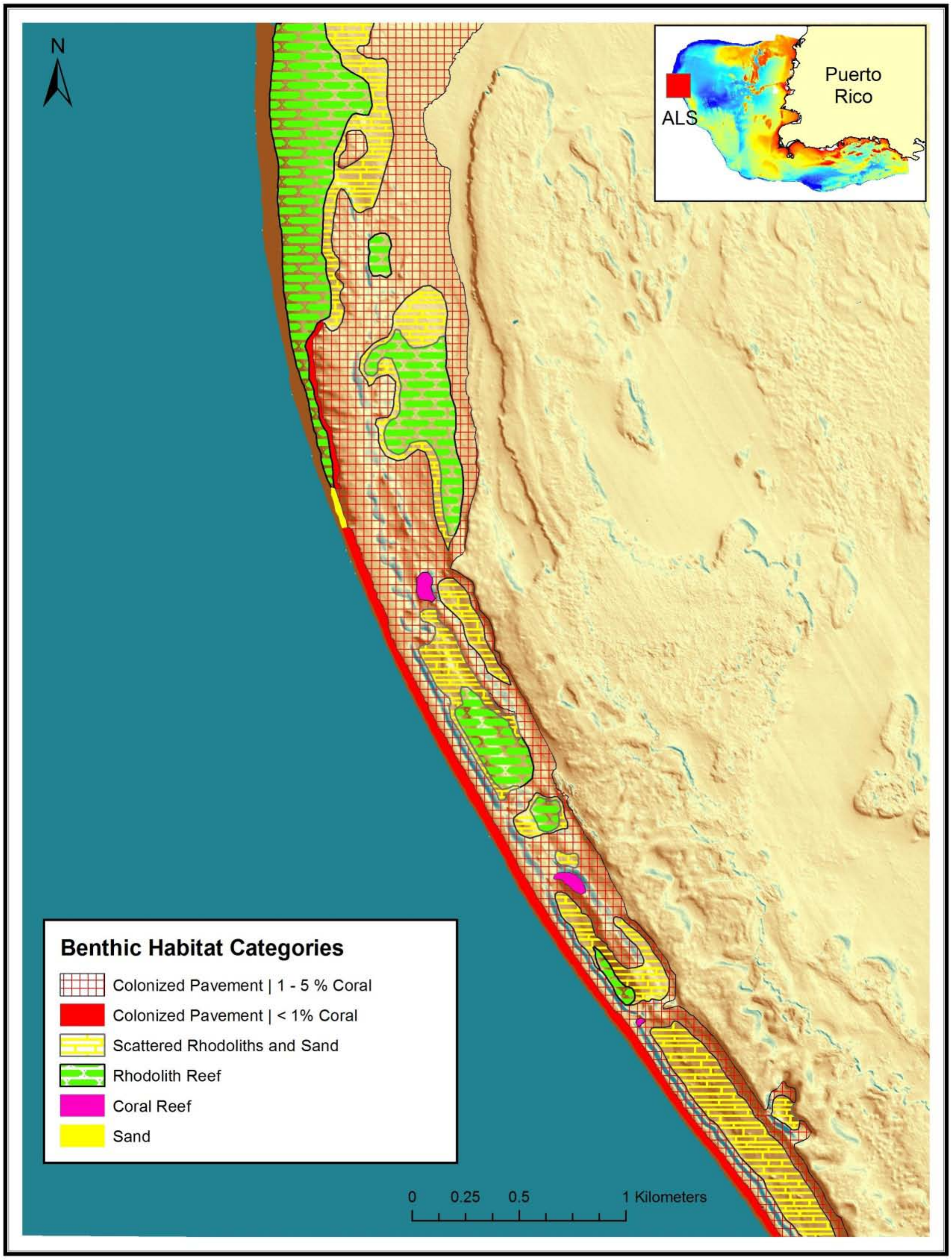



**Figure 7.** Benthic habitat map of Abrir La Sierra between depths of 30–50 meters

**D. Biological Characterization of Physiographic Reef Zones and Benthic Habitats**

1.0. <u>Sessile-benthic Reef Community Structure</u>

### 1.1. Inner Wall (Sessile-Benthic Community)

The inner walls of the deep terrace were surveyed at depths between 31 – 37 m. The benthic habitat was mostly pavement (hard bottom) colonized by benthic algae and other encrusting biota with scattered sand patches. Table 5 presents the percent substrate cover by sessile-benthic categories within photo-transects surveyed at the inner walls. The benthic algal assemblage was comprised of a combination of turf (38.2 %) and fleshy algae (25.1 %). The fan leaf (fleshy) alga, *L. variegata* was a prominent component of the benthic algal assemblage with a mean cover of 17.3% (range: 4.8 – 39.6 %). Sponges were the main sessile-benthic invertebrate component with a mean substrate cover of 13.6 % (range: 9.6 – 21.6 %). A total of 13 species were identified within photo-transects surveyed, and at least four species were identified in each transect. *Agelas conifera, Xestospongia muta* and *Agelas. dispar* were the main sponge taxa in terms of substrate cover among the identified taxa with a combined cover of 6.2 % (Table 5).

Scleractinian corals were represented by 11 species within photo-transects at the inner walls (Table 5). These occurred as isolated, mostly small, encrusting colonies without forming complex structural buildups. Notably higher coral cover and coral structural buildups were present at depths above 30 m in this habitat. Mean substrate cover by scleractinian corals was 4.1 % (range: 2.8 – 6.4 %). Lettuce coral, *Agaricia agaricites* was the most prominent species in terms of cover (2.2 %) and was present in all transects surveyed. Great star and boulder star corals, *Montastraea cavernosa* and *M. annularis* (complex) were present in four out of the seven transects. Table 6 shows the mean density of coral colonies per transect at the inner wall. The mean density was 2.4 colonies/$m^2$ (range: 0.1 – 5.3 col/$m^2$). *Agaricia agaricites, M. annularis* and *S. radians* were the main coral species with individual colonies within photo-transects.

**Table 5**. Percent substrate cover by sessile-benthic categories at the inner wall.

ALS - 30 - 40 m. 2008-10

| | Station - Transects | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Substrate Categories** | **16-1** | **16-2** | **17-1** | **17-2** | **19-1** | **19-2** | **19-3** | **MEAN** |
| Abiotic | 7.6 | 8.4 | 3.6 | 3.2 | 8.4 | 8.8 | 4.8 | **6.4** |
| Benthic algae | | | | | | | | |
| Algal turf | 41.2 | 49.6 | 46.0 | 37.2 | 49.6 | 22.0 | 21.6 | **38.2** |
| Calcareous algae | | | | | | | | |
| *Halimeda sp.* | 0.8 | 0.8 | 0.4 | 1.6 | 0.8 | 0.8 | | **0.7** |
| Fleshy algae | | | | | | | | |
| *Lobophora variegata* | 17.2 | 11.2 | 4.8 | 6.8 | 11.2 | 39.6 | 30.0 | **17.3** |
| unidentified | 5.6 | 5.2 | 2.8 | 2.8 | 5.2 | 6.0 | 6.8 | **4.9** |
| *Dictyota spp.* | 1.6 | 0.8 | 0.8 | 4.8 | 0.8 | 1.6 | 1.6 | **1.7** |
| *Amphiroa sp.* | | | 0.8 | 0.8 | | | | **0.2** |
| Total Benthic Algae | 66.4 | 67.6 | 55.6 | 54.0 | 67.6 | 70.0 | 60.0 | **63.0** |
| Cyanobacteria | 5.2 | 3.2 | 8.0 | 13.2 | 3.2 | 0.0 | 0.0 | **4.7** |
| Sponges | | | | | | | | |
| unidentified sponges | 4.8 | 6.0 | 4.8 | 5.2 | 6.0 | 1.2 | 3.2 | **4.5** |
| *Agelas conifera* | | 2.8 | 6.0 | 3.6 | 2.8 | 4.0 | 5.6 | **3.5** |
| *Xestospongia muta* | 2.4 | | 2.0 | 4.0 | | 2.8 | 1.6 | **1.8** |
| *Agelas dispar* | 1.6 | 0.4 | 1.6 | 1.6 | 0.4 | 0.8 | | **0.9** |
| *Agelas clathrodes* | 0.8 | 0.8 | 0.8 | 2.4 | 0.8 | | | **0.8** |
| *Iotrochota birotulata* | | 0.4 | 1.6 | 2.0 | 0.4 | 0.8 | | **0.7** |
| *Verongula gigantea* | | | 1.6 | 1.2 | | | | **0.4** |
| *Plakortis sp.* | | 0.8 | 1.0 | | 0.8 | | | **0.4** |
| *Agelas cauliformis* | 0.4 | | 0.4 | 1.2 | | | | **0.3** |
| *Aplysina archeri* | | | 0.4 | | | | | **0.1** |
| *Geodia neptuni* | | | | 0.4 | | | | **0.1** |
| *Cliona sp.* | | | | | | | 0.4 | **0.1** |
| *Ircinia felix* | | | 0.4 | | | | | **0.1** |
| *Aplysina lacunosa* | | | 0.4 | | | | | **0.1** |
| Total Sponges | 10.0 | 11.2 | 21.0 | 21.6 | 11.2 | 9.6 | 10.8 | **13.6** |
| Scleractinian corals | | | | | | | | |
| *Agaricia agaricites* | 3.6 | 2.0 | 1.2 | 1.2 | 2.0 | 0.8 | 4.8 | **2.2** |
| *Montastrea annularis* | 2.8 | | | 0.4 | | 0.4 | 1.2 | **0.7** |
| *Montastraea cavernosa* | | 0.4 | 2.0 | 0.4 | 0.4 | | | **0.5** |
| *Meandrina meandrites* | | | 1.2 | | | | | **0.2** |
| *Agaricia sp.* | | | | | | 0.8 | | **0.1** |
| *Porites astreoides* | | | | 0.4 | | 0.4 | | **0.1** |
| *Agaricia lamarki* | | | | | | 0.4 | | **0.1** |
| *Siderastrea siderea* | | | | | | | 0.4 | **0.1** |
| *Siderastrea radians* | | | 0.4 | | | | | **0.1** |
| *Madracis decactis* | | | | 0.4 | | | | **0.1** |
| unidentified | | | | | 0.4 | | | **0.1** |
| Total corals | 6.4 | 2.4 | 4.8 | 2.8 | 2.8 | 2.8 | 6.4 | **4.1** |
| Octocorals | | | | | | | | |
| *Pseudopterogorgia sp.* | 1.2 | 3.6 | | | 3.6 | 6.0 | 13.6 | **4.0** |
| unidentified | 0.8 | | | | | 0.8 | | **0.2** |
| Total Gorgonians | | | 1.2 | | | | | **0.2** |

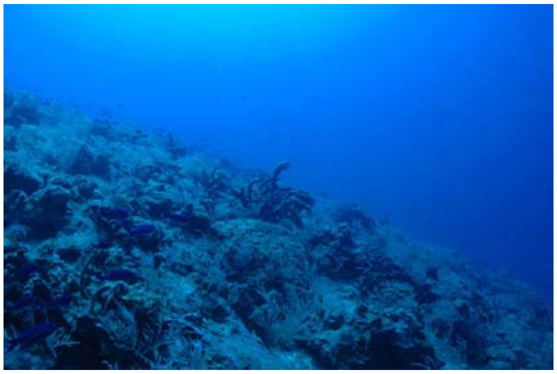
**Table 5.** continued

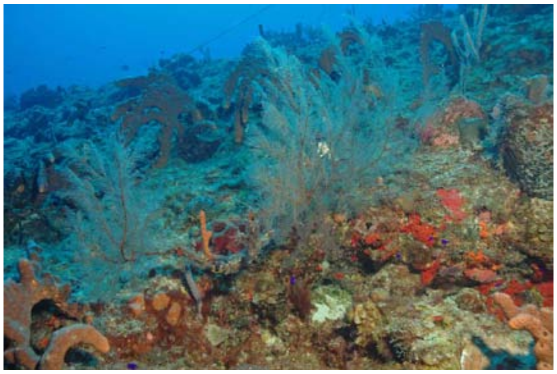
| | | | | |
|---|---|---|---|---|
| Total Antipatharians | | 0.1 | 0.1 | **0.03** |
| Hydrocorals | | | | |
| *Millepora alcicornis* | 0.8 | | | **0.11** |

**Table 6**. Density of coral colonies (# colonies/m$^2$) within photo-transects at the inner wall. Abrir la Sierra. Depth: 30 - 40 m. 2008-10

| | Station - Transect | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Taxa** | **16-1** | **16-2** | **17-1** | **17-2** | **19-1** | **19-2** | **19-3** | **MEAN** |
| ***Scleractinian Corals*** | | | | | | | | |
| *Agaricia agaricites* | 0.3 | 0.6 | 0.1 | 1.6 | 1.4 | 0.3 | 2.5 | **0.97** |
| *Montastraea annularis* | | 0.2 | | 0.1 | 0.8 | 0.2 | 0.9 | **0.31** |
| *Siderastrea radians* | 0.1 | 0.1 | | 0.3 | 0.9 | 0.3 | 0.1 | **0.26** |
| *Porites astreoides* | 0.1 | | | 0.2 | 0.4 | 0.2 | 0.4 | **0.19** |
| *Montastraea cavernosa* | | 0.1 | | 0.6 | | | 0.3 | **0.14** |
| *Agaricia sp.* | | | | | 0.1 | 0.4 | 0.2 | **0.10** |
| *Meandrina meandrites* | | 0.1 | | | 0.4 | 0.1 | | **0.09** |
| *Siderastrea siderea* | | | | | | | 0.5 | **0.07** |
| *Isophyllia sinuosa* | | | | | | 0.4 | 0.1 | **0.07** |
| *Madracis decactis* | | | | 0.2 | | | 0.1 | **0.04** |
| *Agaricia lamarki* | | | | | 0.2 | 0.1 | | **0.04** |
| *Leptoseris cucullata* | | | | | | | 0.2 | **0.03** |
| unidentified | | | | | 0.2 | | | **0.03** |
| *Eusmilia fastigiata* | | | | 0.1 | | | | **0.01** |
| Totals | 0.5 | 1.1 | 0.1 | 3.1 | 4.4 | 2.0 | 5.3 | **2.4** |
| ***Antipatharians*** | | | | | 0.1 | 0.1 | | **0.03** |
| ***Gorgonians*** | | | | | | | | |
| Unidentified | | 1.6 | | | 0.3 | 0.6 | 0.2 | **0.39** |
| *Muricea sp.* | | | | | | | | |
| *Pseudopterogorgia spp.* | 1.1 | 0.4 | | | 4.7 | 6.2 | 8.5 | **3.0** |
| *Gorgonia ventalina* | 0.1 | | | | | 0.1 | | **0.03** |
| **Totals** | 1.2 | 0.4 | 0 | 0 | 4.7 | 6.3 | 8.5 | **3.0** |
| ***Hydrocorals*** | | | | | | | | |
| *Millepora alcicornis* | 1 | 0.6 | | | | 0.2 | 0.5 | **0.3** |

**Photo Album 1.** Inner Wall Benthos





### 1.2. Coral Reef (Sessile-Benthic Community)

Coral reef habitat is common at ALS down to a maximum depth of about 27 m. Only a small section of ALS where live scleractinian coral contributed substantially to the overall reef topographic relief and habitat structural complexity was found associated with the outer shelf wall at station 33 (Figure 1). This reef section appears to be protected from the main swift northward current flow. Sand abrasion and scouring of the seafloor caused by high waves and strong currents could be an important factor limiting the development of complex coral structures below mesophotic depths (>30 m) at ALS. Only two transects were surveyed due to the limited area of the habitat. Turf algae, comprised by a mixed assemblage of short red and brown macroalgae was the dominant category in terms of reef substrate cover with 31.7 %, representing 80 % of the total cover by benthic algae (Table 7). Fleshy algae were mostly comprised by brown algae (Phaeophyta), including the encrusting fan-leaf alga, *L. variegata* and y-twig alga, *Dictyota sp*. Cyanobacterial (blue-green alga) films were observed in the two transects with a mean cover of 3.8 %.

Sponges, represented by eight species within transects were the main invertebrate in terms of reef substrate cover averaging 21.3 % (range: 18.6 – 24.0 *%). Agelas conifera, A. clathrodes* and *Geodia neptuni* comprised the main assemblage among the identified species (Table 7). Sponges contributed substantially to the overall reef structural complexity because of their relatively large size and vertical extension. They also represented an important habitat for juvenile fishes and small motile benthic invertebrates.

Scleractinian corals, represented by 13 species averaged a reef substrate cover of 18.3 % (Table 7), and 9.6 colonies/$m^2$ (Table 8) within transects, which was the highest measured from benthic habitats at ALS within the 30 – 50 m depth range. Boulder star coral, *M. annularis* (complex) was the main coral species in terms of substrate cover and density of colonies with 13.3 % and 4.6 col/$m^2$, representing 72.6 % of the total cover and 48 % of the total colony density by scleractinian corals within photo-transects. In addition to *M. annularis*, lettuce coral, *A. agaricites*, great star coral, *M. cavernosa* and mustard hill coral, *P. astreoides* were present in both transects, and along with the whitestar sheet coral, *A. lamarki* comprised the main scleractinian coral assemblage.

The hydrocoral, Millepora alcicornis was present in the two transects surveyed with a mean density of 0.7 col/m2 (Table 8). Octocorals were mostly represented by the sea plume, *Pseudopterogorgia sp*., and presented a mean substrate cover of 5.3 % and a mean density of 6.7 col/$m^2$.

**Table 7.** Percent substrate cover by sessile-benthic categories at the coral reef habitat in Abrir la Sierra. Depth: 33 m

| | Station - Transect | | |
|---|---|---|---|
| **Substrate Categories** | **33-1** | **33-2** | **MEAN** |
| Abiotic (Sand) | 11.6 | 12.1 | **11.9** |
| Benthic Algae | | | |
| Algal Turf | 32.7 | 30.7 | **31.7** |
| Fleshy Algae | | | |
| *Dictyota sp.* | 3.5 | 7.0 | **5.25** |
| *Lobophora variegata* | 1.0 | 2.0 | **1.5** |
| unidentified | 0.5 | 1.5 | **1.0** |
| Total Benthic Algae | 37.7 | 41.2 | **39.5** |
| Cyanobacteria | 3.5 | 4.0 | **3.8** |
| Sponges | | | |
| *Agelas conifera* | 10.1 | 8.5 | **9.3** |
| Unidentified | 7.0 | 2.0 | **4.5** |
| *Geodia neptuni* | 1.5 | 6.0 | **3.8** |
| *Agelas clathrodes* | | 2.5 | **1.3** |
| *Iotrochota birotulata* | | 2.0 | **1.0** |
| *Pseudoceratina crassa* | | 1.0 | **0.5** |
| *Chondrilla nucula* | | 1.0 | **0.5** |
| *Plakortis sp.* | | 0.5 | **0.3** |
| *Svenzea. zeai* | | 0.5 | **0.3** |
| Total Sponges | 18.6 | 24.0 | **21.3** |
| Scleractinian Corals | | | |
| *Montastraea annularis* | 19.1 | 7.5 | **13.3** |
| *Agaricia agaricites* | 1.5 | 2.0 | **1.8** |
| *Agaricia lamarki* | | 2.0 | **1.0** |
| *Porites astreoides* | 0.5 | 1.0 | **0.8** |
| *Montastraea cavernosa* | 0.5 | 1.0 | **0.8** |
| *Eusmilia fastigiata* | | 0.5 | **0.3** |
| *Siderastrea siderea* | | 0.5 | **0.3** |
| *Siderastrea radians* | 0.5 | | **0.3** |
| Total Corals | 22.1 | 14.5 | **18.3** |
| Octocorals | | | |
| *Pseudopterogorgia sp.* | 6.0 | 4.0 | **5.0** |
| Unidentified | 0.5 | | **0.3** |
| Total Gorgonians | 6.5 | 4.0 | **5.3** |

**Table 8**. Density of coral colonies within photo-transects at the coral reef habitat. Abrir la Sierra. 36 m. 2008-10

| | Station - Transect | | |
|---|---|---|---|
| **Taxa** | **33-1** | **33-2** | **MEAN** |
| ***Scleractinian Corals*** | | | |
| *Montastraea annularis* | 5.3 | 3.8 | **4.55** |
| *Agaricia agaricites* | 1.5 | 2.4 | **1.95** |
| *Montastraea cavernosa* | 0.3 | 1.1 | **0.70** |
| *Agaricia lamarki* | 0.1 | 1 | **0.55** |
| *Porites astreoides* | 0.5 | 0.4 | **0.45** |
| *Siderastrea radians* | 0.8 | | **0.40** |
| *Stephanocoenia intersepta* | 0.3 | 0.3 | **0.30** |
| *Meandrina meandrites* | 0.3 | 0.1 | **0.20** |
| *Siderastrea siderea* | 0.3 | | **0.15** |
| *Madracis decactis* | | 0.3 | **0.15** |
| *Agaricia sp.* | 0.1 | | **0.05** |
| *Eusmilia fastigiata* | | 0.1 | **0.05** |
| *Isophyllastrea rigida* | 0.1 | | **0.05** |
| Totals | 9.6 | 9.5 | **9.6** |
| | | | |
| ***Gorgonians*** | | | |
| Unidentified | 0.6 | 0.1 | **0.35** |
| *Pseudopterogorgia spp.* | 6.5 | 5.9 | **6.20** |
| *Gorgonia ventalina* | 0.3 | | **0.15** |
| **Totals** | 7.4 | 6.0 | **6.7** |
| | | | |
| ***Hydrocorals*** | | | |
| *Millepora alcicornis* | 0.6 | 0.8 | **0.7** |

**Photo Album 2.** Coral Reef Benthos






### 1.3. Rhodolith Reef (Sessile Benthic Community)

Benthic algae, comprised by turf algae, coralline red (*Amphiroa sp*.) fleshy brown (mostly *Lobophora variegata, Dictyopteris sp.*), and calcareous macroalgae (mostly *Halimeda sp.)* were the main sessile-benthic component at the rhodolith reef habitat with a mean combined cover of 73.0 % (range: 56.8 – 78.0 %) (Table 9). In addition, cyanobacterial films were present in nine out of the 10 transects surveyed and covered an average of 10.2% of the reef substrate. The profuse cover by algae at this habitat appears to respond to a competitive advantage over other encrusting biota, including sponges and corals. It is possible that algal rhodoliths, which have been reported to serve as attachment substrates for lettuce corals and sponges at Isla Desecheo and Bajo de Sico (Garcia-Sais et al. 2005, 2007; Garcia-Sais 2010) do not attain sizes large enough at ALS to sustain such growth. Otherwise light conditions appear similar and the habitat appears to be well protected from the abrasive effects caused by surge and ocean currents.

Sponges were present in all transects surveyed with a mean cover of 7.4 %. The giant barrel sponge, *Xestospongia muta* was the most abundant among identified species, with a mean substrate cover of 2.0 %. Other species present within transects included *Agelas clathrodes*, *Amphimedon compressa*, *Monachora sp*., *Callyspongia vaginalis* and *Pseudoceratina crassa*. Because of their typically large size and/or branching growth, barrel and tube sponges were the most important biotic component contributing topographic relief at the rhodolith reef. Abiotic substrates, mostly sand pockets within the algal dominated habitat averaged a mean cover of 8.0 % (Table 9).

Scleractinian corals were only present in four out of the 10 transects surveyed, with a mean substrate cover of 0.1 % (Table 9) and a mean density of 0.06 col/m$^2$ (Table 10). Two of the six coral colonies belonged to the maze coral, *M. meandrites* and other two were from the massive Starlet Coral, *Siderastrea siderea*. Great star and boulder star corals, *M. cavernosa, M. annularis* (complex), mustard-hill coral, *P. astreoides*, smooth flower coral, *Eusmilia fastigiata*, white-star sheet coral, *Agaricia lamarki,* the branching fire hydrocoral, *Millepora sp*. and the wire coral *S. lutkeni* were observed outside transects. Soft corals or gorgonians were present in four transects, with a mean substrate cover of 0.1 %.

**Table 9**.  Percent substrate cover by sessile-benthic categories at the algal rhodolith habitat. Abrir La Sierra. 36 m. 2008-2010

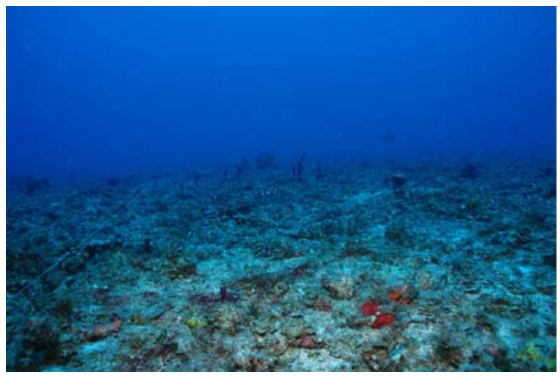
| | Station - Transec | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Substrate Categories** | **10-1** | **10-2** | **10-3** | **10-4** | **10-5** | **10-6** | **10-7** | **10-8** | **10-9** | **10-10** | **MEAN** |
| Abiotic (Sand) | 11.2 | 10.4 | 2.8 | 8 | 3.2 | 14.8 | 8.4 | 9.6 | 9.2 | 2.8 | **8.0** |
| Benthic Algae | | | | | | | | | | | |
| Algal Turf | 26.8 | 33.2 | 48.8 | 26.8 | 22.4 | 34 | 41.6 | 23.6 | 24 | 18.8 | **30.0** |
| Fleshy Algae | | | | | | | | | | | |
| *Lobophora variegata* | 39.2 | 32.4 | 15.6 | 27.6 | 32.4 | 9.2 | 19.2 | 26.8 | 28.8 | 40.4 | **27.2** |
| unidentified | 9.6 | 7.6 | 9.6 | 15.2 | 21.2 | 12.8 | 15.6 | 15.2 | 14.4 | 13.2 | **13.4** |
| *Dictyopteris sp.* | 0.4 | 0.4 | | 0.4 | 0.4 | | | 0.8 | 0.4 | 0.8 | **0.4** |
| Calcareous Algae | | | | | | | | | | | |
| *Halimeda sp.* | 2.0 | 2.0 | 0.8 | 0.8 | 0.4 | 0.8 | | 3.6 | 2.0 | 2.0 | **1.4** |
| Coralline Red lgae | | | | | | | | | | | |
| *Amphiroa sp.* | | 0.4 | 0.8 | 1.2 | 0.4 | | 1.2 | 1.6 | | 0.8 | **0.6** |
| Total Benthic Algae | 78 | 76 | 75.6 | 72 | 77.2 | 56.8 | 77.6 | 71.6 | 69.6 | 76 | **73.0** |
| Cyanobacteria | 10.2 | 5.6 | 14.4 | 13.6 | 11.6 | 25.2 | 9.2 | 10.4 | 8 | 3.6 | **11.2** |
| Sponges | | | | | | | | | | | |
| unidentified | 7.2 | 5.2 | 5.2 | 1.6 | 2.8 | 2 | 3.2 | 4.0 | 4.0 | 3.2 | **3.8** |
| *Xestospongia muta* | 2 | 0.8 | | 1.6 | 0.4 | | | | 4.8 | 10 | **2.0** |
| *Agelas clathrodes* | 1.2 | 1.6 | 1.2 | 1.2 | 0.8 | 0.4 | | 2 | 2 | 0.4 | **1.1** |
| *Monanchora sp.* | | | | | 1.2 | | | 0.4 | | | **0.2** |
| *Amphimedon compressa* | | | | | | | | | | 1.2 | **0.1** |
| *Callyspongia vaginalis* | | | | | | | | | | 1.2 | **0.1** |
| *Agelas sp.* | | | | 0.4 | | | | | 0.4 | | **0.1** |
| *Pseudoceratina crassa* | | | | | | | | | 0.4 | | **0.0** |
| Total Sponges | 10.4 | 7.6 | 6.4 | 4.8 | 5.2 | 2.4 | 3.2 | 6.4 | 11.6 | 16 | **7.4** |
| Scleractinian Corals | | | | | | | | | | | |
| *Meandrina meandrites* | 0.4 | | 0.4 | | | | | | | | **0.08** |
| *Porites sp.* | | | | | 0.4 | | | | | | **0.04** |
| Total Corals | 0.4 | 0 | 0.4 | 0 | 0.4 | 0 | 0 | 0 | 0 | 0 | **0.1** |
| Hydrozoa | | 0.4 | | 1.6 | 2.4 | 0.4 | 1.6 | 1.6 | 1.6 | 1.2 | **1.08** |
| Octocorals | | | 0.4 | | | 0.4 | | | | 0.4 | **0.12** |

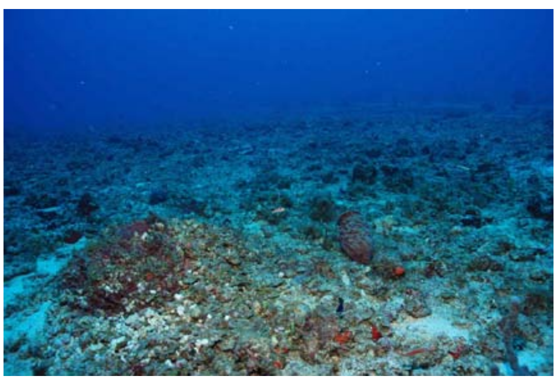
**Table 10**. Density of coral colonies within photo-transects at the rhodolith reef habitat.

