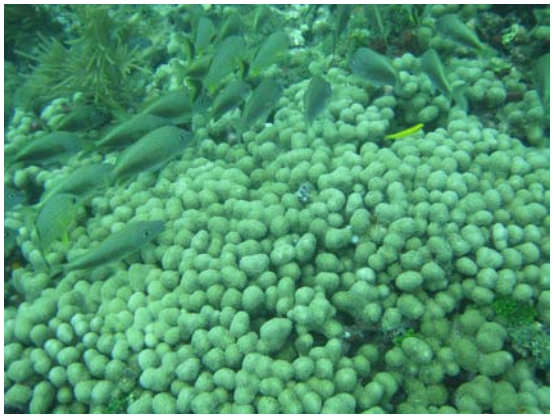
Abundance, Distribution and Condition of Benthic Coral Reef Organisms in the Upper Florida Keys National Marine Sanctuary

2010 Quick Look Report and Data Summary






November 2010

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NOAA CORAL REEF CONSERVATION PROGRAM

Florida Keys National Marine Sanctuary

2010 Quick Look Report and Data Summary

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Cover photo. Examples of benthic coral reef organisms and habitats sampled during 2010 in the upper Florida Keys. Detailed assessments of benthic coral reef organisms were made at Conch Reef, in addition to surveys of Acropora *corals, urchins, anemones/corallimorphs, selected mollusks, and marine debris from Crocker Reef to northern Key Largo. Upper left:* Acropora palmata *at Grecian Rocks SPA, Upper right:* Diadema antillarum *at Watson's Reef, Lower left:* Porites porites *inshore of Conch Reef, Lower right:* Conch Reef ledge

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2010 Executive Summary

During 19 days of fieldwork from June 28th to August 28th, 2010, research scientists from the Center for Marine Science, University of North Carolina at Wilmington, surveyed the density, size, and condition of benthic coral reef organisms in the upper Florida Keys National Marine Sanctuary (FKNMS) from northern Key Largo at Turtle Reef to SW of Crocker Reef near Alligator Light. Benthic surveys at 120 sites focused on the abundance, size, and condition of *Acropora* corals, urchins, anemones and corallimorpharians, and selected mollusks. In addition, surveys of marine debris were undertaken to identify and quantify the type and frequency of lost fishing gear and other debris. In addition to these variables, surveys of species richness, cover, and density of benthic coral reef organisms (algae, sponges, stony corals, and gorgonians) were conducted from inshore to offshore at Conch Reef at nine sites from the inshore edge of the Sanctuary Preservation Area (SPA) out to the Research Only Area (RO) near the Aquarius Undersea Habitat. The 2010 field surveys are part of an ongoing assessment and monitoring program back over a decade that documents the status and condition of benthic coral reef resources in the Florida Keys in relation to cross-shelf position, regional location, and the FKNMS management zones. The 2010 effort afforded the opportunity to continue the temporal data series for many variables assessed during the past decade, as well as to conduct detailed benthic surveys at Conch Reef, which has a long history of scientific experimentation and monitoring tied to the Aquarius Undersea Habitat deployed in 1992. Moreover, we were able to re-visit sites sampled in previous years, including areas adversely impacted by January 2010 cold fronts.

The benthic survey methods used by this program are built around a two-stage stratified random sampling design that partitions the Florida Keys sampling domain by benthic habitat type (nearshore to offshore), regional sector (upper, middle and lower Keys), and management zone (inside and outside of FKNMS no-take zones). The sampling design is coordinated with fishery independent surveys conducted by NOAA Fisheries and RSMAS-UM. During 2010, eight coral reef and hard-bottom habitat types were sampled from inshore of Hawk Channel to the deeper fore-reef from 1.2 m to 14.9 m depth: inshore and mid-channel patch reefs, offshore patch reefs, back reef rubble, shallow hard-bottom, platform margin high-relief spur and groove (< 6 m depth), and the deeper fore-reef (6-15 m depth) encompassing continuous hard-bottom, patchy hard-bottom, and low-relief spur and groove habitats. Sites were further partitioned by management zone within the FKNMS. The 2010 sampling included all of the no-take zones from northern Key Largo to SW of Crocker Reef, designated as Sanctuary Preservation Areas and Special-use Areas/Research Only Areas, as well as corresponding reference sites outside of the no-take zones. For the 120 sites sampled, latitude/longitude points were randomly generated in a geographic information system (GIS) incorporating available benthic habitat and bathymetry data for the sampling domain. At each site,

four 15-m transects were deployed to inventory benthic coral reef organisms and marine debris. At the nine sites surveyed across Conch Reef, data were collected on: depth and topographic complexity; species richness of stony corals, gorgonians, and sponges; percent cover of abiotic (e.g. sand and rubble) and biotic (e.g. algae, sponges, stony corals, gorgonians) components; stony coral density, colony size, and condition; juvenile coral density and size; gorgonian density; density and size (test diameter) of urchins; density of anemones and corallimorpharians; density of selected mollusks (sea slugs, nudibranchs, and certain gastropods); and frequency and biological impacts of marine debris. At the 111 remaining sampling locations, data were collected on: depth and topographic complexity; *Acropora* coral density, size, and condition; urchin density and size; anemone and corallimorpharian density; density and size of selected mollusks; and marine debris.

This report summarizes the major findings and provides descriptive data for the benthic variables measured during 2010. The report is divided by chapter for each of the major categories of variables measured, including a separate section on Conch Reef, and includes data tables, underwater photographs, maps, and data charts. The data were collected by a two-member survey team that conducted 240 SCUBA dives to depths of ~50 feet representing approximately 137 hours of underwater bottom time.

Nine sites from the inshore ledge within Conch Reef SPA seaward to the 15-m depth contour near the Aquarius Undersea Habitat within Conch Reef RO were surveyed in 2010, with three sites sampled in the following configuration: three sites along the ledge on the shoreward side of Conch Reef at mooring buoys C3, C2, and C1; three sites seaward of the mooring buoys at ~9-12 m depth; and three sites along the depth contour of Aquarius. Thus, in each depth zone, three sites were selected to represent the northeastern, central, and southwestern areas of the general reef area. In addition to the variables measured throughout the upper Keys region of the Sanctuary, benthic surveys at Conch Reef also included measurements of species richness (sponges, stony corals, and gorgonians), cover, density, size, and condition measurements for benthic coral reef organisms. Several cross-reef, depth-related patterns were evident for the benthic variables assessed, including coral species richness, sponge species richness, stony coral cover, sponge cover, *Palythoa* cover, and juvenile coral density. For example, sponges were nearly twice as diverse in Conch Reef RO compared to shallower Conch SPA and comprised up to 11.3% of the substratum at some sites. Total stony coral cover across the depth range surveyed was low (maximum of 6.3%), while turf algae and macroalgae such as *Halimeda* and *Dictyota* were dominant (>50% cover) across all three depth zones. Densities of juvenile corals (< 4 cm max. diameter) were two to nearly three times greater in Conch Reef RO compared to Conch Reef SPA. We were encouraged to find a few colonies of both *Acropora* coral species on the inshore ledge of Conch Reef SPA. However,

marine debris, especially lost hook-and-line gear, was relatively prevalent near the Aquarius Habitat. Temporal patterns in species richness, cover, and density of benthic coral reef organisms are discussed in reference to historical surveys at Conch Reef conducted by our program dating back to 1999.

Population assessments of *Acropora* corals conducted in 2010 represent a continuation of focused surveys on the habitat distribution, density, size, and condition of these two corals conducted in 2006 in the upper Keys and in 2007 Keyswide. These surveys are in addition to population assessments of all coral species, including *Acropora* spp., conducted by this program in 1999-2001, 2005, and 2009, as well as similar work in the Dry Tortugas region during 1999-2000, 2006, and 2008. Both species continue to show characteristic distribution patterns, with staghorn coral (*A. cervicornis*) more frequently encountered and in greater densities (up to 0.55 per m^2) and larger colony sizes on offshore patch reefs, followed by mid-channel patch reefs and shallow (< 6 m) hard-bottom. Sparsely distributed staghorn corals were also found on high-relief spur and groove, back reef rubble, and fore-reef habitats. Population abundance estimates (± 95% CI) for the habitats surveyed indicate that there may be ~13.8 ± 12.1 million staghorn coral colonies from SW of Crocker Reef to Turtle Reef. We have noted over the years a general increase in the occurrence of staghorn colonies. However, we also sampled many inshore and bank patch reef sites where staghorn corals suffered partial or complete mortality, presumably due to the January 2010 cold-front event. Elkhorn coral (*A. palmata*) continues to exhibit greater habitat specificity than its congener, with most colonies occurring on high-relief spur and groove reefs from Pickles Reef northwards to Turtle Reef. Relatively extensive thickets still persist at several locations such as South Carysfort Reef, Elbow Reef, Grecian Rocks, and Sand Island. Snail and damselfish predation continue to represent important sources of mortality compared to disease. Population abundance estimates indicate that there may be ~1.126 ± 0.369 million elkhorn corals in the upper Keys region, which is substantially lower than previous estimates (~5.39 million colonies) in 2006.

Five urchin species were encountered and 836 individuals were counted and measured for test diameter (TD) from 7,200 m^2 of benthic habitat surveyed during 2010. Similar to previous years, most (~86%) urchins sampled were either *Echinometra viridis*, which was particularly abundant on many mid-channel and offshore patch reefs, or *Eucidaris tribuloides*, which was most abundant in back reef rubble zones and on high-relief spur and groove reefs. Densities of the long-spined sea urchin (*Diadema antillarum*) are still relatively low (< 0.3 individuals per m^2) by historical (pre-1983) standards; the maximum site-level density recorded during 2010 was only 0.133 individuals per m^2; However, two temporal trends are noteworthy. First, densities of *D. antillarum* have slowly increased since 1999, and the highest densities of larger (> 5 cm TD) individuals presently occur on mid-channel and offshore patch reefs, with abundant

recently settled recruits in back reef rubble zones. Second, there has been a shift in the average and maximum sizes of individuals encountered over the past 10 years to larger individuals. In 2010, individuals as large as 10.0 cm TD were recorded, which we never encountered from 1999-2005. The average size of *Diadema* encountered up until 2005 was < 3.0 cm TD, while 2010 yielded an average size of 4.1 cm TD. The lower overall mean size of *Diadema* in 2010 was lower than in 2009 due to the inclusion of reef rubble sites this year. Where aggregations of urchins were found, there were clear and obvious impacts to the substratum. Assuming these trends continue, and as more space becomes cleared of algae, it will be important to monitor for recruitment of invertebrates.

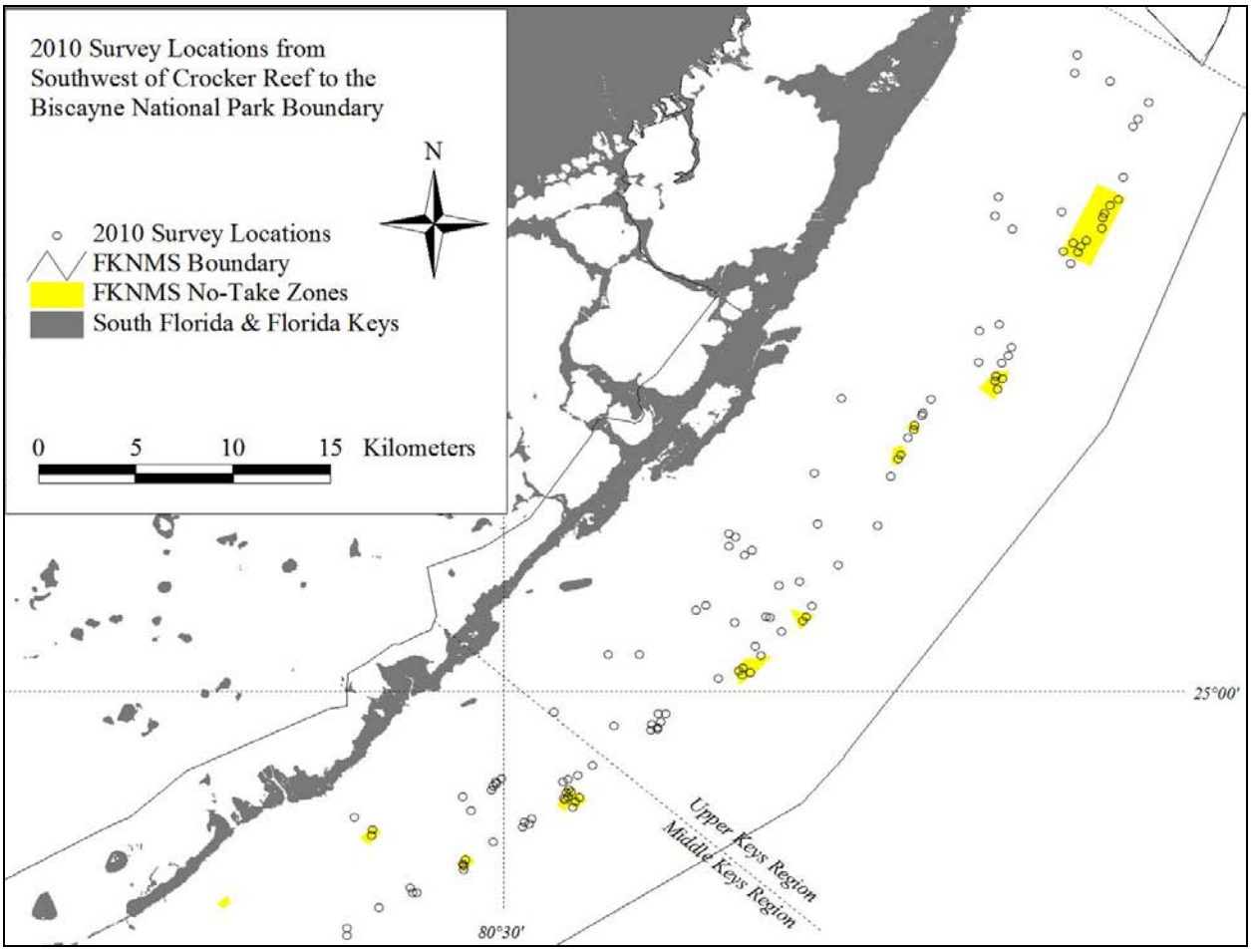
Five anemone species and two corallimorpharian species were encountered during 2010. Although more common in the lower Florida Keys region, which was not sampled this year, no individuals of the knobby anemone (*Heteractis lucida*), the sun anemone (*Stichodactyla helianthus*) or the corallimorpharian *Discosoma sanctithomae* were recorded in the upper Keys. A total of 297 anemones were counted, most of which were *Bartholomea annulata* (87%) or *Condylactis gigantea* (8%). Anemones generally exhibited similar spatial patterns in abundance among habitats in 2010 compared to previous survey years, with *B. annulata* exhibiting the broadest habitat distribution and greatest frequency of occurrence. A total of 311 corallimorpharians were counted, of which ~94% were *Ricordea florida*, followed by one *Discosoma* species (*D. carlgreni*). Similar to previous years, *R. florida* was most abundant on mid-channel and offshore patch reefs, with mean densities as high as 1.55 individuals per m^2.

Surveys of the abundance, size, and substratum occupancy patterns of selected mollusks continued during 2010. All nudibranchs, the sacoglossan *Elysia crispata* (lettuce sea slug), and three gastropod species (*Coralliophila* sp., *Leucozonia nassa*, and *Thais deltoidea*) encountered were enumerated and measured for total or shell length; in addition, the substratum occupied was also noted. Two nudibranch species, *Chromodoris nyalya* (2 individuals) and *Glossodoris sedna* (1 individual), were found, while no *Hypselodoris* nudibranchs were encountered. All 37 lettuce sea slugs (*E. crispata*) recorded were found occupying algal turf micro-habitat on shallow, high-relief spur and groove reefs. Of the three gastropod species inventoried, the deltoid rock snail (*T. deltoidea*), an important micro-herbivore of turf algae, was the most abundant (385 individuals), with most individuals occurring on high-relief spur and groove reefs. Nearly 95% of the individuals encountered were found either occupying algal turf or crustose coralline algae. Of the 91 corallivorous snails (*Coralliophila* sp.) recorded, 96% were found on live coral tissue. Comparison to previous surveys suggests that the density of *Coralliophila* snails is increasing. Particularly noteworthy was the diversity of coral species (8 species) encountered during 2010 with active snail predation, including species of *Acropora*, *Agaricia*, *Diploria*, and *Montastraea*.

Surveys of marine debris, including lost hook-and-line and lobster/crab trap fishing gear, continued in 2010, and represent a continuation of similar efforts conducted Keyswide in 2000, 2001, and 2008. Data collected in 2010 included the type and frequency (density) of debris, as well as the frequency of benthic coral reef organisms impacted by tissue abrasion from debris. Although logistical constraints prevented us from measuring the length or weight of debris, we attempted to retrieve as much material from the bottom as possible. A total of 218 debris items were encountered within 480 belt transects covering 7,200 m^2 of benthic habitat. Marine debris was found at 76 of the 120 sites (63%) and in all habitats and no-take zones sampled. Nearly 69% of the debris encountered consisted of lost hook-and-line fishing gear such as monofilament line, wire leaders, and lead sinkers. The remaining debris consisted of lobster/crab trap gear (20%) and other items such as glass bottles and plastics. A total of 118 organisms were identified that were injured due to abrasion stress from debris, with lost hook-and-line fishing gear (61%) and lobster/crab trap gear (31%) accounting for most of the impacts. Gorgonians (44%) and *Millepora* corals (26%) were the most commonly impacted, probably due to their upright and branching morphology, followed by scleractinian corals, sponges, and *Palythoa*. Densities of marine debris were generally the same or even higher in many Sanctuary no-take zones compared to reference areas for many habitats, with total marine debris densities as high as 20 items per 60 m^2 at some sites.

Two additional observations are noteworthy from the 2010 field surveys. It was obvious from sites previously surveyed in 2009 that the January 2010 cold-front event significantly impacted stony corals and gorgonians, especially on inshore patch reefs (e.g. Tavernier Rocks) and bank patch reefs such as those on Mosquito Bank. Large areas of dead *Montastraea annularis* and *M. faveolata* were common, in addition to large gorgonians such as *Pseudoplexaura* spp. that are now dead and covered with drift macroalgae. The impacts of the January cold front are patchy and appear to be mostly limited to nearshore patch reefs, while offshore patch reefs and platform margin reefs appear to have been only minimally impacted. Second, for the first time since we started this program in 1998, but also including the entire 1990s, we have never encountered Pacific lionfish in the course of conducting benthic surveys. Three lionfish individuals, all of which were juveniles (< 20 cm TL), were encountered at Carysfort Reef (just north of the Lighthouse in ~5 m of water), north of the Aquarius Undersea Habitat (~14 m water depth), and offshore of Little Conch Reef (~10 m water depth). All three individuals were found near ledges or next to coral heads.

Figure 1-1. Sampling locations for benthic coral reef organisms and marine debris in the upper Florida Keys National Marine Sanctuary during June-August 2010. A total of 120 sites were surveyed for *Acropora* corals, urchins, anemones, corallimorpharians, selected mollusks, and debris from Turtle Reef to SW of Crocker Reef. In addition, detailed surveys of the species richness, coverage, density, size, and condition of benthic coral reef organisms were conducted at nine sites from to inshore to offshore within Conch Reef SPA and RO near the Aquarius Undersea Habitat.



I. Introduction

Like many coral reef ecosystems, the Florida Keys have exhibited significant change in recent decades, including loss of urchins (*Diadema antillarum*) and corals due to disease, as well as hypo- and hyperthermal events that have resulted in significant coral loss due to bleaching (Jaap 1984; Dustan and Halas 1987; Aronson and Precht 2001; Chiappone et al. 2002). In addition, localized impacts to reefs are also evident from over-use such as from finfish fishing and harvesting ornamentals, coastal development, and a considerable array of larger-scale phenomena affecting Florida Keys reefs, such as continental influence (Biscayne Bay and Florida Bay exchange) and destructive tropical storms (Precht and Miller 2007). This multitude of stressors has made it difficult to discern the degree to which human activities have affected ecological integrity relative to natural system variability (Somerfield et al. 2008).