Abrir la Sierra. 36 m. 2008-10

| | Station - Transect | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **10-1** | **10-2** | **10-3** | **10-4** | **10-5** | **10-6** | **10-7** | **10-8** | **10-9** | **10-10** | **MEAN** |
| ***Scleractinian Corals*** | | | | | | | | | | | |
| *Siderastrea siderea* | | 0.1 | | | | | 0.1 | | | | **0.02** |
| *Meandrina meandrites* | | | 0.1 | | 0.1 | | | | | | **0.02** |
| *Agaricia agaricites* | 0.1 | | | | | | | | | | **0.01** |
| *Porites sp.* | | | | | | | 0.1 | | | | **0.01** |
| **Totals** | 0.1 | 0.1 | 0.1 | 0 | 0.1 | 0 | 0.2 | 0 | 0 | 0 | |
| | | | | | | | | | | | |
| ***Gorgonians*** | | | | | | | | | | | |
| Unidentified | 0.2 | | 0.1 | | | 0.4 | 0.3 | | | 0.1 | **0.11** |
| *Eunicea sp.* | | | | | | | | | | 0.1 | **0.01** |
| **Totals** | 0.2 | 0 | 0.1 | 0 | 0 | 0.4 | 0.3 | 0 | 0 | 0.2 | **0.12** |

**Photo Album 3.** Rhodolith Reef Benthos





## 1.4. Insular Slope – 30 m (Sessile-Benthic Community)

The reef top of the insular shelf slope is a relatively narrow horizontal section of a ridge that rises from a deep terrace of the insular shelf at ALS and that leads to the shelf drop-off. Sessile-benthic characterizations were performed at the top of the insular slope on five stations along the ridge at depths between 29.3 – 33.2 m. The substrate at the reef top was hard ground or pavement colonized by encrusting biota, with substantial contributions of unconsolidated (abiotic) sediments exposed, or covered by cyanobacterial films. The sessile-benthic community was dominated in terms of substrate cover by benthic algae (mean: 57.3 %). Turf algae, comprised by a mixed assemblage of short, articulated coralline and brown macroalgae was the main component of the benthic algae with a mean cover of 48.8 % (Table 11). Fleshy algae, mostly comprised by the encrusting fan leaf alga, *L. 44idereal44* (mean: 4.3%) were present at all transects. Blue-green algae (cyanobacteria) were present in all 10 transects with a mean reef substrate cover of 11.5 % (range: 0.4 – 31.0%). Cyanobacteria occurred as slimy reddish patches covering unconsolidated sediments in the reef.

Branching and erect sponges, represented by 18 species within transects were the main invertebrate taxa covering substrate at the reef top of ALS with a mean cover of 16.3 % (range:5.2 – 26.4 %) (Table 11). The giant basket sponge, *Xestospongia muta*, tube sponges, *Agelas clathrodes*, *A. 44iderea* and the green finger sponge, *Iotrochota birotulata* were the main components of the sponge assemblage at the reef top. Sponges were present in all transects surveyed and acted as the main structures providing reef topographic relief. Due to the prevailing strong currents at the reef top, several species were observed to use the interior of basket sponges for protection. These included the spiny lobster, *Panulirus argus* and the red hind, *Epinephelus guttatus*. Sponges were also observed to serve as protective/residential habitats for the arrow crab, *Stenorhynchus seticornis* and as recruitment habitat for several reef fish species (*Chromis spp*., *Coryphopterus personatus*, *Clepticus parrae*). Sponges also represent important sources of food for a healthy population of hawksbill turtles in ALS.

Scleractinian corals, represented by 13 species within transects averaged a substrate cover of only 2.1 % at the reef top. Corals occurred mostly as isolated, encrusting and small mound colonies, rarely forming a complex reef structure and contributing only minimally to the reef topographic relief. Lettuce corals, *Agaricia spp*. Were present in 8 out of the 10 transects surveyed and represented the main coral taxa in terms of substrate cover (Table 11) and coral density within transects (Table 12). Other corals common at the reef top included the lesser and greater star corals, *S. radians*, *S. 45idereal*, great star coral, *M. cavernosa* and the ten-ray star coral, *Madracis decactis*. The branching fire coral, *Millepora alcicornis* was present in nine out of the 10 transects with a mean density of 0.2 col/m$^2$ (Table 12). Soft corals (gorgonians) were present in all transects surveyed with a mean substrate cover of 4.5 % and a mean density of 0.2 col/m$^2$.

Abiotic substrate categories, mostly sand and rubble, including scattered algal rhodoliths were prominent at the reef top with a mean cover of 6.8 % (range: 0.8 – 23.0 %). Unconsolidated sediments at the reef top appear to be transported down the slope walls by strong currents and surge action generated by with high waves.

**Table 11**. Percent substrate cover by sessile-benthic categories at the insular slope of ALS – 30 m. 2008-10

| | **Stations – Transects** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Substrate Categories** | **3-1** | **3-2** | **11-1** | **11-2** | **12-1** | **12-2** | **18-1** | **18-2** | **20-1** | **20-2** | **MEAN** |
| Abiotic | 23.0 | 13.6 | 5.2 | 6.5 | 7.2 | 2.4 | 3.2 | 4.0 | 2.4 | 0.8 | **6.8** |
| Benthic algae | | | | | | | | | | | |
| Algal turf | 23.6 | 38.4 | 45.6 | 40.9 | 70.8 | 62.4 | 58.0 | 62.0 | 40.9 | 46.0 | **48.9** |
| Calcareous algae | 0.4 | 0.8 | | | 0.8 | 1.2 | | | | | **0.3** |
| *Halimeda sp.* | | | | 0.4 | | 0.4 | | | 0.4 | | **0.1** |
| Fleshy algae | | | | | | | | | | | |
| *Lobophora variegata* | 2.0 | 1.2 | 6.4 | 8.5 | 2.4 | 1.6 | 0.8 | 2.4 | 11.7 | 5.6 | **4.3** |
| *Dictyota spp.* | | | 3.6 | 2.8 | | 0.8 | | | 4.5 | 5.6 | **1.7** |
| unidentified | 0.8 | 0.8 | 0.8 | 4.1 | 3.6 | 2.0 | 0.8 | 0.4 | 2.0 | 1.6 | **1.7** |
| *Amphiroa sp.* | | | | 0.4 | 0.4 | 1.6 | | | 0.4 | | **0.3** |
| *Wrangelia bicuspidata* | | | 0.4 | 0.4 | | | | | | | **0.1** |
| Total Benthic Algae | 26.8 | 41.2 | 56.8 | 57.5 | 78.0 | 70.0 | 59.6 | 64.8 | 59.9 | 58.8 | **57.3** |
| Cyanobacteria | 31.0 | 9.6 | 15.2 | 13.8 | 1.6 | 0.4 | 4.4 | 6.8 | 16.2 | 16.4 | **11.5** |
| Sponges | | | | | | | | | | | |
| unidentified sponges | 1.6 | 3.2 | 10.8 | 7.7 | 6.0 | 7.6 | 6.4 | 3.6 | 5.7 | 8.4 | **6.10** |
| *Xestospongia muta* | 2.0 | 11.0 | 0.4 | 5.3 | 2.4 | 6.8 | 7.6 | 4.4 | 2.8 | 4.0 | **4.67** |
| *Agelas conifera* | | 1.6 | 0.8 | | 0.8 | 1.6 | 6.8 | 1.2 | 2.4 | 4.4 | **1.96** |
| *Agelas clathrodes* | 0.4 | | 1.2 | 1.6 | 0.4 | | 1.6 | 2.4 | 0.4 | 0.8 | **0.88** |
| *Iotrochota birotulata* | 0.8 | 0.4 | 0.4 | | | 0.4 | 0.8 | 1.2 | 2.0 | 2.4 | **0.84** |

**Table 11.** continued

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Agelas dispar* | | 0.4 | | 0.4 | | | | 2.4 | | | **0.32** |
| *Agelas cauliformis* | | 1.2 | | | 0.4 | | 0.8 | 0.4 | | | **0.28** |
| *Neofibularia. nolitangere* | | 2.0 | | | | | | | | | **0.20** |
| *Svenzea. zeai* | | 1.2 | | | | 0.4 | 0.4 | | | | **0.20** |
| *Petrosia. angulospiculatus* | | | | | | | 0.8 | 1.2 | | | **0.20** |
| *Aiolochroia.crassa* | | 0.8 | | | | | 0.4 | | | | **0.12** |
| *Callyspongia. vaginalis* | | | | | | | 0.4 | 0.4 | | | **0.08** |
| *Ircinia felix* | | | | | | | | | 0.8 | | **0.08** |
| *Niphates. erecta* | | 0.8 | | | | | | | | | **0.08** |
| *Plakortis sp.* | | | | | | | | | 0.4 | 0.4 | **0.08** |
| *Verongula. gigantea* | 0.4 | | | | | | 0.4 | | | | **0.08** |
| *Amphimedon. compressa* | | | | | | | | 0.4 | | | **0.04** |
| *Cliona. delitrix* | | | | | | | | 0.4 | | | **0.04** |
| *Monanchora. arbuscula* | | | | | 0.4 | | | | | | **0.04** |
| Total Sponges | 5.2 | 22.6 | 13.6 | 15.0 | 10.4 | 16.8 | 26.4 | 18.0 | 14.5 | 20.4 | **16.3** |
| Scleractinian corals | | | | | | | | | | | |
| *Agaricia lamarki* | | | | 5.3 | 0.4 | | | | | | **0.57** |
| *Montastraea cavernosa* | | 1.2 | | | | 1.6 | 0.8 | 1.2 | | | **0.48** |
| *Agaricia agaricites* | 0.4 | | 1.2 | 0.8 | 0.4 | 0.4 | | | 1.2 | | **0.44** |
| *Agaricia sp.* | | | | | | | 0.8 | 0.4 | | | **0.12** |
| *Porites astreoides* | | 0.8 | | | | | 0.4 | | | | **0.12** |
| *Siderastrea siderea* | | | | | | 0.8 | | | | | **0.08** |
| *Montastrea annularis* | | | | | | | | | 0.4 | | **0.04** |
| *Siderastrea radians* | | | | | | | 0.4 | | | | **0.04** |
| *Madracis decactis* | | | 0.4 | | | | | | | | **0.04** |
| *Unid. coral* | | | | | | | 0.4 | | | | **0.04** |
| *Porites porites* | | | | | 0.4 | | | | | | **0.04** |
| *Meandrina meandrites* | | | | | 0.4 | | | | | | **0.04** |
| Total corals | 0.4 | 2.0 | 1.6 | 6.1 | 1.6 | 2.8 | 2.8 | 1.6 | 1.6 | 0.0 | **2.1** |
| Octocorals | | | | | | | | | | | |
| unidentified | 10.0 | 8.4 | 4.0 | | 0.4 | 6.0 | 3.2 | 2.4 | 5.3 | 3.6 | **4.3** |
| *Iciligorgia schrammi* | | | | 1.2 | | | | | | | **0.1** |
| *Muricea sp.* | | | | | | 0.8 | | | | | **0.1** |
| Total Gorgonians | 10.0 | 8.4 | 4.0 | 1.2 | 0.4 | 6.8 | 3.2 | 2.4 | 5.3 | 3.6 | **4.5** |
| Hydrocorals | | | | | | | | | | | |
| *Millepora alcicornis* | | 0.4 | | | 0.4 | | 0.4 | 0.4 | | | **0.2** |

**Table 12**. Density of coral colonies within photo-transects at the insular slope. 30 m

Abrir la Sierra. 30 m. 2008-10

| | Stations - Transects | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **3-1** | **3-2** | **11-1** | **11-2** | **12-1** | **12-2** | **18-1** | **18-2** | **20-1** | **20-2** | **MEAN** |
| ***Scleractinian Corals*** | (# colonies/$m^2$) | | | | | | | | | | |
| *Agaricia agaricites* | 0.1 | 0.3 | | 0.2 | 0.3 | 0.1 | 0.5 | 1.1 | 1.1 | 0.4 | **0.41** |
| *Siderastrea radians* | 0.6 | 0.4 | 0.1 | 0.2 | 0.1 | 0.2 | 0.5 | | | | **0.21** |
| *Montastraea cavernosa* | | 0.3 | | | | 0.3 | 0.3 | 0.6 | 0.1 | 0.3 | **0.19** |
| *Siderastrea siderea* | | | | | | 0.3 | 0.1 | 0.6 | 0.6 | 0.2 | **0.18** |
| *Madracis decactis* | | | 0.7 | | | 0.2 | 0.2 | 0.2 | | | **0.13** |
| *Porites astreoides* | | 0.2 | | | | | 0.4 | 0.1 | 0.1 | 0.1 | **0.09** |
| *Agaricia sp.* | | | 0.2 | | | | 0.5 | | 0.1 | 0.1 | **0.09** |
| *Stephanocoenia intersepta* | 0.1 | 0.1 | | | 0.1 | | 0.1 | 0.2 | | | **0.06** |
| *Meandrina meandrites* | | 0.2 | | | 0.2 | | | | | | **0.04** |
| *Agaricia lamarki* | | | | 0.2 | 0.1 | | | | | | **0.03** |
| *Porites porites* | | | | | 0.2 | | | | | | **0.02** |
| *Montastraea annularis* | | | | | | | | | 0.20 | | **0.02** |
| *Scolymia cubensis* | | | | | | | 0.1 | | | | **0.01** |
| Totals | 0.8 | 1.5 | 1 | 0.6 | 1 | 1.1 | 2.7 | 2.8 | 2.2 | 1.1 | **1.5** |
| ***Antipatharians*** | | | | | | | | | | | |
| ***Gorgonians*** | | | | | | | | | | | |
| Unidentified | 6.2 | 3.8 | 0.6 | | 0.4 | 0.9 | 1.9 | 1.8 | 2.3 | 3.2 | **2.11** |
| *Muricea sp.* | | | | | | 0.1 | | | | | **0.01** |
| *Eunicea sp.* | | | | 0.1 | | | | | | | |
| *Iciligorgia schrammi* | | | | 0.8 | | | | | | | **0.08** |
| *Gorgonia ventalina* | | | | | | | | | 0.1 | | **0.01** |
| **Totals** | 6.2 | 3.8 | 0.6 | 0.9 | 0.4 | 1 | 1.9 | 1.8 | 2.4 | 3.2 | **2.2** |
| ***Hydrocorals*** | | | | | | | | | | | |
| *Millepora alcicornis* | 0.1 | 0.5 | 0.1 | | 0.1 | 0.3 | 0.1 | 0.5 | 0.10 | 0.2 | **0.2** |
| *Stylaster roseus* | | 0.1 | | | | | | 0.1 | | | **0.02** |
| **Totals** | 0.1 | 0.6 | 0.1 | 0 | 0.1 | 0.3 | 0.1 | 0.6 | 0.1 | 0.2 | **0.2** |

**Photo Album 4.** Insular Slope 30 Benthos

### 1.5. Insular Slope – 40 m (Sessile-Benthic Community)

At a depth of 40 m, the insular slope was a vertical wall with an angle that varied between 40° – 50° at the five stations surveyed (Figure 1). The substrate was hard ground or pavement with substantial amount of sand and rhodoliths covered by encrusting biota, mostly benthic algae, sponges and cyanobacteria. Scleractinian corals and gorgonians were present, but represented minor components of the reef biota.

The sessile-benthic community was dominated in terms of substrate cover by benthic algae (mean: 69.5 %). Turf algae, a mixed assemblage of short, articulated coralline and brown macroalgae was the main component of the benthic algae with a mean cover of 40.2 % (Table 13). Fleshy algae, largely comprised by the y-twig alga, *Dictyota sp*. and the encrusting fan leaf alga, *L. variegata* were present at all transects with a mean cover of 28.3 %. Blue-green algae (cyanobacteria) were present in all 10 transects with a mean reef substrate cover of 8.5 % (range: 1.5 – 14.7 %).

The assemblage of large branching and barrel sponges was the most conspicuous biotic component of the slope wall habitat at 40 m. Reef substrate cover by sponges averaged 14.9 % (range: 8.5 – 22.1 %) (Table 13). A total of 10 species were identified within transects, and other nine were identified outside transects, for a total of 19 identified species associated with the slope wall at 40 m. The giant basket sponge, *Xestospongia muta*, and branching tube sponges, *Agelas clathrodes*, and *A. conifera* were all present in nine out of the ten transects surveyed and comprised the main components of the sponge assemblage. Both the branching and barrel type sponges were generally large enough to act as protective habitat for reef fishes and invertebrates. At the wall, sponges were observed to function as recruitment habitat for several reef fishes, including the sunshine chromis, *Chromis insolata*, masked goby, *Coryphopterus personatus*, and creole wrasse, *Clepticus parrae*.

Scleractinian corals were represented by nine species within transects, with a mean cover of only 0.06 % (Table 13), and a density of 0.3 col/$m^2$ (Table 14). Typically small, encrusting and isolated colonies prevailed. The numerically dominant species were the blushing star coral, *Stephanocoenia intersepta* and the maze coral, *Meandrina meandrites* (Table 14). Gorgonians were present in eight transects with a mean cover of

3.4 % and a mean density of 1.9 col/m$^2$. Sea plumes, *Pseudopterogorgia spp*. and the deep water sea fan, *Iciligorgia schrammi* were the most abundant at 40 m. Wire black coral, *S. lutkeni* and the hydrocorals, *M. alcicornis* and *Stylaster roseus* were present, but represented minor components of the coral assemblage.

**Table 13**. Percent substrate cover by sessile-benthic categories at the insular slope. 40 m Abrir la Sierra. 2008 -10

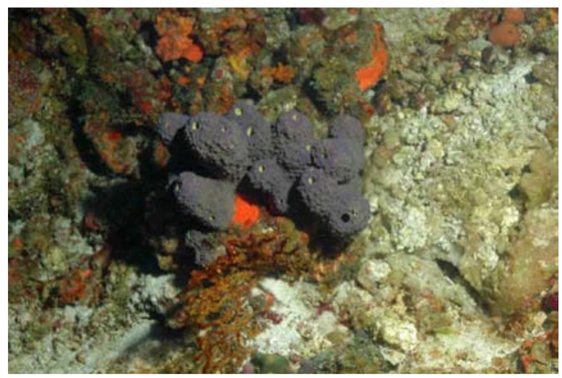
| | Stations - Transects | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Substrate Categories** | **21-1** | **21-2** | **23-1** | **23-2** | **25-1** | **25-2** | **27-1** | **27-2** | **29-1** | **29-2** | **MEAN** |
| Abiotic (sand/rubble) | 2.0 | 1.5 | 3.5 | 5.2 | 1.3 | 1.3 | 5.5 | 0.5 | 5.0 | 1.5 | **2.7** |
| Benthic Algae | | | | | | | | | | | |
| Algal Turf | 62.6 | 60.0 | 33.7 | 40.7 | 40.3 | 30.0 | 29.7 | 36.7 | 37.2 | 31.3 | **40.2** |
| Calcareous Algae | | | | | | | | | | | |
| *Halimeda sp.* | 1.0 | | 0.5 | | 0.7 | 1.3 | 0.5 | 1 | 1.5 | 2.5 | **0.9** |
| Fleshy Algae | | | | | | | | | | | |
| *Dictyota sp.* | 6.6 | 9.0 | 13.6 | 12.9 | 22.8 | 20.0 | 24.1 | 16.6 | 21.1 | 21.7 | **16.8** |
| *Lobophora variegata* | 4.6 | 5.0 | 14.1 | 6.7 | 10.1 | 6.0 | 5.0 | 20.1 | 17.1 | 12.6 | **10.1** |
| unidentified | 4.6 | 2.0 | 2.0 | 0.5 | 0.7 | | 2.5 | 1.0 | 1.0 | | **1.4** |
| Total Benthic Algae | 79.4 | 76.0 | 63.9 | 60.8 | 74.6 | 57.3 | 61.8 | 75.4 | 77.9 | 68.1 | **69.5** |
| Cyanobacteria | 1.5 | 5.0 | 12.1 | 8.3 | 4.0 | 14.7 | 8.0 | 12.1 | 5.0 | 14.7 | **8.5** |
| Sponges | | | | | | | | | | | |
| Unidentified | 4.0 | 6.0 | 5.5 | 10.8 | 9.4 | 4.7 | 4.0 | 5.0 | 6.0 | 6.1 | **6.2** |
| *Agelas conifera* | 8.6 | 7.5 | 4.0 | 6.2 | 0.7 | 0.7 | 0.5 | 1.5 | | 1.5 | **3.1** |
| *Xestospongia muta* | 1.0 | 3.5 | 4.5 | 3.1 | 5.4 | 6.7 | 2.5 | 1.0 | 2.0 | | **3.0** |
| *Agelas clathrodes* | 0.5 | 0.5 | 1.0 | | 0.7 | 2.7 | 2.5 | 0.5 | 0.5 | 1.5 | **1.0** |
| *Agelas dispar* | 1.0 | | 0.5 | 1 | 2 | | | | | 1 | **0.6** |
| *Svenzea. zeai* | | | | | | 2.7 | | | | | **0.3** |
| *Iotrochota birotulata* | | | | 1 | | 1.3 | | | | | **0.2** |
| *Monanchora. arbuscula* | | | | | 0.7 | | | 0.5 | | 0.5 | **0.2** |
| *Plakortis sp.* | 1.0 | | 0.5 | | | | | | | | **0.2** |
| *Pseudoceratina crassa* | | | | | | 0.7 | | 0.5 | | | **0.1** |
| *Ircinia. strobilina* | 1.0 | | | | | | | | | | **0.1** |
| Total Sponges | 17.1 | 17.5 | 16.0 | 22.1 | 18.9 | 19.5 | 9.5 | 9.0 | 8.5 | 10.6 | **14.9** |
| Scleractinian Corals | | | | | | | | | | | |
| *Meandrina meandrites* | | | | | | | 0.5 | | | | **0.05** |
| *Siderastrea radians* | | | 0.1 | | | | | | | | **0.01** |
| Total Corals | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | **0.06** |
| Octocorals | | | | | | | | | | | |
| *Iciligorgia schrammi* | | | 3 | 2.6 | | | 13.6 | 1.5 | 3.5 | 3.5 | **2.8** |
| *Eunicea sp.* | | | 0.5 | 1 | | | 0.5 | 1.5 | | | **0.4** |
| *Pseudopterogorgia sp.* | | | | | | | 0.5 | | 1 | | **0.2** |
| Unidentified | | | | | | | | 0.5 | 0.5 | | **0.1** |
| Total Gorgonians | 0.0 | 0.0 | 3.5 | 3.6 | 0.0 | 0.0 | 14.6 | 3.5 | 5.0 | 3.5 | **3.4** |
| Hydrocorals | | | | | | | | | | | |
| *Millepora alcicornis* | | | 0.3 | | | | | | | | **0.03** |

**Table 14** . Density of coral colonies within photo-transects at the insular slope. 40 m.

Abrir la Sierra. 2008-10

| | Station - Transect | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **21-1** | **21-2** | **23-1** | **23-2** | **25-1** | **25-2** | **27-1** | **27-2** | **29-1** | **29-2** | **MEAN** |
| ***Scleractinian Corals*** | | | | | (# colonies/m$^2$) | | | | | | |
| *Stephanocoenia intersepta* | | | | | 0.2 | | 0.4 | | | 0.3 | **0.09** |
| *Meandrina meandrites* | | | | | 0.3 | | 0.3 | | | | **0.06** |
| *Agaricia agaricites* | 0.3 | | | | | | | | | | **0.03** |
| *Madracis decactis* | | | | | | | | 0.3 | | | **0.03** |
| *Agaricia sp.* | | | | 0.1 | | | | | | | **0.01** |
| *Agaricia lamarki* | | | | | | | 0.1 | | | | **0.01** |
| *I. rigida* | | | | | | | | | | 0.1 | **0.01** |
| *Siderastrea radians* | | | 0.1 | | | | | | | | **0.01** |
| *Siderastrea siderea* | | 0.1 | | | | | | | | | **0.01** |
| **Totals** | **0.3** | **0.1** | **0.1** | **0.1** | **0.5** | **0** | **0.8** | **0.3** | **0** | **0.4** | **0.26** |
| ***Antipatharians*** | 0.1 | | | | | | | | | | **0.01** |
| ***Gorgonians*** | | | | | | | | | | | |
| unidentified | | | 0.3 | 0.1 | | | 0.8 | 4 | 0.8 | 1.6 | **0.76** |
| *Pseudopterogorgia sp.* | | | 0.4 | 0.1 | 0.3 | | 1.8 | 0.9 | 2 | 1.4 | **0.69** |
| *Eunicea sp.* | | 0.6 | | | 1 | | | | 0.4 | 0.3 | **0.23** |
| *Iciligorgia. schrammi* | | | 0.5 | 0.3 | 0.3 | | 0.4 | 0.4 | 0.1 | | **0.2** |
| *Ellisella sp.* | | | | | | | | | | 0.1 | **0.01** |
| **Totals** | 0 | 0.6 | 1.2 | 0.5 | 1.6 | 0 | 3 | 5.3 | 3.3 | 3.4 | **1.9** |
| ***Hydrocorals*** | | | | | | | | | | | |
| *Millepora alcicornis* | 0.1 | | 0.3 | | 0.2 | | | 0.1 | | 0.5 | **0.12** |
| *Stylaster roseus* | 0.1 | | | | | | | | | | **0.01** |
| **Totals** | 0.2 | 0 | 0.3 | 0 | 0.2 | 0 | 0 | 0.1 | 0 | 0.5 | **0.13** |

**Photo Album 5**. Insular Slope 40 Benthos



### 1.6. Insular Slope – 50 m (Sessile-Benthic Community)

At 50 m, the insular slope was a steep vertical wall at the southern section of the study area and much more gradual at the northern section. The quantitative characterization here included corresponds to the southern section, which is representative of the most typical slope condition. Similar to the 40 m depth, the substrate at 50 m was hard ground or pavement with substantial amount of sand and rhodoliths covered by encrusting biota, mostly benthic algae, sponges and cyanobacteria. Scleractinian corals and gorgonians were present, but represented minor components of the reef biota. The slope at 50 m appeared to be more abrupt than at 40 m, with the slope angle probably lower than 40° in most cases.

The sessile-benthic community was dominated in terms of substrate cover by benthic algae (mean: 69.3 %). Turf algae, a mixed assemblage of short, articulated coralline and brown macroalgae was the main component of the benthic algae with a mean cover of 40.3 % (Table 15). Fleshy algae, largely comprised by the encrusting fan leaf alga, *L. variegata* and the y-twig alga, *Dictyota sp*. were present at all transects with a mean cover of 26.4 %. Blue-green algae (cyanobacteria) were present in all 8 transects surveyed at 50 m with a mean reef substrate cover of 1.4 % (range: 0.5 – 3.5 %).

At least 11 species of branching and barrel sponges were present within transects at 50 m with a mean cover of 17.1 % (range: 11.5 – 22.7 %) (Table 15). Sponges were the most conspicuous biotic component of the slope wall habitat at 50 m. Large orange elephant-ear sponge, *A. clathrodes*, branching tube sponges, *A. conifera*, and *A. dispar* and the giant basket sponge, *Xestospongia muta* were the main components of the sponge assemblage. Both the branching and barrel type sponges were generally large enough to act as protective habitat for reef fishes and invertebrates. As previously stated for this habitat at 40 m, sponges were observed to function as recruitment habitat for several reef fishes and as residential habitat for some motile benthic invertebrates.

Scleractinian corals were represented by 12 species within transects, with a mean cover of 0.9 % (Table 15), and a density of 0.8 col/m$^2$ (Table 16). Typically small, encrusting and isolated colonies prevailed. The numerically dominant species were the blushing star coral, *S. intersepta* and lettuce corals, *A. lamarki, A. agaricites* and *Agaricia sp.* (Table 16). Gorgonians were prominent at a depth of 50 m in the slope wall with a mean cover of 3.7 % and a mean density of 4.7 col/m$^2$. The deep water sea fan, *I. schrammi* and sea plumes, *Pseudopterogorgia spp*. were present at all transects surveyed and comprised the main gorgonian assemblage. Wire black coral, *S. lutkeni* was also common at 50 m with four colonies present within transect areas. The hydrocorals, *M. alcicornis* and *S. roseus* were present in low abundance.