While understanding the causes of coral reef decline is a fundamental pursuit among coral reef ecologists, our sampling program was designed specifically to document the status and trends of no-take management zones throughout the FKNMS. To evaluate potential changes in no-take management zones, it is necessary to also document changes caused by natural system variability or stressors, such as mortality events caused by disease or bleaching, coral recruitment events (especially related to *Acropora* corals), or recovery of the previously abundant sea urchin, *Diadema antillarum*. By broadly sampling populations among multiple habitat types across the south Florida shelf, inside and outside of the no-take management zones, and throughout the Florida Keys from south of Miami to the Dry Tortugas, over an 11-year period, we have documented the distribution, abundance, and changes over time, of coral reef organisms and communities in the region. Our data and results are unprecedented in spatial coverage and establish a baseline from which future comparisons can be made, related to further decline, recovery, or stasis. It is important to note that our program began in the late 1990s, long after major declines had already occurred in the region, specifically the loss of *D. antillarum* and *Acropora* corals. One way we are addressing the absence of earlier information (from the 1970s before the major die-offs) is through a data-rescue project that begin in 2010. In partnership with the FKNMS, we have identified a previously-funded NSF project that sampled reefs in the lower Florida Keys during the 1970s, but was never published. We are working with the Principal Investigator of that project to incorporate the historical data set with ours to better understand historical baselines relative to recent patterns.

In 2010, during nearly three weeks of fieldwork in the upper Florida Keys, we sampled 120 different sites stratified by cross-shelf habitat type, along-shelf position, and management zone from northern Key Largo to southwest of Crocker Reef (north of Alligator Light) within the FKNMS. Surveys at all sites were conducted for *Acropora* corals, urchins, anemones and corallimorpharians, selected mollusks, and

marine debris. In addition to these variables, species richness, cover, and densities of corals, gorgonians, and sponges were sampled at nine sites from inshore to offshore across Conch Reef SPA and RO. These measurements add to a growing temporal base of observations made by our program since 1998 (Chiappone et al. 2002a, b; Miller et al. 2002). Previous surveys aided in optimizing a sampling plan for obtaining estimates of abundance and size of benthic coral reef organisms (see previous Quick Look reports at http://people.uncw.edu/millers). Our sampling program is specifically designed to help resource managers evaluate the performance of smaller protected areas (no-take zones) relative to other factors that influence the larger ecosystem.

II. Study Area and Survey Methods

Study area and sampling objectives

The Florida Keys comprise an archipelago of limestone islands spanning more than 360 km from south of Miami to the Dry Tortugas. With the exception of isolated banks in the Flower Gardens area in the Gulf of Mexico, the Florida Keys ecosystem represents the only region of extensive coral reef development in the continental U.S. (Jaap 1984). The islands are part of the larger south Florida shelf, a submerged Pleistocene platform 6-35 km wide and generally < 12 m deep (Lidz et al. 2003). The primary influences on the distribution and development of Florida Keys reefs are paleotopography and fluctuating sea level (Shinn et al. 1989; Lidz et al. 2003). Bedrock throughout south Florida is Pleistocene limestone, either exposed on the seafloor or lying underneath Holocene reefs and sands (Shinn et al. 1989). As one proceeds seaward from the shoreline of the Pleistocene islands, a nearshore rock ledge extends ~2.5 km from the shoreline, with the seabed consisting of hard-bottom, seagrass, and isolated inshore patch reefs (FMRI 1998). Seaward of the island platform is Hawk Channel, a broad trough-like depression dominated by non-coralline, non-oolitic grainstone, dotted with several thousand patch reefs whose distribution is affected by the number and width of tidal passes connecting Florida Bay and the Atlantic Ocean (Marszalek et al. 1977; Shinn et al. 1989). Bands of rock ridges exist further offshore along the outer shelf and on the upper slope from 30-40 m depth before tapering off into the Straits of Florida. The semi-continuous offshore reef tract is emergent in places, in which Holocene reefs sit atop a ridge of Pleistocene corals (~86-78 ka), forming a shelf-margin ledge (Lidz et al. 2003), with a series of outlier reefs seaward of this main reef tract at 30-40 m depth (Lidz 2006). As with inner shelf margin patch reefs, the distribution platform margin reefs reflects exchange processes between Florida Bay and the Atlantic Ocean (Marszalek et al. 1977; Shinn et al. 1989), which is related to the size and orientation of the Pleistocene islands and thus the presence and size of tidal passes, as well as the proximity of the Florida Current to the platform margin (Pitts 1994; Smith 1994).

The 2010 sampling of coral reef benthic invertebrates and marine debris in the upper Florida Keys National Marine Sanctuary (FKNMS) was undertaken as a spatially intensive effort to quantify the distribution, abundance, size, and condition of benthic coral reef organisms. The 2010 surveys conducted from June 28th to August 28th were an outgrowth of previous efforts conducted by our program dating back to 1998 to quantify the abundance and condition of coral reef benthos throughout the FKNMS, including the Tortugas region (Miller et al. 2002). Previous surveys in the FKNMS, excluding the Tortugas region, consist of 80 sites sampled Keyswide in 1999, 45 sites in the lower Keys region in 2000, 108 sites Keyswide in 2001, 195 sites Keyswide in 2005, 107 sites in the upper Keys region in 2006, 235 sites Keyswide in 2007, 145 sites Keyswide in 2008, and 160 sites Keyswide in 2009. Data obtained from

these earlier efforts, together with existing habitat mapping information for the FKNMS, were used to guide the sampling of benthic coral reef organisms and marine debris in 2010. The overall goals of the 2010 sampling effort were two-fold:

- Provide detailed surveys of the species richness, density, size, and condition of benthic coral reef organisms at Conch Reef, including the area around the Aquarius Undersea Habitat; and
- Continue the temporal data sets on the abundance and size of *Acropora* corals, urchins, anemones and corallimorpharians, and selected mollusks, as well as the frequency and impacts of marine debris throughout the upper Florida Keys region.

The 2010 surveys provided the opportunity to conduct detailed benthic sampling at nine sites along a depth gradient at Conch Reef that encompassed low-relief hard-bottom and low-relief spur and groove habitats from the shallow inshore reef edge to the Aquarius Undersea Habitat. We were able to continue population temporal data sets on the population status of several groups of benthic invertebrates dating back to 1999 throughout the upper Keys area. The objectives of the 2010 sampling effort were to provide information on:

- Depth and physical structure (maximum vertical relief) of survey sites;
- Species richness and frequency of occurrence of stony corals, gorgonians, and sponges at Conch Reef;
- Percent cover of abiotic and biotic components at Conch Reef;
- Density, size, and condition (percent live tissue, disease, bleaching, predation) of all stony corals at Conch Reef;
- Density of gorgonians and density and maximum diameter of juvenile (< 4 cm) scleractinian corals at Conch Reef;
- Distribution, density, size, and condition of *Acropora* corals throughout the upper Florida Keys;
- Density and size (test diameter) of sea urchins throughout the upper Florida Keys, representing an ongoing effort to monitor recovery of the historically abundant long-spined sea urchin *Diadema antillarum*;
- Density of sea anemones and corallimorpharians, as well as selected mollusks such as sea slugs, nudibranchs, and certain other gastropods (*Thais*, *Leucozonia*, *Coralliophila*) throughout the upper Florida Keys; and
- Frequency and impacts of marine debris, including lost fishing gear, representing a continuation of efforts carried out in 2000-01 and 2008.

Sampling design and field methodology

The sampling design for assessing benthic coral reef organisms and marine debris encompassed 120 sites visited during June-August 2010. Sites were distributed from northern Key Largo at Turtle Rocks and Turtle Reef, near the boundary between the FKNMS and Biscayne National Park, to SW of Crocker Reef near Alligator Light (Figure 2-1). The sampling design included eight major habitat types, as well as all nine no-take zones designated as Sanctuary Preservation Areas (SPA) or Research Only Areas (RO) in the upper Keys region from Hen and Chickens SPA and Davis Reef SPA northward to Carysfort/S. Carysfort Reef SPA (Table 2-1). Table 2-2 chronologically lists the sampling locations during June-August 2010.

The habitat strata selected for the 2010 sampling incorporated most of the hard-bottom and coral reef habitat types from the island platform (e.g. inshore patch reefs such as Tavernier Rocks) inshore of Hawk Channel to ~15 m depth along the reef tract. However, the 2010 effort did not include nearshore hard-bottom, hard-bottom/seagrass matrix habitats, or deeper (> 15 m) fore reef areas. The habitats sampled during 2010 were inshore and mid-channel patch reefs, offshore patch reefs, back reef rubble, shallow (< 6 m) hard-bottom, inner line reef tract spur and groove from Grecian Rocks northward to Turtle Reef, shallow (< 6 m) high-relief spur and groove along the platform margin, and deeper fore-reef habitats from 7-15 m depth. Deeper fore-reef habitats encompassed continuous, low-relief hard-bottom, patchy hard-bottom, and low-relief spur and groove. Table 2-3 lists the sites by benthic habitat type, along with site-level data on depth and maximum vertical relief. Besides habitat type, sites were further categorized by along-shelf position and management zone (i.e. inside and outside of FKNMS no-take zones). Figures 2-2 to 2-4 show the spatial distribution of sampling locations by habitat type for the 120 sampling locations, along with the boundaries of existing no-take marine reserves in the upper FKNMS. Figures 2-5 to 2-7 provide examples of each of the hard-bottom and coral reef habitat types sampled during 2010.

A geographic information system (GIS) containing digital layers for benthic habitat (FMRI 1998), bathymetry, and no-take marine reserve boundaries was used to facilitate delineation of the sampling survey domain, strata, and sample units. Existing resolution of benthic habitats is such that the survey domain was divided into a grid of individual cells 200 m by 200 m (40,000 m^2) in area that that serve as primary sampling units (Table 2-1). A two-stage sampling scheme following Cochran (1977) was employed to control for spatial variation in population metrics at scales smaller than the grid cell minimum mapping unit. Grid cells containing targeted reef and hard-bottom habitats were designated as primary sample units. A second-stage sample unit was defined as a belt transect of fixed area (15-m x 1-m

in dimension) within a primary sample unit. The size of an individual primary sampling unit allowed divers to swim to the location of any given second-stage sampling unit from a moored or anchored vessel.

To control for spatial variation in the benthic variables assessed, the upper Florida Keys survey domain was partitioned into strata based upon: 1) habitat class, 2) geographic region (along-shelf position), and 3) management zones of the Florida Keys National Marine Sanctuary (FKNMS). A grid system constructed in a geographic information system (GIS) was used to overlay the existing habitat map of the Florida Keys. Cells or blocks 200 m x 200 m in dimension were used to randomly select sites from the combination of habitat type, regional sector, and management zone. Habitats were designated using regional benthic habitat maps (FMRI 1998). The habitat classification scheme accounted for features that correlate with benthic fauna distributions, including cross-shelf position, topographic complexity, and the proportion of sand interspersed among hard-bottom structures. A geographic regional stratification variable was used to account for oceanographic and geological features in the Florida Keys that may influence the distribution and community composition of hard-bottom and reef habitats (Marszalek et al. 1977; Shinn et al. 1989). Regional sectors are defined as follows: upper Florida Keys (BNP boundary south to Pickles Reef), middle Florida Keys (Conch Reef southwest to Moser Channel), and lower Florida Keys (Big Pine Shoal west to Satan Shoal). FKNMS no-take zones are incorporated as a third stratification variable that delineates areas open and closed to consumptive activities. Within each no-take zone, a minimum of two replicate sites are sampled in a given habitat type. The power of the stratified random sampling approach is essentially two-fold: 1) the habitats comprising the most area are initially allocated more sites than those with less area (i.e., a proportional design); and 2) habitats exhibiting more variability with respect to particular metrics (e.g. coral density) are allocated more sites than those with less variability. The ultimate power of this approach is derived more from the number of sites sampled rather than the effort expended per site.

The underwater surveys consisted first of locating randomly selected, pre-determined coordinates with a differential global positioning system. A Garmin® global positioning system receiver (model GPS76) was used to determine the position at each site. The original sampling list encompassed 120 sampling locations, with an additional 120 alternate sites between Alligator Light and the northern FKNMS boundary. If the original waypoint was not the intended habitat type, the closest alternate site was sampled instead. Once on-site, a two-person benthic diver team oriented four transect tapes 15-m in length, marked in 1-m increments, along the bottom. A 1-m wide belt centered on each 15-m long transect tape was surveyed at each site for most of the benthic variables described below, with a total of 60-m^2 surveyed. At all 120 sites sampled during 2010, 15-m^2 belt transect areas were surveyed for:

- Minimum and maximum depth;
- Maximum vertical relief of the substratum such as ledges, spur edges, crevices, coral heads, and sponges;
- Number of colonies, skeletal unit size, live tissue surface area, and condition (bleaching, disease, predation, overgrowth) of *Acropora* corals;
- Numbers and test diameters of sea urchins;
- Numbers of anemones and corallimorpharians;
- Numbers and total lengths or shell lengths of nudibranchs, the lettuce sea slug (*Elysia crispata*), and the gastropods *Coralliophila* sp., *Leucozonia nassa*, and *Thais deltoidea*; and
- The frequency of marine debris and the numbers of benthic organisms exhibiting abrasion stress (partial mortality due to tissue loss).

At Conch Reef, nine sites were sampled from the inshore ledge to the deeper fore-reef along the depth contour of the Aquarius Undersea Habitat. Three sites were selected in each of three depth zones comprising: the inshore ledge (low-relief hard-bottom) of Conch Reef SPA at mooring buoys C1, C2, and C3; offshore of the mooring buoys within the SPA at ~9-12 m depth; and three sites along the depth contour of Aquarius (~14-15 m depth). The three sites in each depth zone were distributed from the northeastern to the central to the southwestern areas of Conch Reef. In addition to the variables described above, measurements at Conch Reef also included benthic cover, species richness, and the density, size, and condition of benthic coral reef organisms. Specifically, transects were surveyed for: depth and maximum vertical relief; stony coral, gorgonian, and sponge species presence-absence; stony coral numbers, colony sizes, and colony condition; juvenile scleractinian coral numbers and maximum diameter; gorgonian colony numbers. Transects were placed in an inshore-to-offshore pattern in each of the three depth zones. Once transects were deployed, divers determined the minimum and maximum depth along the transect using a digital depth gauge, as well as the maximum vertical relief along each transect using a 50-cm scale bar marked in 5-cm increments. Maximum vertical relief took into consideration hard substratum, corals, and sponges, but did not include gorgonian height. Benthic cover was assessed by sampling 100 points spaced 15 cm apart along each transect. Digital photographs of each site were taken to record general site features and organisms encountered.

The 2010 sampling effort (120 sites) required 19 field days from June 28 to August 28th (Table 2-2). Only a few field days were lost due to personnel issues or inclement weather in July and August. The June-August sampling was generally marked by calm conditions, except for late June and during the

third week of July. A private research vessel (M/V *Dual Porpoise*, Key Largo, captained by Scott Fowler) and NOAA/UNCW's Aquarius Reef Base (ARB) in Key Largo provided on-the-water diving support. The survey team consisted of personnel from the Center for Marine Science/UNCW (Mark Chiappone, Leanne Rutten and Thor Dunmire) (Table 2-4). SCUBA tank fills and lodging were provided by NOAA's ARB facility on Key Largo. The sampling effort depended upon 6 to 7 hours in the water daily by a two- or three-person benthic team to complete an average of 6-8 sites per day. Typically 30-40 minutes per site were needed to sample the targeted benthic variables, except at Conch Reef, where 70-90 minute divers were needed per site. Table 2-4 summarizes the diving statistics for 2010. The benthic surveys at the 120 sites required 240 dives comprising ~137 hours of underwater bottom time.

Figure 2-1. Sampling locations for benthic coral reef organisms in the upper Florida Keys National Marine Sanctuary from southwest of Crocker Reef to northern Key Largo during June-August 2010.

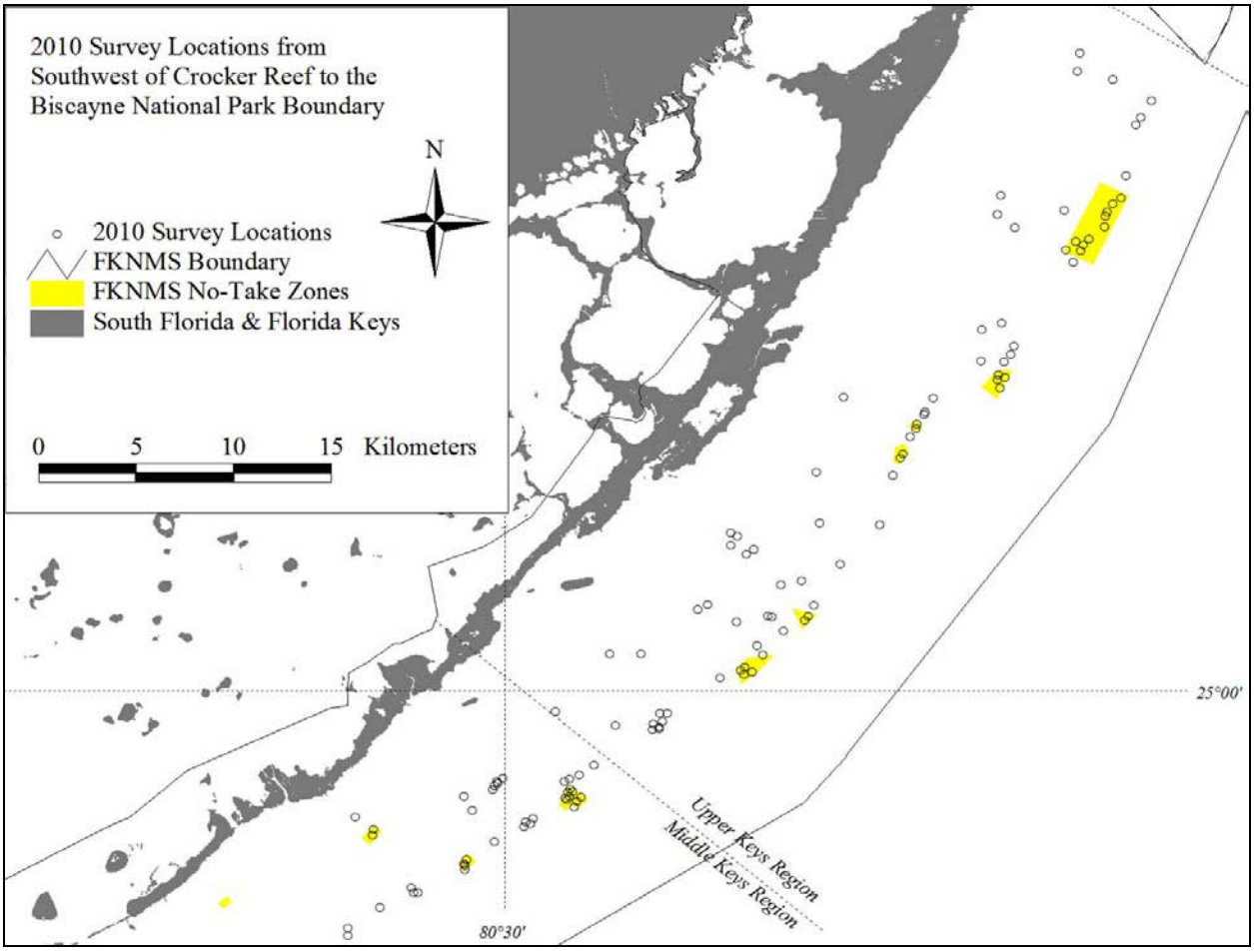


Figure 2-2. Upper Florida Keys sampling locations by benthic habitat type from the southern Biscayne National Park boundary to Carysfort Reef during 2010.

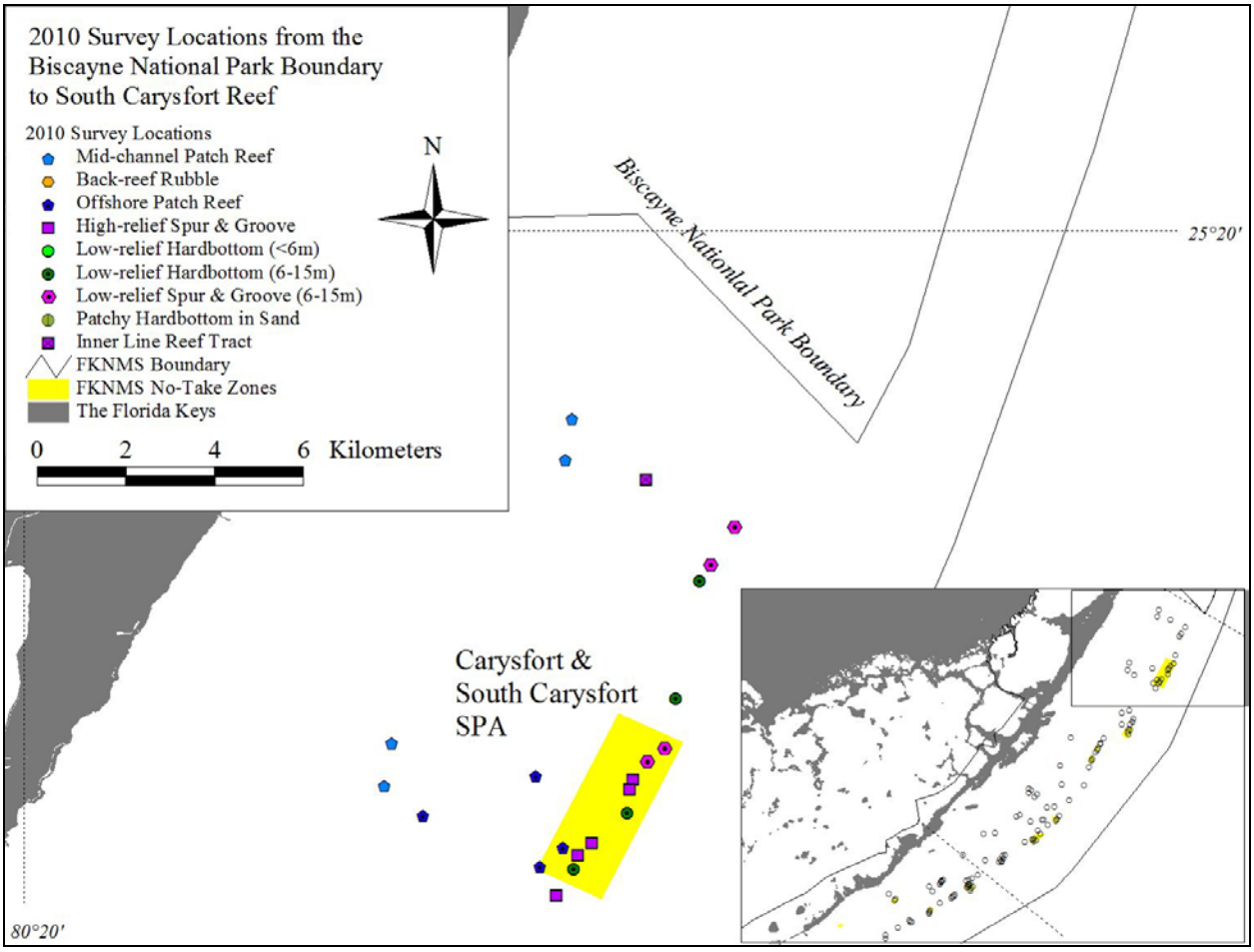


Figure 2-3. Upper Florida Keys sampling locations by benthic habitat type from Elbow Reef to Pickles Reef during 2010.

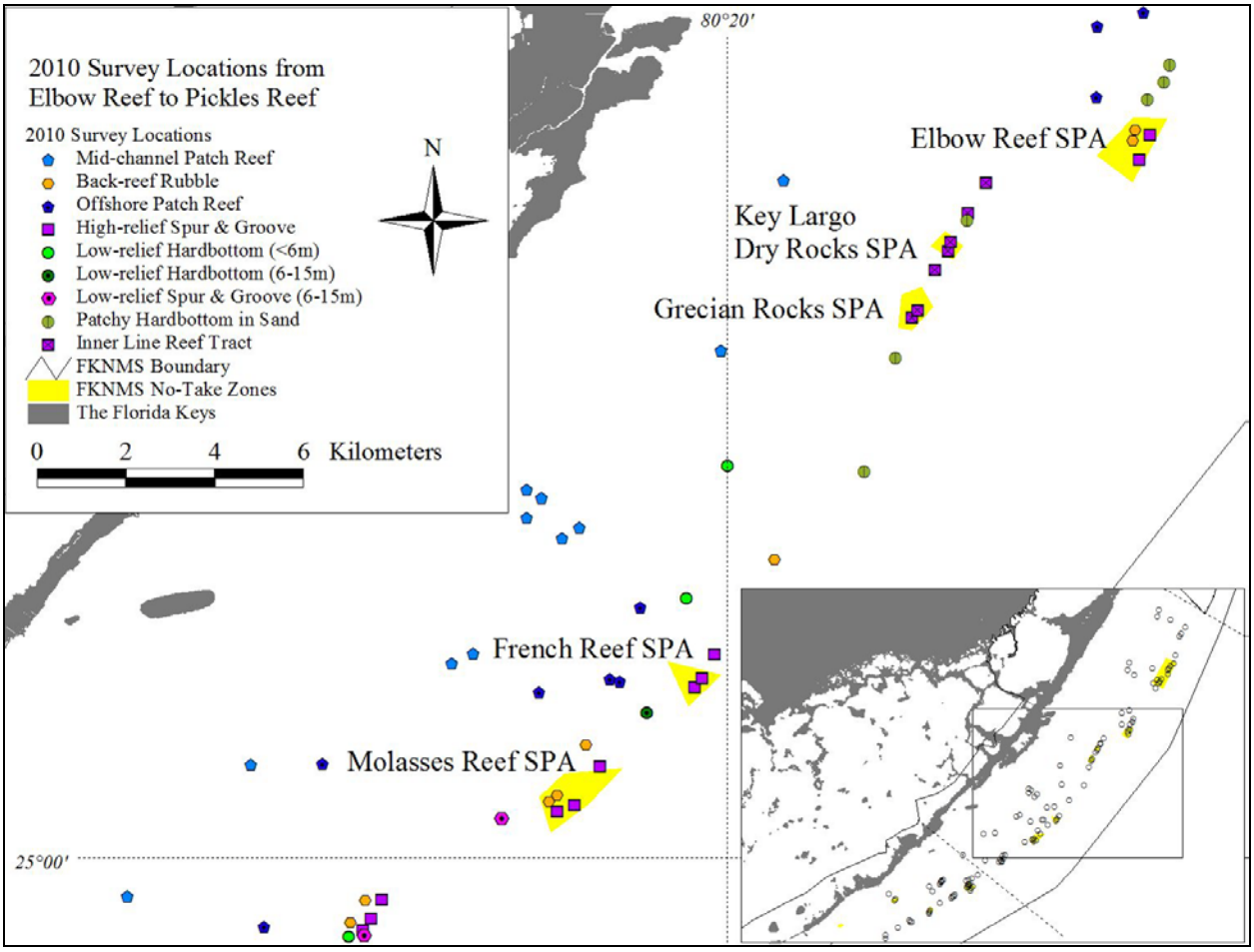


Figure 2-4. Upper Florida Keys sampling locations by benthic habitat type from Conch Reef to Crocker Reef during 2010.

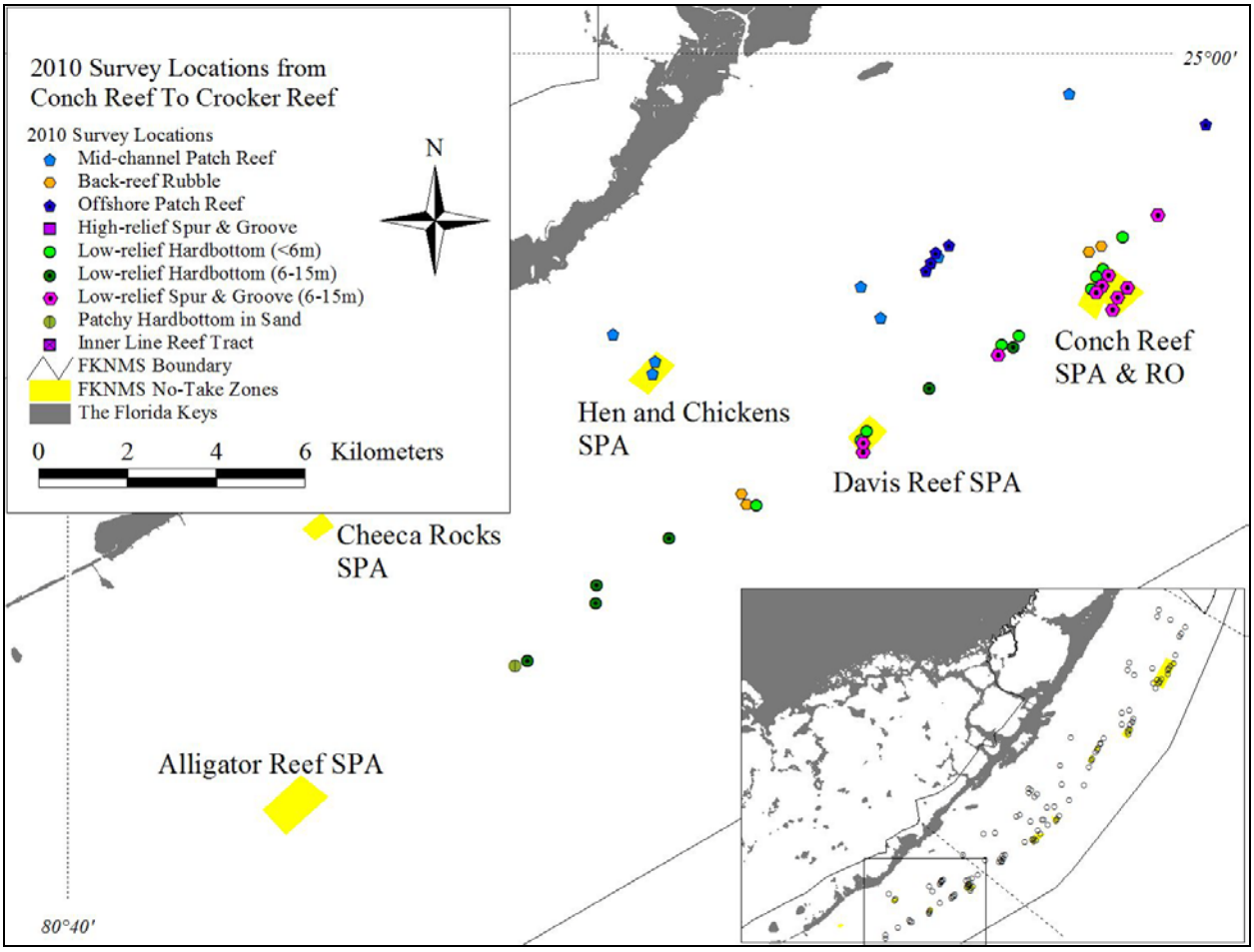


Figure 2-5. Examples of inshore, mid-channel and offshore patch reefs sampled in the upper Florida Keys during 2010.

Inshore patch reef
Site A741, Tavernier Rocks, 2.4-4.6 m
24° 56.594'N, 80° 33.376'W

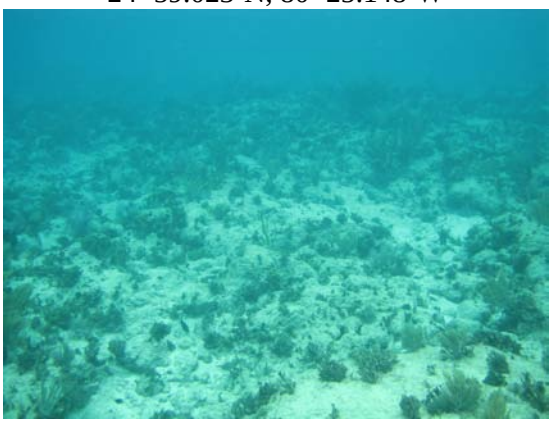
Offshore patch reef
Site B35, West of Elbow Reef, 4.3-6.1 m
25° 09.213'N, 80° 16.074'W

Mid-channel patch reef
Site 637, West of Turtle Rocks, 2.1-3.7 m
25° 17.210'N, 80° 13.425'W

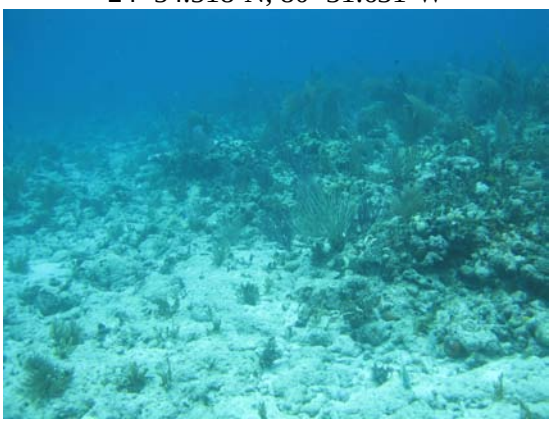
Offshore patch reef
Site A802, Inshore of Conch Reef, 3.7-6.1 m
24° 57.363'N, 80° 29.576'W

Figure 2-6. Examples of shallow (< 6 m) low-relief hard-bottom and high-relief spur and groove reefs sampled in the upper Florida Keys during 2010.

Low-relief hard-bottom
Site 693, Little Pickles Reef, 4.3-5.5 m
24° 59.023'N, 80° 25.148'W



Low-relief hard-bottom
Site A932, Crocker Reef, 3.4-4.3 m
24° 54.518'N, 80° 31.631'W



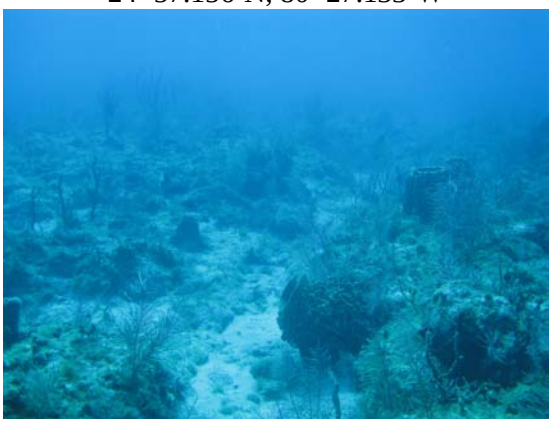
High-relief spur and groove
Site 700, South Carysfort Reef, 1.5-5.2 m
25° 12.566'N, 80° 13.102'W

High-relief spur and groove
Site 711, Sand Island, 3.0-5.2 m
25° 01.089'N, 80° 22.099'W

Figure 2-7. Examples of deeper (6-15 m) fore-reef habitats sampled in the upper Florida Keys during 2010.

Low-relief hard-bottom
Site A94, Little Conch Reef, 8.8-10.1 m
24° 56.428'N, 80° 28.515'W

Low-relief spur and groove
Site 626, Conch Reef, 13.4-14.3 m
24° 57.156'N, 80° 27.133'W



Patchy hard-bottom
Site B57, East of Dry Rocks, 6.4-7.9 m
25° 07.719'N, 80° 17.641'W

Low-relief spur and groove
Site 709, Pickles Reef, 8.5-9.4 m
24° 59.031'N, 80° 24.968'W

Table 2-1. Survey effort for benthic coral reef organisms in the upper Florida Keys National Marine Sanctuary during June-August 2010. Sites are arranged by habitat type, regional sector, and management zone. Available sites (n_{tot}) reflect the number of 200 m x 200 m sites based upon FMRI (2001) habitat mapping data. Asterisked sites (**) are FKNMS no-take zones represented by Sanctuary Preservation Areas (SPA), Ecological Reserves (ER), or Research Only Areas (RO). n_{tot} (%) = proportion of sites available in a particular stratum relative to the total number of sites in the sampling domain.

Habitat type/region/protection	Sites sampled (n)	% of Effort	Sites available (n_{tot})	n_{tot} (%)	n/n_{tot} (%)
Mid-channel patch reef (MPR)					
Upper Florida Keys					
Reference sites	15	12.50	706	11.06	2.12
Middle Florida Keys					
Reference sites	4	3.33	165	2.58	2.42
Hen and Chickens SPA**	2	1.67	9	0.14	22.22
MPR Habitat Total	**21**	**17.50**	**880**	**13.78**	**2.39**
Offshore patch reef (OPR)					
Upper Florida Keys					
Reference sites	11	9.17	1,025	16.05	1.07
Carysfort/S. Carysfort SPA**	2	1.67	28	0.44	7.14
Middle Florida Keys					
Reference sites	4	3.33	94	1.47	4.26
OPR Habitat Total	**17**	**14.17**	**1,147**	**17.96**	**1.48**
Back reef rubble (BRR)					
Upper Florida Keys					
Reference sites	4	3.33	61	0.96	6.56
Elbow Reef SPA	2	1.67	9	0.14	22.22
Molasses Reef SPA	2	1.67	6	0.09	33.33
Middle Florida Keys					
Reference sites	4	3.33	158	2.47	2.53
BRR Habitat Total	**12**	**10.00**	**234**	**3.66**	**5.13**
Shallow (< 6 m) hard-bottom (LHB)					
Upper Florida Keys					
Reference sites	3	2.50	775	12.14	0.39
Middle Florida Keys					
Reference sites	4	3.33	176	2.76	2.27
Conch Reef SPA**	3	2.50	5	0.08	60.00
Davis Reef SPA**	2	1.67	2	0.03	100.00
LHBS Habitat Total	**12**	**10.00**	**958**	**15.00**	**1.25**
Inner line spur and groove (IRT)					
Upper Florida Keys					
Reference sites	4	3.33	78	1.22	5.13
Dry Rocks SPA**	2	1.67	4	0.06	50.00
Grecian Rocks SPA**	2	1.67	13	0.20	15.38
IRT Habitat Total	**8**	**6.67**	**95**	**1.49**	**8.42**
High-relief spur and groove (HSG)					
Upper Florida Keys					
Reference sites	6	5.00	34	0.53	17.65
Carysfort/S. Carysfort SPA**	4	3.33	39	0.61	10.26
Elbow Reef SPA**	2	1.67	16	0.25	12.50
French Reef SPA**	2	1.67	12	0.19	16.67
Molasses Reef SPA**	2	1.67	14	0.22	14.29
HSG Habitat Total	**16**	**13.33**	**115**	**1.80**	**13.91**

Habitat type/region/protection	Sites sampled (n)	% of Effort	Sites available (n_{tot})	n_{tot} (%)	n/n_{tot} (%)
Patchy (6-15 m) hard-bottom (PHB)					
Upper Florida Keys					
Reference sites	6	5.00	217	3.40	2.76
Middle Florida Keys					
Reference sites	2	1.67	128	2.00	1.56
PHB Habitat Total	**8**	**6.67**	**345**	**5.40**	**2.32**
Deeper (6-15 m) hard-bottom (LHBD)					
Upper Florida Keys					
Reference sites	3	2.50	662	10.37	0.45
Carysfort/S. Carysfort SPA**	2	1.67	39	0.61	5.13
Middle Florida Keys					
Reference sites	4	3.33	311	4.87	1.29
LHBD Habitat Total	**9**	**7.50**	**1,012**	**15.85**	**0.89**
Low-relief spur and groove (LSG)					
Upper Florida Keys					
Reference sites	5	4.17	709	11.10	0.71
Carysfort/S. Carysfort SPA**	2	1.67	54	0.85	3.70
Middle Florida Keys					
Reference sites	2	1.67	807	12.64	0.25
Conch Reef SPA**	3	2.50	14	0.22	21.43
Conch Reef RO**	3	2.50	6	0.09	50.00
Davis Reef SPA**	2	1.67	9	0.14	22.22
LSG Habitat Total	**17**	**14.17**	**1,599**	**25.04**	**1.06**
Sampling Design Total	**120**	**100.00**	**6,385**	**100.00**	**1.88**

Table 2-2. Chronological list of the 120 sites surveyed for benthic coral reef organisms in the upper Florida Keys National Marine Sanctuary during June-August 2010. Asterisked sites (**) are Sanctuary Preservation Areas (SPA), Ecological Reserves (ER), or Research Only Areas (RO).