**Table 15**. Percent substrate cover by sessile-benthic categories at the insular slope. 50 m. Abrir la Sierra. 2009-10

| | Stations - Transects | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Substrate Categories** | **22-1** | **22-2** | **24-1** | **24-2** | **26-1** | **26-2** | **28-1** | **28-2** | **MEAN** |
| Abiotic (sand/rubble) | 7.5 | 9.1 | 8.0 | 13.3 | 4.0 | 2.0 | 2.5 | 3.0 | **6.2** |
| Benthic Algae | | | | | | | | | |
| Algal Turf | 43.7 | 43.7 | 47.3 | 38.7 | 27.0 | 30.0 | 42.5 | 49.5 | **40.3** |
| Calcareous Algae | | | | | | | | | |
| *Halimeda sp.* | 0.5 | 1.5 | 1.3 | | 1.5 | 2.5 | 8.5 | 5 | **2.6** |
| Fleshy Algae | | | | | | | | | |
| *Lobophora variegata* | 25.1 | 17.6 | 14.7 | 14.0 | 24.0 | 23.0 | 16.5 | 14.0 | **18.6** |
| *Dictyota sp.* | 3.0 | 9.6 | 6.7 | 6.0 | 13.0 | 14.0 | 4.0 | 3.0 | **7.4** |
| unidentified | | | 1.3 | | 1.5 | | | | **0.4** |
| Total Benthic Algae | 72.3 | 72.4 | 71.3 | 58.7 | 67.0 | 69.5 | 71.5 | 71.5 | **69.3** |
| Cyanobacteria | 0.5 | 0.5 | 2.7 | 0.7 | 0.5 | 1.0 | 3.5 | 1.5 | **1.4** |
| Sponges | | | | | | | | | |
| Unidentified | 10.1 | 8.0 | 10.0 | 11.3 | 10.5 | 12.0 | 10.5 | 12.0 | **10.6** |
| *Agelas clathrodes* | 2.0 | | 2.7 | 6.7 | 2.0 | 1.0 | 4.5 | 1.0 | **2.5** |
| *Xestospongia muta* | 0.5 | 1.5 | 1.3 | 3.3 | 0.5 | 0.5 | 3.0 | 2.5 | **1.6** |
| *Agelas conifera* | 1.0 | 2.0 | | 0.7 | 2.0 | 5.5 | | | **1.4** |
| *Pseudoceratina crassa* | | | | 0.7 | | 1.5 | | | **0.3** |
| *Agelas. dispar* | | | | | 0.5 | 0.5 | | 0.5 | **0.2** |
| *Svenzea. zeai* | | | | | | 1.0 | | 0.5 | **0.2** |
| *Iotrochota birotulata* | | | 0.7 | | | 0.5 | | | **0.2** |
| *Petrocia. pellasarca* | | | | | | | 1 | | **0.1** |
| *Amphimedon. compressa* | | | | | | | 0.5 | | **0.1** |
| *Monanchora. arbuscula* | 0.5 | | | | | | | | **0.1** |
| Total Sponges | 14.1 | 11.5 | 14.7 | 22.7 | 15.5 | 22.5 | 19.5 | 16.5 | **17.1** |
| Scleractinian Corals | | | | | | | | | |
| *Agaricia lamarki* | 3.0 | | | | | | | | **0.4** |
| *Stephanocoenia intersepta* | 0.5 | | 0.7 | | | 1.0 | | | **0.3** |
| *Agaricia agaricites* | | | | | | 2.0 | | | **0.3** |
| *Agaricia grahame* | | | 0.7 | | | | | | **0.1** |
| *Montastraea annularis* | 0.5 | | | | | | | | **0.1** |
| *Madracis decactis* | | 0.5 | | | | | | | **0.1** |
| *Meandrina meandrites* | | | | | | | | | **0.0** |
| *Siderastrea radians* | | | | | | | | | **0.0** |
| Total Corals | 4.0 | 0.5 | 1.4 | 0.0 | 0.0 | 3.0 | 0.0 | 0.0 | **0.9** |

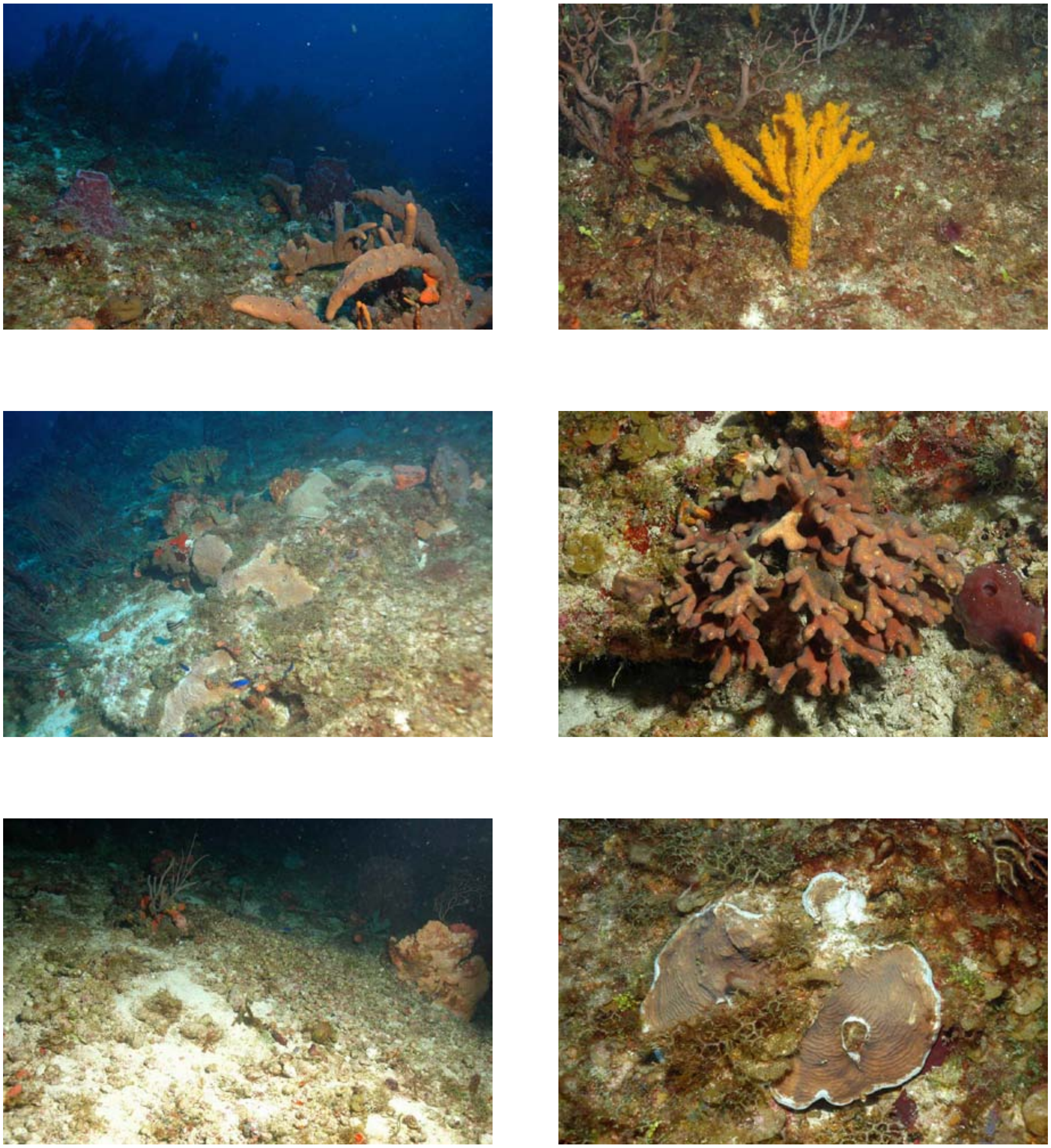
**Table15.** continued

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Octocorals | | | | | | | | | |
| *Iciligorgia. schrammi* | 0.5 | 1.5 | 2 | 4.7 | 9.5 | 2 | | | **2.5** |
| *Pseudopterogorgia sp.* | 1.0 | 4.5 | | | 2 | | | | **0.9** |
| *Eunicea sp.* | | | | | 1.5 | | | | **0.2** |
| Total Gorgonians | 1.5 | 6.0 | 2.0 | 4.7 | 13.0 | 2.0 | 0.0 | 0.0 | **3.7** |

**Table 16**. Density of coral colonies within photo-transects at the insular slope. 50 m.
Abrir la Sierra. 2008-10

| | **Stations - Transects** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **22-1** | **22-2** | **24-1** | **24-2** | **26-1** | **26-2** | **28-1** | **28-2** | **MEAN** |
| ***Scleractinian Corals*** | | | | | | | | | |
| *Stephanocoenia intersepta* | 0.4 | | 0.2 | 0.3 | 0.6 | 0.3 | 0.1 | 0.3 | **0.28** |
| *Agaricia lamarki* | 0.9 | | | 0.2 | | 0.1 | 0.1 | 0.1 | **0.18** |
| *Agaricia agaricites* | | 0.1 | | | | 0.5 | | | **0.08** |
| *Agaricia sp.* | | | | | 0.4 | | | | **0.05** |
| *Agaricia grahame* | | | 0.2 | 0.2 | | | | | **0.05** |
| *Madracis decactis* | | | 0.2 | | 0.1 | | | | **0.04** |
| *Madracis sp.* | | 0.3 | | | | | | | **0.04** |
| *Porites sp.* | | 0.1 | | | | | | 0.1 | **0.03** |
| *Siderastrea radians* | | | 0.2 | | | | | | **0.03** |
| *Meandrina meandrites* | | | | | | | 0.1 | | **0.01** |
| *Montastraea annularis* | 0.1 | | | | | | | | **0.01** |
| *Scolymia cubensis* | | | | | | | | 0.1 | **0.01** |
| **Totals** | **1.4** | **0.5** | **0.8** | **0.7** | **1.1** | **0.9** | **0.3** | **0.6** | **0.8** |
| ***Antipatharians*** | 0.5 | 0.1 | | 0.2 | | 0.3 | | | **0.14** |
| ***Gorgonians*** | 0.6 | | | 0.3 | | | 0.5 | 0.3 | **0.2** |
| *Pseudopterogorgia sp.* | 2.3 | 9.3 | 0.3 | 0.5 | 5.6 | 1.3 | 2.1 | 2.9 | **3.0** |
| *Iciligorgia schrammi* | 0.3 | 0.4 | 0.8 | 1.8 | 1.6 | 0.3 | 0.5 | 1.5 | **0.9** |
| *Ellisella sp.* | 0.5 | 0.3 | 0.3 | 0.5 | 0.5 | 1 | | 0.5 | **0.5** |
| *Eunicea sp.* | | | | 0.2 | 0.8 | | | 0.1 | **0.1** |
| **Totals** | 3.7 | 10 | 1.4 | 3.3 | 8.5 | 2.6 | 3.1 | 5.3 | **4.7** |
| ***Hydrocorals*** | | | | | | | | | |
| *Millepora alcicornis* | 0.1 | | | | | | | | **0.01** |
| *Stylaster roseus* | 0.1 | | | | | | | | **0.01** |
| **Totals** | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.03** |

**Photo Album 6.** Insular Slope 50 Benthos



### 1.7. Comparative Analysis of Sessile-Benthic Community Structure Between Habitat/Zones

A non-metric multidimensional scaling (MDS) plot of Bray-Curtis sessile-benthic community structure similarities between reef physiographic zones and benthic habitats of ALS is presented in Figure 8. Euclidean distances were calculated based on the rank order abundance (non-metric) of all taxonomic components from each physiographic zone or benthic habitat. The largest distance, or difference in community structure resulted between the coral reef (CR) and rhodolith habitats (RR), and also between the CR and the slope wall habitats at depths of 40 (SL 40) and 50 m (SL 50). Statistically significant differences (ANOSIM, $p < 0.001$) were observed between RR and all other habitats, and between CR and all other habitats, except the inner wall (IW). Slope habitats at 40 and 50 m (SL 40, SL 50) were different from those at the IW and SL 30. Differences were not statistically significant between IW and the SL 30, and between the SL 40 and SL 50 (Table 17).

The main substrate features that characterized the reef physiographic zones and benthic habitats surveyed at ALS are presented in Table 18. Transects at RR presented an average similarity of 64.8 %, which was the highest among reef physiographic zones. Similarity at the RR habitat was mostly contributed by fleshy algae, particularly the encrusting fan alga, *L. 57lumier5757*, turf algae, cyanobacteria and abiotic cover (SIMPER Analysis, Table 18). Similarity at the CR habitat averaged 57.1 %, contributed mostly by scleractinian corals, *P. astreoides* and *M. annularis*, sponges, *A. 57lumier* and *G. neptuni*, turf algae and abiotic cover. At the IW, similarity of substrate cover by benthic categories averaged 52.2 %, contributed by algal turf, *L. 57lumier5757*, abiotic, *A. agaricites* and *A. conifera*. SL 30 m presented a mean similarity of 44.5 %, driven mostly by algal turf, *X. muta*, cyanobacteria and abiotic (sand/ rubble). Benthic categories averaged 63.3 % at SL 40, contributed mostly by algae, including *Dictyota sp*., turf, *L. variegata* and cyanobacteria. At SL 50, similarity of cover by benthic categories averaged 58.6 %, driven by turf algae, *L. variegata*, abiotic and *Dictyota sp* (see Table 18).

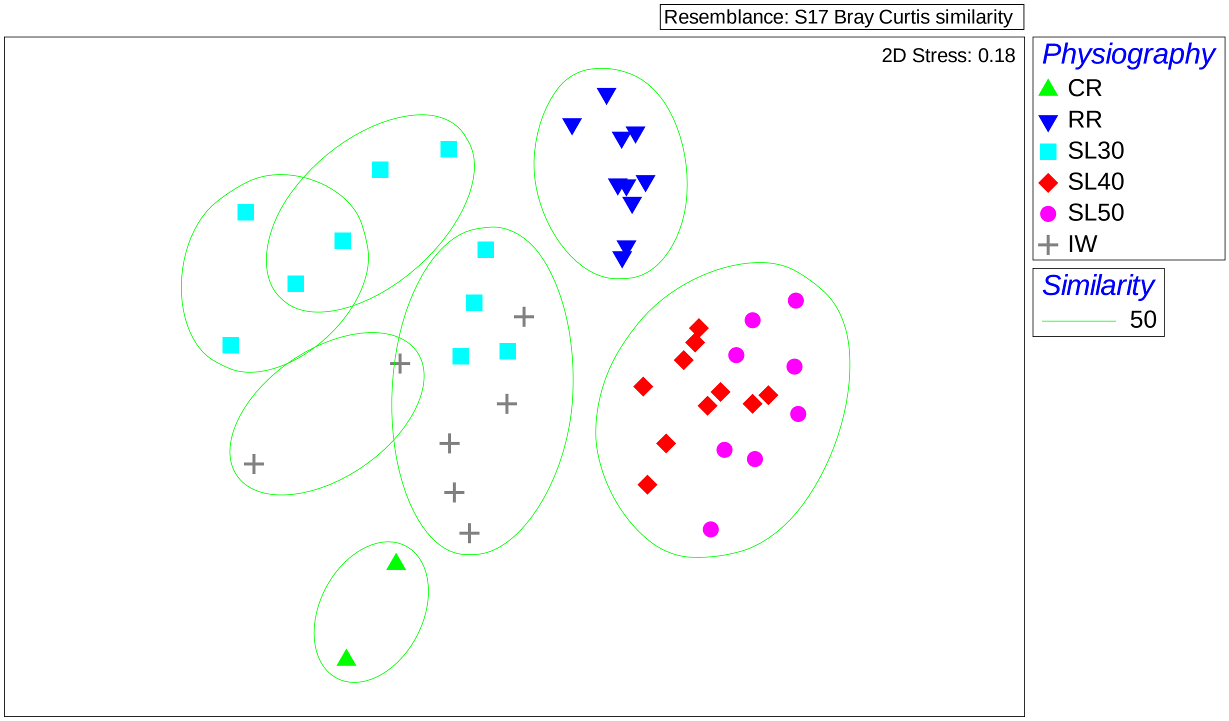



**Figure 8**. Non-metric multidimensional scaling plot based on Bray-Curtis similarities between the community structure of sessile-benthic communities at reef physiographic zones and benthic habitats surveyed from Abrir la Sierra. Circles include transects with community structure similarities of at least 50 %.

The main benthic categories that contributed mostly to the dissimilarity between the various reef physiographic zones and habitats surveyed at ALS are presented in Table 19. Dissimilarity was highest between RR and CR (73.8 %), and lowest between the SL 40 and SL 50 (43.2 %). RR was different from all other habitats by the relatively higher substrate cover by benthic algae (mean: 73 %) and lower cover by scleractinian corals, gorgonians and sponges (Figure 9). Although this habitat was mostly devoid of sessile-benthic invertebrate fauna, it presented the highest density of motile megabenthic invertebrates, particularly queen conch, *Strombus gigas*, as it appears that RR functions as an essential habitat for this commercially important invertebrate. The CR habitat was also different from most other habitats (except IW). Dissimilarity between CR and other habitats was mostly driven by the relatively higher cover by scleractinian corals, gorgonians, sponges and abiotic substrate categories (Figure 9), and relatively lower cover by cyanobacteria, turf and fleshy algae (e.g. *L. variegata, Dictyota sp.*) (Table 19).

**Table 17**. Pairwise analysis of similarities in the rank order of percent reef substrate cover by sessile-benthic categories at physiographic zones and benthic habitats surveyed from Abrir la Sierra

Sample statistic (Global R): 0.819
Significance level of sample statistic: 0.1%

| Groups | R Statistic | Significance Level % | Possible Permutations | Actual Permutations | Number >= Observed |
|---|---|---|---|---|---|
| CR, RR | 1 | 1.5 | 66 | 66 | 1 |
| CR, SL30 | 0.872 | 1.5 | 66 | 66 | 1 |
| CR, SL40 | 1 | 1.5 | 66 | 66 | 1 |
| CR, SL50 | 1 | 2.2 | 45 | 45 | 1 |
| CR, IW | 0.513 | 8.3 | 36 | 36 | 3 |
| RR, SL30 | 0.733 | 0.1 | 92378 | 999 | 0 |
| RR, SL40 | 0.996 | 0.2 | 92378 | 999 | 1 |
| RR, SL50 | 0.998 | 0.1 | 43758 | 999 | 0 |
| RR, IW | 0.854 | 0.2 | 19448 | 999 | 1 |
| SL30, SL40 | 0.89 | 0.1 | 92378 | 999 | 0 |
| SL30, SL50 | 0.983 | 0.1 | 43758 | 999 | 0 |
| SL30, IW | 0.339 | 0.2 | 19448 | 999 | 1 |
| SL40, SL50 | 0.426 | 0.1 | 43758 | 999 | 0 |
| SL40, IW | 0.934 | 0.1 | 19448 | 999 | 0 |
| SL50, IW | 0.947 | 0.2 | 6435 | 999 | 1 |

IW and SL 30, 40 and 50 represent colonized pavement habitats with variations of sessile-benthic community structure driven mostly by substrate cover of scleractinian corals, gorgonians and cover by cyanobacteria. IW exhibited less cover by gorgonians than slope stations (Figure 9). This was mostly influenced by the relatively high prevalence of the deep water fan, *Iciligorgia schrammi* and sea plumes, *Pseudopterogorgia spp*.at wall stations. Conversely, IW presented relatively higher cover by scleractinian corals (mean: 4.1 %) than slope wall stations (range: 0.9 – 2.1). Cyanobacteria exhibited a trend of decreasing cover with depth.

The analysis of community structure similarities suggests that there are essentially three habitat types within the different reef physiographic zones studied at ALS. These include the rhodolith reef habitat, the coral reef habitat, and the colonized pavement habitat. A mostly un-colonized pavement habitat with scattered algal nodules and sand was observed to be widely distributed within the deep terrace of the outer shelf at ALS, but was not quantitatively characterized. This habitat was mostly devoid of sessile-benthic fauna and flora, but presented a series of small scattered hard ground promontories with high fish aggregations. The sandy habitat was also a typical residential habitat for the sand tilefish, *Malacanthus plumieri*.

**Table 18**. SIMPER. Analysis of species contributions to similarity within reef physiographic zones and benthic habitats at ALS. 2008 -10. RR=rhodolith reef; CR=coral reef; IW=Inner Wall; SL 30=slope 30 m; SL 40=slope 40 m; SL50=slope 50 m.

***Group RR*** *(*Average similarity: 64.77)

| Species | **Av.Abund** | **Av.Sim** | **Contrib%** | **Cum.%** |
|---|---|---|---|---|
| *Lobophora variegata* | 0.16 | 14.12 | 21.81 | 21.81 |
| Algal turf | 0.14 | 12.2 | 18.83 | 40.64 |
| Cyanobacteria | 0.13 | 10.23 | 15.79 | 56.43 |
| Abiotic (Sand) | 0.12 | 9.4 | 14.51 | 70.94 |

***Group CR*** (Average similarity: 57.14)

| Species | Av.Abund | Av.Sim | Contrib% | Cum.% |
|---|---|---|---|---|
| *Porites astreoides* | 0.07 | 6.47 | 11.32 | 11.32 |
| *Agelas conifera* | 0.09 | 6.05 | 10.58 | 21.9 |
| *Geodia neptuni* | 0.06 | 5.31 | 9.29 | 31.19 |
| Abiotic (Sand) | 0.07 | 5.23 | 9.16 | 40.35 |
| Algal turf | 0.07 | 5.23 | 9.15 | 49.51 |
| *Montastraea annularis* | 0.08 | 4.61 | 8.07 | 57.58 |

***Group IW*** (Average similarity: 52.22)

| Species | Av.Abund | Av.Sim | Contrib% | Cum.% |
|---|---|---|---|---|
| Algal turf | 0.1 | 8.01 | 15.34 | 15.34 |
| *Lobophora variegata* | 0.09 | 6.56 | 12.57 | 27.91 |
| Abiotic (Sand) | 0.07 | 5.64 | 10.81 | 38.72 |
| *Agaricia agaricites* | 0.08 | 5.02 | 9.61 | 48.33 |
| *Agelas conifera* | 0.06 | 4.35 | 8.33 | 56.65 |

***Group SL30*** (Average similarity: 44.48)

| Species | Av.Abund | Av.Sim | Contrib% | Cum.% |
|---|---|---|---|---|
| Algal turf | 0.11 | 10.15 | 22.81 | 22.81 |
| *Xestospongia muta* | 0.08 | 6.37 | 14.32 | 37.13 |
| Cyanobacteria | 0.08 | 5.51 | 12.38 | 49.51 |
| Abiotic (Sand) | 0.07 | 5.09 | 11.45 | 60.96 |

***Group SL40*** (Average similarity: 63.25)

| Species | Av.Abund | Av.Sim | Contrib% | Cum.% |
|---|---|---|---|---|
| *Dictyota spp.* | 0.13 | 11.58 | 18.31 | 18.31 |
| Algal turf | 0.13 | 11.46 | 18.12 | 36.43 |
| *Lobophora variegata* | 0.09 | 7.84 | 12.39 | 48.82 |
| Cyanobacteria | 0.09 | 7.78 | 12.31 | 61.13 |

***Group SL50*** (Average similarity: 58.59)

| Species | Av.Abund | Av.Sim | Contrib% | Cum.% |
|---|---|---|---|---|
| Algal turf | 0.13 | 11.26 | 19.23 | 19.23 |
| *Lobophora variegata* | 0.12 | 10.61 | 18.12 | 37.34 |
| *Abiotic (sand/rubble)* | 0.1 | 7.98 | 13.62 | 50.96 |
| *Dictyota spp.* | 0.09 | 7.85 | 13.4 | 64.36 |

**Table 19.** Average dissimilarity and species contributions to dissimilarity of substrate cover by sessile-benthic categories at the different reef physiographic zones and habitats in Abrir la Sierra. 2008-10

***Groups CR & RR*** Average dissimilarity = 73.76

| Species | Group CR Av.Abund | Group RR Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Lobophora variegata* | 0.02 | 0.16 | 6.77 | 5.32 | 9.18 | 9.18 |
| *Cyanobacteria* | 0.04 | 0.13 | 4.35 | 2.01 | 5.9 | 15.09 |
| *Agelas conifera* | 0.09 | 0 | 4.33 | 3.23 | 5.87 | 20.96 |
| *Millepora alcicornis* | 0 | 0.09 | 4.31 | 1.61 | 5.84 | 26.8 |
| *Montastraea annulari* | 0.08 | 0 | 3.97 | 2.32 | 5.39 | 32.19 |
| *Amphiroa sp.* | 0 | 0.08 | 3.91 | 1.26 | 5.31 | 37.49 |
| *Algal turf* | 0.07 | 0.14 | 3.61 | 1.67 | 4.89 | 42.39 |
| *Porites astreoides* | 0.07 | 0 | 3.27 | 97.31 | 4.43 | 46.82 |
| *Pseudopterogorgia sp.* | 0.06 | 0 | 3.02 | 2.73 | 4.09 | 50.91 |
| *Geodia neptuni* | 0.06 | 0 | 2.94 | 9.93 | 3.99 | 54.9 |
| *Siderastrea radians* | 0.06 | 0 | 2.82 | 0.97 | 3.82 | 58.72 |

***Groups CR & SL30*** Average dissimilarity = 65.35

| Species | Group CR Av.Abund | Group SL30 Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Xestospongia muta* | 0 | 0.08 | 3.85 | 3.27 | 5.89 | 5.89 |
| *Montastraea annulari* | 0.08 | 0.01 | 3.42 | 1.84 | 5.23 | 11.12 |
| *Geodia neptuni* | 0.06 | 0 | 2.94 | 9.93 | 4.51 | 15.62 |
| *Pseudopterogorgia sp.* | 0.06 | 0 | 2.88 | 2.45 | 4.41 | 20.04 |
| *Siderastrea radians* | 0.06 | 0.01 | 2.82 | 1.02 | 4.31 | 24.35 |
| *Porites astreoides* | 0.07 | 0.01 | 2.79 | 2.85 | 4.27 | 28.62 |
| *Cyanobacteria* | 0.04 | 0.08 | 2.53 | 1.29 | 3.86 | 32.48 |
| *Agelas conifera* | 0.09 | 0.05 | 2.47 | 1.48 | 3.78 | 36.26 |
| *Iotrochota birotulata* | 0.03 | 0.06 | 2.39 | 1.15 | 3.65 | 39.91 |
| *Algal turf* | 0.07 | 0.11 | 2.16 | 1.51 | 3.3 | 43.22 |
| *Halimeda sp.* | 0.04 | 0.01 | 1.9 | 2.6 | 2.91 | 46.12 |
| *Montastraea cavernosa* | 0.04 | 0 | 1.87 | 3.23 | 2.87 | 48.99 |
| *Coralline Red Algae* | 0 | 0.04 | 1.85 | 0.76 | 2.83 | 51.82 |

***Groups RR & SL30*** Average dissimilarity = 59.86

| Species | Group RR Av.Abund | Group SL30 Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Lobophora variegata* | 0.16 | 0.05 | 5.22 | 2.96 | 8.72 | 8.72 |
| *Millepora alcicornis* | 0.09 | 0.01 | 3.95 | 1.66 | 6.59 | 15.31 |
| *Amphiroa sp.* | 0.08 | 0.03 | 3.56 | 1.33 | 5.95 | 21.25 |
| *Abiotic (Sand)* | 0.12 | 0.07 | 3.06 | 1.48 | 5.11 | 26.36 |
| *Cyanobacteria* | 0.13 | 0.08 | 3.01 | 1.37 | 5.04 | 31.4 |
| *Iotrochota birotulata* | 0 | 0.06 | 2.84 | 1.18 | 4.74 | 36.14 |
| *Xestospongia muta* | 0.05 | 0.08 | 2.67 | 1.75 | 4.46 | 40.6 |
| *Halimeda sp.* | 0.05 | 0.01 | 2.41 | 1.1 | 4.03 | 44.63 |
| *Agelas conifera* | 0 | 0.05 | 2.26 | 1.36 | 3.78 | 48.41 |

**Table 19.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| *Algal turf* | 0.14 | 0.11 | 2.1 | 1.36 | 3.51 | 51.92 |

***Groups CR & SL40*** Average dissimilarity = 65.38

| Species | Group CR Av.Abund | Group SL40 Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Dictyota spp.* | 0.05 | 0.13 | 4.23 | 3.42 | 6.47 | 6.47 |
| *Montastraea annulari* | 0.08 | 0 | 3.97 | 2.32 | 6.08 | 12.54 |
| *Xestospongia muta* | 0 | 0.07 | 3.74 | 1.95 | 5.72 | 18.26 |
| *Lobophora variegata* | 0.02 | 0.09 | 3.65 | 3.13 | 5.59 | 23.85 |
| *Porites astreoides* | 0.07 | 0 | 3.27 | 97.31 | 5 | 28.85 |
| *Algal turf* | 0.07 | 0.13 | 2.95 | 1.63 | 4.51 | 33.36 |
| *Geodia neptuni* | 0.06 | 0 | 2.94 | 9.93 | 4.5 | 37.86 |
| *Siderastrea radians* | 0.06 | 0 | 2.82 | 1.02 | 4.31 | 42.18 |
| *Pseudopterogorgia sp.* | 0.06 | 0.01 | 2.72 | 2.17 | 4.15 | 46.33 |
| *Agelas conifera* | 0.09 | 0.07 | 2.65 | 1.47 | 4.06 | 50.39 |
| *Cyanobacteria* | 0.04 | 0.09 | 2.63 | 2.45 | 4.03 | 54.42 |
| *I. schrammi* | 0 | 0.05 | 2.52 | 1.04 | 3.86 | 58.28 |
| *Agaricia agaricites* | 0.05 | 0 | 2.48 | 5.26 | 3.79 | 62.07 |

***Groups RR & SL40*** Average dissimilarity = 53.60

| Species | Group RR Av.Abund | Group SL40 Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Dictyota spp.* | 0.01 | 0.13 | 5.87 | 4.57 | 10.95 | 10.95 |
| *Millepora alcicornis* | 0.09 | 0 | 4.23 | 1.64 | 7.89 | 18.84 |
| *Amphiroa sp.* | 0.08 | 0 | 3.91 | 1.28 | 7.3 | 26.14 |
| *Agelas conifera* | 0 | 0.07 | 3.6 | 1.28 | 6.72 | 32.86 |
| *Abiotic (Sand)* | 0.12 | 0.06 | 3.33 | 1.52 | 6.21 | 39.07 |
| *Lobophora variegata* | 0.16 | 0.09 | 3.13 | 1.89 | 5.85 | 44.92 |
| *Xestospongia muta* | 0.05 | 0.07 | 2.81 | 1.53 | 5.25 | 50.17 |
| *I. schrammi* | 0 | 0.05 | 2.52 | 1.06 | 4.71 | 54.88 |