Site #	Date	Site location	Latitude (N)	Longitude (W)	Habitat type
631	6/28/2010	Marker 33	25º 08.208	80º 19.871	Mid-channel patch reef
630	6/28/2010	SE of Cannon Patch	25º 06.139	80º 20.630	Mid-channel patch reef
627	6/28/2010	Mosquito Bank	25º 04.451	80º 22.991	Mid-channel patch reef
628	6/28/2010	Mosquito Bank	25º 04.350	80º 22.811	Mid-channel patch reef
643	6/28/2010	White Bank(NW of French)	25º 03.022	80º 21.612	Offshore patch reef
641	6/28/2010	White Bank (West of French)	25º 01.988	80º 22.836	Offshore patch reef
640	6/28/2010	White Bank (West of Molasses)	25º 01.114	80º 25.467	Offshore patch reef
535	6/29/2010	Hen and Chickens Reef	24º 56.262	80º 32.861	Mid-channel patch reef
534	6/29/2010	Hen and Chickens Reef	24º 56.115	80º 32.893	Mid-channel patch reef
533	6/29/2010	West of Conch Reef	24º 56.791	80º 30.129	Mid-channel patch reef
A74	6/29/2010	West of Conch Reef	24º 57.168	80º 30.364	Mid-channel patch reef
A73	6/29/2010	West of Conch Reef	24º 57.529	80º 29.427	Mid-channel patch reef
633	6/30/2010	Basin Hill Shoals	25º 13.250	80º 15.618	Mid-channel patch reef
634	6/30/2010	Basin Hill Shoals	25º 13.772	80º 15.533	Mid-channel patch reef
637	6/30/2010	West of Turtle Rocks	25º 17.210	80º 13.425	Mid-channel patch reef
636	6/30/2010	West of Turtle Rocks	25º 17.713	80º 13.342	Mid-channel patch reef
659	6/30/2010	Turtle Reef	25º 16.976	80º 12.438	Inner line reef tract
649	6/30/2010	West of Carysfort Reef	25º 13.377	80º 13.781	Offshore patch reef
653	6/30/2010	Carysfort Reef	25º 12.501	80º 13.456	Offshore patch reef
648	7/1/2010	East of Basin Hill Shoals	25º 12.895	80º 15.147	Offshore patch reef
715	7/1/2010	North of Carysfort Reef	25º 16.396	80º 11.368	Low-relief spur and groove (6-15 m)
677	7/1/2010	North of Carysfort Reef	25º 15.937	80º 11.659	Low-relief spur and groove (6-15 m)
676	7/1/2010	North of Carysfort Reef	25º 15.740	80º 11.796	Low-relief hard-bottom (6-15 m)
675	7/1/2010	North of Carysfort Reef	25º 14.316	80º 12.084	Low-relief hard-bottom (6-15 m)
701	7/1/2010	Carysfort Reef C5	25º 13.332	80º 12.603	High-relief spur and groove
B67	7/1/2010	Carysfort Reef C2	25º 13.210	80º 12.643	High-relief spur and groove
679	7/2/2010	North Carysfort Reef	25º 13.706	80º 12.224	Low-relief spur and groove (6-15 m)
717	7/2/2010	North Carysfort Reef	25º 13.540	80º 12.437	Low-relief spur and groove (6-15 m)
678	7/2/2010	North Carysfort Reef	25º 12.921	80º 12.669	Low-relief hard-bottom (6-15 m)
716	7/2/2010	South Carysfort Reef	25º 12.245	80º 13.321	Low-relief hard-bottom (6-15 m)
700	7/2/2010	South Carysfort Reef	25º 12.566	80º 13.102	High-relief spur and groove
700A	7/2/2010	South Carysfort Reef	25º 12.412	80º 13.268	High-relief spur and groove
B66	7/2/2010	South of S. Carysfort (Maitland)	25º 11.924	80º 13.531	High-relief spur and groove
B39	7/2/2010	SW Carysfort Reef	25º 12.277	80º 13.727	Offshore patch reef
629A	7/24/2010	Mosquito Bank	25º 04.107	80º 22.986	Mid-channel patch reef
629B	7/24/2010	Mosquito Bank	25º 03.987	80º 22.347	Mid-channel patch reef
629	7/24/2010	Mosquito Bank	25º 03.857	80º 22.555	Mid-channel patch reef
B25A	7/24/2010	Inshore of Molasses Reef	25º 02.463	80º 23.635	Mid-channel patch reef
B25	7/24/2010	Inshore of Molasses Reef	25º 02.342	80º 23.895	Mid-channel patch reef
B25B	7/24/2010	Inshore of Molasses Reef	25º 01.109	80º 26.336	Mid-channel patch reef
638	7/24/2010	Inshore of Pickles Reef	24º 59.513	80º 27.832	Mid-channel patch reef
639	7/24/2010	Inshore of Pickles Reef	24º 59.137	80º 26.178	Offshore patch reef
696	7/25/2010	NE Pickles Reef	24º 59.465	80º 24.748	High-relief spur and groove
695	7/25/2010	Pickles Reef P3	24º 59.244	80º 24.873	High-relief spur and groove
697	7/25/2010	Pickles Reef P1	24º 59.095	80º 24.974	High-relief spur and groove
688A	7/25/2010	Pickles Reef	24º 59.185	80º 25.129	Back reef rubble
688B	7/25/2010	Pickles Reef	24º 59.461	80º 24.949	Back reef rubble
693	7/25/2010	Little Pickles Reef	24º 59.023	80º 25.148	Low-relief hard-bottom (< 6 m)
710	7/25/2010	SW of Molasses Reef SPA	25º 00.453	80º 23.293	Low-relief spur and groove (6-15 m)
706	7/26/2010	Molasses Reef	25º 00.543	80º 22.621	High-relief spur and groove
707	7/26/2010	Molasses Reef	25º 00.617	80º 22.411	High-relief spur and groove
B62	7/26/2010	Molasses Reef	25º 00.664	80º 22.716	Back reef rubble
691	7/26/2010	Molasses Reef	25º 00.738	80º 22.614	Back reef rubble
688	7/26/2010	Sand Island	25º 01.345	80º 22.268	Back reef rubble

Site #	Date	Site location	Latitude (N)	Longitude (W)	Habitat type
711	7/26/2010	Sand Island	25º 01.089	80º 22.099	High-relief spur and groove
712	7/26/2010	SW of French Reef	25º 01.741	80º 21.530	Low-relief hard-bottom (6-15 m)
642	7/26/2010	SE of White Bank Dry Rocks	25º 02.145	80º 21.976	Offshore patch reef
662	7/27/2010	Grecian Rocks	25º 06.532	80º 18.312	Inner line reef tract
663	7/27/2010	Grecian Rocks	25º 06.627	80º 18.236	Inner line reef tract
B42	7/27/2010	Little Grecian Rocks	25º 07.112	80º 18.028	Inner line reef tract
660	7/27/2010	Key Largo Dry Rocks	25º 07.342	80º 17.868	Inner line reef tract
661	7/27/2010	Key Largo Dry Rocks	25º 07.454	80º 17.843	Inner line reef tract
656	7/27/2010	North Dry Rocks	25º 07.803	80º 17.631	Inner line reef tract
657	7/27/2010	North-North Dry Rocks	25º 08.175	80º 17.407	Inner line reef tract
704	7/28/2010	French Reef	25º 02.044	80º 20.944	High-relief spur and groove
705	7/28/2010	French Reef	25º 02.161	80º 20.862	High-relief spur and groove
699	7/28/2010	North of French Reef	25º 02.453	80º 20.703	High-relief spur and groove
664	7/28/2010	North of French Reef	25º 03.128	80º 21.048	Low-relief hard-bottom (< 6 m)
B33	7/28/2010	East of White Bank Dry Rocks	25º 02.122	80º 21.857	Offshore patch reef
689	7/29/2010	Inshore of Dixie Shoal	25º 03.596	80º 19.977	Back reef rubble
665	7/29/2010	Inshore of Dixie Shoal	25º 04.736	80º 20.548	Low-relief hard-bottom (< 6 m)
671	7/29/2010	South of Grecian Rocks	25º 06.045	80º 18.512	Patchy hard-bottom (6-15 m)
702	7/29/2010	Elbow Reef	25º 08.458	80º 15.552	High-relief spur and groove
703	7/29/2010	Elbow Reef	25º 08.752	80º 15.421	High-relief spur and groove
702A	7/29/2010	Elbow Reef	25º 08.811	80º 15.602	Back reef rubble
702B	7/29/2010	Elbow Reef	25º 08.685	80º 15.630	Back reef rubble
B35	7/29/2010	West of Elbow Reef	25º 09.213	80º 16.074	Offshore patch reef
626	7/30/2010	Conch Reef	24º 57.156	80º 27.133	Low-relief spur and groove (6-15 m)
B16	7/30/2010	Conch Reef	24º 57.303	80º 27.361	Low-relief spur and groove (6-15 m)
A86	7/30/2010	Conch Reef C3	24º 57.384	80º 27.421	Low-relief hard-bottom (< 6 m)
555A	7/30/2010	Conch Reef	24º 57.593	80º 27.591	Back reef rubble
555B	7/30/2010	Conch Reef	24º 57.658	80º 27.449	Back reef rubble
625	7/31/2010	Conch Reef	24º 57.031	80º 27.253	Low-relief spur and groove (6-15 m)
610	7/31/2010	Conch Reef	24º 57.169	80º 27.448	Low-relief spur and groove (6-15 m)
555	7/31/2010	Conch Reef C2	24º 57.292	80º 27.504	Low-relief hard-bottom (< 6 m)
708	7/31/2010	NE of Conch Reef	24º 58.028	80º 26.767	Low-relief spur and groove (6-15 m)
B24	8/1/2010	Conch Reef	24º 56.885	80º 27.312	Low-relief spur and groove (6-15 m)
611	8/1/2010	Conch Reef	24º 57.092	80º 27.520	Low-relief spur and groove (6-15 m)
554	8/1/2010	Conch Reef C1	24º 57.139	80º 27.565	Low-relief hard-bottom (< 6 m)
552	8/2/2010	SW of Crocker Reef	24º 52.562	80º 34.563	Patchy hard-bottom (6-15 m)
551	8/2/2010	SW of Crocker Reef	24º 52.621	80º 34.415	Low-relief hard-bottom (6-15 m)
568	8/2/2010	SW of Crocker Reef	24º 53.324	80º 33.581	Low-relief hard-bottom (6-15 m)
569	8/2/2010	SW of Crocker Reef	24º 53.543	80º 33.568	Low-relief hard-bottom (6-15 m)
A931	8/2/2010	SW of Crocker Reef	24º 54.109	80º 32.691	Low-relief hard-bottom (6-15 m)
A932	8/2/2010	Crocker Reef	24º 54.518	80º 31.631	Low-relief hard-bottom (< 6 m)
583	8/2/2010	Crocker Reef	24º 54.519	80º 31.751	Back reef rubble
578	8/2/2010	Crocker Reef	24º 54.650	80º 31.815	Back reef rubble
612	8/4/2010	Davis Reef	24º 55.157	80º 30.349	Low-relief spur and groove (6-15 m)
613	8/4/2010	Davis Reef	24º 55.264	80º 30.349	Low-relief spur and groove (6-15 m)
556	8/4/2010	Davis Reef	24º 55.306	80º 30.367	Low-relief hard-bottom (< 6 m)
A87	8/4/2010	Davis Reef	24º 55.412	80º 30.291	Low-relief hard-bottom (< 6 m)
A84	8/4/2010	Little Conch Reef	24º 56.463	80º 28.657	Low-relief hard-bottom (< 6 m)
A85	8/4/2010	Little Conch Reef	24º 56.568	80º 28.444	Low-relief hard-bottom (< 6 m)
A801	8/4/2010	Inshore of Conch Reef	24º 57.464	80º 29.513	Offshore patch reef
A802	8/4/2010	Inshore of Conch Reef	24º 57.363	80º 29.576	Offshore patch reef
A741	8/26/2010	Tavernier Rocks	24º 56.594	80º 33.376	Mid-channel patch reef
A941	8/26/2010	North of Davis Reef	24º 55.928	80º 29.533	Low-relief hard-bottom (6-15 m)
A942	8/26/2010	Little Conch Reef	24º 56.335	80º 28.709	Low-relief spur and groove (6-15 m)
A94	8/26/2010	Little Conch Reef	24º 56.428	80º 28.515	Low-relief hard-bottom (6-15 m)
579A	8/26/2010	Inshore of Conch Reef	24º 57.586	80º 29.456	Offshore patch reef
579B	8/26/2010	Inshore of Conch Reef	24º 57.673	80º 29.298	Offshore patch reef
579C	8/26/2010	NE of Conch Reef	24º 57.776	80º 27.185	Low-relief hard-bottom (< 6 m)
709	8/27/2010	Pickles Reef	24º 59.031	80º 24.968	Low-relief spur and groove (6-15 m)
B71	8/27/2010	Dixie Shoal	25º 04.670	80º 18.888	Patchy hard-bottom (6-15 m)

Site #	Date	Site location	Latitude (N)	Longitude (W)	Habitat type
B51	8/27/2010	East of Dry Rocks	25º 07.719	80º 17.641	Patchy hard-bottom (6-15 m)
644	8/28/2010	Watson's Reef	25º 10.076	80º 16.062	Offshore patch reef
645	8/28/2010	Watson's Reef	25º 10.249	80º 15.503	Offshore patch reef
B57	8/28/2010	SE of Watson's Reef	25º 09.608	80º 15.180	Patchy hard-bottom (6-15 m)
682	8/28/2010	North of Elbow Reef	25º 09.393	80º 15.255	Patchy hard-bottom (6-15 m)
713	8/28/2010	North of Elbow Reef	25º 09.184	80º 15.447	Patchy hard-bottom (6-15 m)

Table 2-3. Site locations and physical data for benthic surveys in the upper Florida Keys National Marine Sanctuary during June-August 2010. Sites are arranged from southwest to northeast by habitat type. Asterisked sites (**) are Sanctuary Preservation Areas (SPA) or Research Only Areas (RO). Mean ± 1 SE transect depth and maximum vertical relief are based upon surveys of four 15-m x 1-m transects per site.

Site number/site location	Latitude (N)	Longitude (W)	Mean depth (m)	Max. vertical relief (cm)
Inshore and mid-channel patch reefs				
Middle Florida Keys				
A741 – Tavernier Rocks	24º 56.594	80º 33.376	3.6 ± 0.3	95 ± 17
534 – Hen and Chickens SPA**	24º 56.115	80º 32.893	5.6 ± 0.5	171 ± 25
535 – Hen and Chickens SPA**	24º 56.262	80º 32.861	4.5 ± 0.2	243 ± 25
A74 – West of Conch Reef	24º 57.168	80º 30.364	4.0 ± 0.2	53 ± 7
533 – West of Conch Reef	24º 56.791	80º 30.129	6.0 ± 0.2	78 ± 8
A73 – West of Conch Reef	24º 57.529	80º 29.427	3.5 ± 0.2	27 ± 6
Middle Florida Keys Total (6)			4.5 ± 0.4	111 ± 33
Upper Florida Keys				
638 – Inshore of Pickles Reef	25º 59.513	80º 27.832	3.8 ± 0.1	83 ± 15
B25B – Inshore of Molasses Reef	25º 01.109	80º 26.336	2.7 ± 0.1	61 ± 24
B25 – Inshore of Molasses Reef	25º 02.342	80º 23.895	2.9 ± 0.1	50 ± 11
B25A – Inshore of Molasses Reef	25º 02.463	80º 23.635	2.8 ± 0.1	29 ± 7
627 – Mosquito Bank	25º 04.451	80º 22.991	2.4 ± 0.2	78 ± 12
629A – Mosquito Bank	25º 04.107	80º 22.986	2.1 ± 0.1	74 ± 9
628 – Mosquito Bank	25º 04.350	80º 22.811	2.5 ± 0.3	110 ±11
629 – Mosquito Bank	25º 03.857	80º 22.555	2.8 ± 0.1	44 ± 5
629B – Mosquito Bank	25º 03.987	80º 22.347	2.4 ± 0.1	31 ± 18
630 – SE of Cannon Patch Reef	25º 06.139	80º 20.630	3.5 ± 0.2	62 ± 5
631 – Marker 33	25º 08.208	80º 19.871	4.5 ± 0.4	71 ± 10
633 – Basin Hill Shoals	25º 13.250	80º 15.618	2.3 ± 0.2	61 ± 9
634 – Basin Hill Shoals	25º 13.772	80º 15.533	3.4 ± 0.1	73 ± 13
637 – West of Turtle Rocks	25º 17.210	80º 13.425	3.1 ± 0.3	63 ± 11
636 – West of Turtle Rocks	25º 17.713	80º 13.342	3.3 ± 0.3	116 ± 3
Upper Florida Keys Total (15)			3.0 ± 0.2	67 ± 6
Mid-channel Patch Reef Total (21)			**3.4 ± 0.2**	**80 ± 11**
Offshore patch reefs				
Middle Florida Keys				
A802 – Inshore of Conch Reef	24º 57.363	80º 29.576	4.6 ± 0.2	66 ± 10
A801 – Inshore of Conch Reef	24º 57.464	80º 29.513	4.2 ± 0.0	72 ± 12
579A – Inshore of Conch Reef	24º 57.586	80º 29.456	4.3 ± 0.4	102 ± 12
579B – Inshore of Conch Reef	24º 57.673	80º 29.298	3.9 ± 0.1	43 ± 4
Middle Florida Keys Total (4)			4.2 ± 0.1	71 ± 12
Upper Florida Keys				
639 – Inshore of Pickles Reef	24º 59.137	80º 26.178	7.9 ± 0.1	48 ± 7
640 – White Bank (West of Molasses)	25º 01.114	80º 25.467	3.4 ± 0.2	44 ± 8
641 – White Bank (West of Molasses)	25º 01.988	80º 22.836	4.4 ± 0.2	48 ± 3
642 – SE of White Bank Dry Rocks	25º 02.145	80º 21.976	6.8 ± 0.2	100 ±14
B33 – East of White Bank Dry Rocks	25º 02.122	80º 21.857	5.7 ± 0.2	81 ± 14
643 – White Bank (NW of French)	25º 03.022	80º 21.612	4.5 ± 0.1	22 ± 2
B35 – West of Elbow Reef	25º 09.213	80º 16.074	5.0 ± 0.1	136 ±24
644 – Watson's Reef	25º 10.076	80º 16.062	4.4 ± 0.4	114 ± 37
645 – Watson's Reef	25º 10.249	80º 15.503	5.6 ± 0.1	84 ± 17
648 – East of Basin Hill Shoals	25º 12.895	80º 15.147	2.4 ± 0.1	40 ± 10
649 – West of Carysfort Reef	25º 13.377	80º 13.781	2.7 ± 0.2	38 ± 4
B39 – Carysfort Reef SPA**	25º 12.277	80º 13.727	5.1 ± 0.2	59 ± 8
653 – Carysfort Reef SPA**	25º 12.501	80º 13.456	3.6 ± 0.2	64 ± 7
Upper Florida Keys Total (13)			4.7 ± 0.4	67 ± 9
Offshore Patch Reef Total (17)			**4.6 ± 0.4**	**68 ± 8**