***Groups SL30 & SL40*** Average dissimilarity = 55.40

| Species | Group SL30 Av.Abund | Group SL40 Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Dictyota spp.* | 0.03 | 0.13 | 5.09 | 2.43 | 9.19 | 9.19 |
| *Iotrochota birotulata* | 0.06 | 0.02 | 2.75 | 1.22 | 4.97 | 14.16 |
| *Agelas conifera* | 0.05 | 0.07 | 2.68 | 1.17 | 4.84 | 19 |
| *I. schrami* | 0 | 0.05 | 2.52 | 1.06 | 4.56 | 23.56 |
| *Lobophora variegata* | 0.05 | 0.09 | 2.25 | 1.53 | 4.07 | 27.63 |
| *A. dispar* | 0.02 | 0.04 | 2.24 | 1.03 | 4.04 | 31.67 |
| *Cyanobacteria* | 0.08 | 0.09 | 2.11 | 1.54 | 3.81 | 35.48 |
| *M.arbuscula* | 0.01 | 0.04 | 2.03 | 0.72 | 3.67 | 39.15 |
| *Coralline Red Algae* | 0.04 | 0 | 1.85 | 0.78 | 3.34 | 42.49 |
| *Eunicea sp.* | 0 | 0.04 | 1.82 | 0.73 | 3.29 | 45.78 |
| *Xestospongia muta* | 0.08 | 0.07 | 1.75 | 1.31 | 3.15 | 48.93 |
| *Abiotic (Sand)* | 0.07 | 0.06 | 1.72 | 1.11 | 3.11 | 52.04 |

**Table 19.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| *Halimeda sp.* | 0.01 | 0.04 | 1.72 | 1.41 | 3.1 | 55.14 |

***Groups CR & SL50*** Average dissimilarity = 63.63

| Species | Group CR Av.Abund | Group SL50 Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Lobophora variegata* | 0.02 | 0.12 | 4.85 | 6.43 | 7.63 | 7.63 |
| *Montastraea annulari* | 0.08 | 0 | 3.85 | 2.19 | 6.05 | 13.67 |
| *Porites astreoides* | 0.07 | 0 | 3.27 | 96.67 | 5.13 | 18.8 |
| *Agelas clathrodes* | 0.02 | 0.08 | 3.19 | 1.44 | 5.02 | 23.82 |
| *Geodia neptuni* | 0.06 | 0 | 2.94 | 9.87 | 4.63 | 28.45 |
| *Algal turf* | 0.07 | 0.13 | 2.88 | 1.78 | 4.52 | 32.97 |
| *Siderastrea radians* | 0.06 | 0 | 2.82 | 0.97 | 4.43 | 37.4 |
| *Xestospongia muta* | 0 | 0.06 | 2.77 | 1.72 | 4.35 | 41.75 |
| *Agelas conifera* | 0.09 | 0.04 | 2.71 | 1.49 | 4.26 | 46.01 |
| *I. schrami* | 0 | 0.05 | 2.51 | 1.17 | 3.94 | 49.95 |
| *Pseudopterogorgia sp.* | 0.06 | 0.02 | 2.4 | 1.77 | 3.77 | 53.72 |
| *Agaricia agaricites* | 0.05 | 0.01 | 2.29 | 3.24 | 3.6 | 57.31 |

***Groups RR & SL50*** Average dissimilarity = 53.24

| Species | Group RR Av.Abund | Group SL50 Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Cyanobacteria* | 0.13 | 0.03 | 4.68 | 2.08 | 8.78 | 8.78 |
| *Millepora alcicornis* | 0.09 | 0 | 4.31 | 1.64 | 8.1 | 16.88 |
| *Amphiroa sp.* | 0.08 | 0 | 3.91 | 1.28 | 7.35 | 24.23 |
| *Dictyota spp.* | 0.01 | 0.09 | 3.8 | 3.9 | 7.14 | 31.37 |
| *Halimeda sp.* | 0.05 | 0.07 | 2.78 | 1.23 | 5.23 | 36.6 |
| *I. schrami* | 0 | 0.05 | 2.51 | 1.2 | 4.71 | 41.31 |
| *Abiotic (Sand)* | 0.12 | 0.09 | 2.43 | 1.31 | 4.57 | 45.89 |
| *Xestospongia muta* | 0.05 | 0.06 | 2.41 | 1.51 | 4.53 | 50.41 |
| *Agelas clathrodes* | 0.06 | 0.08 | 2.29 | 1.27 | 4.31 | 54.72 |
| *Lobophora variegata* | 0.16 | 0.12 | 1.96 | 1.42 | 3.69 | 58.41 |
| *Algal turf* | 0.14 | 0.13 | 1.96 | 1.47 | 3.68 | 62.09 |
| *Stephanocoenia intersepta* | 0 | 0.04 | 1.88 | 0.76 | 3.53 | 65.62 |

***Groups SL30 & SL50*** Average dissimilarity = 59.45

| Species | Group SL30 Av.Abund | Group SL50 Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Halimeda sp.* | 0.01 | 0.07 | 3.3 | 1.31 | 5.55 | 5.55 |
| *Lobophora variegata* | 0.05 | 0.12 | 3.3 | 2.28 | 5.55 | 11.1 |
| *Dictyota spp.* | 0.03 | 0.09 | 3.13 | 1.79 | 5.26 | 16.36 |
| *Cyanobacteria* | 0.08 | 0.03 | 2.82 | 1.37 | 4.74 | 21.1 |
| *Agelas clathrodes* | 0.03 | 0.08 | 2.76 | 1.41 | 4.64 | 25.74 |
| *Iotrochota birotulata* | 0.06 | 0.01 | 2.61 | 1.14 | 4.38 | 30.13 |
| *I. schrammi* | 0 | 0.05 | 2.51 | 1.2 | 4.22 | 34.35 |
| *Abiotic (Sand)* | 0.07 | 0.09 | 1.99 | 1.39 | 3.36 | 37.7 |
| *Stephanocoenia intersepta* | 0 | 0.04 | 1.88 | 0.76 | 3.16 | 40.86 |

**Table 19.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| *Agelas conifera* | 0.05 | 0.04 | 1.87 | 1.32 | 3.15 | 44.01 |
| *Coralline Red Algae* | 0.04 | 0 | 1.85 | 0.78 | 3.11 | 47.12 |
| *Xestospongia muta* | 0.08 | 0.06 | 1.83 | 1.47 | 3.08 | 50.2 |
| *Agelas cauliformis* | 0.03 | 0 | 1.71 | 0.65 | 2.88 | 53.09 |

***Groups SL40 & SL50*** Average dissimilarity = 43.22

| Species | Group SL40 Av.Abund | Group SL50 Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Cyanobacteria* | 0.09 | 0.03 | 2.96 | 2.35 | 6.86 | 6.86 |
| *Agelas conifera* | 0.07 | 0.04 | 2.83 | 1.2 | 6.55 | 13.41 |
| *I. schrami* | 0.05 | 0.05 | 2.54 | 1.35 | 5.87 | 19.28 |
| *Halimeda sp.* | 0.04 | 0.07 | 2.5 | 1.17 | 5.78 | 25.06 |
| *Agelas clathrodes* | 0.05 | 0.08 | 2.48 | 1.34 | 5.74 | 30.8 |
| *Eunicea sp.* | 0.04 | 0.02 | 2.23 | 0.82 | 5.16 | 35.96 |
| *Xestospongia muta* | 0.07 | 0.06 | 2.17 | 1.48 | 5.02 | 40.98 |
| *Dictyota spp.* | 0.13 | 0.09 | 2.15 | 1.64 | 4.98 | 45.96 |
| *M.arbuscula* | 0.04 | 0.01 | 2.14 | 0.73 | 4.95 | 50.91 |

***Groups CR & IW*** Average dissimilarity = 54.10

| Species | Group CR Av.Abund | Group IW Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Lobophora variegata* | 0.02 | 0.09 | 3.31 | 1.96 | 6.11 | 6.11 |
| *Montastraea annulari* | 0.08 | 0.02 | 3.24 | 1.74 | 5.99 | 12.1 |
| *Geodia neptuni* | 0.06 | 0 | 2.84 | 7.26 | 5.26 | 17.36 |
| *Siderastrea radians* | 0.06 | 0.01 | 2.82 | 1.04 | 5.21 | 22.57 |
| *Porites astreoides* | 0.07 | 0.01 | 2.6 | 2.35 | 4.81 | 27.38 |
| *A. dispar* | 0 | 0.05 | 2.54 | 1.57 | 4.69 | 32.06 |
| *Plakortis sp.* | 0 | 0.04 | 2.13 | 0.8 | 3.93 | 36 |
| *Pseudopterogorgia sp.* | 0.06 | 0.06 | 2 | 1.32 | 3.7 | 39.7 |
| *Agaricia agaricites* | 0.05 | 0.08 | 1.96 | 1.33 | 3.61 | 43.31 |
| *Xestospongia muta* | 0 | 0.04 | 1.88 | 1.38 | 3.47 | 46.79 |
| *Agelas conifera* | 0.09 | 0.06 | 1.85 | 1.24 | 3.42 | 50.2 |
| *Algal turf* | 0.07 | 0.1 | 1.73 | 1.46 | 3.2 | 53.4 |
| *Total Antipatharians* | 0 | 0.03 | 1.7 | 0.61 | 3.14 | 56.54 |

***Groups RR & IW*** Average dissimilarity = 62.01

| Species | Group RR Av.Abund | Group IW Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Cyanobacteria* | 0.13 | 0.04 | 4.26 | 1.73 | 6.88 | 6.88 |
| *Millepora alcicornis* | 0.09 | 0.01 | 4.15 | 1.63 | 6.69 | 13.56 |
| *Agaricia agaricites* | 0 | 0.08 | 3.79 | 1.9 | 6.11 | 19.67 |
| *Amphiroa sp.* | 0.08 | 0.01 | 3.65 | 1.32 | 5.89 | 25.56 |
| *Lobophora variegata* | 0.16 | 0.09 | 3.47 | 1.68 | 5.59 | 31.15 |
| *Agelas conifera* | 0 | 0.06 | 3.11 | 2.04 | 5.01 | 36.16 |
| *Pseudopterogorgia sp.* | 0 | 0.06 | 2.93 | 1.3 | 4.73 | 40.89 |
| *Abiotic (Sand)* | 0.12 | 0.07 | 2.75 | 1.35 | 4.44 | 45.33 |
| *Algal turf* | 0.14 | 0.1 | 2.68 | 1.42 | 4.33 | 49.66 |

**Table 19.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| *A. dispar* | 0 | 0.05 | 2.54 | 1.62 | 4.09 | 53.75 |

***Groups SL30 & IW*** Average dissimilarity = 57.20

| Species | Group SL30 Av.Abund | Group IW Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Pseudopterogorgia sp.* | 0 | 0.06 | 2.87 | 1.31 | 5.03 | 5.03 |
| *Agaricia agaricites* | 0.02 | 0.08 | 2.82 | 1.41 | 4.94 | 9.96 |
| *Cyanobacteria* | 0.08 | 0.04 | 2.67 | 1.3 | 4.66 | 14.62 |
| *A. dispar* | 0.02 | 0.05 | 2.35 | 1.53 | 4.12 | 18.74 |
| *Lobophora variegata* | 0.05 | 0.09 | 2.27 | 1.57 | 3.98 | 22.72 |
| *Plakortis sp.* | 0.01 | 0.04 | 2.24 | 0.94 | 3.92 | 26.64 |
| *Xestospongia muta* | 0.08 | 0.04 | 2.2 | 1.52 | 3.85 | 30.49 |
| *Iotrochota birotulata* | 0.06 | 0.04 | 2.19 | 1.14 | 3.82 | 34.31 |
| *Agelas cauliformis* | 0.03 | 0.02 | 2.11 | 0.93 | 3.68 | 38 |
| *Agelas conifera* | 0.05 | 0.06 | 2 | 1.51 | 3.49 | 41.49 |
| *Coralline Red Algae* | 0.04 | 0 | 1.85 | 0.78 | 3.24 | 44.73 |
| *Abiotic (Sand)* | 0.07 | 0.07 | 1.78 | 1.29 | 3.11 | 47.84 |
| *Total Antipatharians* | 0 | 0.03 | 1.7 | 0.63 | 2.97 | 50.81 |
| *Dictyota spp.* | 0.03 | 0.03 | 1.61 | 1.88 | 2.81 | 53.62 |

***Groups SL40 & IW*** Average dissimilarity = 55.42

| Species | Group SL40 Av.Abund | Group IW Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Dictyota spp.* | 0.13 | 0.03 | 5.01 | 3.86 | 9.04 | 9.04 |
| *Agaricia agaricites* | 0 | 0.08 | 3.79 | 1.9 | 6.84 | 15.88 |
| *Pseudopterogorgia sp.* | 0.01 | 0.06 | 2.79 | 1.32 | 5.04 | 20.92 |
| *Cyanobacteria* | 0.09 | 0.04 | 2.62 | 1.71 | 4.73 | 25.65 |
| *Agelas conifera* | 0.07 | 0.06 | 2.59 | 1.34 | 4.67 | 30.32 |
| *I. schrami* | 0.05 | 0 | 2.52 | 1.06 | 4.55 | 34.87 |
| *Plakortis sp.* | 0.02 | 0.04 | 2.48 | 0.94 | 4.48 | 39.36 |
| *Xestospongia muta* | 0.07 | 0.04 | 2.45 | 1.49 | 4.42 | 43.78 |
| *A. dispar* | 0.04 | 0.05 | 2.4 | 1.53 | 4.32 | 48.1 |
| *Algal turf* | 0.13 | 0.1 | 2 | 1.21 | 3.61 | 51.71 |
| *Iotrochota birotulata* | 0.02 | 0.04 | 1.92 | 1.47 | 3.47 | 55.17 |

***Groups SL50 & IW*** Average dissimilarity = 55.67

| Species | Group SL50 Av.Abund | Group IW Av.Abund | Av.Diss | Diss/SD | Contrib% | Cum.% |
|---|---|---|---|---|---|---|
| *Agaricia agaricites* | 0.01 | 0.08 | 3.54 | 1.77 | 6.36 | 6.36 |
| *Agelas clathrodes* | 0.08 | 0.03 | 2.95 | 1.45 | 5.31 | 11.67 |
| *Dictyota spp.* | 0.09 | 0.03 | 2.94 | 2.97 | 5.29 | 16.96 |
| *Pseudopterogorgia sp.* | 0.02 | 0.06 | 2.65 | 1.32 | 4.76 | 21.71 |
| *Halimeda sp.* | 0.07 | 0.03 | 2.6 | 1.14 | 4.66 | 26.38 |
| *I. schrami* | 0.05 | 0 | 2.51 | 1.2 | 4.5 | 30.88 |
| *Plakortis sp.* | 0 | 0.04 | 2.13 | 0.82 | 3.82 | 34.71 |
| *A. dispar* | 0.02 | 0.05 | 2.06 | 1.33 | 3.7 | 38.41 |

**Table 19.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| *Agelas conifera* | 0.04 | 0.06 | 2.06 | 1.37 | 3.69 | 42.1 |
| *Algal turf* | 0.13 | 0.1 | 1.94 | 1.32 | 3.48 | 45.58 |
| *Stephanocoenia intersepta* | 0.04 | 0 | 1.88 | 0.76 | 3.37 | 48.95 |
| *Xestospongia muta* | 0.06 | 0.04 | 1.84 | 1.47 | 3.3 | 52.25 |

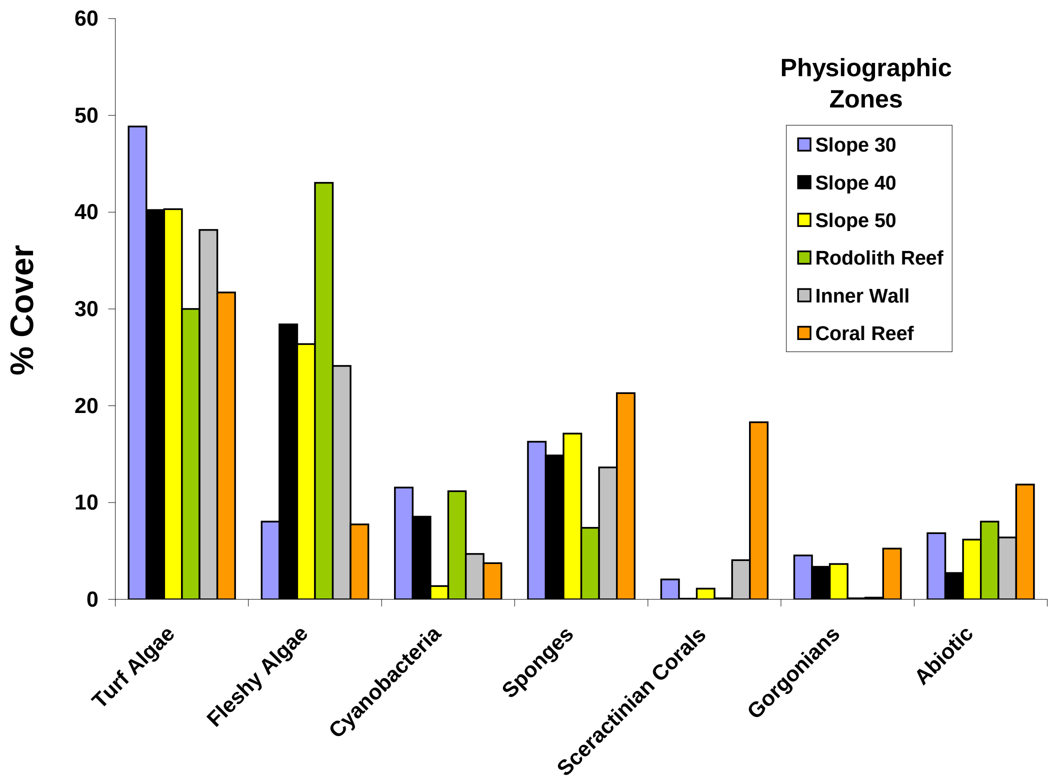



**Figure 9**. Variation of percent substrate cover by the main sessile-benthic categories on physiographic reef zones surveyed at Abrir la Sierra. 2008-10.

## 2.0 Community Structure of Reef Fishes

### 2.1. Inner Wall (Fish Community)

A total of 53 fish species were identified from the Inner Wall (IW), including 36 within belt-transects with a combined mean abundance of 52.3 Ind/30 $m^2$ (range: 15 – 120 Ind/30 $m^2$) and a mean richness of 12 spp/30 $m^2$. An assemblage of seven species represented 78.9 % of the total individuals within transects (Table 20). Ten species were only represented by one individual within the seven transects surveyed. The two numerically dominant species (*Clepticus parrae*, *Coryphopterus personatus*) were found aggregated as swarms of post-recruitment juveniles associated with branching sponges in one or two transects. The other five components of the numerically dominant assemblage that included *Chromis cyanea, Stegastes partitus, Halichoeres garnoti, Thalassoma bifasciatum* and *Holocentrus rufus* were present in at least four of the seven transects. Bicolor damselfish, *S. partitus* was present in all transects and the squirrelfish, *H. rufus* was present in six.

**Table 20.** Taxonomic composition and abundance of fishes within belt-transects at the Inner Wall Abrir la Sierra. 2008-19.

| | | Belt-Transects | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | |
| ***SPECIES*** | **COMMON NAME** | (Ind/30 $m^2$) | | | | | | | **Mean** |
| *Clepticus parrae* | Creole Wrasse | 0 | 0 | 0 | 0 | 0 | 102 | 0 | **14.57** |
| *Coryphopterus personatus* | Masked Goby | 45 | 0 | 5 | 0 | 0 | 0 | 0 | **7.14** |
| *Chromis cyanea* | Blue Chromis | 4 | 11 | 5 | 8 | 10 | 0 | 8 | **6.57** |
| *Stegastes partitus* | Bicolor Damselfish | 8 | 5 | 11 | 8 | 4 | 4 | 4 | **6.29** |
| *Halichoeres garnoti* | Yellowhead Wrasse | 9 | 9 | 4 | 3 | 0 | 2 | 0 | **3.86** |
| *Thalassoma bifasciatum* | Bluehead Wrasse | 0 | 1 | 3 | 6 | 1 | 0 | 0 | **1.57** |
| *Holocentrus rufus* | Longspine Squirrelfish | 2 | 2 | 2 | 2 | 0 | 1 | 0 | **1.29** |
| *Scarus taeniopterus* | Princess Parrotfish | 0 | 0 | 1 | 2 | 4 | 0 | 0 | **1.00** |
| *Sparisoma viride* | Stoplight Parrotfish | 2 | 0 | 1 | 0 | 0 | 3 | 0 | **0.86** |
| *Coryphopterus evelynae* | Sharknose Goby | 0 | 0 | 0 | 0 | 1 | 3 | 1 | **0.71** |
| *Acanthurus bahianus* | Ocean Surgeon | 3 | 0 | 0 | 0 | 0 | 1 | 1 | **0.71** |
| *Sparisoma aurofrenatum* | Redband Parrotfish | 0 | 0 | 2 | 1 | 1 | 0 | 0 | **0.57** |
| *Coryphopterus lipernes* | Peppermint Goby | 0 | 3 | 1 | 0 | 0 | 0 | 0 | **0.57** |
| *Coryphopterus glaucofraenum* | Bridled Goby | 2 | 0 | 0 | 2 | 0 | 0 | 0 | **0.57** |
| *Chromis insolata* | Sunshine Chromis | 2 | 0 | 0 | 2 | 0 | 0 | 0 | **0.57** |
| *Chaetodon sedentarius* | Reef Butterflyfish | 2 | 0 | 2 | 0 | 0 | 0 | 0 | **0.57** |

**Table 20.** continued

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Chaetodon capistratus* | Four-eye Butterflyfish | 1 | 0 | 1 | 0 | 0 | 2 | 0 | **0.57** |
| *Epinephelus guttatus* | Red Hind | 1 | 0 | 1 | 1 | 0 | 0 | 0 | **0.43** |
| *Canthigaster rostrata* | Sharpnose Puffer | 0 | 0 | 1 | 2 | 0 | 0 | 0 | **0.43** |
| *Epinephelus cruentatus* | Graysby | 0 | 1 | 0 | 1 | 0 | 0 | 0 | **0.29** |
| *Xanthichthys ringens* | Sargassum Triggerfish | 0 | 0 | 1 | 1 | 0 | 0 | 0 | **0.29** |
| *Serranus tigrinus* | Harlequin Bass | 0 | 1 | 1 | 0 | 0 | 0 | 0 | **0.29** |
| *Scarus iserti* | Striped Parrotfish | 0 | 0 | 0 | 1 | 1 | 0 | 0 | **0.29** |
| *Hypoplectrus chlorurus* | Yellowtail Hamlet | 0 | 0 | 0 | 0 | 0 | 1 | 1 | **0.29** |
| *Equetus lanceolatus* | Jackknife Fish | 0 | 0 | 2 | 0 | 0 | 0 | 0 | **0.29** |
| *Epinephelus fulva* | Coney | 0 | 1 | 0 | 0 | 1 | 0 | 0 | **0.29** |
| *Sparisoma taeniopterus* | Princess Parrotfish | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **0.14** |
| *Sparisoma radians* | Bucktooth Parrotfish | 0 | 0 | 0 | 1 | 0 | 0 | 0 | **0.14** |
| *Sparisoma atomarium* | Greenblotch Parrotfish | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **0.14** |
| *Pseudupeneus maculatus* | Spotted Goatfish | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **0.14** |
| *Hypoplectrus indigo* | Indigo Hamlet | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **0.14** |
| *Gramma loreto* | Fairy Basslet | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **0.14** |
| *Chromis multilineata* | Brown Chromis | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **0.14** |
| *Chaetodon striatus* | Banded Butterflyfish | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **0.14** |
| *Bodianus rufus* | Spanish Hogfish | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **0.14** |
| *Amblycirrhitus pinos* | Redspotted Hawkfish | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **0.14** |
| | **TOTAL INDIVIDUALS** | **84** | **37** | **46** | **41** | **23** | **120** | **15** | **52.3** |
| | **TOTAL SPECIES** | **15** | **12** | **19** | **15** | **8** | **10** | **5** | **12** |

**Fishes outside transects**: *Holacanthus ciliaris, Acanthurus coeruleus, Haemulon sciurus, Pomacanthus paru, Opistognathus aurifrons, Lachnolaimus maximus, Balistes vetula, Mycteroperca bonaci, M. venenosa, Epinephelus striatus, Sphyraena barracuda, Decapterus macarellus, Lutjanus analis, L. apodus, Scomberomorus regalis, Caranx crysos, Ocyurus chrysurus*

The top four most abundant fish species (*C. parrae*, *C. personatus, C. cyanea* and *S. partitus*), which accounted for 66 % of the total individuals within transects are well known zooplanktivores. The next two most abundant species (*T. bifasciatum and H. garnoti*) are opportunistic carnivores which also feed on zooplankton during their juvenile stages. Thus, it is evident that the food web of fishes associated with the IW reef zone was strongly based on zooplankton food. Herbivores were not highly abundant, but were represented by a species rich assemblage that included six parrotfishes and one doctorfish within transects. Opportunistic carnivores that feed mostly on benthic invertebrates were represented by at least 10 species, which included wrasses, gobies, hamlets, basses, goatfishes, hawkfishes and small groupers, such as the coney, graysbe and the red hind (Table 20).

Top predators of the IW reef zone included the Nassau, black and yellowfin groupers (*Epinephelus striatus, Mycteroperca bonaci, M. venenosa*), yellowtail, dog and mutton snappers (*Ocyurus chrysurus*, *Lutjanus jocu, L. analis*) and reef sharks (*Carcharhinus perezi*) observed in low abundance during active search surveys (Table 21). Red hind was the most abundant fish of commercial value at the IW. It was present within three belt-transect areas, for a mean density of 1.4 Ind/100 $m^2$. Two individuals of the lion fish, *Pterois volitans* were observed at depths of 33 m and 39 m' at the base of the inner wall. Lion fish were observed under a coral ledge and inside a giant barrel sponge, *Xestospongia muta.*

Motile megabenthic invertebrates were observed outside transects at the inner wall. These included the arrow crab, *Stenorhynchus seticornis*, the cleaner shrimp, *Periclimenes pedersoni*, and one spiny lobster, *Panulirus argus.*

**Table 21**. Taxonomic composition and size distribution of large and/or commercially important fish and shellfish species observed during a 30 min.active search survey (ASEC) at the Inner Wall in ALS. Depth: 30 – 35 m. Abrir la Sierra, 2008-10.

| ***Fishes*** | **Size Distribution (cms)** |
|---|---|
| *Balistes vetula* | 3 – (40 – 45) |
| *Carcharhinus perezi* | 1 - 120 |
| *Decapterus macarellus* | 100 – (12 - 16) |
| *Epinephelus guttatus* | 1 – 20; 4 – (20 – 30); 2 – (30 – 40) |
| *Epinephelus striatus* | 1 – 50; |
| *Lachnolaimus maximus* | 1 – 50 |
| *Lutjanus analis* | 3 – (45 – 50); |
| *Lutjanus apodus* | 2 – 30; 2 – 40 |
| *Mycteroperca bonaci* | 1 – 58; 1 – 72 |
| *Mycteroperca venenosa* | 1 – 40; 1 - 50 |
| *Ocyurus chrysurus* | 4 – (35 – 40) |
| *Pterois volitans* | 1 – 16; 1 - 20 |
| *Scomberomorus regalis* | 2 – (50 – 60) |
| *Sphyraena barracuda* | 1 – 70; 1- 90 |
| **Invertebrates** | |
| *Panulirus argus* | 1 – 30 cephalothorax |

**Photo Album 7**. Inner Wall Fish

## 2.2. Coral Reef (Fish Community)

A total of 59 fish species were identified from the coral reef habitat (CR), including 36 within belt-transects with a combined mean abundance of 344.0 Ind/30 $m^2$ (range: 197 – 491 Ind/30 $m^2$) and a mean richness of 26 spp/30 $m^2$. Two species represented 61.0 % of the total individuals within belt-transects. These were the masked goby, *C. personatus* (mean: 110 ind/30 $m^2$), and the mackerel scad, *D. macarellus* (mean: 100 ind/30$m^2$). Swarms of adult masked gobies were observed below ledges formed by boulder star coral, *M. annularis*, and in substrate discontinuities over sandy bottoms. Streaming schools of mackerel scad was observed in mid-water over the reef. An assemblage of 16 fish species were observed in the two transects surveyed (Table 22). Of these, *H. flavolineatum, M. jacobus, H. sciurus, H. garnoti* and *S. taeniopterus* were the most abundant. Most of the ichthyofauna were typical shallow-water species, except the cherubfish, *Centropyge argi*, sunshine chromis, *Chromis insolata*, longsnout butterflyfish, *Chaetodon aculeatus* and the sargassum triggerfish, *Xanthychthys ringens*.

**Table 22.** Taxonomic composition and abundance of fishes within belt-transects at the coral reef habitat, Abrir la Sierra. Depth: 33 m. 2008-19.

| | | Belt-Transects | | |
|---|---|---|---|---|
| | | 1 | 2 | |
| ***SPECIES*** | **COMMON NAME** | (Ind/30 $m^2$) | | **Mean** |
| *Coryphopterus personatus* | Masked Goby | 170 | 50 | **110.0** |
| *Decapterus macarellus* | Mackerel Scad | 200 | 0 | **100.0** |
| *Coryphopterus lipernes* | Peppermint Goby | 58 | 62 | **60.0** |
| *Haemulon flavolineatum* | French Grunt | 14 | 20 | **17.0** |
| *Myripristis jacobus* | Blackbar Soldierfish | 7 | 7 | **7.0** |
| *Haemulon plumieri* | White Grunt | 0 | 10 | **5.0** |
| *Haemulon sciurus* | Bluestriped Grunt | 1 | 8 | **4.5** |
| *Clepticus parrae* | Creole Wrasse | 0 | 8 | **4.0** |
| *Halichoeres garnoti* | Yellowhead Wrasse | 2 | 5 | **3.5** |
| *Stegastes partitus* | Bicolor Damselfish | 6 | 0 | **3.0** |
| *Scarus taeniopterus* | Princess Parrotfish | 5 | 1 | **3.0** |
| *Gramma loreto* | Fairy Basslet | 3 | 2 | **2.5** |
| *Anisotremus virginicus* | Porkfish | 1 | 3 | **2.0** |
| *Chromis multilineata* | Brown Chromis | 3 | 0 | **1.5** |
| *Chaetodon capistratus* | Four-eye Butterflyfish | 1 | 2 | **1.5** |
| *Thalassoma bifasciatum* | Bluehead Wrasse | 3 | 0 | **1.5** |
| *Epinephelus fulva* | Coney | 1 | 2 | **1.5** |
| *Paranthias furcifer* | Creole fish | 2 | 1 | **1.5** |

**Table 22.** continued

| | | | | |
|---|---|---|---|---|
| *Sparisoma viride* | Stoplight Parrotfish | 1 | 2 | **1.5** |
| *Sparisoma aurofrenatum* | Redband Parrotfish | 0 | 3 | **1.5** |
| *Chromis cyanea* | Blue Chromis | 2 | 0 | **1.0** |
| *Chaetodon aculeatus* | Longsnout Butterflyfish | 2 | 0 | **1.0** |
| *Canthigaster rostrata* | Sharpnose Puffer | 1 | 1 | **1.0** |
| *Bodianus rufus* | Spanish Hogfish | 2 | 0 | **1.0** |
| *Holocentrus marianus* | Longjaw Squirrelfish | 1 | 1 | **1.0** |
| *Epinephelus guttatus* | Red Hind | 1 | 1 | **1.0** |
| *Equetus punctatus* | Spotted Drum | 0 | 2 | **1.0** |
| *Gobiosoma evelynae* | Sharknose Goby | 0 | 2 | **1.0** |
| *Stegastes leucostictus* | Beaugregory | 1 | 0 | **0.5** |
| *Hypoplectrus chlorurus* | Yellowtail Hamlet | 1 | 0 | **0.5** |
| *Hypoplectrus unicolor* | Butter Hamlet | 1 | 0 | **0.5** |
| *Caranx ruber* | Bar Jack | 1 | 0 | **0.5** |
| *Holocentrus rufus* | Longspine Squirrelfish | 0 | 1 | **0.5** |
| *Holacanthus ciliaris* | Queen Angelfish | 0 | 1 | **0.5** |
| *Acanthurus chirurgus* | Doctorfish | 0 | 1 | **0.5** |
| *Mycteroperca venenosa* | Yellowfin Grouper | 0 | 1 | **0.5** |
| | **TOTAL INDIVIDUALS** | **491** | **197** | **344** |
| | **TOTAL SPECIES** | **27** | **25** | **26** |

**Fishes outside transects:** *Acanthurus bahianus, A. coeruleus, Apogon townsendi, Balistes vetula, Calamus bajonado, Caranx lugubris, Centropyge argi, Chaetodon sedentarius, C. striatus, Chromis insolata, Gymnothorax funebris, Holacanthus tricolor, Hypoplectrus puella, Lachnolaimus maximus, Lactophrys polygonia, L. triqueter, Lutjanus analis, Malacanthus plumieri, Ocyurus chrysurus, Pomacanthus paru, Pseudupeneus maculatus, Serranus tigrinus, Xanthichthys ringens*

The community structure of fishes at the coral reef habitat was comprised of a wide variety of fish ecological types, reflecting the complexity of the habitat and the availability of multiple microhabitats. The pelagic component was highly dynamic, with the presence of schooling zooplanktivores, such as mackerel scad, creole fish, creole wrasse, and several large predators, including blue runners, *C. crysos*, great barracuda, *S. barracuda* and black jacks, *C. lugubris*. Large yellowtail snappers were present in mid-water as well. A wide variety of small opportunistic demersal carnivores were present, including three species of grunts, three species of squirrelfishes, three species of gobies, wrasses, basslets, hamlets, and small groupers, including graysbe, coney and red hinds. The herbivorous assemblage was not very prominent, comprised of only three species of parrotfishes and a couple of doctorfishes present in relatively low abundance. Sandy sections in the reef were the habitat of the sand tilefish, *Malacanthus plumieri*, another opportunistic carnivore of the reef community.

Top predators of the CR habitat included the yellowfin grouper, mutton snapper, and a large hogfish (Table 23). Motile megabenthic invertebrates were observed outside transects at the CR. These included the arrow crab, *Stenorhynchus seticornis*, the cleaner shrimp, *Periclimenes pedersoni*, one spiny lobster, *Panulirus argus* and two queen conch, *Strombus gigas.*

**Table 23**. Taxonomic composition and size distribution of large and/or commercially important fish and shellfish species observed during a 30 min.active search survey (ASEC) at a coral reef habitat. Depth: 33m. Abrir la Sierra, 2008-10.

| ***Fishes*** | **Size Distribution (cms)** |
|---|---|
| *Decapterus macarellus* | 200 – (12 - 16) |
| *Epinephelus guttatus* | 1 – 20; 4 – (20 – 30); 2 – (30 – 40) |
| *Lachnolaimus maximus* | 1 – 60 |
| *Lutjanus analis* | 2 – (40 – 50); |
| *Mycteroperca venenosa* | 1 – 40; 1 - 50 |
| *Ocyurus chrysurus* | 4 – (35 – 40) |
| *Sphyraena barracuda* | 1 – 70; 1- 90 |
| **Invertebrates** | |
| *Strombus gigas* | 3 - (24 – 30 ) carapace length |
| *Panulirus argus* | 1 – 20 cephalothorax |

**Photo Album 8.** Coral Reef Fish

## 2.3. Rhodolith Reef (Fish Community)

A total of 46 species were identified from the rhodolith reef habitat at a depth of 36 m, including 33 within belt-transects with a mean abundance of 41.3 Ind/30 $m^2$ and a mean richness of 11 spp/30 $m^2$ (Table 24). Two species represented almost 58 % of the total individuals within belt-transects, these were the bicolor damselfish (*S. partitus*) and the cherubfish (*C. argi*). These species were present in all transects surveyed and appear to represent demersal territorial residents of the extensive rhodolith reef habitat. In addition to the aforementioned species, the yellowhead jawfish (*O. aurifrons*), greenblotch parrotfish (*S. atomarium*), lantern bass (*S. baldwini*), yellowhead wrasse (*H. garnoti*), tobacco fish (*S. tabacarius*) and the bluehead wrasse (*T. bifasciatum*) comprised the main fish assemblage in terms of abundance within belt-transects.

Specific studies are needed to ascertain the feeding habits of the bicolor damselfish and the cherubfish at the rhodolith reef, but both are known to be benthic algae grazers, although the bicolor damselfish will also eat a variety of small carnivorous diets, including zooplankton, polychaetes, hydroids and ascidians. The herbivorous assemblage is also represented by four parrotfishes (*S. atomarium, S rubripinne, S. radians* and *S. viride*). Small opportunistic carnivores include a specious rich assemblage that includes four species of basses (*S. baldwini, S. tabacarius, S. annularis* and S. tigrinus), three species of wrasses (*T. bifasciatum, H. garnoti*, and *H. cyanocephalus*), gobies, squirrelfishes, lizard fishes, jawfishes, tilefishes, hawkfishes, and small groupers, such as the graysbe, coney and red hind. Large pelagic and/or demersal fish predators were present in low abundance at the algal rhodolith reef habitat. Queen triggerfish (*B. vetula*), mutton snapper (*L. analis*) and the southern stingray (*D. americana*) appear to be the main demersal predators, whereas the great hammerhead (*Sphyrna mokarran*) is undoubtedly the main pelagic predator, and was also observed to reach to the bottom of the reef.

**Table 24.** Taxonomic composition and abundance of fishes within belt-transects at the Rhodolith Reef habitat. Abrir la Sierra. 36 m. 2008-10

| | | Belt-Transects | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | |
| SPECIES | COMMON NAME | (Ind/30 m$^2$) | | | | | | | | | | | | **MEAN** |
| *Stegastes partitus* | Bicolor Damselfish | 17 | 13 | 17 | 10 | 17 | 8 | 6 | 9 | 29 | 8 | 8 | 14 | **13.0** |
| *Centropyge argi* | Cherubfish | 14 | 10 | 9 | 13 | 15 | 13 | 7 | 11 | 15 | 5 | 9 | 10 | **10.9** |
| *Opistognathus aurifrons* | Yellowhead Jawfish | 0 | 2 | 1 | 8 | 0 | 7 | 16 | | 0 | 1 | 2 | 0 | **3.1** |
| *Sparisoma atomarium* | Greenblotch Parrotfish | 1 | 2 | 3 | 3 | 7 | 2 | 2 | 6 | 1 | 2 | 4 | 4 | **3.1** |
| *Serranus baldwini* | Lantern Bass | 2 | 0 | 0 | 1 | 6 | 5 | | 1 | | | 2 | 2 | **1.6** |
| *Halichoeres garnoti* | Yellowhead Wrasse | 2 | 0 | 2 | 1 | 2 | | 1 | 1 | 1 | 2 | 3 | 3 | **1.5** |
| *Serranus tabacarius* | Tobacco Fish | 2 | 2 | 1 | 2 | 1 | 1 | 0 | | 2 | 1 | 0 | 1 | **1.1** |
| *Thalassoma bifasciatum* | Bluehead Wrasse | 4 | 1 | 1 | 0 | 2 | 1 | 0 | 1 | 2 | 0 | 0 | 1 | **1.1** |
| *Serranus tigrinus* | Harlequin Bass | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 2 | 1 | 0 | **0.7** |
| *Bleniidae* | Blenny (unid) | 0 | 0 | 0 | 1 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | **0.5** |
| *Pseudupeneus maculatus* | Spotted Goatfish | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | **0.5** |
| *Serranus annularis* | Orangeback Bass | 0 | 0 | 2 | 0 | 0 | 0 | 1 | | 1 | 2 | 0 | 0 | **0.5** |
| *Chaetodon aculeatus* | Longsnout Butterflyfish | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 2 | | **0.4** |
| *Holocentrus rufus* | Squirrelfish | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | **0.4** |
| *Halichoeres cyanocephalus* | Wrasse | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | **0.3** |
| *Canthigaster rostrata* | Caribbean Puffer | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | **0.3** |
| *Chaetodon sedentarius* | Reef Butterflyfish | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.3** |
| *Microspathodon chrysurus* | Yellowtail Damselfish | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.3** |
| *Xanthichthys ringens* | Sargassum Triggerfish | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.3** |
| *Amblycirrhitus pinos* | Red-spotted Hawkfish | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **0.2** |
| *Cephalopholis fulva* | Coney | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | **0.2** |
| *Malacanthus plumieri* | Sand Tilefish | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.2** |
| *Pomacanthus arcuatus* | Grey Angelfish | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | **0.2** |
| *Sargocentron coruscus* | Reef Squirrelfish | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **0.2** |
| *Synodus synodus* | Red Lizardfish | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | **0.2** |
| *Acanthurus chirurgus* | Doctorfish | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **0.1** |
| *Acanthurus coeruleus* | Blue Tang | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **0.1** |
| *Cantherhines pullus* | Tail-light Filefish | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.1** |
| *Cephalopholis cruentatus* | Graysbe | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.1** |
| *Gobiosoma evelynae* | Sharknose Goby | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.1** |
| *Holocentrus adscensionis* | Longjaw Squirrelfish | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **0.1** |
| *Sparisoma radians* | Bucktooth Parrotfish | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.1** |
| *Sparisoma viride* | Stoplight Parrotfish | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **0.1** |
| | **TOTAL INDIVIDUALS** | **43** | **35** | **41** | **48** | **57** | **44** | **41** | **34** | **57** | **27** | **32** | **37** | **41.3** |
| | **TOTAL SPECIES** | **8** | **10** | **13** | **14** | **12** | **11** | **10** | **10** | **12** | **12** | **9** | **9** | **11** |

**Fishes Outside Transects:**
*Balistes vetula, Bothus lunatus, Chaetodon ocellatus, Chromis cyanea, Coryphopterus glaucofraenum, Dasyatis americana, Epinephelus guttatus, Gymnothorax miliaris, Halichoeres radiatus, Lachnolaimus maximus, Lutjanus analis, Sparisoma aurofrenatum, Sphyraena barracuda, Sphyrna mokarran*

Motile megabenthic invertebrates present within belt-transects are presented in Table 25. The queen conch (*Strombus gigas*) was the most prominent motile invertebrate with a mean of 0.7 Ind/30 $m^2$ within belt-transects. Given the high abundance of queen conch in the rhodolith reef habitat, it is possibly one of the main herbivores, which in turn may be prey for large stingrays. Additional surveys were directly addressed to determine queen conch density within the rhodolith reef habitat by enumeration of individuals within two 50 x 3 m (150 $m^2$) belt-transects. The mean abundance overall, including all belt-transects surveyed was of 28 Ind in 660 $m^2$, equivalent to 0.042 Ind/$m^2$, or 42 Ind per 1,000 $m^2$ of rhodolith reef habitat. Maximum patch density was of 17 Ind/150 $m^2$, or 0.11 Ind/$m^2$. The arrow crab (*S. seticornis)* was observed to live mostly associated with giant barrel sponges (*X. muta*) in the reef.

**Table 25**. Taxonomic composition and abundance of invertebrates within belt-transects at the rhodolith reef habitat. 36 m. Abrir la Sierra (ALS). 2008-10.

| | | Belt - Transects | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **MEAN** |
| *Stenorhynchus seticornis* | Arrow Crab | | | 1 | 1 | | | | 1 | | | | 1 | **0.3** |
| *Strombus gigas* | Queen Conch | | | | 1 | | | 2 | | | | 4 | 1 | **0.7** |
| | **TOTAL SPECIES** | **0** | **0** | **1** | **2** | **0** | **0** | **1** | **1** | **0** | **0** | **1** | **2** | **0.7** |
| | **TOTAL INDIVIDUALS** | **0** | **0** | **1** | **2** | **0** | **0** | **2** | **1** | **0** | **0** | **4** | **2** | **1.0** |

### Outside Transects

| | |
|---|---|
| *Holothuria sp.* | Sea Cucumber |
| *Stenopus hispidus* | Banded Coral Shrimp |
| *Isostichopus badionotus* | Three rowed Cucumber |

Density Estimate - *Strombus gigas* (Transect Area : 150 m2)

| Surveys | Area |
|---|---|
| Transects 1-12 | 360 |
| ASEC 1 | 150 |
| ASEC 2 | 150 |
| Total Area: | 660 |
| Total Individuals: | 28 |
| Density | 0.042 Ind/m2 |

**Photo Album 9.** Rhodolith Reef Fish

## 2.4. Insular Slope – 30 m (Fish Community)

A total of 55 fish species, including 30 within belt-transects were identified from the top of the insular slope of ALS at a depth of 30 m (Table 26). Mean abundance within transects was 49.8 Ind/30 $m^2$ (range: 32 – 73 Ind/30 $m^2$), and richness was 11.6 spp/30 $m^2$. A small assemblage of five species were present in at least seven of the eight transects surveyed and represented 80.1 % of the total individuals. These included *S. partitus, T. bifasciatum, H. garnoti, C. cyanea,* and *S. iserti*.

The benthic environment at the top of the insular slope is characterized by strong currents and relatively low rugosity provided by sponges and isolated coral heads. This appears to favor a fish community strongly dominated by opportunistic carnivores. At least 27 of the 55 fish species identified from SL 30 are small opportunistic benthic invertebrate feeders. These include a species rich assemblage of wrasses, basses, grunts, gobies, puffers, hawkfishes, hogfishes, squirrelfishes, morays, triggerfishes and small groupers, such as coneys, graysbys, and the rock and red hinds. Herbivores were represented by five parrotfishes, three doctorfishes and two damselfishes. Blue chromis was the only prominent zooplanktivore present in the benthic habitat. Large demersal predators included the black and yellowfin groupers, *M bonaci, M. venenosa*, and the mutton snapper, *L. analis* (Table 27).

The top of the insular slope appears to be the most important residential habitat of the red hind (*E. guttatus*) at ALS. The abundance of *E. guttatus* within belt-transects at SL 30 (0.9 Ind/30 $m^2$) suggests that its population stock size at the top of the insular slope (colonized pavement 1 – 5% in the benthic habitat map, Figure 7), is in the order of 300 ind/ha. The total area of SL 30 at ALS has been estimated to be 137 ha. This habitat was also observed to be a prime habitat for the queen conch, *S. gigas*.

**Table 26.** Taxonomic composition and abundance of fishes within belt-transects at the insular slope. 30 m. Abrir la Sierra. 2008-10.

| | | **Belt-Transects** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | |
| **SPECIES** | **COMMON NAME** | (Ind/30 $m^2$) | | | | | | | | | **Mean** |
| *Stegastes partitus* | Bicolor Damselfish | 0 | 15 | 10 | 15 | 12 | 24 | 22 | 20 | 26 | **16.0** |
| *Thalassoma bifasciatum* | Bluehead Wrasse | 1 | 4 | 5 | 7 | 1 | 13 | 18 | 10 | 18 | **8.6** |
| *Halichoeres garnoti* | Yellowhead Wrasse | 11 | 2 | 3 | 3 | 12 | 2 | 7 | 11 | 3 | **6.0** |
| *Chromis cyanea* | Blue Chromis | 5 | 6 | 2 | 0 | 5 | 9 | 1 | 5 | 14 | **5.2** |

**Table 26.** continued

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Scarus iserti* | Stripped Parrotfish | 5 | 5 | 8 | 10 | 1 | 1 | 1 | 4 | 2 | **4.1** |
| *Sparisoma aurofrenatum* | Redband Parrotfish | 0 | 0 | 1 | 1 | 2 | 3 | 1 | 3 | 0 | **1.2** |
| *Holocentrus rufus* | Longspine Squirrelfish | 1 | 0 | 1 | 1 | 1 | 3 | 1 | 2 | 1 | **1.2** |
| *Epinephelus guttatus* | Red Hind | 1 | 0 | 1 | 0 | 1 | 1 | 2 | 2 | 0 | **0.9** |
| *Chaetodon capistratus* | Four-eye Butterflyfish | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 1 | | **0.9** |
| *Acanthurus bahianus* | Ocean Surgeon | 0 | 0 | 4 | 0 | 0 | 0 | 1 | 0 | 1 | **0.7** |
| *Serranus tigrinus* | Harlequin Bass | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | **0.7** |
| *Coryphopterus lipernes* | Peppermint Goby | 3 | 0 | 0 | 0 | 0 | 0 | 1 | *0* | 0 | **0.4** |
| *Acanthurus chirurgus* | Doctorfish | 1 | 0 | 3 | 0 | 0 | 0 | 0 | *0* | 0 | **0.4** |
| *Scarus taeniopterus* | Princess Parrotfish | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | **0.4** |
| *Pomacentrus paru* | French Angelfish | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | **0.4** |
| *Canthigaster rostrata* | Sharpnose puffer | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **0.3** |
| *Chaetodon aculeatus* | Longsnout Butterflyfish | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | **0.3** |
| *Gobiosoma evelynae* | Sharknose Goby | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | **0.2** |
| *Sphyraena barracuda* | Great Barracuda | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **0.2** |
| *Cephalopholis cruentatus* | Graysby | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | **0.2** |
| *Balistes vetula* | Queen Triggerfish | 0 | 1 | 0 | 0 | 0 | 1 | 0 | *0* | 0 | **0.2** |
| *Amblycirrhitus pinos* | Redspotted Hawkfish | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | **0.2** |
| *Epinephelus adscensionis* | Rock Hind | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **0.1** |
| *Sparisoma radians* | Bucktooth Parrotfish | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **0.1** |
| *Microspathodon chrysurus* | Yellowtail Damselfish | 0 | 1 | 0 | 0 | 0 | 0 | 0 | *0* | 0 | **0.1** |
| *Haemulon flavolineatum* | French Grunt | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | **0.1** |
| *Gymnothorax moringa* | Spotted Moray | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **0.1** |
| *Chromis insolata* | Sunshine chromis | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **0.1** |
| *Chaetodon ocellatus* | Spotfin Butterflyfish | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **0.1** |
| *Chaetodipterus faber* | Spadefish | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **0.1** |
| | **TOTAL INDIVIDUALS** | **32** | **36** | **46** | **39** | **42** | **59** | **58** | **63** | **73** | **49.8** |
| | **TOTAL SPECIES** | **11** | **9** | **13** | **7** | **13** | **11** | **14** | **13** | **13** | **11.6** |

Fishes outside transects: *Acanthurus coeruleus*, *Bodianus rufus, Calamus bajonado*, *Caranx crysos, Cephalopholis fulva*, *Chaetodon sedentarius*, *Decapterus macarellus, Haemulon macrostomum*, *Haemulon sciurus*, *Holacanthus ciliaris*, *Holacanthus tricolor*, *Holocentrus adscensionis*, *Lachnolaimus maximus, Lactophrys triqueter, Lutjanus analis, Melichthys niger*, *Mycteroperca bonaci, M. venenosa* , *Pomacanthus arcuatus*, *Priacanthus cruentatus*, *Pseudupeneus maculatus*, *Scarus vetula*, *Serranus tigrinus*, *Xanthichthys ringens*

**Table 27**. Taxonomic composition and size distribution of large and/or commercially important fish and shellfish species observed during a 30 min. active search survey (ASEC) at the insular slope (SL 30). Depth: 30m. Abrir la Sierra, 2008-10.

| ***Fishes*** | **Size Distribution (cms)** |
|---|---|
| *Caranx crysos* | 2 – (50) |
| *Epinephelus guttatus* | 14 – (25); 26 – (30); 7 – (31 – 35) |
| *Lachnolaimus maximus* | 1 – (60) |
| *Lutjanus analis* | 1 – (45); |
| *Mycteroperca bonaci* | 1 – (50) |
| *Mycteroperca venenosa* | 1 – (25); 1 – (50), 1 – (70) |
| *Lachnolaimus maximus* | 1 – (50) |
| *Sphyraena barracuda* | 1 – 80 |
| **Invertebrates** | |
| *Strombus gigas* | 1 - (25), 8 – (30) carapace length |

**Photo Album 10**. Slope 30m Fish






## 2.5. Insular Slope – 40 m (Fish Community)

A total of 40 fish species, including 35 within belt-transects were identified from the insular slope of ALS at a depth of 40 m (Table 28). Mean abundance within transects was 114.2 Ind/30 $m^2$ (range: 31 – 559 Ind/30 $m^2$), and richness was 9.9 spp/30 $m^2$. The abundance of one species, the masked goby (*C. personatus*) (mean: 67.1 Ind/30 $m^2$) represented 58.7 % of the total individuals within belt-transects. Sunshine chromis (C*. insolata*) was also numerically prominent with a mean abundance of 15.6 Ind/30 $m^2$, representing 13.7 % of the total fish abundance at 40 m. The two aforementioned species were present mostly as guilds of post-recruitment and early juveniles associated with branching sponges and gorgonians in the slope. Although in lower abundance, guilds of early juvenile blue chromis (*C. cyanea*) were also present at 40 m. Adults of these species were observed, but typically in lower abundance compared to the early juvenile stages. The yellowhead wrasse (*H. garnoti*) and the bicolor damselfish (*S. partitus*) were present in all transects surveyed, and along with masked goby and sunshine chromis comprised the numerically dominant assemblage of the insular slope at 40 m.

At 40 m in the insular slope of ALS, the physical conditions of the benthic habitat are characterized by a steep bathymetry and a substrate of pavement with scattered algal rhodoliths colonized by benthic algae, sponges and small isolated coral colonies. There is substantial transport of sand and rubble from the reef top down the slope. The conditions of low substrate rugosity and prevalence of mostly small habitats associated with rhodoliths, branching sponges and small coral heads appears to favor a fish community numerically dominated by small reef fish species that can use such microhabitats. These include the bicolor damselfish, cherubfish, squirrelfish, masked goby and post-recruitment gobies and chromis. Four of the smallest growing parrotfishes, including the greenblotch, bucktooth, princess and redband were also present within belt-transects and appear to be part of the resident fish assemblage.

Fish trophic structure at 40 m in the insular slope was characterized by the presence of a species rich assemblage of opportunistic carnivores such as wrasses, basses, gobies, squirrelfishes, and small groupers, such as coneys, graysbys, and red hinds. Herbivores were represented by four parrotfishes, one doctorfish and the cherubfish. Sunshine and blue chromis was the most prominent zooplanktivores present in the benthic habitat, but many opportunistic carnivores, including gobies, wrasses, basslets, jawfishes, hawkfishes and others may be feeding upon demersal zooplankton. Specific research of the role of demersal zooplankton in the feeding habits of mesophotic reef fishes needs to be performed. Butterflyfishes were represented by three species. These fishes are known to feed on hydrozoans, coral polyps and small worms in the reef. Queen triggerfish, dog snapper and red hind appear to be the most common demersal predators of intermediate size, whereas the nurse shark and the black grouper were the largest demersal predators observed (Table 29). Pelagic predators of the insular slope include the great barracuda, black jacks and cero mackerels.

Motile megabenthic invertebrates were not observed within belt-transects. Arrow crabs (S. seticornis) and cleaner shrimps (*P. pedersoni*) were observed to be common at the insular slope.

**Table 28.** Taxonomic composition and abundance of fishes within belt-transects at the insular slope. 40 m. Abrir la Sierra. 2008-10

| | | Belt-Transects | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | |
| ***SPECIES*** | **COMMON NAME** | **(Ind/30 m$^2$)** | | | | | | | | | | **Mean** |
| *Coryphopterus personatus* | Masked Goby | 100 | 0 | 64 | 60 | 310 | 0 | 70 | 0 | 0 | 515 | **67.1** |
| *Chromis insolata* | Sunshine Chromis | 127 | 0 | 12 | 0 | 0 | 0 | 1 | 0 | 0 | 24 | **15.6** |
| *Halichoeres garnoti* | Yellowhead Wrasse | 5 | 11 | 5 | 4 | 9 | 4 | 4 | 13 | 7 | 3 | **6.9** |
| *Stegastes partitus* | Bicolor Damselfish | 4 | 7 | 10 | 3 | 6 | 9 | 6 | 7 | 1 | 6 | **5.9** |
| *Centropyge argi* | Cherubfish | 3 | 1 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 0 | **3.7** |
| *Chromis cyanea* | Blue Chromis | 2 | 0 | 29 | 4 | 1 | 0 | 0 | 0 | 0 | 3 | **4.0** |
| *Thalassoma bifasciatum* | Bluehead Wrasse | 1 | 6 | 2 | 0 | 0 | 3 | 0 | 0 | 6 | 0 | **1.8** |
| *Holocentrus rufus* | Squirrelfish | 0 | 1 | 1 | 2 | 2 | 0 | 5 | 1 | 1 | 1 | **1.4** |
| *Chaetodon sedentarius* | Reef Butterflyfish | 2 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | **0.8** |
| *Caranx crysos* | Blue Runners | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | **0.6** |
| *Xanthichthys ringens* | Sargassum Triggerfish | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | **0.4** |
| *Sparisoma radians* | Bucktooth Parrotfish | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **0.4** |
| *Serranus tigrinus* | Harlequin Bass | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | **0.4** |
| *Scarus taeniopterus* | Princess Parrotfish | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.4** |
| *Chaetodon capistratus* | Four-eye Butterflyfish | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | **0.4** |
| *Sparisoma aurofrenatum* | Redband Parrotfish | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **0.3** |
| *Coryphopterus glaucofraenum* | Bridled Goby | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | **0.3** |
| *Chaetodon aculeatus* | Longsnout Butterfly | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **0.3** |

**Table 28.** continued

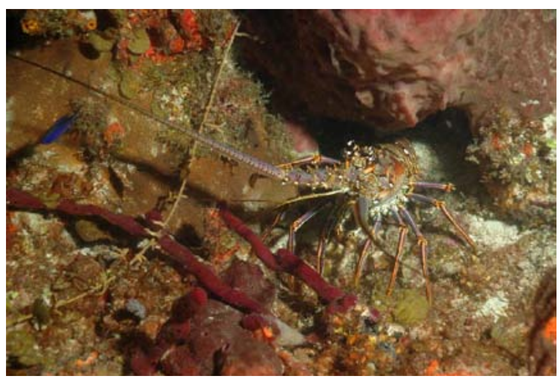
| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Canthigaster rostrata* | Sharpnose Puffer | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.3** |
| *Serranus tabacarius* | Tobaccofish | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.2** |
| *Bodianus rufus* | Spanish Hogfish | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | **0.2** |
| *Epinephelus fulva* | Coney | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | **0.2** |
| *Opistognathus aurifrons* | Yellowhead Jawfish | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.1** |
| *Gramma loreto* | Fairy Basslet | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **0.1** |
| *Epinephelus guttatus* | Red Hind | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.1** |
| *Apogon townsendi* | Belted Cardinalfish | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.1** |
| *Acanthurus bahianus* | Ocean Surgeon | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **0.1** |
| *Sparisoma atomarium* | Greenblotch Parrotfish | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | **0.1** |
| *Pseudupeneus maculatus* | Spotted Goatfish | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | **0.1** |
| *Pomacanthus paru* | French Angelfish | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | **0.1** |
| *Epinephelus cruentatus* | Graysby | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | **0.1** |
| *Ginglymostoma cirratum* | Nurse Shark | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **0.1** |
| Hypoplectrus puella | Barred Hamlet | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **0.1** |
| *Balistes vetula* | Queen triggerfish | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **0.1** |
| *Pomacanthus arcuatus* | Gray Angelfish | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **0.1** |
| | **Total individuals** | **253** | **31** | **138** | **78** | **328** | **52** | **97** | **29** | **22** | **559** | **114.2** |
| | **Total species** | **15** | **10** | **16** | **9** | **5** | **7** | **12** | **6** | **9** | **9** | **9.9** |

**Fishes Outside Transects :** *Caranx lugubris, Epinephelus guttatus, Lutjanus jocu, Mycteroperca bonaci, Scomberomorus regalis, Serranus tabacarius, Sparisoma atomarium*

**Table 29**. Taxonomic composition and size distribution of large and/or commercially important fish and shellfish species observed during a 30 min. active search survey (ASEC) at the insular slope (SL 40). Depth: 40m. Abrir la Sierra, 2008-10.

| ***Fishes*** | **Size Distribution (cms)** |
|---|---|
| *Caranx lugubris* | 1 – (55) |
| *Epinephelus guttatus* | 3 – (25); 2 – (30); 1 – (31 – 35) |
| *Lutjanus jocu* | 1 – (40); |
| *Mycteroperca bonaci* | 1 – (45) |
| *Scomberomorus regalis* | 1 – (55) |
| *Sphyraena barracuda* | 1 – 60 |

**Photo Album 11**. Insular Slope 40m Fish



## 2.6. Insular Slope – 50 m (Fish Community)

A total of 34 fish species, including 25 within belt-transects were identified from the insular slope at 50 m with a mean abundance of 174 Ind/30 $m^2$ (range: 49 – 391 Ind/30 $m^2$). Species richness averaged 9.9 spp/30 $m^2$. High variation of fish abundance between transects was driven by fluctuations of numerically dominant species with highly aggregated distributions. As described for the insular slope at 40 m, sunshine chromis (*C. insolata*) and masked gobies (*C. personatus*) exhibited large aggregations of post-recruitment juveniles associated with sponges, gorgonians and substrate discontinuities at 50 m. The combined abundance of the aforementioned species (151.8 Ind/30 $m^2$) represented 87.2 % of the total individuals within transects. Older juveniles and adults of both species were observed in lower quantities. Yellowhead wrasse, bicolor damselfish, cherubfish, squirrelfish, and blue chromis were present in at least six of the eight transects surveyed and along with the aforementioned species appear to comprise the main resident demersal ichthyofauna. Aside from the marked increment of sunshine chromis aggregations and a general decline of species from shallow water, fish community structure at 50 m was similar to the insular slope at 40 m.