Site number/site location	Latitude (N)	Longitude (W)	Mean depth (m)	Max. vertical relief (cm)
Back reef rubble				
Middle Florida Keys				
578 – Crocker Reef	24º 54.650	80º 31.815	5.1 ± 0.2	15 ± 3
583 – Crocker Reef	24º 54.519	80º 31.751	5.7 ± 0.2	24 ± 5
555A – Conch Reef	24º 57.593	80º 27.591	2.1 ± 0.1	18 ± 3
555B – Conch Reef	24º 57.658	80º 27.449	2.5 ± 0.1	29 ± 5
Middle Florida Keys Total (4)			3.8 ± 0.9	22 ± 1
Upper Florida Keys				
688A – Pickles Reef	24º 59.185	80º 25.129	2.6 ± 0.0	31 ± 2
688B – Pickles Reef	24º 59.461	80º 24.949	2.4 ± 0.0	20 ± 2
B62 – Molasses Reef SPA**	25º 00.664	80º 22.716	3.0 ± 0.2	27 ± 3
691 – Molasses Reef SPA**	25º 00.738	80º 22.614	2.9 ± 0.2	21 ± 3
688 – Sand Island	25º 01.345	80º 22.268	2.5 ± 0.1	19 ± 1
689 – Inshore of Dixie Shoal	25º 03.596	80º 19.977	5.8 ± 0.1	25 ± 3
702B – Elbow Reef SPA**	25º 08.685	80º 15.630	3.8 ± 0.1	19 ± 3
702A – Elbow Reef SPA**	25º 08.811	80º 15.602	4.2 ± 0.0	20 ± 2
Upper Florida Keys Total (8)			3.4 ± 0.4	22 ± 0
Back Reef Rubble Total (12)			**3.5 ± 0.4**	**22 ± 0**
Low-relief hard-bottom (< 6 m)				
Middle Florida Keys				
A932 – Crocker Reef	24º 54.518	80º 31.631	3.8 ± 0.0	51 ± 8
556 – Davis Reef SPA**	24º 55.306	80º 30.367	6.4 ± 0.1	67 ± 8
A87 – Davis Reef SPA**	24º 55.412	80º 30.291	5.6 ± 0.0	60 ± 21
A84 – Little Conch Reef	24º 56.463	80º 28.657	3.9 ± 0.3	52 ± 4
A85 – Little Conch Reef	24º 56.568	80º 28.444	4.5 ± 0.1	42 ± 4
554 – Conch Reef C1**	24º 57.139	80º 27.565	5.0 ± 0.1	67 ± 7
555 – Conch Reef C2**	24º 57.292	80º 27.504	5.0 ± 0.2	55 ± 9
A86 – Conch Reef C3**	24º 57.384	80º 27.421	5.9 ± 0.1	79 ± 12
579C – NE of Conch Reef	24º 57.776	80º 27.185	5.1 ± 0.1	48 ± 4
Middle Florida Keys Total (9)			5.0 ± 0.3	58 ± 4
Upper Florida Keys				
693 – Little Pickles Reef	24º 59.023	80º 25.148	4.8 ± 0.1	35 ± 6
664 – North of French Reef	25º 03.128	80º 21.048	4.7 ± 0.2	89 ± 34
665 – Inshore of Dixie Shoal	25º 04.736	80º 20.548	3.9 ± 0.1	26 ± 2
Upper Florida Keys Total (3)			4.5 ± 0.3	50 ± 20
Shallow Hard-bottom Total (17)			**4.9 ± 0.2**	**56 ± 5**
High-relief spur & groove				
Upper Florida Keys				
697 – Pickles Reef P1	24º 59.095	80º 24.974	4.5 ± 0.1	56 ± 12
695 – Pickles Reef P3	24º 59.244	80º 24.873	4.5 ± 0.2	72 ± 9
696 – NE Pickles Reef	24º 59.465	80º 24.748	4.0 ± 0.1	59 ± 11
706 – Molasses Reef SPA**	25º 00.543	80º 22.621	5.4 ± 0.1	208 ± 32
707 – Molasses Reef SPA**	25º 00.617	80º 22.411	4.4 ± 0.3	86 ± 16
711 – Sand Island	25º 01.089	80º 22.099	4.2 ± 0.2	120 ± 18
704 – French Reef SPA**	25º 02.044	80º 20.944	6.2 ± 0.1	118 ± 19
705 – French Reef SPA**	25º 02.161	80º 20.862	5.8 ± 0.4	83 ± 10
699 – North of French Reef	25º 02.453	80º 20.703	3.3 ± 0.4	50 ± 13
662 – Grecian Rocks SPA**	25º 06.532	80º 18.312	3.5 ± 0.1	120 ± 9
663 – Grecian Rocks SPA**	25º 06.627	80º 18.236	2.8 ± 0.2	101 ± 18
B42 – Little Grecian Rocks	25º 07.112	80º 18.028	4.0 ± 0.1	183 ± 15
660 – Key Largo Dry Rocks**	25º 07.342	80º 17.868	3.1 ± 0.2	159 ± 39
661 – Key Largo Dry Rocks**	25º 07.454	80º 17.843	3.1 ± 0.5	130 ± 30
656 – North Dry Rocks	25º 07.803	80º 17.631	3.3 ± 0.1	133 ± 39
657 – North-North Dry Rocks	25º 08.175	80º 17.407	3.8 ± 0.2	123 ± 13
702 – Elbow Reef SPA**	25º 08.458	80º 15.552	6.4 ± 0.1	109 ± 18
703 – Elbow Reef SPA**	25º 08.752	80º 15.421	6.5 ± 0.1	188 ± 19
B66 – South of S. Carysfort	25º 11.924	80º 13.531	3.7 ± 0.2	63 ± 18

Site number/site location	Latitude (N)	Longitude (W)	Mean depth (m)	Max. vertical relief (cm)
700A – South Carysfort Reef**	25º 12.412	80º 13.268	3.4 ± 0.3	86 ± 21
700 – South Carysfort Reef**	25º 12.566	80º 13.102	4.0 ± 0.4	160 ± 30
B67 – Carysfort Reef C2**	25º 13.210	80º 12.643	3.8 ± 0.2	138 ± 28
701 – Carysfort Reef C5**	25º 13.332	80º 12.603	3.7 ± 0.1	174 ± 42
659 – Turtle Reef	25º 16.976	80º 12.438	3.9 ± 0.2	74 ± 12
Upper Florida Keys Total (24)			4.2 ± 0.2	116 ± 9
High-relief Spur & Groove Total (42)			**4.2 ± 0.2**	**116 ± 9**
Deeper Fore-reef (6-15 m)				
Middle Florida Keys				
552 – SW of Crocker Reef	24º 52.562	80º 34.563	8.0 ± 0.1	45 ± 6
551 – SW of Crocker Reef	24º 52.621	80º 34.415	8.8 ± 0.1	26 ± 3
568 – SW of Crocker Reef	24º 53.324	80º 33.581	9.5 ± 0.2	27 ± 12
569 – SW of Crocker Reef	24º 53.543	80º 33.568	8.2 ± 0.1	16 ± 7
A931 – SW of Crocker Reef	24º 54.109	80º 32.691	7.3 ± 0.1	21 ± 7
612 – Davis Reef SPA**	24º 55.157	80º 30.349	10.3 ± 0.1	31 ± 7
613 – Davis Reef SPA**	24º 55.264	80º 30.349	10.7 ± 0.0	35 ± 3
A941 – North of Davis Reef	24º 55.928	80º 29.533	7.7 ± 0.2	53 ± 13
A942 – Little Conch Reef	24º 56.335	80º 28.709	8.1 ± 0.5	54 ± 16
A94 – Little Conch Reef	24º 56.428	80º 28.515	9.6 ± 0.2	36 ± 8
B24 – Conch Reef RO**	24º 57.092	80º 27.520	14.2 ± 0.1	80 ± 14
625 – Conch Reef RO**	24º 57.169	80º 27.448	13.7 ± 0.1	58 ± 6
611 – Conch Reef SPA**	24º 57.303	80º 27.361	9.4 ± 0.1	47 ± 8
626 – Conch Reef RO**	24º 56.885	80º 27.312	13.9 ± 0.1	49 ± 4
610 – Conch Reef SPA**	24º 57.031	80º 27.253	10.5 ± 0.2	50 ± 4
B16 – Conch Reef SPA**	24º 57.156	80º 27.133	11.7 ± 0.0	29 ± 6
Middle Florida Keys Total (16)			10.1 ± 0.6	41 ± 4
Upper Florida Keys				
708 – NE of Conch Reef	24º 58.028	80º 26.767	9.8 ± 0.1	44 ± 4
709 – Pickles Reef	24º 59.031	80º 24.968	9.1 ± 0.0	35 ± 4
710 – SW of Molasses Reef SPA	25º 00.453	80º 23.293	7.2 ± 0.1	38 ± 6
712 – SW of French Reef	25º 01.741	80º 21.530	8.0 ± 0.0	24 ± 5
B71 – Dixie Shoal	25º 04.670	80º 18.888	7.6 ± 0.2	63 ± 5
671 – South of Grecian Rocks	25º 06.045	80º 18.512	8.0 ± 0.1	64 ± 14
B51 – East of Dry Rocks	25º 07.719	80º 17.641	6.9 ± 0.1	36 ± 4
713 – North of Elbow Reef	25º 09.184	80º 15.447	9.0 ± 0.2	56 ± 10
682 – North of Elbow Reef	25º 09.393	80º 15.255	10.5 ± 0.2	41 ± 10
B57 – SE of Watson's Reef	25º 09.608	80º 15.180	10.2 ± 0.2	53 ± 3
716 – South Carysfort Reef**	25º 12.245	80º 13.321	8.9 ± 0.3	35 ± 3
678 – North Carysfort Reef**	25º 12.921	80º 12.669	7.6 ± 0.1	20 ± 5
717 – North Carysfort Reef**	25º 13.540	80º 12.437	8.3 ± 0.2	33 ± 6
679 – North Carysfort Reef**	25º 13.706	80º 12.224	7.8 ± 0.1	43 ± 6
675 – North of Carysfort Reef	25º 14.316	80º 12.084	8.0 ± 0.2	57 ± 7
676 – North of Carysfort Reef	25º 15.740	80º 11.796	9.9 ± 0.1	48 ± 9
677 – North of Carysfort Reef	25º 15.937	80º 11.659	10.4 ± 0.2	28 ± 2
715 – North of Carysfort Reef	25º 16.396	80º 11.368	9.1 ± 0.1	50 ± 6
Upper Florida Keys Total (18)			8.7 ± 0.3	43 ± 3
Deeper Fore-reef Total (34)			**9.4 ± 0.3**	**42 ± 3**

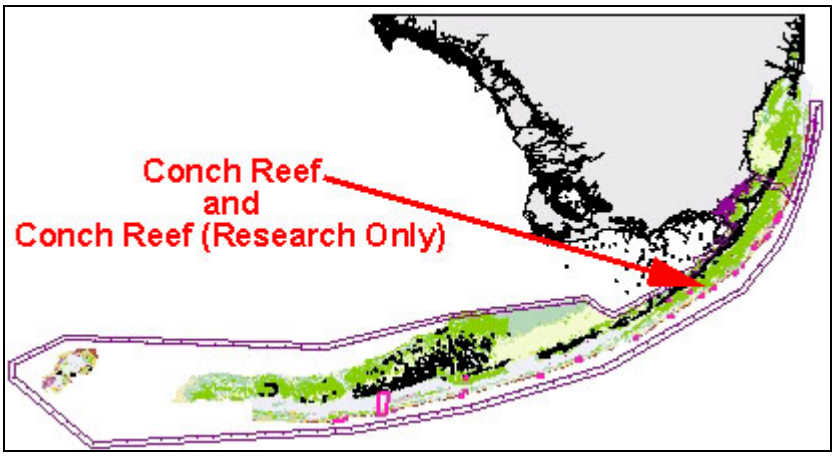
Table 2-4. SCUBA diving effort for benthic coral reef surveys in the upper Florida Keys National Marine Sanctuary during June-August 2010.

Scientific Diver	Affiliation	No. of dives	Depth range (m)	Bottom time
Mark Chiappone	CMS/UNCW	120	2.4-14.6 m	68 hr 52 min
Leanne Rutten	CMS/UNCW	104	2.7-14.9 m	59 hr 48 min
Thor Dunmire	CMS/UNCW	16	2.4-14.9 m	8 hr 31 min
Total all divers		240	0.5-16.8 m	137 hr 11 min

III. Benthic Surveys at Conch Reef

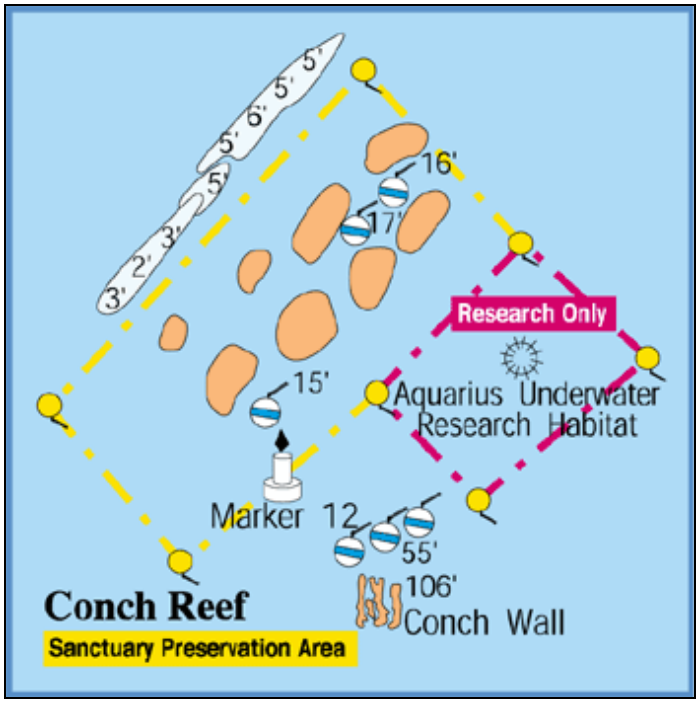
Background

Part of the focus of the 2010 benthic surveys in the upper Florida Keys region was to quantify the abundance, size, and condition of coral reef benthos along a depth gradient at Conch Reef. Conch Reef is a platform margin reef southeast of Plantation Key located between Little Conch Reef and Davis Reef to the southwest and Pickles Reef to the northeast (see figure below). The main reef is located about 9 km (5 nautical miles) south of Tavernier Key and is a continuation of the Florida Reef Tract, a semi-continuous series of offshore bank-barrier reefs beginning at Fowey Rocks in northern Biscayne National Park. Inshore of Conch Reef is a mosaic of sparse to dense seagrass, bare sand, rubble, and offshore patch reefs that extend into Hawk Channel as one approaches the shoreline.



Behind the main reef is a back-reef rubble zone shoreward of the mooring buoys and outside of the Sanctuary Preservation Area (SPA) (see figure below). An inshore ledge marks the shoreward side of the main reef, demarcated by three vessel mooring buoys, which then grades into a low-relief hard-bottom habitat dominated mostly by algae and gorgonians. The inshore ledge has a vertical face roughly 1.5-2.0 m in vertical relief and consists of relict (very old) and flattened elkhorn coral, with numerous holes and crevices. This ledge structure is also present at Little Conch, Davis Reef, Crocker Reef, and Alligator Reef (Robbin 1981) and represents a series of once-flourishing elkhorn coral reef flats that became senescent upon the formation of Florida Bay ~3,500 years ago. The shallow (< 6 m) hard-bottom habitat extends seaward into a low-relief spur and groove and hard-bottom habitat to the seaward boundary of the SPA. Adjacent to the seaward edge of the SPA is the Research Only Area (RO), which begins as a low-relief spur and groove and hard-bottom habitat on the shoreward side of the RO that extends offshore to ~21-m water depth. The Aquarius undersea habitat is found near the central area of the RO and has been

at this location since 1992 (see www.uncw.edu/aquarius for more information on Aquarius Reef Base, ARB). Seaward of the Aquarius habitat is Conch Wall, a nearly vertical escarpment that plunges to 30-m water depth outside of the RO.



The purpose of the benthic surveys at Conch Reef during July-August 2010 was to provide current information on the species richness, cover, density, and size of benthic coral reef organisms across the reef area. Our program has sampled Conch Reef several times in multiple habitats from < 6 m to 15 m depth since 1999, including two Aquarius missions carried out in 2002 and 2003. Further information on the history of research in this area is available through NOAA's National Undersea Research Program at the University of North Carolina at Wilmington (www.uncwil.edu/nurc/) and previous quick look and data summary reports by our program (people.uncw.edu/millers) provide site-level data dating back to 1999 for Conch Reef specifically and for our Keyswide efforts in general. During the 2010 fieldwork, we were able to allocate three full days of sampling at Conch Reef (Figure 3-1), including sites within the SPA and RO from the inshore edge of the reef out to the depth contour of the Aquarius habitat (Figure 3-1). Based upon logistics, we were able to sample three sites in each of three depth intervals or zones across Conch Reef as follows:

- Three sites along the shallow, inshore ledge from the northeastern (mooring buoy C1) to the central (C2) to the southwestern (C3) extent of the ledge within the SPA (Figure 3-2);

- Three sites offshore of the ledge area in the low-relief spur and groove habitat within the SPA (Figure 3-3);
- Three sites along the depth contour of the Aquarius undersea laboratory in the low-relief spur and groove habitat within the RO, seaward of the SPA (Figure 3-4).

Thus, the sampling plan consisted of three sites sampled in each depth zone across Conch Reef from the shallow, inshore ledge to the depth contour of Aquarius, for a total of nine sites. Logistical constraints prevented us from sampling the 22-27 m depth range at Conch RO in 2010, which were previously surveyed during Aquarius missions in 2002 and 2003.

At each site in each depth zone, four 15-m transects were deployed in an inshore-to-offshore configuration. On the shallower (< 6 m) area of Conch Reef SPA, transects were placed on the inshore edge of the ledge and orientated seaward. On low-relief spur and groove habitats in Conch Reef SPA and RO, transects were placed from inshore to offshore along the low-profile spurs. Transects were used to sample the following variables:

- Minimum and maximum depth along each transect, as well as the maximum vertical relief, including substratum features such as reef framework, coral heads, and sponges;
- Numbers of species and transect frequency of occurrence for sponges, stony corals, and gorgonians in 15-m x 1-m belt transect areas along each transect;
- Benthic cover of abiotic and biotic components, in which 100 points were sampled every 15 cm along each of the four transects per site (i.e. 400 points assessed per site);
- Numbers, sizes (diameter, height), estimated live vs. dead tissue surface area, and condition (e.g. bleaching, disease, predation, and overgrowth) of all stony corals (Milleporina and Scleractinia) by species (> 4 cm in max. diameter) in 10-m x 1-m belt transect areas along two of the four transects per site;
- Numbers and maximum diameter of all juvenile (< 4 cm max. diameter) scleractinian corals by species that were clearly the result of sexually-derived recruitment and not fragmentation in ten 0.65-cm x 0.48-cm quadrats per transect along two transects per site;
- Numbers of gorgonians by species in 8-m x 1-m belt transect areas along two of the four transects per site, including both branching and encrusting species;
- Numbers and test diameters of all urchins by species in 15-m x 1-m belt transect areas along all four transects per site;

- Numbers of all corallimorpharians and most anemones by species in 15-m x 1-m belt transect areas along all four transects per site;
- Numbers and total or shell lengths of selected mollusks, including nudibranchs, lettuce sea slugs (*Elysia crispata*), and selected gastropods (*Coralliophila* sp., *Leucozonia nassa*, *Thais deltoidea*) by species in 15-m x 1-m belt transect areas along all four transects per site;
- Transect frequency of occurrence, density, and biological impacts of all marine debris, including lost fishing gear, in 15-m x 1-m belt transect areas along all four transects per site.

Note that the data on *Acropora* corals, urchins, anemones and corallimorpharians, selected mollusks, and marine debris are presented in other sections of this report with the remaining 111 upper Keys sites. The sections below highlight aspects of the composition of benthic coral reef organisms at the nine sites across Conch Reef.

Depth and Topographic Complexity

Table 3-1 lists the depth and maximum vertical relief data for the nine sites sampled across Conch Reef comprising shallow (< 6 m) hard-bottom and deeper low-relief spur and groove habitats. Figure 3-5 illustrates the depth and maximum vertical relief data for individual sites and pooled sites by depth range. The average maximum vertical relief was greatest (67 ± 7 cm) at shallow Conch SPA, followed by Conch RO (62 ± 9 cm) (Table 3-1). At shallow Conch Reef SPA, higher (> 75 cm) vertical relief features were associated with pillar coral stands near mooring C1 and the inshore ledge (Figure 3-2), while higher vertical relief features in Conch Reef RO consisted of *Xestospongia muta* sponges or the occasional large (> 1 m high) *Montastraea faveolata* coral head (Figure 3-4). Vertical relief was lowest in the deeper area of Conch Reef SPA and consisted of low-profile features (< 30 cm high) such as smaller *X. muta* sponges and colonies of *Solenastrea bournoni* (Figure 3-3).

Species Richness of Sponges, Stony Corals, and Gorgonians

Species richness surveys consisted of assessments of the presence-absence and transect frequency of occurrence (% of transects present) of all stony coral, gorgonian, and sponge taxa encountered in four 15-m x 1-m belt transects per site. Data presented below are reported as the total numbers of species recorded from 60-m^2 sampling areas per site, as well as the totals numbers of species and the averages of three sites for species richness and frequency of occurrence in each depth interval across Conch Reef. Table 3-2 provides site-level species richness data for stony corals, gorgonians, and sponges at the three shallow Conch Reef SPA sites, while Tables 3-3 and 3-4 provide species richness data for deeper Conch Reef SPA and Conch Reef RO, respectively. Figure 3-6 illustrates total species richness and averages for each

depth interval. Sponge species richness exhibited a clear depth-related trend (Figure 3-6, top), with relatively fewer species encountered at shallow Conch SPA and the most number of sponge species along the 12-15 m depth contour within Conch RO. For stony corals, a similar depth-related pattern was also evident, but with only slightly greater numbers of species encountered with increasing depth (Figure 3-6, middle). A different pattern was evident for gorgonian species richness, where more species were encountered in deeper Conch SPA, followed by shallower Conch SPA and Conch RO (Figure 3-6, bottom).