Fish trophic structure at 50 m appears to be based on zooplankton, small benthic invertebrates and benthic algae. The two most abundant species (e.g. sunshine chromis and masked goby) are well known zooplanktivores, but the community of zooplankton from mesophotic reefs in the Caribbean is unknown. The variety of opportunistic carnivores, which includes the wrasses, basslets, basses, hogfishes, hamlets, squirrelfishes, and small groupers, such as coney, graysbe and red hind is indicative of high availability of small epibenthic invertebrates. Butterflyfishes (*Chaetodon aculeatus, C. sedentarius, C. capistratus*) and angelfishes (*Centropyge argi, Pomacanthus paru*) were common at the insular slope. These may be feeding upon small worms and/or cnidarian polyps, except the cherubfish which is known to be a benthic algal grazer. Three parrotfishes, perhaps the bicolor damselfish and the cherubfish appear to comprise the main herbivorous assemblage at 50 m. Large black groupers (*M. bonaci*) were present at 50 m (Table 31) and seem to be the largest demersal predator of the slope, along with nurse sharks, also reported for the slope at 40 m.

Motile megabenthic invertebrates observed within belt-transects at 50 m include the arrow crab and cleaner shrimp (Table 32). Queen conch (*S. gigas*) and the sea cucumber, ujhudsfyhopi were observed outside transects.

**Table 30.** Taxonomic composition and abundance of fishes within belt-transects at the insular slope. 50 m. Abrir la Sierra. 2008-10

| | | Belt-Transects | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| **SPECIES** | **COMMON NAME** | **(Ind/30 m²)** | | | | | | | | **Mean** |
| *Chromis insolata* | Sunshine Chromis | 54 | 36 | 30 | 14 | 200 | 10 | 200 | 193 | **77.7** |
| *Coryphopterus personatus* | Masked Goby | 150 | 0 | 0 | 174 | 130 | 40 | 25 | 180 | **74.1** |
| *Halichoeres garnoti* | Yellowhead Wrasse | 2 | 16 | 8 | 2 | 8 | 2 | 4 | 6 | **6.0** |
| *Stegastes partitus* | Bicolor Damselfish | 1 | 0 | 3 | 4 | 7 | 8 | 3 | 1 | **3.7** |
| *Gramma loreto* | Fairy Basslet | 0 | 1 | 0 | 1 | 14 | 0 | 0 | 2 | **2.3** |
| *Chromis cyanea* | Blue Chromis | 0 | 4 | 2 | 3 | 0 | 2 | 4 | 0 | **1.9** |
| *Centropyge argi* | Cherubfish | 1 | 1 | 0 | 1 | 0 | 1 | 5 | 1 | **1.3** |
| *Holocentrus rufus* | Squirrelfish | 1 | 0 | 1 | 1 | 3 | 1 | 0 | 2 | **1.0** |
| *Scarus taeniopterus* | Princess Parrotfish | 0 | 3 | 2 | 0 | 0 | 2 | 0 | 0 | **0.9** |
| *Chaetodon aculeatus* | Longsnout Butterflyfish | 1 | 1 | 0 | 0 | 0 | 3 | 1 | 0 | **0.8** |
| *Chaetodon sedentarius* | Reef Butterflyfish | 0 | 1 | 1 | 0 | 0 | 2 | 0 | 1 | **0.6** |
| *Sparisoma aurofrenatum* | Redband Parrotfish | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | **0.5** |
| *Serranus tabacarius* | Tobaccofish | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0.4** |
| *Epinephelus cruentatus* | Graysby | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | **0.3** |
| *Coryphopterus glaucofraenum* | Bridled Goby | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | **0.3** |
| *Serranus annularis* | Orangeback Bass | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | **0.3** |
| *Serranus tigrinus* | Harlequin Bass | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | **0.3** |
| *Hypoplectrus nigricans* | Black Hamlet | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | **0.3** |
| *Chaetodon striatus* | Banded Butterflyfish | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | **0.3** |
| *Pomacanthus paru* | French Angelfish | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **0.1** |
| *Xanthichthys ringens* | Sargassum Triggerfish | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **0.1** |
| *Hypoplectrus puella* | Barred Hamlet | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **0.1** |
| *Epinephelus fulva* | Coney | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **0.1** |
| *Halichoeres cyanocephalus* | Yellowcheek Wrasse | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **0.1** |
| *Epinephelus guttatus* | Red Hind | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **0.0** |
| | **Total individuals** | 216 | 68 | 49 | 200 | 364 | 75 | 246 | 391 | **174.0** |
| | **Total species** | 11 | 11 | 8 | 8 | 8 | 14 | 9 | 10 | **9.9** |

**Fishes outside transects**: *Balistes vetula, Bodianus rufus, Canthigaster rostrata , Lachnolaimus maximus, Mycteroperca bonaci, Ocyurus chrysurus, Paranthias furcifer, Pomacanthus paru , Serranus annularis, Sparisoma atomarium, Sphyraena barracuda*

**Table 31**. Taxonomic composition and size distribution of large and/or commercially important fish and shellfish species observed during a 30 min. active search survey (ASEC) at the insular slope (SL 50). Depth: 50m. Abrir la Sierra, 2008-10.

| ***Fishes*** | **Size Distribution (cms)** |
|---|---|
| *Epinephelus guttatus* | 2 – (25); 2 – (30) |
| *Lachnolaimus maximus* | 1 – (35); |
| *Mycteroperca bonaci* | 1 – (60); 2 – (80 -90) |
| *Ocyurus chrysurus* | 3 – (40 - 50) |
| *Sphyraena barracuda* | 1 – 50 |

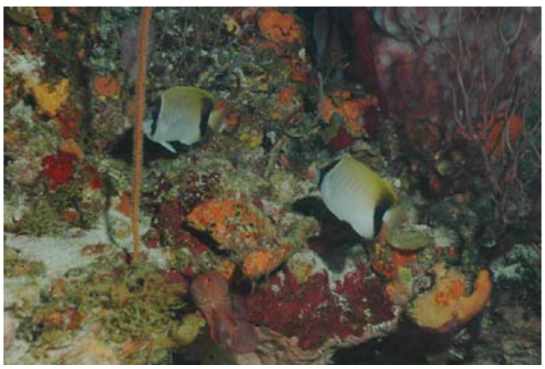
**Table 32**. Taxonomic composition and abundance of invertebrates within belt-transects at the insular slope. 50 m. Abrir la Sierra (SL 50). 2008-10.

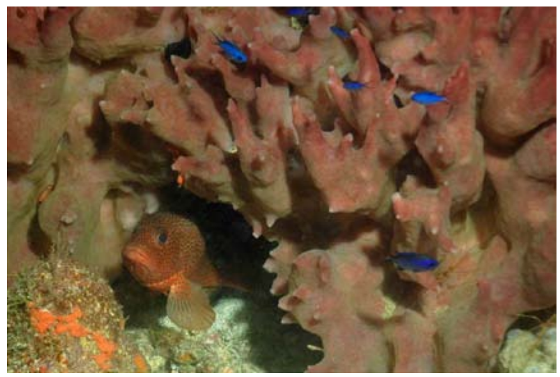
| | | **Belt-Transects** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **Mean** |
| *Stenorhynchus seticornis* | Arrow Crab | 1 | | 1 | 1 | | | | 1 | **0.5** |
| *Periclimenes pedersoni* | Cleaner Shrimp | | | | 1 | | | 2 | | **0.4** |
| | **TOTAL SPECIES** | **1** | **0** | **1** | **2** | **0** | **0** | **1** | **1** | **2** |
| | **TOTAL INDIVIDUALS** | **1** | **0** | **1** | **2** | **0** | **0** | **2** | **1** | **0.9** |

**Outside Transects**

| | |
|---|---|
| *Holothuria sp.* | Sea Cucumber |
| *Strombus gigas* | Queen Conch |

**Photo Album 12**. Slope 50m Fish





## 2.7. Comparative Analysis of Fish Community Structure Between Habitat/Zones

A non-metric multidimensional scaling (MDS) plot of Bray-Curtis fish community structure similarities between mesophotic reef physiographic zones and benthic habitats of ALS is presented in Figure 10. Euclidean distances were calculated based on the rank order abundance (non-metric) of all taxonomic fish components from each physiographic zone or benthic habitat. Statistically significant differences (ANOSIM, $R > 0.674$, $p < 0.001$) were observed between RR and all other habitats, and between CR and all other habitats, except the inner wall (IW). Slope habitats at 40 and 50 m (SL 40, SL 50) were different from those at the IW and SL 30. Differences were not statistically significant between IW and the SL stations, and between the SL 40 and SL 50 (Table 33).

**Table 33**. ANOSIM. Pairwise analysis of similarities in the rank order of fish abundance between mesophotic physiographic zones and benthic habitats surveyed from Abrir la Sierra, 2008 - 10

Sample statistic (Global R): 0.674; Significance level of sample statistic: 0.1%
Pairwise Tests

| Groups | R Statistic | Significance Level % | Possible Permutations | Actual Permutations | Number |
|---|---|---|---|---|---|
| CR 33, SL 30 | 1 | 1.8 | 55 | 55 | 1 |
| CR 33, SL 40 | 0.872 | 1.5 | 66 | 66 | 1 |
| CR 33, SL 50 | 1 | 2.2 | 45 | 45 | 1 |
| CR 33, RR 36 | 1 | 1.1 | 91 | 91 | 1 |
| CR 33, IW 34 | 0.461 | 8.3 | 36 | 36 | 3 |
| SL 30, SL 40 | 0.385 | 0.1 | 92378 | 999 | 0 |
| SL 30, SL 50 | 0.858 | 0.1 | 24310 | 999 | 0 |
| SL 30, RR 36 | 0.945 | 0.1 | 293930 | 999 | 0 |
| SL 30, IW 34 | 0.351 | 0.2 | 11440 | 999 | 1 |
| SL 40, SL 50 | 0.089 | 13.6 | 43758 | 999 | 135 |
| SL 40, RR 36 | 0.737 | 0.1 | 646646 | 999 | 0 |
| SL 40, IW 34 | 0.2 | 3.2 | 19448 | 999 | 31 |
| SL 50, RR 36 | 0.968 | 0.1 | 125970 | 999 | 0 |
| SL 50, IW 34 | 0.479 | 0.2 | 6435 | 999 | 1 |
| RR 36, IW 34 | 0.875 | 0.1 | 50388 | 999 | |

Similarities of fish community structure within the CR habitat (Table 34) were mostly contributed by an assemblage of shallow reef fishes that use protective coral structures as residential habitats, such as *Myripristis jacobus, Holocentrus adscensionis, Haemulon flavolineatum, Epinephelus fulva,* and *Coryphopterus lipernes*, a small goby that lives directly on top of live corals, particularly over boulder star coral (*M. annularis).* The CR station was surveyed near the base of a wall within the deep terrace, thus it resembles a shelf-edge environment. *Paranthias furcifer*, a fish commonly associated with shelf-edge reef zones and slope walls contributed to the similarity within CR stations (Table 34). Despite the large dissimilarity between the CR habitat and other benthic habitats or reef physiographic zones, the results here presented must be evaluated with caution due to the small number of transects surveyed at the CR (2).

The second highest similarity of fish community structure within benthic habitats studied at ALS was observed at the RR reef. Fish community structure, based on the rank order abundance of fish species from the RR was significantly different from all other habitats studied. The most important taxa that contributed to the similarity within the RR habitat included the cherubfish, *C argi*, bicolor damselfish, *S. partitus*, greenblotch parrotfish, *S. atomarium*, and the tobacco fish, *S. tabacarius*. Both the cherubfish and the greenblotch parrotfish exhibited their peek abundance at the RR. These species have been previously reported from rhodolith reef habitats at Isla Desecheo and Bajo de Sico (García-Sais et al., 2005, 2007), and proposed as indicator species of mesophotic habitats (García-Sais, 2010).

Fish assemblages of the inner wall (IW) and insular slope wall (SL) presented relatively lower within (group) habitat similarity than the CR and RR. The low similarity appeared to be associated with high variability of species rank abundance in transects surveyed. Such variability was related to the patchy distribution of numerically dominant species, such as masked goby, *C. personatus* and creole wrasse, *C. parrae* within the replicate transect matrix. The relatively high abundance of *C. personatus* in transect 1 of the IW could have been influenced by the high coral cover and associated substrate rugosity in that transect. Likewise, high variability of fish community structure within SL 40 was influenced by the patchy distribution of post-recruitment juvenile aggregations of sunshine chromis, *C. insolata*, masked goby and creole wrasse. The later taxa were observed to be associated with scattered branching and barrel sponges as protective habitat.

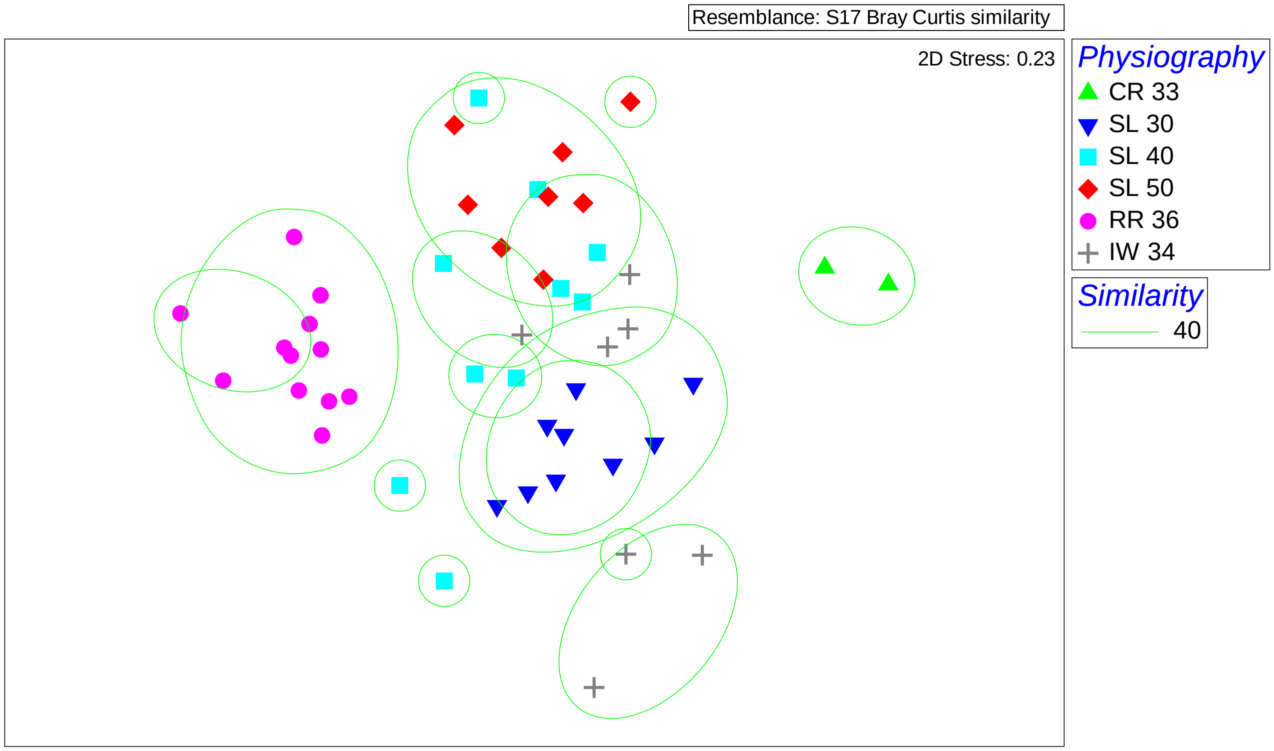



**Figure 10**. Non-metric multidimensional scaling plot based on Bray-Curtis similarities between the community structure of fishes at mesophotic reef physiographic zones and benthic habitats surveyed from Abrir la Sierra. Circles include transects with community structure similarities of at least 40 %.

**Table 34**. SIMPER. Analysis of fish species contributions to similarity within reef physiographic zones and benthic habitats at ALS. 2008 -10. RR=rhodolith reef; CR=coral reef; IW=Inner Wall; SL 30=slope 30 m; SL 40=slope 40 m; SL50=slope 50 m.

| | | | | |
|---|---|---|---|---|
| **Group CR** | Average similarity: 50.94 | | | |
| ***Species*** | Av.Abund | Av.Sim | Contrib% | Cum.% |
| *Myripristis jacobus* | 0.05 | 5.14 | 10.09 | 10.09 |
| *Holocentrus adscensionis* | 0.05 | 5.14 | 10.09 | 20.18 |
| *Coryphopterus lipernes* | 0.05 | 5.09 | 10 | 30.18 |
| *Haemulon flavolineatum* | 0.05 | 4.6 | 9.04 | 39.22 |
| *Epinephelus fulva* | 0.04 | 3.27 | 6.41 | 45.63 |
| *Paranthias furcifer* | 0.04 | 3.24 | 6.37 | 51.99 |
| **Group RR** | Average similarity: 45.11 | | | |
| *Centropyge argi* | 0.12 | 10.55 | 23.39 | 23.39 |
| *Stegastes partitus* | 0.11 | 8.88 | 19.69 | 43.08 |
| *Sparisoma atomarium* | 0.09 | 6.88 | 15.25 | 58.33 |
| *Serranus tabacarius* | 0.06 | 3.67 | 8.14 | 66.47 |

**Table 34.** continued

| | | | | |
|---|---|---|---|---|
| *Pseudupeneus maculatus* | 0.07 | 2.6 | 5.76 | 72.23 |
| *Halichoeres garnoti* | 0.04 | 2.57 | 5.69 | 77.92 |
| **Group SL 30** | Average similarity: 44.28 | | | |
| *Stegastes partitus* | 0.1 | 7.38 | 16.66 | 16.66 |
| *Halichoeres garnoti* | 0.08 | 6.56 | 14.81 | 31.47 |
| *Thalassoma bifasciatum* | 0.09 | 6.47 | 14.6 | 46.08 |
| *Scarus iserti* | 0.09 | 5.3 | 11.96 | 58.04 |
| *Chromis cyanea* | 0.06 | 3.82 | 8.63 | 66.67 |
| **Group SL 50** | Average similarity: 42.80 | | | |
| *Chromis insolata* | 0.13 | 10.45 | 24.42 | 24.42 |
| *Halichoeres garnoti* | 0.1 | 8 | 18.7 | 43.12 |
| *Coyphopterus personatus* | 0.09 | 4.99 | 11.66 | 54.77 |
| *Stegastes partitus* | 0.06 | 3.9 | 9.11 | 63.89 |
| *Holocentrus rufus* | 0.06 | 3.54 | 8.26 | 72.15 |
| **Group SL 40** | Average similarity: 32.03 | | | |
| *Halichoeres garnoti* | 0.13 | 8.83 | 27.56 | 27.56 |
| *Stegastes partitus* | 0.09 | 6.05 | 18.9 | 46.46 |
| *Holocentrus rufus* | 0.07 | 4 | 12.48 | 58.94 |
| *Coryphopterus personatus* | 0.08 | 2.77 | 8.64 | 67.58 |
| *Chaetodon sedentarius* | 0.06 | 2.33 | 7.26 | 74.84 |
| **Group IW 34** | Average similarity: 29.33 | | | |
| *Stegastes partitus* | 0.09 | 6.99 | 23.85 | 23.85 |
| *Chromis cyanea* | 0.09 | 4.78 | 16.31 | 40.16 |
| *Holocentrus rufus* | 0.05 | 2.81 | 9.58 | 49.74 |
| *Halichoeres garnoti* | 0.05 | 2.71 | 9.25 | 58.99 |
| *Gobiosoma evelynae* | 0.06 | 1.83 | 6.24 | 65.23 |
| *Scarus taeniopterus* | 0.05 | 1.33 | 4.53 | 69.76 |
| *Thalassoma bifasciatum* | 0.03 | 1.13 | 3.86 | 73.62 |

In terms of seafloor area covered, the three main benthic habitats associated with mesophotic reef physiographic zones at ALS, (e.g. rhodolith reef, colonized pavement, and scattered rhodolith and corals in sand) exhibited marked differences of fish community structure. We do not provide a quantitative assessment of the scattered rhodolith and corals in sand habitat, but this habitat is mostly un-colonized by sessile-benthic biota. Resident fishes of the sandy areas include the sand tilefish, *Malacanthus plumieri*, which makes large nests with the available rhodoliths. Such structure may reach 50 cm in some cases and provides microhabitat for several fish species, including the cherubfish, bicolor damselfish, yellowhead wrasse, and small parrotfishes that graze on the algal turf and fleshy macroalgae colonizing rhodoliths. Species that inhabit or forage in the sandy bottom include the yellowhead jawfish, *Opistognathus aurifrons*, the queen conch, the mutton snapper and large demersal predators, such as the reef shark, *Carcharhinus perezi*, which was observed close to the sandy substrate at this habitat. Otherwise, most of the ichthyofauna associated with this habitat was heavily concentrated on a series of small rock promontories interspersed in the sandy environment. These include a wide variety of shallow coral reef fishes (see appendix 2), but above all appear to be prime foraging and/or residential habitats for red hinds.

Rhodolith reef and colonized pavement were the main benthic habitats quantitatively characterized in this study. Differences were observed between colonized pavement habitats of different reef physiographic zones, such as the top of the insular slope at 30 m and the deepest zone of the insular slope surveyed at 50 m. Differences between these two zones were mostly driven by the higher rank abundance of bluehead wrasse, *T. bifasciatum* and the parrotfishes, *S. aurofrenatum, S. iserti* at 30 m, whereas masked goby, *C. personatus*, sunshine fish, *C. insolata* and bicolor damselfish, *S. partitus* were most prominent at 50 m (Table 35). The abundance of bluehead wrasse was found to decline with depth at Isla Desecheo (García-Sais, 2010). As previously stated, the insular slope wall, particularly at 40 and 50 m was observed to function as a recruitment habitat for sunshine fish and masked gobies. The slope at 50 m is also a preferred habitat by butterflyfishes, particularly the reef and longsnout butterflyfish, *C. aculeatus*, *C. sedentarius* which appear to find suitable food at the insular slope wall. No significant differences of fish community structure were found between the colonized pavement habitats of the inner wall and the colonized pavement habitats of the insular slope walls.

Differences of fish community structure between the rhodolith reef and colonized pavement habitats was mostly associated with the higher rank order abundance of C. argi, S. atomarium, S. tabacarius, S. baldwini and P. maculatus at the RR, and higher rank abundance of *C. personatus, C. insolata, T. bifasciatum, S, iserti* and *S. aurofrenatum* at SL and IW stations (Table 35).

Total fish abundance and species richness peaked at the coral reef habitat (33m) with a mean of 344 Ind/transect and 26 spp/transect (Figure 11). Both fish abundance and species richness were lowest at RR and almost identical in magnitude to IW and SL 30.

Fish abundance increased markedly with increasing depth down the insular slope, whereas species richness remained constant. Such abundance increase was associated with the occurrence of large aggregations of post-recruitment juveniles of *C. personatus* and *C. insolata*. Fish abundance and species richness from depths of 36 – 38 m at RR habitats from ALS were similar to deeper RR habitats at Isla Desecheo (50m) and Bajo de Sico (50m). At equivalent depths, the CR habitat at ALS was similar in fish abundance and species richness to CR stations both Isla Desecheo and BDS. Results from the CR station at ALS must be analyzed with caution due to the small sample size. Conversely, marked differences of both richness and abundance resulted from different benthic habitats at the same depth, suggesting that habitat type is more important than depth as a determinant of fish community structure within this depth range.

**Table 35**. SIMPER. Average dissimilarity and species contributions to dissimilarity of fish rank abundance at the different reef physiographic zones and habitats in Abrir la Sierra. 2008-10

| ***Groups CR 33 & SL 30*** | | **Average dissimilarity = 84.51** | | | |
|---|---|---|---|---|---|
| | **Group CR 33** | **Group SL 30** | | | |
| ***Species*** | **Av.Abund** | **Av.Abund** | **Av. Diss** | **Contrib%** | **Cum.%** |
| *Stegastes partitus* | 0.01 | 0.1 | 4.43 | 5.24 | 5.24 |
| *Scarus iserti* | 0 | 0.09 | 4.26 | 5.05 | 10.29 |
| *Thalassoma bifasciatum* | 0.01 | 0.09 | 3.83 | 4.53 | 14.82 |
| *Halichoeres garnoti* | 0.03 | 0.08 | 2.75 | 3.25 | 18.07 |
| *Chromis cyanea* | 0.01 | 0.06 | 2.6 | 3.07 | 21.15 |
| *Myripristis jacobus* | 0.05 | 0 | 2.58 | 3.05 | 24.2 |
| *Holocentrus adscensionis* | 0.05 | 0 | 2.58 | 3.05 | 27.25 |
| *Epinephelus adscensionis* | 0 | 0.05 | 2.52 | 2.98 | 30.23 |
| *Sparisoma aurofrenatum* | 0.03 | 0.06 | 2.51 | 2.96 | 33.2 |
| *Serranus tigrinus* | 0 | 0.05 | 2.4 | 2.84 | 36.04 |
| *Haemulon flavolineatum* | 0.05 | 0 | 2.28 | 2.7 | 38.74 |
| ***Groups CR 33 & SL 40*** | | **Average dissimilarity = 86.85** | | | |
| | **Group CR 33** | **Group SL 40** | | | |
| ***Species*** | **Av.Abund** | **Av.Abund** | **Av.Diss** | **Contrib%** | **Cum.%** |
| *Halichoeres garnoti* | 0.03 | 0.13 | 5.02 | 5.78 | 5.78 |
| *Stegastes partitus* | 0.01 | 0.09 | 4.12 | 4.75 | 10.53 |
| *Coryphopterus personatus* | 0.04 | 0.08 | 3.44 | 3.96 | 14.49 |
| *Holocentrus rufus* | 0.01 | 0.07 | 3.44 | 3.96 | 18.45 |
| *Chaetodon sedentarius* | 0 | 0.06 | 3.1 | 3.57 | 22.02 |
| *Myripristis jacobus* | 0.05 | 0 | 2.58 | 2.97 | 24.99 |
| *Holocentrus adscensionis* | 0.05 | 0 | 2.58 | 2.97 | 27.96 |
| *Coryphopterus lipernes* | 0.05 | 0 | 2.56 | 2.95 | 30.91 |
| *Haemulon flavolineatum* | 0.05 | 0 | 2.44 | 2.8 | 33.71 |
| *Serranus tigrinus* | 0 | 0.05 | 2.3 | 2.65 | 36.36 |
| *Epinephelus fulva* | 0.04 | 0.02 | 2.29 | 2.63 | 38.99 |
| *Thalassoma bifasciatum* | 0.01 | 0.04 | 2.19 | 2.52 | 41.51 |

**Table 35.** continued

| | | | | | |
|---|---|---|---|---|---|
| *Bodianus rufus* | 0.03 | 0.03 | 2.19 | 2.52 | 44.03 |
| ***Groups SL 30 & SL 40*** | | **Average dissimilarity = 70.41** | | | |
| | **Group SL 30** | **Group SL 40** | | | |
| ***Species*** | **Av.Abund** | **Av.Abund** | **Av.Diss** | **Contrib%** | **Cum.%** |
| *Scarus iserti* | 0.09 | 0 | 4.26 | 6.06 | 6.06 |
| *Coryphopterus personatus* | 0 | 0.08 | 3.82 | 5.42 | 11.48 |
| *Thalassoma bifasciatum* | 0.09 | 0.04 | 3.44 | 4.88 | 16.36 |
| *Halichoeres garnoti* | 0.08 | 0.13 | 3.13 | 4.44 | 20.8 |
| *Chaetodon sedentarius* | 0 | 0.06 | 3.1 | 4.4 | 25.2 |
| *Stegastes partitus* | 0.1 | 0.09 | 2.85 | 4.04 | 29.24 |
| *Serranus tigrinus* | 0.05 | 0.05 | 2.83 | 4.02 | 33.26 |
| *Sparisoma aurofrenatum* | 0.06 | 0.02 | 2.78 | 3.95 | 37.21 |
| *Holocentrus rufus* | 0.05 | 0.07 | 2.55 | 3.62 | 40.82 |
| *Epinephelus adscensionis* | 0.05 | 0 | 2.52 | 3.58 | 44.4 |
| *Balistes vetula* | 0.03 | 0.02 | 2.32 | 3.29 | 47.7 |
| *Chromis cyanea* | 0.06 | 0.03 | 2.28 | 3.24 | 50.93 |
| *Epinephelus guttatus* | 0.04 | 0.01 | 2.09 | 2.97 | 53.9 |
| ***Groups CR 33 & SL 50*** | | **Average dissimilarity = 86.57** | | | |
| | **Group CR 33** | **Group SL 50** | | | |
| ***Species*** | **Av.Abund** | **Av.Abund** | **Av.Diss** | **Contrib%** | **Cum.%** |
| *Chromis insolata* | 0 | 0.13 | 6.29 | 7.27 | 7.27 |
| *Halichoeres garnoti* | 0.03 | 0.1 | 3.85 | 4.45 | 11.72 |
| *Coryphopterus personatus* | 0.04 | 0.09 | 3.78 | 4.37 | 16.08 |
| *Holocentrus rufus* | 0.01 | 0.06 | 2.88 | 3.32 | 19.41 |
| *Epinephelus cruentatus* | 0 | 0.06 | 2.81 | 3.25 | 22.66 |
| *Stegastes partitus* | 0.01 | 0.06 | 2.71 | 3.13 | 25.78 |
| *Chaetodon sedentarius* | 0 | 0.05 | 2.61 | 3.01 | 28.8 |
| *Myripristis jacobus* | 0.05 | 0 | 2.58 | 2.98 | 31.78 |
| *Holocentrus adscensionis* | 0.05 | 0 | 2.58 | 2.98 | 34.76 |
| *Coryphopterus lipernes* | 0.05 | 0 | 2.56 | 2.96 | 37.71 |
| *Haemulon flavolineatum* | 0.05 | 0 | 2.44 | 2.81 | 40.52 |
| *Scarus taeniopterus* | 0.04 | 0.04 | 2.36 | 2.73 | 43.25 |
| *Chaetodon aculeatus* | 0.02 | 0.04 | 2.2 | 2.54 | 45.8 |
| *Chromis cyanea* | 0.01 | 0.05 | 2.19 | 2.53 | 48.33 |
| *Paranthias furcifer* | 0.04 | 0 | 2.1 | 2.43 | 50.76 |
| *Epinephelus fulva* | 0.04 | 0.01 | 2.09 | 2.41 | 53.17 |
| ***Groups SL 30 & SL 50*** | | **Average dissimilarity = 75.78** | | | |
| | **Group SL 30** | **Group SL 50** | | | |
| ***Species*** | **Av.Abund** | **Av.Abund** | **Av.Diss** | **Contrib%** | **Cum.%** |
| *Chromis insolata* | 0 | 0.13 | 6.2 | 8.18 | 8.18 |
| *Coryphopterus personatus* | 0 | 0.09 | 4.72 | 6.23 | 14.41 |
| *Thalassoma bifasciatum* | 0.09 | 0 | 4.44 | 5.86 | 20.27 |
| *Scarus iserti* | 0.09 | 0 | 4.26 | 5.63 | 25.9 |
| *Serranus tigrinus* | 0.05 | 0.03 | 3.11 | 4.1 | 30 |
| *Stegastes partitus* | 0.1 | 0.06 | 2.85 | 3.76 | 33.76 |
| *Sparisoma aurofrenatum* | 0.06 | 0.03 | 2.82 | 3.72 | 37.47 |
| *Epinephelus cruentatus* | 0 | 0.06 | 2.81 | 3.71 | 41.19 |
| *Chaetodon sedentarius* | 0 | 0.05 | 2.61 | 3.44 | 44.63 |

**Table 35.** continued

| | | | | | |
|---|---|---|---|---|---|
| *Epinephelus adscensionis* | 0.05 | 0 | 2.52 | 3.33 | 47.96 |
| *Chaetodon aculeatus* | 0.02 | 0.04 | 2.2 | 2.9 | 50.86 |
| ***Groups SL 40 & SL 50*** | | **Average dissimilarity = 65.59** | | | |
| | **Group SL 40** | **Group SL 50** | | | |
| ***Species*** | **Av.Abund** | **Av.Abund** | **Av.Diss** | **Contrib%** | **Cum.%** |
| *Chromis insolata* | 0.02 | 0.13 | 5.22 | 7.96 | 7.96 |
| *Coryphopterus personatus* | 0.08 | 0.09 | 4.35 | 6.64 | 14.59 |
| *Chaetodon sedentarius* | 0.06 | 0.05 | 3.26 | 4.96 | 19.56 |
| *Epinephelus cruentatus* | 0.03 | 0.06 | 3.13 | 4.77 | 24.33 |
| *Serranus tigrinus* | 0.05 | 0.03 | 3.03 | 4.62 | 28.94 |
| *Halichoeres garnoti* | 0.13 | 0.1 | 3.02 | 4.6 | 33.55 |
| *Stegastes partitus* | 0.09 | 0.06 | 2.94 | 4.49 | 38.03 |
| *Holocentrus rufus* | 0.07 | 0.06 | 2.83 | 4.31 | 42.34 |
| *Chromis cyanea* | 0.03 | 0.05 | 2.23 | 3.39 | 45.74 |
| *Chaetodon aculeatus* | 0.02 | 0.04 | 2.21 | 3.37 | 49.11 |
| *Thalassoma bifasciatum* | 0.04 | 0 | 2.18 | 3.33 | 52.43 |
| ***Groups CR 33 & RR 36*** | | **Average dissimilarity = 92.14** | | | |
| | **Group CR 33** | **Group RR 36** | | | |
| ***Species*** | **Av.Abund** | **Av.Abund** | **Av.Diss** | **Contrib%** | **Cum.%** |
| *Centropyge argi* | 0 | 0.12 | 6.18 | 6.71 | 6.71 |
| *Stegastes partitus* | 0.01 | 0.11 | 4.53 | 4.92 | 11.63 |
| *Sparisoma atomarium* | 0 | 0.09 | 4.42 | 4.79 | 16.42 |
| *Pseudupeneus maculatus* | 0 | 0.07 | 3.25 | 3.53 | 19.95 |
| *Serranus tabacarius* | 0 | 0.06 | 3.24 | 3.52 | 23.47 |
| *Holocentrus adscensionis* | 0.05 | 0.01 | 2.66 | 2.88 | 26.36 |
| *Serranus baldwini* | 0 | 0.05 | 2.62 | 2.84 | 29.2 |
| *Myripristis jacobus* | 0.05 | 0 | 2.58 | 2.8 | 32 |
| *Coryphopterus lipernes* | 0.05 | 0 | 2.56 | 2.78 | 34.77 |
| *Haemulon flavolineatum* | 0.05 | 0 | 2.44 | 2.64 | 37.42 |
| *Serranus tigrinus* | 0 | 0.05 | 2.36 | 2.56 | 39.97 |
| ***Groups SL 30 & RR 36*** | | **Average dissimilarity = 79.36** | | | |
| | **Group SL 30** | **Group RR 36** | | | |
| ***Species*** | **Av.Abund** | **Av.Abund** | **Av.Diss** | **Contrib%** | **Cum.%** |
| *Centropyge argi* | 0 | 0.12 | 6.18 | 7.79 | 7.79 |
| *Sparisoma atomarium* | 0 | 0.09 | 4.42 | 5.57 | 13.36 |
| *Scarus iserti* | 0.09 | 0 | 4.26 | 5.37 | 18.73 |
| *Pseudupeneus maculatus* | 0 | 0.07 | 3.25 | 4.1 | 22.83 |
| *Serranus tabacarius* | 0 | 0.06 | 3.24 | 4.09 | 26.91 |
| *Thalassoma bifasciatum* | 0.09 | 0.03 | 3.23 | 4.07 | 30.99 |
| *Serranus tigrinus* | 0.05 | 0.05 | 2.98 | 3.76 | 34.75 |
| *Sparisoma aurofrenatum* | 0.06 | 0 | 2.93 | 3.7 | 38.45 |
| *Chromis cyanea* | 0.06 | 0 | 2.92 | 3.68 | 42.13 |
| *Serranus baldwini* | 0 | 0.05 | 2.62 | 3.3 | 45.43 |
| *Epinephelus adscensionis* | 0.05 | 0 | 2.52 | 3.18 | 48.6 |
| ***Groups SL 40 & RR 36*** | | **Average dissimilarity = 77.04** | | | |
| | **Group SL 40** | **Group RR 36** | | | |
| ***Species*** | **Av.Abund** | **Av.Abund** | **Av.Diss** | **Contrib%** | **Cum.%** |
| *Centropyge argi* | 0.02 | 0.12 | 5.21 | 6.77 | 6.77 |

**Table 35.** continued

| | | | | | |
|---|---|---|---|---|---|
| *Halichoeres garnoti* | 0.13 | 0.04 | 4.4 | 5.71 | 12.47 |
| *Sparisoma atomarium* | 0 | 0.09 | 4.21 | 5.46 | 17.94 |
| *Coryphopterus personatus* | 0.08 | 0 | 3.82 | 4.95 | 22.89 |
| *Pseudupeneus maculatus* | 0.01 | 0.07 | 3.3 | 4.28 | 27.17 |
| *Holocentrus rufus* | 0.07 | 0.02 | 3.18 | 4.12 | 31.29 |
| *Chaetodon sedentarius* | 0.06 | 0.01 | 3.1 | 4.02 | 35.32 |
| *Serranus tabacarius* | 0.01 | 0.06 | 3.01 | 3.91 | 39.23 |
| *Serranus tigrinus* | 0.05 | 0.05 | 2.87 | 3.72 | 42.95 |
| *Serranus baldwini* | 0 | 0.05 | 2.62 | 3.4 | 46.35 |
| *Stegastes partitus* | 0.09 | 0.11 | 2.52 | 3.27 | 49.61 |
| ***Groups SL 50 & RR 36*** | | **Average dissimilarity = 80.52** | | | |
| | **Group SL 50** | **Group RR 36** | | | |
| ***Species*** | **Av.Abund** | **Av.Abund** | **Av.Diss** | **Contrib%** | **Cum.%** |
| *Chromis insolata* | 0.13 | 0 | 6.29 | 7.81 | 7.81 |
| *Coryphopterus personatus* | 0.09 | 0 | 4.72 | 5.86 | 13.67 |
| *Sparisoma atomarium* | 0 | 0.09 | 4.42 | 5.49 | 19.16 |
| *Centropyge argi* | 0.04 | 0.12 | 4.26 | 5.3 | 24.46 |
| *Serranus tabacarius* | 0.02 | 0.06 | 3.46 | 4.3 | 28.75 |
| *Pseudupeneus maculatus* | 0 | 0.07 | 3.25 | 4.04 | 32.79 |
| *Halichoeres garnoti* | 0.1 | 0.04 | 3.23 | 4.01 | 36.8 |
| *Serranus tigrinus* | 0.03 | 0.05 | 3.07 | 3.82 | 40.62 |
| *Epinephelus cruentatus* | 0.06 | 0.01 | 2.91 | 3.62 | 44.24 |
| *Holocentrus rufus* | 0.06 | 0.02 | 2.63 | 3.27 | 47.51 |
| *Chaetodon sedentarius* | 0.05 | 0.01 | 2.63 | 3.27 | 50.78 |
| ***Groups CR 33 & IW 34*** | | **Average dissimilarity = 80.89** | | | |
| | **Group CR 33** | **Group IW 34** | | | |
| ***Species*** | **Av.Abund** | **Av.Abund** | **Av.Diss** | **Contrib%** | **Cum.%** |
| *Chromis cyanea* | 0.01 | 0.09 | 4.29 | 5.3 | 5.3 |
| *Hypoplectrus chlorurus* | 0.03 | 0.07 | 3.96 | 4.89 | 10.19 |
| *Stegastes partitus* | 0.01 | 0.09 | 3.62 | 4.47 | 14.67 |
| *Gobiosoma evelynae* | 0.02 | 0.06 | 3.22 | 3.98 | 18.65 |
| *Myripristis jacobus* | 0.05 | 0 | 2.58 | 3.19 | 21.84 |
| *Holocentrus adscensionis* | 0.05 | 0 | 2.58 | 3.19 | 25.03 |
| *Epinephelus fulva* | 0.04 | 0.03 | 2.56 | 3.17 | 28.19 |
| *Scarus taeniopterus* | 0.04 | 0.05 | 2.48 | 3.07 | 31.26 |
| *Haemulon flavolineatum* | 0.05 | 0 | 2.44 | 3.01 | 34.27 |
| *Sparisoma viride* | 0.03 | 0.04 | 2.19 | 2.71 | 36.98 |
| *Coryphopterus lipernes* | 0.05 | 0.01 | 2.13 | 2.63 | 39.61 |
| *Paranthias furcifer* | 0.04 | 0 | 2.1 | 2.6 | 42.22 |
| *Holocentrus rufus* | 0.01 | 0.05 | 2.1 | 2.6 | 44.81 |
| *Acanthurus bahianus* | 0 | 0.04 | 2.07 | 2.56 | 47.38 |
| *Halichoeres garnoti* | 0.03 | 0.05 | 1.96 | 2.42 | 49.79 |
| ***Groups SL 30 & IW 34*** | | **Average dissimilarity = 68.68** | | | |
| | **Group SL 30** | **Group IW 34** | | | |
| ***Species*** | **Av.Abund** | **Av.Abund** | **Av.Diss** | **Contrib%** | **Cum.%** |
| *Scarus iserti* | 0.09 | 0.01 | 3.73 | 5.44 | 5.44 |
| *Hypoplectrus chlorurus* | 0 | 0.07 | 3.4 | 4.95 | 10.39 |
| *Thalassoma bifasciatum* | 0.09 | 0.03 | 3.27 | 4.75 | 15.14 |

**Table 35.** continued

| | | | | | |
|---|---|---|---|---|---|
| *Chromis cyanea* | 0.06 | 0.09 | 3.18 | 4.63 | 19.78 |
| *Gobiosoma evelynae* | 0.01 | 0.06 | 3.14 | 4.58 | 24.35 |
| *Scarus taeniopterus* | 0.01 | 0.05 | 2.73 | 3.97 | 28.32 |
| *Sparisoma aurofrenatum* | 0.06 | 0.04 | 2.69 | 3.92 | 32.24 |
| *Serranus tigrinus* | 0.05 | 0.02 | 2.53 | 3.68 | 35.93 |
| *Epinephelus adscensionis* | 0.05 | 0 | 2.52 | 3.67 | 39.6 |
| *Acanthurus bahianus* | 0.02 | 0.04 | 2.35 | 3.42 | 43.02 |
| *Stegastes partitus* | 0.1 | 0.09 | 2.31 | 3.36 | 46.38 |
| *Halichoeres garnoti* | 0.08 | 0.05 | 2.15 | 3.13 | 49.51 |
| ***Groups SL 40 & IW 34*** | | **Average dissimilarity = 72.61** | | | |
| | **Group SL 40** | **Group IW 34** | | | |
| ***Species*** | **Av.Abund** | **Av.Abund** | **Av.Diss** | **Contrib%** | **Cum.%** |
| *Halichoeres garnoti* | 0.13 | 0.05 | 4.16 | 5.73 | 5.73 |
| *Chromis cyanea* | 0.03 | 0.09 | 3.77 | 5.2 | 10.93 |
| *Coryphopterus personatus* | 0.08 | 0.01 | 3.69 | 5.09 | 16.02 |
| *Hypoplectrus chlorurus* | 0 | 0.07 | 3.4 | 4.68 | 20.7 |
| *Chaetodon sedentarius* | 0.06 | 0.03 | 3.1 | 4.27 | 24.97 |
| *Gobiosoma evelynae* | 0 | 0.06 | 3.07 | 4.23 | 29.21 |
| *Scarus taeniopterus* | 0.01 | 0.05 | 2.71 | 3.73 | 32.93 |
| *Holocentrus rufus* | 0.07 | 0.05 | 2.69 | 3.71 | 36.64 |
| ***Groups SL 50 & IW 34*** | | **Average dissimilarity = 74.81** | | | |
| | **Group SL 50** | **Group IW 34** | | | |
| ***Species*** | **Av.Abund** | **Av.Abund** | **Av.Diss** | **Contrib%** | **Cum.%** |
| *Chromis insolata* | 0.13 | 0.01 | 5.98 | 8 | 8 |
| *Coryphopterus personatus* | 0.09 | 0.01 | 4.41 | 5.89 | 13.89 |
| *Chromis cyanea* | 0.05 | 0.09 | 3.57 | 4.78 | 18.66 |
| *Hypoplectrus chlorurus* | 0 | 0.07 | 3.4 | 4.55 | 23.21 |
| *Epinephelus cruentatus* | 0.06 | 0.03 | 3.25 | 4.35 | 27.56 |
| *Scarus taeniopterus* | 0.04 | 0.05 | 3.16 | 4.23 | 31.78 |
| *Gobiosoma evelynae* | 0 | 0.06 | 3.07 | 4.11 | 35.89 |
| *Halichoeres garnoti* | 0.1 | 0.05 | 3.04 | 4.06 | 39.95 |

| **Groups RR 36 & IW 34** | | **Average dissimilarity = 82.01** | | | |
|---|---|---|---|---|---|
| | **Group RR 36** | **Group IW 34** | | | |
| **Species** | **Av.Abund** | **Av.Abund** | **Av.Diss** | **Contrib%** | **Cum.%** |
| *Centropyge argi* | 0.12 | 0 | 6.18 | 7.54 | 7.54 |
| *Chromis cyanea* | 0 | 0.09 | 4.59 | 5.6 | 13.14 |
| *Sparisoma atomarium* | 0.09 | 0 | 4.18 | 5.1 | 18.24 |
| *Hypoplectrus chlorurus* | 0 | 0.07 | 3.4 | 4.15 | 22.38 |
| *Pseudupeneus maculatus* | 0.07 | 0.02 | 3.34 | 4.07 | 26.46 |
| *Serranus tabacarius* | 0.06 | 0 | 3.24 | 3.95 | 30.41 |
| *Gobiosoma evelynae* | 0 | 0.06 | 3.11 | 3.79 | 34.2 |
| *Scarus taeniopterus* | 0 | 0.05 | 2.62 | 3.2 | 37.4 |
| *Serranus baldwini* | 0.05 | 0 | 2.62 | 3.19 | 40.59 |
| *Serranus tigrinus* | 0.05 | 0.02 | 2.54 | 3.1 | 43.69 |

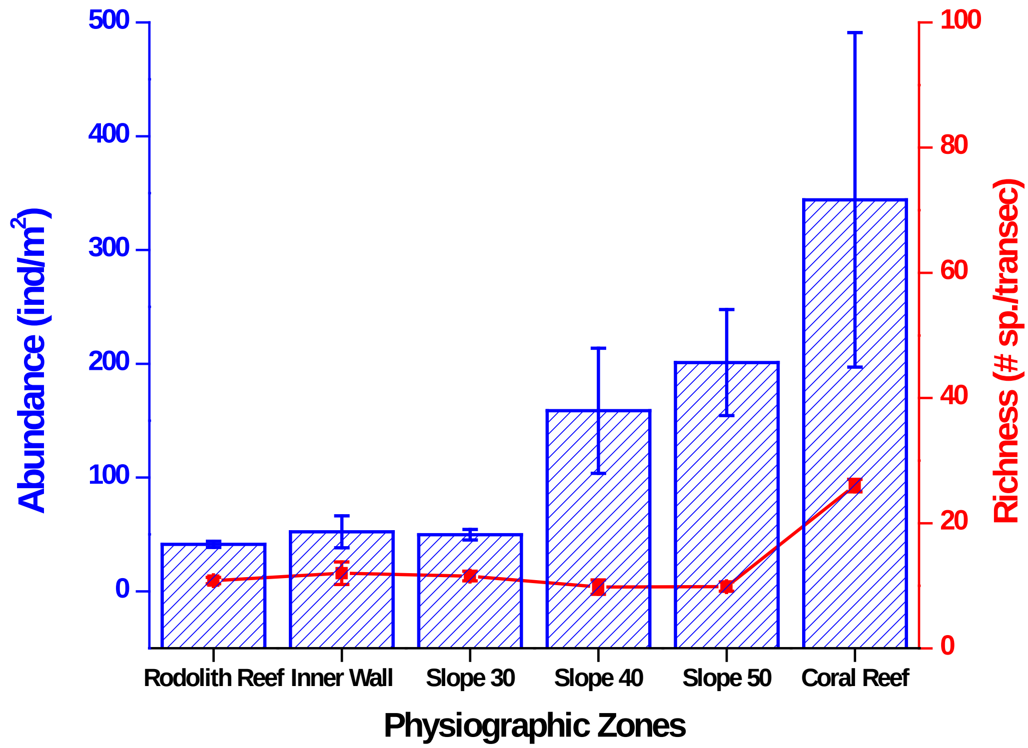



**Figure 11.** Mean fish abundance and species richness from physiographical zones and benthic habitats surveyed at Abil la Sierra.

## VII. Conclusions

1) The main bathymetry features of the mesophotic habitat at ALS within the 30-50 m depth range consist of two internal slope walls, a deep outer shelf terrace and an insular slope. Such features were considered the main reef physiographic zones at ALS
2) Mesophotic benthic habitats at ALS included colonized pavement, rhodolith reefs, coral reef, and scattered rhodoliths and sand.
3) Inner walls of the deep terrace exhibited moderate live coral cover, consistent with the classification of a coral reef habitat down to a maximum depth of approximately 27 - 28 m. Below 30 m, reef substrate consisted mostly of pavement (hard bottom) colonized by algae, sponges and scattered corals that typically declined in abundance and diversity with increasing depth.
4) Boulder star coral, *Montastraea annularis* was the main structural component of the coral reef habitat and was observed to be in good condition
5) Statistically significant differences of benthic community structure were detected between the rhodolith reef (RR) and all other habitats, and between the coral reef (CR) and all other habitats, except the inner wall (IW). Slope habitats at 40 and 50 m (SL 40, SL 50) were different from those at the IW and SL 30. Differences were not statistically significant between IW and the SL 30, and between the SL 40 and SL 50.

6) RR was different from all other habitats by the relatively higher substrate cover by benthic algae and lower cover by scleractinian corals, gorgonians and sponges. Although this habitat was mostly devoid of sessile-benthic invertebrate fauna, it presented the highest density of motile megabenthic invertebrates, particularly queen conch, *Strombus gigas*, as it appears that RR functions as an essential habitat for this commercially important invertebrate at ALS.
7) Dissimilarity of sessile-benthic community structure between CR and other habitats at ALS was mostly driven by the relatively higher cover by scleractinian corals, gorgonians, sponges and abiotic substrate categories, and relatively lower cover by cyanobacteria, turf and fleshy algae.
8) IW and SL 30, 40 and 50 represented colonized pavement habitats with variations of sessile-benthic community structure driven mostly by cover of scleractinian corals, gorgonians and cyanobacteria. IW exhibited less cover by gorgonians than slope stations. Conversely, IW presented relatively higher cover by scleractinian corals than slope wall stations.
9) A mostly un-colonized pavement habitat with scattered rhodoliths and sand was observed to be widely distributed within the deep terrace at ALS, but was not quantitatively characterized. This habitat presented a series of small interspersed hard ground promontories with corals and high fish aggregations.
10) A total of 100 species of reef fishes were identified from mesophotic habitats (30 – 50 m) at ALS during this study.
11) The three main benthic habitats associated with mesophotic reef zones at ALS, (e.g. rhodolith reef, colonized pavement, and scattered rhodolith and sand) exhibited marked differences of fish community structure.
12) Differences were also noted between colonized pavement habitats of different reef zones, such as the top of the insular slope at 30 m and the deepest zone of the insular slope surveyed at 50 m. Differences between these two zones were mostly driven by the higher abundance of bluehead wrasse, *T. bifasciatum* and parrotfishes, *S. aurofrenatum, S. iserti* at 30 m, whereas masked goby, *C. personatus*, sunshine fish, *C. insolata* and bicolor damselfish, *S. partitus* were most prominent at 50 m
13) Differences of fish community structure between the rhodolith reef and colonized pavement habitats were mostly associated with higher abundance of *C. argi, S. atomarium, S. tabacarius, S. baldwini* and *P. maculatus* at the RR, and higher abundance of *C. personatus, C. insolata, T. bifasciatum, S, iserti* and *S. aurofrenatum* at SL and IW stations.
14) The scattered rhodolith and sand habitat was mostly un-colonized by sessile-benthic biota. Resident fishes of the sandy areas included the sand tilefish, *Malacanthus plumieri*, cherubfish, bicolor damselfish, yellowhead wrasse, and small parrotfishes observed grazing on the benthic algae colonizing rhodoliths.
15) Species that inhabited or foraged in the sandy bottom habitat included the yellowhead jawfish, *Opistognathus aurifrons*, queen conch, mutton snapper and large demersal predators, such as the reef shark, *Carcharhinus perezi*.
16) Otherwise, most of the ichthyofauna associated with the sandy habitat at ALS was heavily concentrated on a series of small rock promontories interspersed in the sandy environment. These included a wide variety of shallow coral reef

fishes, but above all, such promontories appeared to be prime foraging and/or residential habitat for red hinds.

17) Red hind and queen conch were observed to be the most prominent species of commercial value within mesophotic habitats (30 – 50 m) at ALS. Mutton snappers were observed in relatively low quantities.

18) Red hinds were found distributed along the entire range of mesophotic reef zones and benthic habitats at ALS. Although more geographically extensive studies need to be performed to provide an assessment of its population densities, it appeared that the highest densities of red hinds were present at the top of the insular slope (SL 30), at the rhodolith reef (36 – 40 m) and on the small rock promontories of the scattered rhodolith and sand habitat within the deep terrace.

19) Queen conch were also widely distributed in mesophotic habitats of ALS, but it was particularly evident that their preferred habitat was the rhodolith reef, where they seem to find optimum foraging conditions, perhaps due to the extensive macroalgal availability. High abundance of queen conch was also noted at the top of the insular slope (30 – 33 m) and at the scattered rhodolith and sand habitat.

20) Despite the permanent fishing closure of queen conch at ALS, there is still active fishing on the adult population, as evidenced by the common findings of recently opened shells at the bottom.

21) Black groupers, ranging in size from 50 – 80 cm were observed at depths of 35 – 50 m at the insular slope, where they seem to be the most prominent demersal predator.

22) During the mutton snapper (*Lutjanus analis*) spawning aggregation event at ALS in May 2009, water current flow structure was characterized by a swift, highly dominant north-northwest flow that appeared to be topographically steered by the shelf-edge bottom contours. Such water current pattern would transport and disperse fertilized eggs and early larvae towards the west-northwest coast of PR and Mona Passage.

23) Two individuals of the lionfish, *Pterois volitans* were observed at depths between 33 – 40 m within the deep terrace of ALS.

## VIII. Literature Cited


Armstrong R, Singh H, Torres J, Nemeth R, Can A, Roman C, Justice R, Riggs L, García-Moliner G (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. Cont Shelf Res 26:194-205

Ballantine DL, Appeldoorn RS Yoshioka P. Weil E, Armstrong R, Garcia JR, Otero E, Pagan F, Sherman C, Hernandez-Delgado EA, Bruckner A, Lilyestrom C (2008) Chapter 9, Biology and Ecology of Puerto Rican Coral Reefs, Pp 375-406. In: B.M. Reigl, R.E. Dodge (eds.). *Coral Reefs of the USA*. Springer Science.

Bright T J (1977) Coral reefs, nepheloid layers, gas seeps and brine flows on hard banks in the northeastern Gulf of Mexico. Proc. 3rd Int. Coral Reef Symp. 1:40-46

Bright TJ, Kramer GP, Minnery GA, Viada ST (1984) Hermatypes of the Flower Garden Banks, northwestern Gulf of Mexico: a comparison to other western Atlantic reefs. Bull Mar Sci 34:461-476

Brokovich E (2008) Coral reef fish assemblages in the upper twilight zone (<65 m). In: Por FD (ed) Aqaba-Eilat, the Improbable Gulf Environment, Biodiversity and Preservation. Magnes Press, Jerusalem, p 255-266

Brokovich E, Einbinder S, Shashar N, Kiflawi M, Kark S (2008) Descending to the twilight-zone: changes in coral reef fish assemblages along a depth gradient down to 65 m. Mar Ecol Prog Ser 371:253-262

Cappo M, De ath G, Speare P (2007) Inter-reef vertebrate communities of the Great Barrier Reef Marine Park determined by baited remote underwater video stations. Mar Ecol Prog Ser 350:209-221

Colin PL (1974) Observation and collection of deep reef fishes off the coasts of Jamaica and Honduras. Mar Biol 24 (1):29-38

Colin PL (1976) Observation of deep reef fishes in the Tongue-of-the-Ocean, Bahamas. Bull Mar Sci 26:603-605

Colin PL (1978) Carebbean Reef Invertebrates and Plants T.F.H. Publications, Inc. Ltd Neptune City, N.J., USA.