Along the shallow ledge of Conch SPA, a total of 32 sponge, 22 stony coral, and 21 gorgonian taxa were encountered across the three sites (Table 3-2). Total numbers of species for all three groups were generally similar from the northeastern to the southwestern area of the reef. The most frequently encountered sponges were *Agelas wiedenmayaari* (present on 92% ± 8% of transects), *Amphimedon compressa* (92% ± 8%), *Ircinia felix* (83% ± 17%), and *Ulosa rüetzleri* (75% ± 14%), all of which exhibit an encrusting morphology in this particular habitat. Most other sponges were relatively rare (present on < 10% of the sampled transects). The most frequently encountered stony corals were *Millepora alcicornis* (100% ± 0% of transects), *Siderastrea siderea* (92% ± 8%), *Agaricia agaricites* (83% ± 8%), and *M. complanata* (67% ± 8%) (Table 3-2). Note from Table 3-2 that both *Acropora* species were present on shallow Conch SPA, as well as *Dendrogyra cylindrus*. The most frequently encountered gorgonians were *Gorgonia ventalina* (100% ± 0%), *Pseudopterogorgia americana* (100% ± 0%), *Eunicea tourneforti* (92% ± 8%), and *Muricea muricata* (92% ± 8%).

Proceeding seaward of the mooring buoys at shallow Conch SPA, the deeper (8-12 m) low-relief spur and groove habitat within Conch SPA yielded greater sponge species, but similar total numbers of stony corals and gorgonians compared to the shallower reef (Figure 3-6). A total of 43 sponge, 21 stony coral, and 21 gorgonian taxa were encountered across the three sites sampled in deeper Conch SPA (Table 3-3). Stony coral and gorgonian species richness were similar to shallow Conch SPA, but sponge species richness was substantially greater (43 species encountered vs. 32 species at shallow Conch SPA). Total numbers of species for all three groups were similar from the northeastern to the southwestern area of the reef. The most frequently encountered sponges were *Amphimedon compressa* (100% ± 0% of transects), *Aplysina cauliformis* (100% ± 0%), *Niphates digitalis* (100% ± 0%), *Ircinia felix* (92% ± 8%) and *Xestospongia muta* (92% ± 8%). In contrast to shallower Conch SPA, the deeper area of Conch SPA has a greater prevalence of vase and massive species, reflecting, perhaps, less wave exposure or some other factor that precludes many globular, vase, tube, and branching species from occurring on the shallower reef area. The most frequent story corals were *Millepora alcicornis* (100% ± 0%), *Siderastrea radians*

(100% ± 0%), *Agaricia agaricites* (92% ± 8%), *Porites astreoides* (92% ± 8%), and *Siderastrea siderea* (92% ± 8%) (Table 3-3). *Montastraea cavernosa* and *Stephanocoenia michelini* were more frequently encountered in this habitat compared to shallower Conch SPA. Common gorgonians were *Muricea elongata* (100% ± 0%) and two sea plume species, *Pseudopterogorgia acerosa* (100% ± 0%) and *P. americana* (100% ± 0%). Four other gorgonian species were found on 92% ± 8% of the sampled transects (Table 3-3).

Along the 12-15 m depth contour within Conch Reef RO, a total of 43 sponge, 24 stony coral, and 21 gorgonian taxa were encountered across the three sites (Table 3-3). Total species richness for stony corals and gorgonians were similar to deeper Conch SPA, but slightly greater numbers of stony coral taxa (24 species) were encountered in the RO compared to the 21 species encountered within the SPA (Figure 3-6). The most frequently encountered sponges were *Amphimedon compressa* (100% ± 0% of transects), *Aplysina cauliformis* (100% ± 0%), *Ircinia strobilina* (100% ± 0%), *Niphates digitalis* (100% ± 0%), and *N. erecta* (100% ± 0%), *I. felix* (92% ± 8%) and *Ulosa rüetzleri* (92% ± 8%). Similar to deeper Conch SPA, the depth range sampled in Conch RO contains a greater prevalence of rope, vase, and massive sponges (Table 3-4). The most frequently encountered corals were *Millepora alcicornis* (100% ± 0%) and *Siderastrea siderea* (100% ± 0%), followed by *Porites astreoides* (92% ± 8%) and *Stephanocoenia michelini* (92% ± 8%) (Table 3-3). Species encountered in Conch Reef RO, but not found in the Conch Reef SPA, included *Agaricia lamarcki*, two *Mycetophyllia* species, and the entire *Montastraea* species complex, including *M. annularis*, *M. faveolata*, and *M. franksi*. The most common gorgonians were *Erythropodium caribaeorum* (100% ± 0%) and three sea plume species (*Pseudopterogorgia acerosa*, *P. americana*, and *P. bipinnata*), all of which were found on every sampled transect in Conch RO. Encrusting gorgonians, in particular *E. caribaeorum* and the encrusting form of *Briareum asbestinum*, were more commonly encountered in Conch RO compared to Conch SPA, while sea fans (*Gorgonia ventalina*) were less prevalent (Table 3-4).

Benthic Cover

Coverage of abiotic (e.g. sand and rubble) and biotic components of the substratum was assessed at each of the nine sites among three depth zones at Conch Reef SPA and RO by determining the bottom type every 15 cm per 15-m transect (100 points per transect) along four transects per site. Thus, a total of 400 points were assessed per site, yielding 1,600 points of coverage data for all three sites combined in each of the three depth zones. Mean coverage values for abiotic and biotic components for shallow Conch Reef SPA, deeper Conch Reef SPA, and Conch Reef RO are shown in Tables 3-5, 3-6, and 3-7, respectively. Figure 3-7 illustrates depth-related patterns in mean coverage (%) of stony corals, sponges, and the

colonial zoanthid *Palythoa*, while Figure 3-8 shows mean coverage patterns across Conch Reef for algal turf, crustose coralline, and macroalgal functional groups.

Mean coverage (%) of abiotic and biotic components of the substratum at shallow Conch Reef SPA is provided in Table 3-5. Mean stony coral cover ranged from 1.25% to 3.5% among the three sites, with increasing stony coral cover apparent from the northeastern to the southwestern area of the shallow reef (Figure 3-7, top). Stony coral cover was mostly comprised of milleporid hydrocorals, followed by *Siderastrea siderea* (Table 3-5). Mean sponge cover ranged from 0.75% to 5%, while *Palythoa* cover ranged from 3.5% to 7%. Total sponge cover across all three sites was similar to stony coral cover (2.25%), while *Palythoa* cover was slightly greater (4.83%). Encrusting gorgonians were relatively rare (< 1%), while branching gorgonians comprised upwards of 5% of the benthic cover. Total algal cover was quite high, ranging from 74% to 81.5%. Across all three sites, most of the total algal cover was comprised of various macroalgae (48.7% of the total algal cover), followed by algal turf (38.2% of the total) and crustose coralline algae (12.8% of the total). Two trends across shallow Conch Reef SPA were apparent in terms of algae: crustose coralline algal cover was more than three times greater near the southwestern extent of the reef, while macroalgal cover, especially *Dictyota* spp., was about twice as high near the northeastern extent of the reef (Figure 3-8).

Mean coverage of abiotic and biotic components in the low-relief spur and groove habitat towards the seaward end of Conch Reef SPA is provided in Table 3-6. Mean stony coral cover ranged from 1% to 1.75% among the three sites and overall was slightly lower than at shallower Conch Reef SPA (Figure 3-7, top). Similar to shallower Conch Reef SPA, stony coral cover increased slightly from the northeastern to the southwestern extent of the low-relief spur and groove habitat (Figure 3-7, top) and was mostly comprised of milleporid hydrocorals, followed by *Siderastrea siderea* (Table 3-6). Mean sponge cover ranged from 4% to 8%, while *Palythoa* mean cover ranged from 0% to 1%; thus, sponge cover was greater in deeper Conch Reef SPA, while *Palythoa* cover was lower compared to the shallower portion of the reef (Figure 3-7). Encrusting gorgonians on deeper Conch Reef SPA were relatively rare (< 1%), while branching gorgonians comprised upwards of 2.75% of the benthic cover. Algae were the dominant bottom type on deeper Conch Reef SPA (Table 3-6); mean cover ranged from 59.75% to 72.75% across the three sites. Most of the total algal cover was comprised of various macroalgae (52.8% of the total algal cover), followed by algal turf (44.4% of the total). In contrast to shallower Conch Reef SPA, crustose coralline algae comprised < 1% of the substratum and accounted for only 1.4% of the total algal cover (Figure 3-8). Two spatial patterns in algal cover were apparent across deeper Conch Reef SPA: the

predominance of algal turf towards the northeastern extent of the reef and the relatively higher cover by macroalgae, especially *Dictyota* spp., towards the southwestern area of the reef (Figure 3-8).

Table 3-7 lists the coverage values for abiotic and biotic components along the 12-15 m depth contour within Conch Reef RO. Mean stony coral cover ranged from 3.25% to 6.25% among the three sites and thus was slightly greater than in either of the two habitats surveyed in Conch Reef SPA (Figure 3-7, top). However, mean coral cover for all three sites combined was still < 5%. Similar to Conch Reef SPA, total stony coral cover in Conch Reef RO was mostly represented by milleporid hydrocorals, followed by *Siderastrea siderea*, but also *Stephanocoenia michelini* (Table 3-7). The most distinctive difference between Conch RO and Conch Reef SPA is the relatively high coverage by sponges in the former area (Figure 3-7), which, next to algae, are the second most abundant group in terms of benthic cover. Mean sponge cover among the three sites sampled within Conch Reef RO ranged from 9.25% to 11.25%. In contrast to Conch Reef SPA, encrusting gorgonians in Conch Reef RO were more abundant, with mean coverage ranging from 3% to 4.5% across the three sites (Table 3-7); this pattern reflects the greater abundance of *Erythropodium caribaeorum* and the encrusting form of *Briareum asbestinum*. Branching gorgonians comprised upwards of 4.75% of the substratum. Like Conch Reef SPA, algae were the dominant bottom type within Conch Reef RO (Table 3-7), although total algal cover was slightly lower, averaging 66.3% across the three sites. Most of the total algal cover was comprised of various macroalgae (68.8% of the total algal cover), followed by algal turf (15.2% of the total) and crustose coralline algae (12.8%). Similar to shallower Conch Reef SPA, crustose coralline algae comprised up to 9.75% of the substratum at particular sites within Conch Reef RO (Figure 3-8).

Coral Density

The density, size, and condition of stony corals (Milleporina and Scleractinia) greater than 4 cm in maximum diameter was assessed within two 10-m x 1-m belt transect areas per site among three sites in three depth intervals across Conch Reef. Thus, a total sample size of 20 m^2 was surveyed per site (60 m^2 per depth interval). Colonies were considered to be continuous skeletal units that may have had more than one patch of live tissue (physiological colonies). For each colony, measurements were made of size (min. diameter, max. diameter, and height), the percentage of the colony that was dead (recent and older), as well as condition assessments that included bleaching, disease, predation, and overgrowth. Table 3-8 provides numbers, relative abundance, and mean densities (no. per m^2) of all corals encountered within sampled belt transects for each of the depth intervals sampled across Conch Reef, while Figure 3-9 illustrates mean density patterns for milleporid hydrocorals, total scleractinian corals, and *Siderastrea siderea*, the most abundant scleractinian coral at Conch Reef. Table 3-9 lists the numbers, relative

abundance, and mean density values for eleven coral species encountered at Conch Reef that can attain larger colony sizes that are mostly represented by mounding or haystack morphologies.

A total of 308 stony corals were counted and measured across the three sites at shallow Conch Reef SPA, with a total of 15 coral taxa represented by two milleporid hydrocoral species and 13 scleractinian species (Table 3-8). For all three sites combined, *Millepora alcicornis* was the most abundant (137 colonies, 44.5% of the total), with an overall mean density of 2.28 ± 0.59 colonies per m^2. Milleporid hydrocorals comprised 54.2% of the total colonies encountered. Relatively abundant scleractinian corals were represented by three species that comprised ~38% of the total stony corals counted and ~82% of all scleractinians: *Agaricia agaricites* (51 colonies, 16.6%), *Siderastrea siderea* (48 colonies, 15.6%), and *Porites astreoides* (17 colonies, 5.5%). Mean stony coral densities did not vary substantially (5.05 to 5.25 per m^2) across shallow Conch Reef SPA (Table 3-8); however, mean densities of *Millepora* corals were four times greater in the central region of the SPA near mooring buoy C2, while scleractinian densities were lowest in this area (Figure 3-9). The only relatively abundant and large coral at shallow Conch Reef SPA is *S. siderea*, whose densities were greatest in the northeastern area of the SPA near mooring buoy C1, followed by the southwestern area near mooring buoy C3 (Figure 3-9). Roughly 85% of the 48 colonies measured among all three sites at shallow Conch Reef SPA were between 4 cm and 15 cm in maximum diameter, with the balance in the 15 cm to 50 cm size interval (Table 3-9). Other massive corals were either absent or only represented by one or a few colonies across all three sampling locations.

The coral assemblage within the low-relief spur and groove habitat in deeper (6-15 m) Conch Reef SPA was characterized by similar numbers of species (Table 3-8), but greater site-level densities (Figure 3-9) for both *Millepora* spp. and scleractinian corals compared to shallow Conch Reef SPA. A total of 350 colonies were measured among the three sites combined, with total site-level densities ranging from 2.6 to 8.1 colonies per m^2 (Table 3-8). *Millepora alcicornis* was the most abundant stony coral (214 colonies, 61.1% of the total), with a pooled mean density of 3.57 ± 1.05 colonies per m^2. Relatively abundant scleractinian corals were also similar to the shallower reef area and comprised ~73% of all scleractinians: *Siderastrea siderea* (41 colonies, 11.7%), *Agaricia agaricites* (23 colonies, 6.6%), *Porites astreoides* (18 colonies 5.1%), and *Stephanocoenia michelini* (17 colonies, 4.9%). Fewer stony corals were encountered in the northeastern area of the SPA compared to areas offshore or mooring buoys C2 and C3 (Figure 3-9). Densities by size class for *S. siderea* on deeper Conch Reef SPA were similar to the shallower reef (Table 3-9). Notable differences between shallower and deeper Conch Reef SPA included greater densities of several species in the deeper, low-relief spur and groove habitat, particularly *M. alcicornis*, *P. porites*, and

S. michelini. In contrast, the overall mean density of *A. agaricites* was more than two times greater on shallower Conch Reef.

The three sites sampled within the 12-15 m depth interval in Conch Reef RO yielded a total of 600 stony corals, represented by one *Millepora* species and 18 scleractinian species (Table 3-8). Stony coral density was clearly greater in Conch Reef RO compared to either depth interval in Conch Reef SPA for both *Millepora* and total scleractinians (Figure 3-9). However, relative abundance patterns were mostly similar, with *M. alcicornis* the most abundant coral (379 colonies, 57.4% of the total), followed by three species that comprised ~71% of all scleractinian corals: *Siderastrea siderea* (83 colonies, 12.6% of all stony corals), *Agaricia agaricites* (63 colonies, 9.5%), and *Porites astreoides* (53 colonies, 8%) (Table 3-8). Comparisons to the low-relief spur and groove habitat in Conch Reef SPA illustrate that several corals are more abundant in Conch Reef RO: *M. alcicornis* (6.32 vs. 3.57 per m^2), *A. agaricites* (1.05 vs. 0.38 per m^2), *Madracis decactis* (0.12 vs. 0.02 per m^2), *P. astreoides* (0.88 vs. 0.30 per m^2), *S. siderea* (1.38 vs. 0.68 per m^2), and *Stephanocoenia michelini* (0.60 vs. 0.28 per m^2) (Table 3-8). Several species in Conch Reef RO were not encountered in the shallower or deeper portions of the SPA, including several massive framework species such as *Diploria labyrinthiformis*, *D. strigosa*, *Montastraea annularis*, and *M. faveolata* (Table 3-9). However, densities among size classes were generally similar for some of the common massive corals (e.g. *S. siderea*) found across all three depth intervals sampled.

Juvenile Scleractinian Corals

Juvenile scleractinian corals were sampled along two 15-m transects per site at three sites in each of the three depth intervals across Conch Reef, by randomly placing and sampling ten 0.65-cm x 0.48-cm quadrats along each transect (6.24 m^2 area per site). The majority of corals less than four cm in maximum diameter encountered in the quadrats were considered recruits or juveniles. Newly settled corals are visible in the field at approximately 1-10 mm diameter, corresponding to an age less than one year old, while colonies approaching four cm in diameter are approximately 1-3 years old. As colonies attain larger sizes, it becomes difficult to distinguish recently settled recruits from colonies resulting from fragmentation. Larval recruits can be distinguished from new daughter colonies because they are smaller than post-fission products, most are roughly circular in shape, and recruits generally settle on coralline rock made by different species. Based on previous studies of the size at first reproduction of Caribbean reef corals, we used the 4-cm size criterion as a conservative estimate of juvenile coral abundance. Although *Siderastrea radians* and *Favia fragum* reproduce at smaller sizes (< 2 cm diameter), colonies of these species were incorporated into the juvenile surveys. Juveniles of all scleractinian corals found were identified to the lowest taxonomic level possible in the field. Table 3-10 provides the total numbers,

relative abundance, and mean densities of all juvenile scleractinian corals encountered at Conch Reef, while Figure 3-10 illustrates spatial patterns within each depth interval and across the reef from shallow Conch SPA to the 12-15 m depth contour within the RO.

A total of 56.16 m^2 of substratum was sampled for juvenile scleractinian corals at Conch Reef during 2010, with a total of 203 juveniles represented by 13 coral taxa encountered from surveys of nine sites. Juvenile size (max. diameter) ranged from 0.4 cm to 3.9 cm and averaged 2.18 ± 0.06 cm, with approximately 47% of the juvenile corals 2.0 cm or smaller in maximum diameter. Differences in total mean juvenile coral densities were clearly apparent from the shallower area of Conch Reef SPA to the 12-15 m depth interval in Conch Reef RO (Figure 3-10, middle). A total of 38 juveniles representing seven coral taxa were encountered among three sites at shallower Conch Reef SPA, with an overall mean density of 2.72 ± 1.12 juveniles per m^2 (Table 3-10). Mean juvenile densities were at least 2.5 times greater in the northeastern (i.e. mooring buoy C1) and the southwestern (i.e. mooring buoy C3) areas of the reef compared to the central reef area (Table 3-10 and Figure 3-10, middle). A similar pattern was evident in the number of coral species encountered as juveniles (Figure 3-10, top). For all three sites combined at shallow Conch Reef SPA, *Agaricia agaricites* (18 juveniles, 47.4% of the total) and *Siderastrea radians* (7 juveniles, 18.4%), both of which are brooding species, were the most abundant, comprising ~66% of all juvenile corals encountered (Table 3-10). Juveniles of broadcasting coral species were relatively rare (8 juveniles, 21%) and represented by just three species.

In the low-relief spur and groove habitat (6-15 m depth) at Conch Reef SPA, mean juvenile density was slightly higher (3.10 ± 1.45 per m^2) compared to the shallower reef (Table 3-10), with more species encountered as juveniles (Figure 3-10, top). Mean juvenile coral density was 2.9 to 5.3 times greater in the central area of deeper Conch SPA compared to the northeastern and southwestern areas, a pattern opposite to that on the shallower reef (see above). A total of 58 juveniles among ten coral taxa were found in deeper Conch Reef SPA among the three sites. Four species, two of which are broadcast spawning corals, accounted for ~71% of the juvenile corals: *Siderastrea radians* (17 juveniles, 29.3% of the total), *Porites astreoides* (12 juveniles, 20.7%), *Montastraea cavernosa* (6 juveniles, 10.3%), and *S. siderea* (6 juveniles, 10.3%) (Table 3-10). Mean density of *Agaricia agaricites* was more than 3.5 times lower in the deeper area of Conch Reef SPA (0.27 ± 0.09 per m^2) compared to the shallower hard-bottom area (0.96 ± 0.52 per m^2) (Table 3-10). However, several species were more abundant in the deeper area of Conch Reef SPA compared to the shallower reef: *M. cavernosa*, *P. astreoides*, *S. radians,* and *S. siderea*.

The three sites sampled from 12-15 m depth within Conch Reef RO yielded relatively similar numbers of species as the two depth intervals within Conch Reef SPA (Figure 3-10, top), but there were substantially greater mean juvenile densities for most sites (Table 3-10) and for all three sites combined in the RO (Figure 3-10, middle). A total of 107 juvenile corals represented by nine taxa were encountered among the three RO sites, with mean site-level density ranging from 1.92 ± 0.32 juveniles per m^2 in the southwestern area of the reef to 8.49 ± 4.01 per m^2 in the central area of the reef. The mean density for all three sites (5.72 ± 1.96 per m^2) was 1.9-2.1 times greater than for the two habitats sampled within Conch Reef SPA. Three species comprised ~77% of all juvenile corals: *Siderastrea siderea* (49 juveniles, 45.8% of the total), *Porites astreoides* (21 individuals, 19.6%), and *Agaricia agaricites* (12 juveniles, 11.2%) (Table 3-10). Compared to the shallower and deeper areas of Conch Reef SPA, juveniles of *Dichocoenia stokesi* and *Montastraea faveolata* were only found in the RO. In addition, juveniles of *M. cavernosa*, *P. astreoides*, *S. siderea*, and *Stephanocoenia michelini* were also more abundant in the RO.

Gorgonian Density

In addition to species richness surveys (see above), gorgonians (Octocorallia) were also sampled for colony numbers across Conch Reef. Gorgonian densities (no. per m^2) were estimated for each of the nine sites sampled among the three depth intervals at Conch Reef by surveying 8-m x 1-m belt transect areas along two transects per site, thus yielding a sample size of 16-m^2 per site, 48-m^2 per depth interval, and 144-m^2 for all sites combined. Table 3-11 provides total numbers of colonies encountered, relative abundances, and mean densities by species, while Figure 3-10 (bottom) shows mean gorgonian densities across Conch Reef. Total gorgonian densities were more or less similar from shallow Conch Reef SPA seaward to the RO, although some differences were apparent within depth intervals from the northeastern to the southwestern areas of the reef (Figure 3-10, bottom).

Within the shallow (< 6 m) hard-bottom habitat of Conch Reef SPA, a total of 557 gorgonian colonies represented by 20 species were enumerated (Table 3-11). Mean site-level densities ranged from 7.63 ± 1.63 colonies per m^2 in the northeastern area of the reef near the C1 mooring buoy to 18.06 ± 6.56 colonies per m^2 in the central area of the reef near C2. Two species accounted for ~79% of all gorgonians counted at shallow Conch Reef SPA: *Gorgonia ventalina* (242 colonies, 43.4% of the total) and *Pseudopterogorgia americana* (197 colonies, 35.4%). For all three sites combined, this translates into a mean density of nearly five sea fans per m^2 and roughly four slimy sea plumes per m^2.

Within the low-relief spur and groove habitat of deeper Conch Reef SPA, overall mean gorgonian density was similar to the shallower reef (Figure 3-10, bottom), although site-level densities showed greater

variability, ranging from 6.25 ± 1.13 colonies per m^2 in the northeastern area of the reef to 16.00 ± 1.25 per m^2 in the central area of the SPA (Table 3-11). A total of 596 gorgonian colonies among 19 taxa were encountered. In contrast to the shallower area of Conch Reef, the low-relief spur and groove habitat was dominated by sea plumes (*Pseudopterogorgia* spp.), which comprised ~64% of all gorgonians (Table 3-11). Several species exhibited greater densities in the deeper SPA area compared to the shallower reef: *Erythropodium caribaeorum*, *Eunicea fusca*, *Muricea elongata*, *P. acerosa*, and *P. americana*. Other species, namely *Gorgonia ventalina* and *Muricea muricata*, were less abundant.

The three low-relief spur and groove sites sampled across Conch Reef RO from 12-15 m depth yielded 456 gorgonian colonies among 17 species (Table 3-11). Total mean gorgonian density was slightly lower in the RO (9.50 ± 0.65 per m^2) compared to shallower (11.60 ± 3.26 per m^2) and deeper (12.42 ± 3.10 per m^2) Conch Reef SPA (Figure 3-10, bottom). Site-level mean gorgonian density was more or less similar among the three sites sampled across the RO (Table 3-11). Of the 456 gorgonians enumerated, sea plumes (*Pseudopterogorgia* spp., 292 colonies, 64% of the total) and the encrusting gorgonian *Erythropodium caribaeorum* (81 colonies, 17.8%) comprised ~82% of all gorgonians encountered (Table 3-11). Compared to the shallower and deeper sites within Conch Reef SPA, mean densities of *Briareum asbestinum* and *E. caribaeorum* were greater, while *Gorgonia ventalina*, *Muricea muricata*, *Plexaurella dichotoma*, and *Pseudoplexaura* spp. were less abundant.

Temporal Patterns (1999-2010) at Conch Reef

Conch Reef SPA and RO have been sampled intermittently by our program dating back to 1999. Previous quick look and data summary reports available at http://people.uncw.edu/millers provide site-level data collected at Conch Reef during 1999, 2001, 2005, and 2008-2009. In addition, two Aquarius missions were conducted during the summers of 2002 and 2003 (D.W. Swanson, unpublished data). The two ten-day Aquarius missions consisted of surveys of stony coral species richness, benthic cover, juvenile coral surveys, and density and size surveys of five scleractinian coral species. The 2002 Aquarius mission sampled three replicate sites each in the 10-m depth range of Conch Reef SPA, the 20-m depth range of Conch Reef RO, and the 30-m depth range of Conch RO. The 2003 Aquarius mission sampled three replicate sites in the 10-m and 30-m depth ranges of the SPA and RO, respectively. Table 3-12 summarizes the benthic sampling effort at shallow and deeper Conch Reef SPA, as well as Conch Reef RO, from 1999 through 2010. In all years, a minimum of two replicate sites were sampled in each depth interval. During 1999-2003, 25-m transects were used instead of 15-m transects, the latter of which have been used since 2005, and belt transect areas have been slightly adjusted over time for species richness,

gorgonian density, and density estimates of benthic cnidarians, urchins, and mollusks. Several figures illustrate some of the temporal patterns for measure variables at Conch Reef during the past decade.

Figure 3-11 illustrates temporal patterns in the site species richness of sponges, stony corals, and gorgonians at Conch Reef during 1999-2010. Site species richness values reflect the total number of species found in either 80-m^2 (1999-2001) or 60-m^2 sample areas (2005-present) per site. Averages were computed for each time interval for each habitat and depth interval surveyed at Conch Reef. In the shallow (< 6 m), low-relief hard-bottom community within Conch Reef SPA, there was little overall change in gorgonian species richness, but a declining trend in both stony coral and sponge species richness, especially sponge species richness from 2009 to 2010 (Figure 3-11, top). In the low-relief spur and groove habitat of Conch Reef SPA, there was little change in stony coral, gorgonian, or sponge species richness (Figure 3-11, middle). A somewhat similar pattern was observed in the low-relief spur and groove habitat from 12-15 m depth within Conch Reef RO, particularly for corals and gorgonians; however, there was an increasing trend in sponge species richness (Figure 3-11, bottom).

Figure 3-12 illustrates temporal patterns in the benthic cover of stony corals, the colonial zoanthid *Palythoa*, and sponges. At shallow Conch Reef SPA, there was a small increase in total stony coral cover from 1.5% in 2001 to 2.25% by 2010 (Figure 3-12, top). This change was mostly due to an increase in cover by milleporid hydrocorals from 0.38% in 2001 to 1.33% by 2010. A small decrease in scleractinian coral cover from 1.13% to 0.92% occurred during the same time interval. In contrast to deeper sites within Conch Reef SPA and RO, mean *Palythoa* cover increased from 1.88% in 2001 to 4.83% by 2010. Total sponge cover also exhibited an increase from 1.63% in 2001 to 2.33% by 2010. Within the deeper area of Conch Reef SPA, total coral cover increased from 1% in 1999 to 2.5% by 2010; however, most of the increase was due to *Millepora* coral cover. Mean *Palythoa* cover increased from 0.25% in 1999 to 0.33% by 2010, while total sponge cover increased from 3.25% in 1999 to 6.5% by 2010 (Figure 3-12, middle). Both of these patterns contrasted with those observed at shallow Conch Reef SPA. Within Conch Reef RO, there was an increase in total coral cover from 1.38% in 1999 to 4.58% in 2010 (Figure 3-12, bottom). In contrast to Conch Reef SPA, the increase in total coral cover within the RO was partly due to *Millepora* (0.38 to 1.67% increase), as well as scleractinians corals, which exhibited an increase in mean cover from 1% to 2.92%. There was no change in the mean coverage by *Palythoa*, which is relatively rare in this depth range. Perhaps the most noticeable change within the RO since 1999 was the increase in total sponge cover from 7.13% in 1999 to 10.5% by 2010; this is similar to the pattern observed in the low-relief spur and groove habitat (6-15 m depth) in Conch Reef SPA.

Temporal trends in the coverage by algal functional groups at Conch Reef are illustrated in Figure 3-13. At shallow Conch Reef SPA, there was a declining trend in coverage by crustose coralline algae, from 16.1% in 2001 to 9.9% by 2010, as well as a decrease in macroalgae from 52.1% in 2001 in 2001 to 37.8% by 2010 (Figure 3-13, top). The decrease in macroalgae was mostly due to a large decrease in *Dictyota* spp., from 41% cover in 2001 to 31.8% in 2010, as well as a smaller (1%) decrease in *Halimeda* spp. There was also a concurrent increase in mean algal turf cover, from 16.3% in 2001 to 29.7% by 2010. At deeper Conch Reef SPA, there was little change in mean coverage by crustose coralline algae (0.88% to 0.92%) and macroalgae (27.1% to 34.1%) (Figure 3-13, middle); however, there was a large decline in mean algal turf cover from 55.8% to 34.1%. This latter pattern may be due to the difficulty in consistently assessing turf algae vs. sediment-covered turf algae, which predominates in this habitat. Coverage by algal functional groups changed in terms of absolute and relative coverage in the low-relief spur and groove habitat (12-15 m depth) within Conch Reef RO. There was a declining trend in coverage by crustose coralline algae from 19% in 1999 to 8.5% by 2010, as well as a decline in turf algae from 37.3% in 1999 to 10.1% by 2010 (Figure 3-13, bottom). There was a concurrent increase in macroalgal cover from 25.6% in 1999 to 45.7% in 2010, due to a small increase in *Halimeda* spp. (0.38% in 1999 to 0.5% in 2010) and *Lobophora variegata* (1.38% to 4.75%), as well as a larger increase in *Dictyota* spp. (23.4% to 39.1%).

Temporal patterns in the mean density of juvenile scleractinian corals, gorgonians, and the urchin *Eucidaris tribuloides* are illustrated in Figure 3-14. For all three habitats sampled at Conch Reef since 1999, there has been a slight decrease in the mean number of coral species observed as juveniles; in other words, fewer coral species are now encountered as juveniles (< 4 cm) compared to 1999-2001. However, all three areas sampled at Conch Reef have exhibited increasing trends in mean density of juvenile corals: 1.52 per m^2 in 2001 to 2.03 per m^2 in 2010 for shallow Conch Reef SPA; 2.24 per m^2 in 1999 to 3.1 per m^2 in 2010 for the deeper area of Conch Reef SPA; and 3.21 per m^2 in 1999 to 5.72 per m^2 in 2010 within the 12-15 depth range within Conch Reef RO (Figure 3-14, top). Total gorgonian densities exhibited increased in both the shallow (9.9 per m^2 in 2001 to 11.6 per m^2 in 2010) and deeper areas (8.38 per m^2 in 2001 to 12.42 per m^2 in 2010) of Conch Reef SPA, but exhibited a slight decrease from 11.45 per m^2 in 1999 to 9.5 per m^2 in 2010 within Conch Reef RO (Figure 3-14, middle). Although urchins are rare in the low-relief spur and groove habitats of Conch Reef SPA and RO, *Eucidaris tribuloides* is the most abundant urchin on the shallower reef in Conch Reef SPA. Mean density for this urchin significantly increased from 2001 to 2010, although mean densities have fluctuated by upwards of one order of magnitude during the past decade (Figure 3-14, bottom).

Finally, five scleractinian corals were monitored during Aquarius missions in 2002 and 2003. Belt transects 25-m x 0.8-m (10 m^2) in dimension were surveyed at multiple sites in three depth intervals corresponding to 10-m depth within Conch Reef SPA and the 20-m depth and 30-m depth contours within Conch Reef RO. In 2010, similar surveys were carried out as described above, except replicate 15-m transects were used at each of three sites in three depth intervals across Conch Reef. Each colony encountered was measured for maximum and minimum diameter, as well as colony height.

Data for five of the coral species assessed at Conch Reef are presented in Figures 3-15 and 3-16 for the 9-12 m depth interval within Conch Reef SPA and the 13-20 m depth interval within Conch Reef RO. Figure 3-15 illustrates temporal changes in mean densities of two common brooding corals, *Agaricia agaricites* and *Porites astreoides*, at Conch Reef SPA and RO between 2002-03 and 2010. Both species increased in density in deeper Conch Reef SPA during this time interval, but the increase in *P. astreoides* was substantially greater. In contrast, mean density of *A. agaricites* slightly declined at 13-20 m depth within Conch Reef RO, while there was little change in density of *P. astreoides*. Figure 3-16 illustrates mean densities by size class (max. diameter) for three broadcast spawning corals: *Montastraea cavernosa*, *Siderastrea siderea*, and *Stephanocoenia michelini*. Mean densities of *M. cavernosa* remained largely unchanged in Conch Reef SPA. In Conch Reef RO, however, there were declines in *M. cavernosa* colonies that were 4-15 cm, 15-50 cm, or 50-100 cm in maximum diameter, as well as a decline in total density. Mean density of *S. siderea* increased in Conch Reef SPA, particularly in the smaller (< 15 m) size class. A somewhat similar pattern for this species was evident in Conch Reef RO, in that the density of smaller (< 15 cm) corals increased, as well as total density. In contrast, *S. siderea* colonies 15-50 cm in maximum diameter declined within Conch Reef RO. Mean densities of *S. michelini* for individual and combined size classes largely remained unchanged in Conch Reef SPA. In Conch Reef RO, however, there was a decline in the smallest (< 15 cm) size class of colonies, as well as total density.

Figure 3-1. Sampling locations within the Conch Reef Sanctuary Preservation Area (SPA) and Research Only Area (RO) near the Aquarius Undersea Habitat, offshore of Tavernier, Florida. Three sites were sampled at depth intervals of 5 m (inshore ledge), 10 m (seaward edge of the SPA) and 14 m. At each site, four 15-m transects were orientated from inshore-to-offshore and surveyed for the richness, cover, density, and size of various benthic coral reef organisms.

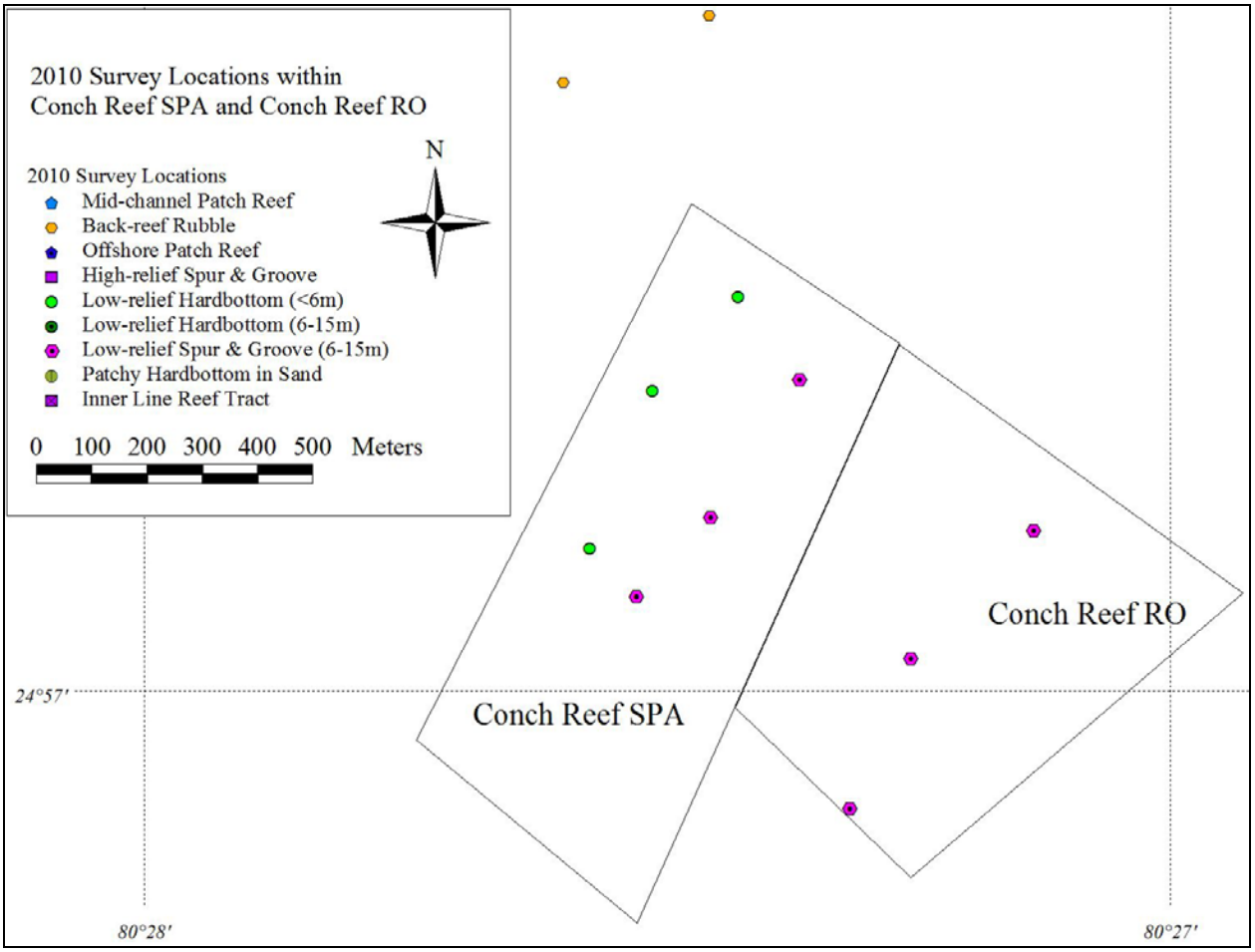


Figure 3-2. Images of shallow Conch Reef SPA near mooring buoys C1, C2, and C3 taken during July-August 2010.

Site A86 – Low-relief hard-bottom (< 6 m)
Conch Reef C3, 4.9-6.7 m
24° 57.384 N, 80° 27.421 W

Site A86 – Low-relief hard-bottom (< 6 m)
Conch Reef C3, 4.9-6.7 m
24° 57.384 N, 80° 27.421 W

Site 555 – Low-relief hard-bottom (< 6 m)
Conch Reef C2, 4.6-6.1 m
24° 57.292 N, 80° 27.504 W

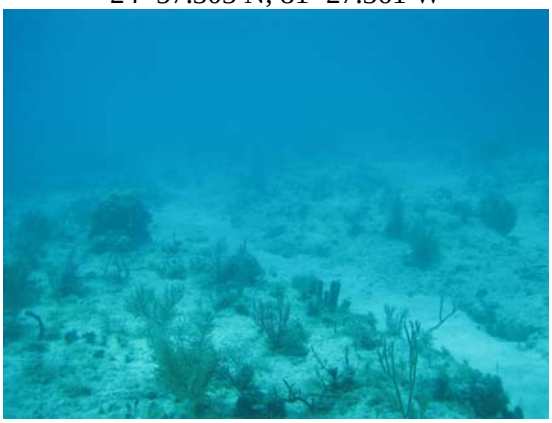
Site 555 – Low-relief hard-bottom (< 6 m)
Conch Reef C2, 4.6-6.1 m
24° 57.292 N, 80° 27.504 W

Site 554 – Low-relief hard-bottom (< 6 m)
Conch Reef C1, 4.6-5.5 m
24° 57.139 N, 80° 27.565 W

Site 554 – Low-relief hard-bottom (< 6 m)
Conch Reef C1, 4.6-5.5 m
24° 57.139 N, 80° 27.565 W

Figure 3-3. Images of the low-relief spur and groove habitat at Conch Reef SPA offshore of mooring buoys C1 (site 611), C2 (site 610), and C3 (site B16) taken during July-August 2010.