Colin PL and Clavijo IE (1988) Spawning activity of fishes producing pelagic eggs on a shelf edge coral reef, southwestern Puerto Rico. Bull. Mar. Sci. 43: 249-279

Collete BB, Rutzler K (1977) Reef fishes over sponge bottoms off the mouth of the Amazon River. Proc 3 rd Int Coral Reef Symp 1:305-310

Dennis GD, Bright TJ (1988) Reef fish assemblages on hard banks in the northwest Gulf of Mexico. Bull Mar Sci 43:280-307

Dennis GD, Smith-Vaniz WF, Colin PL, Hensley DA, McGehee A (2005) Shore fishes from islands of the Mona Passage, Greater Antilles with comments on their zoogeography. Carib J Sci 41 (4): 716-743

Earle SA (1972) The influence of herbivores on the marine plants of Great Lameshur Bay, with an annotated list of plants. Nat. Hist. Mus., Los Angeles Co., Sci. Bull. 14:17-44

Esteves R (2005) Dispersal of Reef Fish Larvae from Knonw Spawning Sites in La Parguera. MS dissertation UPR Mayaguez, 64p.

Feitoza BM, Rosa RS, Rocha LA (2005) Ecology and zoogeography of deep-reef fishes in northeastern Brazil. Bull. Mar. Sci. 76:725-742

García-Sais JR (2010). Reef habitats and associated sessile-benthic and fish assemblages across a euphotic-mesophotic gradient in Isla Desecheo, Puerto Rico. Coral Reefs (in press).

García-Sais JR, Castro R, Sabater J, R Esteves, Carlo M (2009). Mesophotic benthic habitats and associated marine communities at Abrir La Sierra, Puerto Rico. Progress report submitted to the CFMC/NMFS.

García-Sais JR, Castro R, Sabater J, Carlo M (2007). Characterization of benthic habitats and associated reef communities at Bajo de Sico Seamount, Mona Passage, Puerto Rico. Final Report submitted to Caribbean Fishery Management Council (CFMC/NOAA). 91 p

García-Sais JR, Castro R, Sabater J, Carlo M (2005). 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 Caribbean Fishery Management Council (CFMC/NOAA). 215 p. www.caribbeanfmc.com/index/reni.pdf

García-Sais JR, Castro R, Sabater J, Carlo M (2004). Monitoring of coral reef communities from Isla de Vieques, Puerto Rico, 2004. Final Report submitted to the Department of Natural and Environmental Resources (DNER), U. S. Coral Reef National Monitoring Program, NOAA, 118 p

Gilbert CR (1972) Characteristics of the western Atlantic reef-fish fauna. Quart. J. Florida Acad. Sci., 35: 130-144

Grana F (2005) Listado de peces reportados para la región de Puerto Rico e Isla Virgenes. Compendio preparado para el Consejo de Pesca del Caribe/NMFS/NOAA. San Juan, Puerto Rico. 203 pp.

Halley RB, Garrison VE, Ciembronowicz KT, Edwards R, Jaap WC, Mead G, Earle S, Hine AC, Jarret B, Locker SD, Naar DF, Donahue B, Dennis GD, Twichell DC (2007). Pulley Ridge – The United States' deepest coral reef? http//sofia.er.usgs.gov/publications/ofr/03-54/abstracts/pulleyridge_03geerab.html

Humann P, Deloach N (2003) Reef Coral Identification. New World publications. 2nd Edition. Jacksonville, Florida, USA. 278 p.

Humann P, Deloach N (2006) Reef Fish Identification. New World publications. 3rd Edition. Jacksonville, Florida, USA. 481 p

Itzkowitz M, Haley M, Otis C, Evers D (1991) Reconnaissance of the deeper Jamaican coral reef fish communities. N E Gulf Sci. 12:25-34

Lukens RR (1981) Observations of deep-reef ichthyofauna from the Bahama and Cayman Islands, with notes on relative abundance and depth distribution. Gulf Res. Rep. 7: 79-81

Matos-Caraballo, D., J. M. Posada, and B. E. Luckhurst. 2006. Fishery-dependent evaluation of a spawning aggregation of tiger grouper (*Mycteroperca tigris*) at Vieques island, Puerto Rico. Bull. Mar. Sci. 79 (1): 1-16

Matos-Caraballo, D. And W. Padilla. Description of the tiger grouper (*Mycteroperca tigris*) fishery of Vieques, Puerto Rico. Proc. Gulf Carib. Fish. Inst. 48: 143-153

Menza C, Kendall M, Rogers C, Miller J (2007) A deep reef in deep trouble. Cont Shelf Res. 27: 2224-2230.

Nelson W R, Appeldoorn R S (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 RS, Smith TB, Blondeau J, Kadison ES, Calnan JM, Gass J (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/NOAA). 90 p

Nemeth RS (2005) Population characteristics of a recovering US Virgin Islands red hind spawning aggregation following protection. Mar Ecol Prog Ser 286:81-97

Porter JW (1972) Patterns of species diversity in Caribbean Reef Corals. Ecology 53:745-748.

Rodriguez-Jeréz-Jeréz Y (2004) Zooplankton communities of Isla Desecheo and adjacent waters of Mona Passage. MS Thesis. Department of Marine Sciences, U. Puerto Rico, Mayaguez. 85 p.

Randall JE (1967) Food habits of fishes of the West Indies. Stud. Trop. Oceanogr. 5:665-847

Rocha LA (2003) Patterns of distribution and processes of speciation in Brazilian reef fishes. J. Biogeogr. 30:1161-1171

Rogers CS (1983) Sub-lethal and lethal effects of sediments applied to common Caribbean reef corals in the field. Mar Poll Bull 14:378-382.

Sadovy, Y., P. L. Colin, and M. L. Domeier. 1994. Aggregation and spawning in the tiger grouper, Mycteroperca tigris (Pisces: Serranidae). Copeia 1994: 511-516

Singh H, Armstrong R, Gilbes F, Eustice R, Roman C, Pizarro O, Torres J (2004). Imaging coral I: Imaging coral habitats with the Seabed AUV. Subsurface Sensing Technologies and Applications. 5:25-42

Thresher R, Colin P (1986) Trophic structure, diversity and abundance of fishes of the deep reef (30-300 m) at Enewetak, Marshall Islands. Bull Mar Sci 38:253-272

## IX. Appedices

**Appendix 1**. Species list of benthic organisms identified from mesophotic ref physiographic zones and benthic habitats of Abrir la Sierra, 30 - 50 m. 2008-10

| | | IW | SL 30 | SL 40 | SL 50 | RR | CR | SRS |
|---|---|---|---|---|---|---|---|---|
| **ALGAE** | | | | | | | | |
| **Chlorophyta** | | | | | | | | |
| *Halimeda discoidea* | Chlorophyta | | | X | | X | | X |
| *Halimeda sp.* | Chlorophyta | X | X | X | X | | | |
| *Udotea sp.* | Chlorophyta | | | X | | X | | |
| **Rhodophyta** | | | | | | | | |
| *Amphiroa sp.* | Rhodophyta | X | X | | | X | | |
| *Wrangelia bicuspidata* | Rhodophyta | | X | | | | | |
| **Phaeophyta** | | | | | | | | |
| *Dictyopteris sp.* | Phaeophyta | | | | | X | | X |
| *Dictyota spp.* | Phaeophyta | X | X | X | X | X | X | |
| *Lobophora variegata* | Phaeophyta | X | X | X | X | X | X | X |
| **Cyanophyta** | | | | | | | | |
| Cyanobacteria | Cyanobacteria | X | X | X | X | X | | X |
| **INVERTEBRATES** | | | | | | | | |
| **Porifera** | | | | | | | | |
| *Agelas cauliformis* | Sponge | | X | | | | | |
| *Agelas citrina* | Sponge | | | | | X | | |
| *Agelas clathrodes* | Sponge | X | X | X | X | X | X | X |
| *Agelas conifera* | Sponge | X | X | X | X | X | X | X |
| *Agelas sp.* | Sponge | | | | | X | | |
| *Agelas dispar* | Sponge | X | X | X | X | X | | X |
| *Agelas tubulata* | Sponge | | | X | | X | | X |
| *Aiolochroia crassa* | Sponge | | X | X | | X | | X |
| *Amphimedon compressa* | Sponge | | X | X | X | X | | X |
| *Aplysina archeri* | Sponge | X | | X | | X | | |
| *Aplysina cauliformis* | Sponge | X | | X | | X | | X |
| *Aplysina fulva* | Sponge | | | X | | X | | X |
| *Aplysina lacunosa* | Sponge | X | | X | | | | X |
| *Callyspongia armigera* | Sponge | | | | | X | | |
| *Callyspongia plicifera* | Sponge | | | X | | X | | |
| *Callyspongia vaginalis* | Sponge | | X | X | | X | | |
| *Chondrilla nucula* | Sponge | | | X | | X | X | X |
| *Cliona delitrix* | Sponge | | X | | | | | |
| *Cliona sp.* | Sponge | X | | | | | | |
| *Cribrochalina infundibulum* | Sponge | | | X | | | | |
| *Desmapsamma anchorata* | Sponge | | | | | | | X |
| *Ectyoplasia ferox* | Sponge | | | X | | | | |
| *Geodia neptuni* | Sponge | X | | X | | | X | X |
| *Gorgonia ventalina* | Sponge | | | X | | | X | |
| *Hyrtios sp.* | Sponge | | | X | | X | | X |
| *Iotrochota birotulata* | Sponge | X | X | X | X | | X | X |
| *Ircinia felix* | Sponge | X | X | | | | | X |

**Appendix 1**. continued

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Ircinia strobilina* | Sponge | | | X | | | | |
| *Ircinia spp.* | Sponge | | | X | | X | | |
| *Monanchora arbuscula* | Sponge | | X | X | X | X | | |
| *Neofibularia nolitangere* | Sponge | | X | | | | | |
| *Niphates erecta* | Sponge | | X | X | | X | | |
| *Oceanapia bartschi* | Sponge | | | X | | | | X |
| *Petrosia pellasarca* | Sponge | | | | X | X | | |
| *Plakortis angulospiculatus* | Sponge | | X | | | | | |
| *Plakortis halichondrioides* | Sponge | | | | | | | |
| *Plakortis spp.* | Sponge | X | X | X | | X | X | |
| *Plankinastrella spp.* | Sponge | | | X | | | | |
| *Pseudoceratina crassa* | Sponge | | | X | X | X | X | |
| *Smenospongia conulosa* | Sponge | | | | | | | X |
| *Suberea sp.* | Sponge | | | X | | | | |
| *Svenzea zeai* | Sponge | | X | X | X | X | X | X |
| *Verongia gigantea* | Sponge | X | X | | | | | |
| *Xestospongia muta* | Sponge | X | X | X | X | X | | X |
| **Cnidaria** | | | | | | | | |
| *Agaricia agaricites* | Coral | X | X | X | X | X | X | X |
| *Agaricia grahamae* | Coral | | | X | X | X | | X |
| *Agaricia lamarcki* | Coral | X | X | X | X | X | X | X |
| *Agaricia sp.* | Coral | X | X | X | X | | X | |
| *Diploria strigosa* | Coral | | | X | | | | |
| *Eusmilia fastigiata* | Coral | | | | | | X | |
| *Isophyllia rigida* | Coral | | | X | | | X | |
| *Madracis decactis* | Coral | X | X | X | X | | X | |
| *Meandrina brasiliensis* | Coral | | | | | X | | X |
| *Meandrina meandrites* | Coral | X | | X | X | X | X | X |
| *Montastraea annularis* | Coral | X | X | X | X | X | X | |
| *Montastraea cavernosa* | Coral | X | X | X | | X | X | X |
| *Mycetophyllia aliciae* | Coral | | | X | | X | | |
| *Porites astreoides* | Coral | X | X | X | | X | X | X |
| *Porites porites* | Coral | | | | | X | | |
| *Porites sp.* | Coral | | | | X | X | | |
| *Scolymia cubensis* | Coral | | | | X | | | |
| *Siderastrea radians* | Coral | X | X | X | X | | X | X |
| *Siderastrea siderea* | Coral | X | X | X | | X | X | X |
| *Stephanocoenia intersepta* | Coral | | | X | X | | X | |
| *Hydrozoa* | Hydrozoan | | | X | | X | | X |
| *Millepora alcicornis* | Hydrocoral | X | X | X | X | | X | |
| *Stylaster roseus* | Hydrocoral | | | X | X | | | |
| *Ellisella sp.* | Octocoral | | | X | X | | | X |
| *Eunicea sp.* | Octocoral | | | X | X | X | | X |
| *Gorgonia spp.* | Octocoral | | | | | | | X |
| *Iciligorgia schrammi* | Octocoral | | X | X | X | | | |
| *Muricea sp.* | Octocoral | | X | X | | | | X |
| *Unident. Octocoral* | Octocoral | | | | | X | | |
| *Plexaura spp.* | Octocoral | | | X | | | | X |

**Appendix 1**. continued

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Plexaurella spp.* | Octocoral | | | **X** | | **X** | | **X** |
| *Pseudoplexaura spp.* | Octocoral | | | **X** | | | | |
| *Pseudopterogorgia sp.* | Octocoral | **X** | | **X** | **X** | **X** | **X** | **X** |
| *Pterogorgia spp.* | Octocoral | | | | | | | **X** |
| *Antipatharia* | Antipatharia | **X** | | **X** | | | | |
| *Stichopathes leutkeni* | Antipatharia | | | **X** | | **X** | | **X** |
| **Mollusca** | | | | | | | | |
| *Octopus vulgaris* | Octopus | | | | | | | **X** |
| *Strombus costatus* | Gastropod | | | | | | | **X** |
| *Strombus gigas* | Gastropod | | | | | **X** | | **X** |
| **Arthropoda** | | | | | | | | |
| *Panulirus argus* | Lobster | | | | | | | **X** |
| *Periclimenes pedersoni* | Shrimp | **?** | **?** | **?** | **?** | **?** | **?** | **?** |
| *Stenopus hispidus* | Shrimp | **?** | **?** | **?** | **?** | **?** | **?** | **?** |
| *Stenorhynchus seticornis* | Shrimp | **?** | **?** | **?** | **?** | **?** | **?** | **?** |
| **Echinodermata** | | | | | | | | |
| *Eostichopus arnesoni* | Holothurian | | | | | **X** | | |
| *Holothuria mexicana* | Holothurian | | | | | | | |

**Collected in the general area**

| | |
|---|---|
| Order Ctenostomata | Bryozoa |
| *Udotea cyathiformis* | Chlorophyta |
| *Rhipoceohalus phoenix f. longifolius* | Chlorophyta |
| *Neomeris annulata* | Chlorophyta |
| *Halimeda gracilis* | Chlorophyta |
| *Ventricaria ventricosa* | Chlorophyta |
| *Plexaura homomalla* | Octocoral |
| *Dictyota pennatifida* | Phaeophyta |
| Sabellidae | Polychaeta |
| Serpulidae | Polychaeta |
| *Galaxaura oblongata* | Rhodophyta |
| *Galaxaura subverticillata* | Rhodophyta |
| *Dasya sp.* | Rhodophyta |
| *Jania adherens* | Rhodophyta |

**Appendix 2.** List of fish species observed at mesophotic reef physiographic zones and benthic habitats in Abrir la Sierra. 30 – 50 m. 2008-10

| ***SPECIES*** | **COMMON NAME** | **CR** | **SL 30** | **SL 40** | **SL 50** | **RR** | **IW** | **SRS** |
|---|---|---|---|---|---|---|---|---|
| *Acanthurus bahianus* | Ocean Surgeon | | x | x | | | x | |
| *Acanthurus chirurgus* | Doctorfish | x | x | | | | | |
| *Acanthurus coeruleus* | Blue Tang | | | | | x | | |
| *Alectis ciliaris* | African Pompano | | | | | | | x |
| *Amblycirrhitus pinos* | Redspotted Hawkfish | | x | | | x | x | |
| *Anisotremus virginicus* | Porkfish | | x | | | | | |
| *Apogon townsendi* | Belted Cardinalfish | | | x | | | | |
| *Balistes vetula* | Queen Triggerfish | | x | x | | | | x |
| *Blenniidae* | Blenny (unid) | | | | | x | | |
| *Bodianus rufus* | Spanish Hogfish | x | | x | | | x | x |
| *Calamus pennatula* | Pluma | | | | | | | |
| *Cantherhines pullus* | Tail-light Filefish | | | | | x | | |
| *Canthigaster rostrata* | Sharpnose puffer | x | x | x | | x | x | |
| *Caranx crysos* | Blue Runners | | | x | | | | |
| *Caranx ruber* | Bar Jack | x | | | | | | |
| *Carcharhinus perezi* | Reef Shark | | | | | | | x |
| *Centropyge argi* | Cherubfish | | | x | x | x | | x |
| *Chaetodipterus faber* | Spadefish | | x | | | | | |
| *Chaetodon aculeatus* | Longsnout Butterflyfish | x | x | x | x | x | | x |
| *Chaetodon capistratus* | Four-eye Butterflyfish | x | x | x | | | x | x |
| *Chaetodon ocellatus* | Spotfin Butterflyfish | | x | | | | | |
| *Chaetodon sedentarius* | Reef Butterflyfish | | | x | x | x | x | x |
| *Chaetodon striatus* | Banded Butterflyfish | | | | x | | x | |
| *Chromis cyanea* | Blue Chromis | x | x | x | x | | x | x |
| *Chromis insolata* | Sunshine fish | | x | x | x | | x | x |
| *Chromis multilineata* | Brown Chromis | x | | | | | x | |
| *Clepticus parrae* | Creole Wrasse | x | | | | | x | x |
| *Coryphopterus glaucofraenum* | Bridled Goby | | | x | x | | x | |
| *Coryphopterus personatus* | Masked Goby | x | | x | x | | x | x |
| *Coryphopterus lipernes* | Peppermint Goby | x | x | | | | x | x |
| *Decapterus macarellus* | Mackerel Scad | x | | | | | | |
| *Epinephelus adscensionis* | Rock Hind | | x | | | | | |
| *Epinephelus cruentatus* | Graysby | | | x | x | x | x | x |
| *Epinephelus fulva* | Coney | x | x | x | x | x | x | x |
| *Epinephelus guttatus* | Red Hind | x | x | x | x | | x | x |
| *Equetus lanceolatus* | Jackknife Fish | | | | | | x | |

**Appendix 2.** continued

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Equetus punctatus* | Spotted Drum | x | | | | | | |
| *Ginglymostoma cirratum* | Nurse Shark | | | x | | | | |
| *Gobiosoma evelynae* | Sharknose Goby | x | x | | | x | x | |
| *Gramma loreto* | Fairy Basslet | x | | x | x | | x | x |
| *Gymnothorax funebris* | Green Moray | x | | | | | | |
| *Gymnothorax moringa* | Spotted Moray | | x | | | | | |
| *Haemulon flavolineatum* | French Grunt | x | x | | | | | |
| *Haemulon macrostomum* | Spanish Grunt | | x | | | | | |
| *Haemulon sciurus* | Bluestriped Grunt | x | | | | | | x |
| *Haemulon plumieri* | White Grunt | x | | | | | | x |
| *Halichoeres cyanocephalus* | Yellowcheek Wrasse | | | | | x | | x |
| *Halichoeres garnoti* | Yellowhead Wrasse | x | x | x | x | x | x | x |
| *Halichoeres cyanopterus* | Yellowcheek Wrasse | | | x | x | | | x |
| *Holacanthus ciliaris* | Queen Angelfish | x | | | | | | |
| *Holacanthus tricolor* | Rock Beauty | x | x | | | | | |
| *Holocentrus adscensionis* | Longjaw Squirrelfish | x | | | | x | | |
| *Holocentrus rufus* | Longspine Squirrelfish | x | x | x | x | x | x | x |
| *Hypoplectrus chlorurus* | Yellowtail Hamlet | x | | | | | x | |
| *Hypoplectrus indigo* | Indigo Hamlet | | | | | | x | |
| *Hypoplectrus nigricans* | Black Hamlet | | | | x | | | |
| *Hypoplectrus puella* | Barred Hamlet | | | x | x | | | |
| *Hypoplectrus unicolor* | Butter Hamlet | x | | | | | | |
| *Lachnolaimus maximus* | Hogfish | x | x | x | x | | x | x |
| *Lactophrys polygonia* | Honeycomb Cowfish | x | | | | | | |
| *Lactophrys triqueter* | Smooth trunkfish | | x | | | | | |
| *Lactophrys triqueter* | Smooth Trunkfish | x | | | | | | |
| *Lutjanus analis* | Mutton Snapper | x | x | | | | x | x |
| *Lutjanus apodus* | Schoolmaster Snapper | | | | | x | | |
| *Lutjanus jocu* | Dog Snapper | | | | x | x | | |
| *Malacanthus plumieri* | Sand Tilefish | | | | | x | | x |
| *Melichthys niger* | Black Durgon | | x | | | | | |
| *Microspathodon chrysurus* | Yellowtail Damselfish | | x | | | x | | |
| *Mycteroperca bonaci* | Black Grouper | | | x | x | | | |
| *Mycteroperca venenosa* | Yellowfin Grouper | x | | | | | | |
| *Myripristis jacobus* | Blackbar Soldierfish | x | | | | | | x |
| *Negaprion brevirostris* | Lemon Shark | | | | | | | |
| *Ocyurus chrysurus* | Yellowtail Snapper | x | | x | x | | | x |
| *Opistognathus aurifrons* | Yellowhead Jawfish | | | x | | x | | x |

**Appendix 2**. continued

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Paranthias furcifer* | Creole fish | x | | | | | | |
| *Pomacanthus arcuatus* | Gray Angelfish | | | x | | x | | x |
| *Pomacentrus paru* | French Angelfish | | x | x | x | | | x |
| *Priacanthus cruentatus* | Bigeye | | x | | | | | |
| *Pseudupeneus maculatus* | Spotted Goatfish | | | x | | x | x | x |
| *Sargocentron coruscus* | Reef Squirrelfish | | | | | x | | |
| *Scarus iserti* | Stripped Parrotfish | | x | | | | x | x |
| *Scarus taeniopterus* | Princess Parrotfish | x | x | x | x | | x | x |
| *Scarus vetula* | Queen Parrotfish | | x | | | | | |
| *Scomberomorus regalis* | Cero | | | | | | x | x |
| *Serranus annularis* | Orangeback Bass | | | | x | x | | |
| *Serranus baldwini* | Lantern Bass | | | | | x | | |
| *Serranus tabacarius* | Tobaccofish | | | x | x | x | | x |
| *Serranus tigrinus* | Harlequin Bass | | x | x | x | x | x | |
| *Sparisoma atomarium* | Greenblotch Parrotfish | | | x | | x | x | |
| *Sparisoma aurofrenatum* | Redband Parrotfish | x | x | x | x | | x | |
| *Sparisoma radians* | Bucktooth Parrotfish | | x | x | | x | x | x |
| *Sparisoma viride* | Stoplight Parrotfish | x | | | | x | x | x |
| *Sphyraena barracuda* | Great Barracuda | | x | | | | | x |
| *Sphyrna mokarran* | Great Hammerhead | | | | | | | |
| *Stegastes leucostictus* | Beaugregory | x | | | | | | |
| *Stegastes partitus* | Bicolor Damselfish | x | x | x | x | x | x | x |
| *Synodus synodus* | Red Lizardfish | | | | | x | | |
| *Thalassoma bifasciatum* | Bluehead Wrasse | x | x | x | | x | x | x |
| *Xanthichthys ringens* | Sargassum Triggerfish | | | x | x | x | x | x |

**Appendix 3.** Active Search Surveys (ASEC) station position with information on target species taxonomy and size of individuals observed.

| Tr | Latitude | Longitude | Species Name | Common Name | # - (inches) | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 18.0669 | -67.4219 | *Mycteroperca venenosa* | Yellowfin Grouper | 1 – 30” | 2 – 34” | | |
| | 18.0689 | -67.4231 | *Epinephelus guttatus* | Red Hind | 1 – 12” | 1 – 18” | 1 – 24” | |
| | | | *Strombus gigas* | Conch | 2 | | | |
| 2 | 18.0689 | -67.4231 | *Epinephelus guttatus* | Red Hind | 4 – 11” | 3 -12” | 1 – 14” | 1 – 16” |
| | 18.0703 | -67.4243 | *Strombus gigas* | Conch | 10 | | | |
| 3 | 18.0703 | -67.4243 | *Epinephelus guttatus* | Red Hind | 4 – 12” | | | |
| | 18.0725 | -67.4256 | *Cephalopholis fulva* | Coney | 2 – 10” | | | |
| | | | *Caranx latus* | Horse-eye Jack | 4 – 20” | | | |
| | | | *Sphyraena barracuda* | Great Barracuda | 4 – 5’ | | | |
| | | | *Ginglymostoma cirratum* | Nurse Shark | 1 – 5’ | | | |
| | | | *Ocyurus chrysurus* | Yellowtail Snapper | 35 | | | |
| 4 | 18.0725 | -67.4256 | *Epinephelus guttatus* | Red Hind | 1 - 12' | 1 - 13" | | |
| | 18.0730 | -67.4241 | *Lutjanus apodus* | Schoolmaster Snapper | 47 (12-15") | | | |
| | | | *Lutjanus jocu* | Dog Snapper | 3 (22-28") | | | |
| | | | *Epinephelus striatus* | Nassau Grouper | 1 - 18" | 1 - 32" | | |
| | | | *Negaprion brevirostris* | Lemon Shark | 1 - 5' | | | |
| | | | *Ocyurus chrysurus* | Yellowtail Snapper | 15 | | | |
| | | | *Strombus gigas* | Conch | dead shells | | | |
| 5 | 18.0582 | -67.4158 | *Epinephelus guttatus* | Red Hind | 12 (12-16") | | | |
| | 18.0606 | -67.4173 | *Lutjanus analis* | Mutton Snapper | 1 - 24" | 1 - 28" | | |
| 6 | 18.0606 | -67.4173 | *Epinephelus guttatus* | Red Hind | 10 (10-12") | 4 (14-16") | | |
| | 18.0627 | -67.4188 | *Lutjanus analis* | Mutton Snapper | 1 - 30" | | | |
| | | | | Spiny Lobster | 2 (3-4lb) | | | |
| 7 | 18.0747 | -67.4266 | *Epinephelus guttatus* | Red Hind | 3 - 13" | 1 - 14" | 2 - 15" | 1 - 16" |
| | 18.0761 | -67.4266 | *Sphyraena barracuda* | Great Barracuda | 1 - 40" | | | |
| | | | *Strombus gigas* | Conch | 1 | | | |

**Appendix 3**. Continued

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8 | 18.0770 | -67.4263 | *Epinephelus guttatus* | Red Hind | 1 - 12" | 1 - 18" | | |
| | 18.0806 | -67.4273 | *Lutjanus analis* | Mutton Snapper | 16" | | | |
| | | | *Strombus gigas* | Conch | 8 | | | |
| 9 | 18.0829 | -67.4286 | *Epinephelus guttatus* | Red Hind | 2 - 13" | 4 - 15" | 1 - 16" | |
| | 18.0806 | -67.4277 | *Balistes vetula* | Queen Triggerfish | 1 - 18" | 1 - 19" | 1 - 22" | |
| 10 | 18.0878 | -67.4327 | *Epinephelus guttatus* | Red Hind | 3 - 12" | 2 - 16" | 2 - 18" | |
| | 18.0914 | -67.4332 | *Lutjanus jocu* | Dog Snapper | 1 - 18" | | | |
| | | | *Lutjanus analis* | Mutton Snapper | 1 - 24" | | | |
| | | | *Strombus gigas* | Conch | 3 | | | |
| 11 | 18.0728 | -67.4248 | *Epinephelus guttatus* | Red Hind | 1 - 14" | 1 -15" | | |
| | 18.0744 | -67.4252 | *Sphyraena barracuda* | Greate Barracuda | 40" | | | |
| | | | *Balistes vetula* | Queen Triggerfish | 1 -18" | 1 -20" | | |
| | | | *Lutjanus analis* | Mutton Snapper | 1 - 22" | | | |
| | | | *Caranx crysos* | Blue Runner | 1 - 18" | | | |
| | | | *Lutjanus apodus* | Schoolmaster Snapper | 90 (15-20") | | | |
| | | | *Scomberomorus regalis* | Cero | | | | |
| | | | *Strombus gigas* | Conch | dead shells | | | |
| 12 | 18.1026 | -67.4337 | *Epinephelus guttatus* | Red Hind | 2 - 14" | | | |
| | 18.1034 | -67.4342 | | Spiny Lobster | 3 - 3lb | 4 - 4lb | 4 - 5lb | 2 - 6lb |
| | | | *Strombus gigas* | Conch | 1 | | | |
| | | | *Mithrax* | Crab | 1 | | | |
| 13 | 18.0995 | -67.4325 | *Lutjanus cyanopterus* | Cubera Snapper | 1 - 3' | | | |
| | 18.1010 | -67.4329 | *Epinephelus guttatus* | Red Hind | 1 - 12" | | | |
| | | | *Strombus gigas* | Conch | 12 | | | |
| | | | *Ocyurus chrysurus* | Yellowtail Snapper | 4 - 15" | | | |
| 14 | 18.0975 | -67.4342 | *Epinephelus guttatus* | Red Hind | 1 - 10" | 1 - 15" | 2 - 17" | |
| | 18.1004 | -67.4333 | | | | | | |
| 15 | 18.0716 | -67.4256 | *Epinephelus guttatus* | Red Hind | 3 – 12” | | | |
| | 18.0749 | -67.4271 | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 16 | 18.0749 | -67.4271 | *Lacholaimus maximus* | Hogfish | 1-12” | | |
| | 18.0764 | -67.4282 | | | | | |
| 17 | 18.0764 | -67.4282 | *Epinephelus guttatus* | Red Hind | 10 - 9" | 12 - 12" | 10 - 9" |
| | 18.0778 | -67.4292 | *Mycteroperca venenosa* | Yellowfin Grouper | 1 - 12" | 1 - 20" | 1 - 36" |
| 18 | 18.0778 | -67.4292 | *Epinephelus guttatus* | Red Hind | 1 - 12" | 5 - 14" | 4 - 10" |
| | 18.0791 | -67.4302 | | | | | |