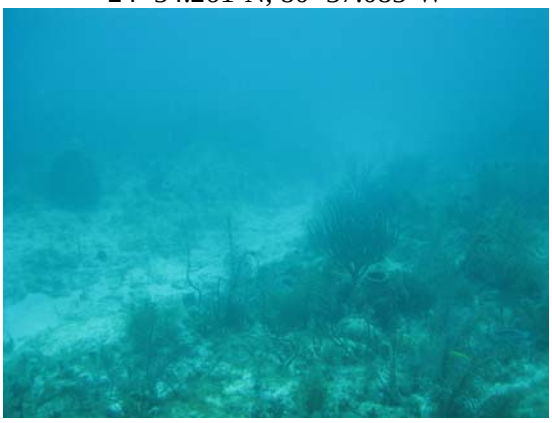
Site B16 – Low-relief spur and groove
Offshore of Conch Reef C3, 11.3-11.9 m
24° 57.303 N, 81° 27.361 W



Site B16 – Low-relief spur and groove
Offshore of Conch Reef C3, 11.3-11.9 m
24° 57.303 N, 81° 27.361 W

Site 610 – Low-relief spur and groove
Offshore of Conch Reef C2, 9.8-11.3 m
24° 57.169 N, 81° 27.448 W

Site S96 – Mid-channel patch reef
Cheeca Rocks SPA, 3.0-4.9 m
24° 54.261'N, 80° 37.085'W



Site 611 – Low-relief spur and groove
Offshore of Conch Reef C1, 8.8-10.1 m
24° 57.092 N, 81° 27.520 W

Site 611 – Low-relief spur and groove
Offshore of Conch Reef C1, 8.8-10.1 m
24° 57.092 N, 81° 27.520 W

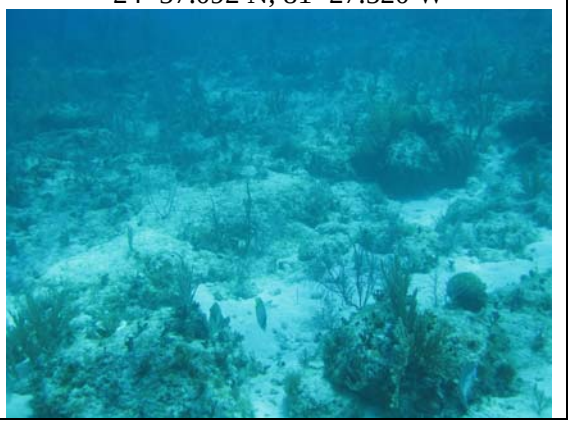
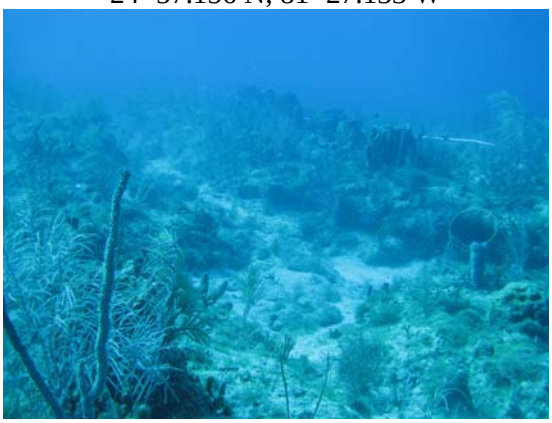
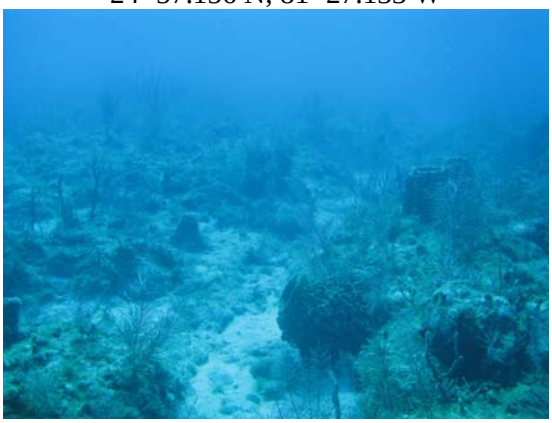


Figure 3-4. Images of the low-relief spur and groove habitat at Conch Reef RO near the Aquarius Undersea Habitat taken during July-August 2010.

Site 626 – Low-relief spur and groove
North of Aquarius Habitat, 13.4-14.3 m
24° 57.156 N, 81° 27.133 W



Site 626 – Low-relief spur and groove
North of Aquarius Habitat, 13.4-14.3 m
24° 57.156 N, 81° 27.133 W



Site 625 – Low-relief spur and groove
Inshore of Aquarius Habitat, 13.1-14.3 m
24° 57.031 N, 81° 27.253 W

Site 625 – Low-relief spur and groove
Inshore of Aquarius Habitat, 13.1-14.3 m
24° 57.031 N, 81° 27.253 W

Site B24 – Low-relief spur and groove
South of Aquarius Habitat, 13.4-14.9 m
24° 56.885 N, 81° 27.312 W

Site B24 – Low-relief spur and groove
South of Aquarius Habitat, 13.4-14.9 m
24° 56.885 N, 81° 27.312 W

Figure 3-5. Mean transect depth (m) (top) and maximum vertical relief of the substratum (cm) (bottom) at Conch Reef Sanctuary Preservation Area (SPA) and Research Only Area (RO), as determined from benthic surveys of four 15-m x 1-m transects per site at three sites in each of three depth zones during July-August 2010. Pooled values represent the mean of the 12 total transects at three sites in each depth zone.

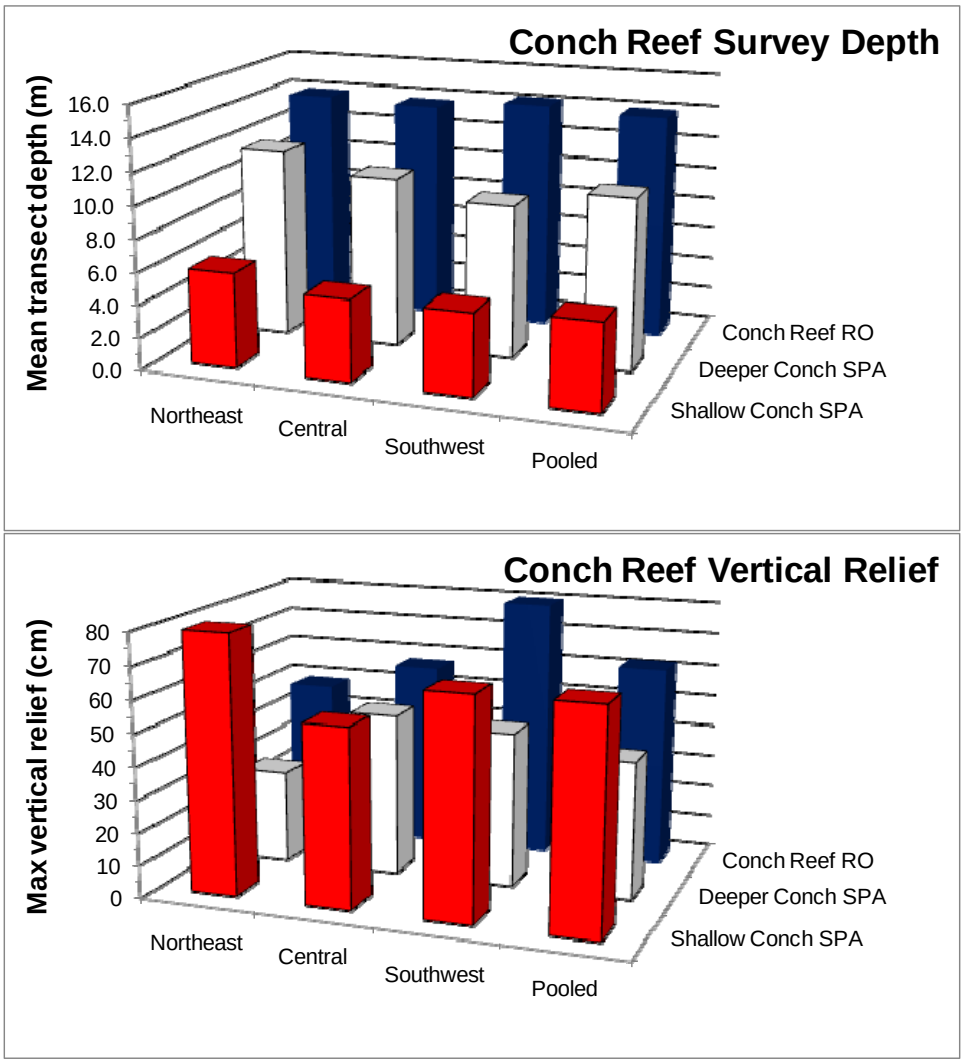


Figure 3-6. Species richness (no. species per 60 m^2) of sponges (top), stony corals (middle), and gorgonians (bottom) at Conch Reef SPA and RO, as determined from surveys of four 15-m x 1-m transects per site at three sites in each of three depth zones during July-August 2010.

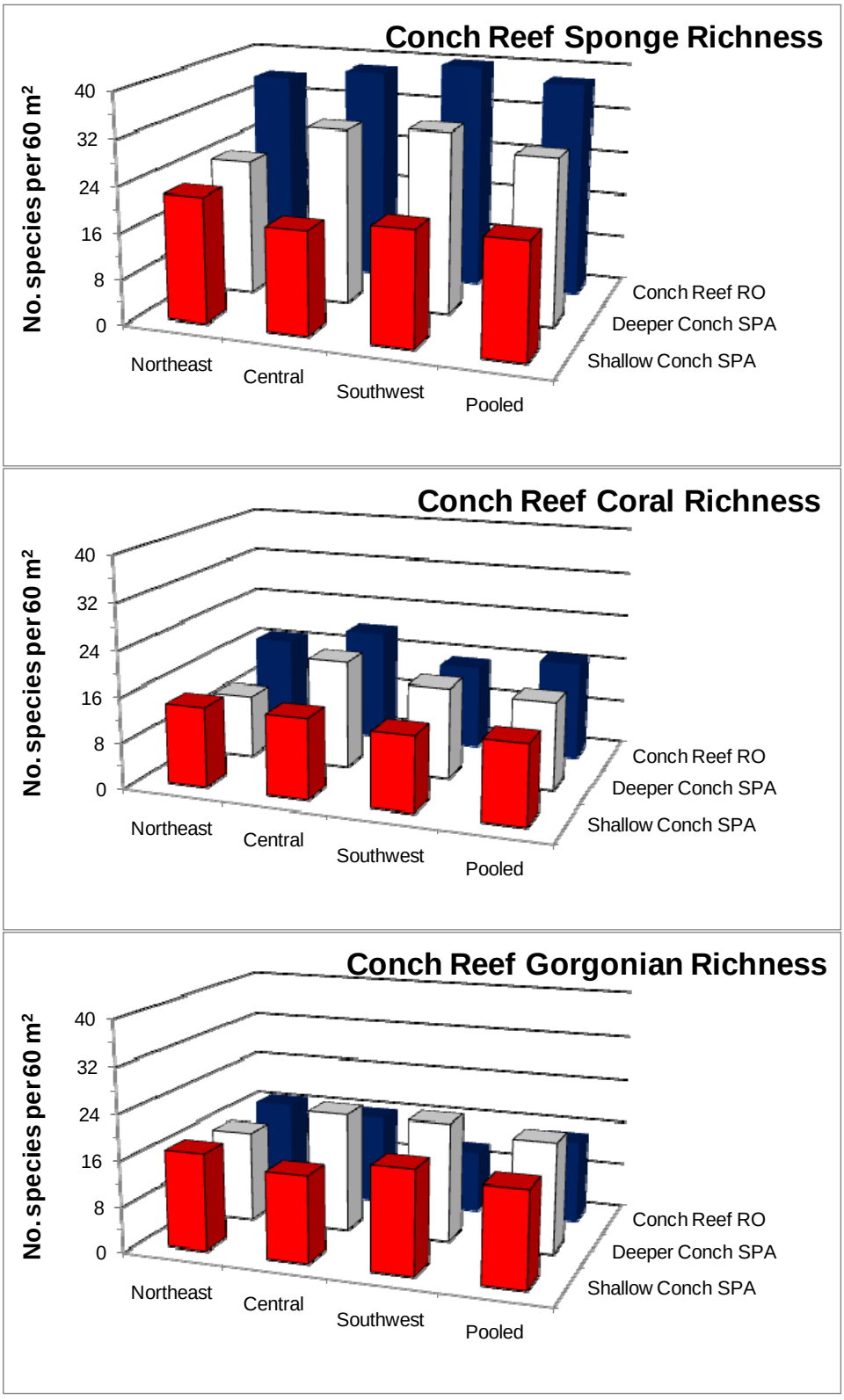


Figure 3-7. Mean coverage (%) of stony corals (top), sponges (middle), and Palythoa (bottom) at Conch Reef SPA and RO, as determined from surveys of 100 points along each of four 15-m transects per site at three sites in each of three depth zones during July-August 2010.

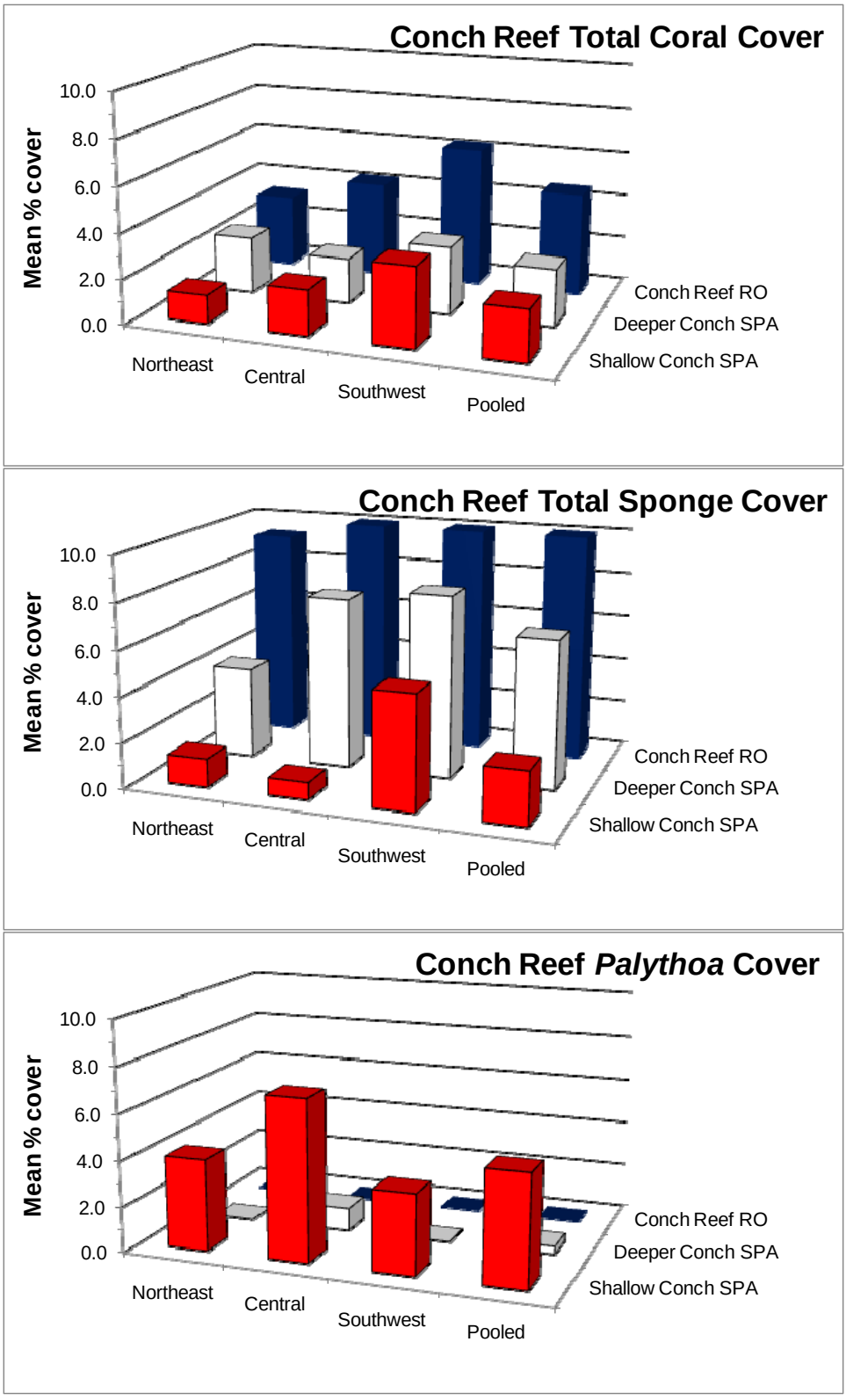


Figure 3-8. Mean coverage (%) of algal turfs (top), crustose coralline algae (middle), and macroalgae (bottom) at Conch Reef SPA and RO, as determined from surveys of 100 points along each of four 15-m transects per site at three sites in each of three depth zones during July-August 2010.

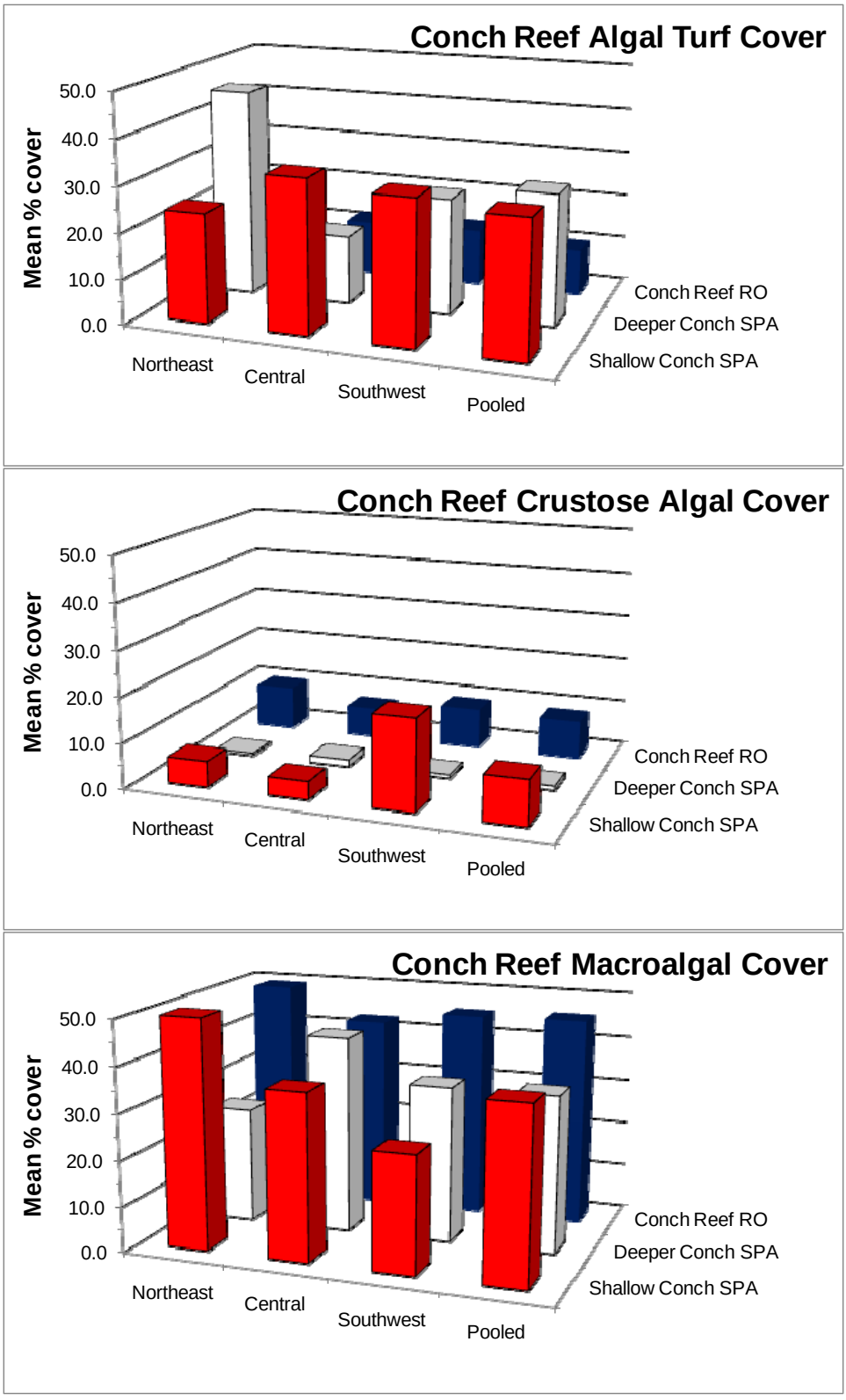


Figure 3-9. Mean density (no. colonies per m^2) of *Millepora* spp. (top), scleractinian corals (middle), and *Siderastrea siderea* (bottom) at Conch Reef SPA and RO, as determined from surveys of two 10-m x 1-m belt transects per site at three sites in each of three depth zones during July-August 2010.

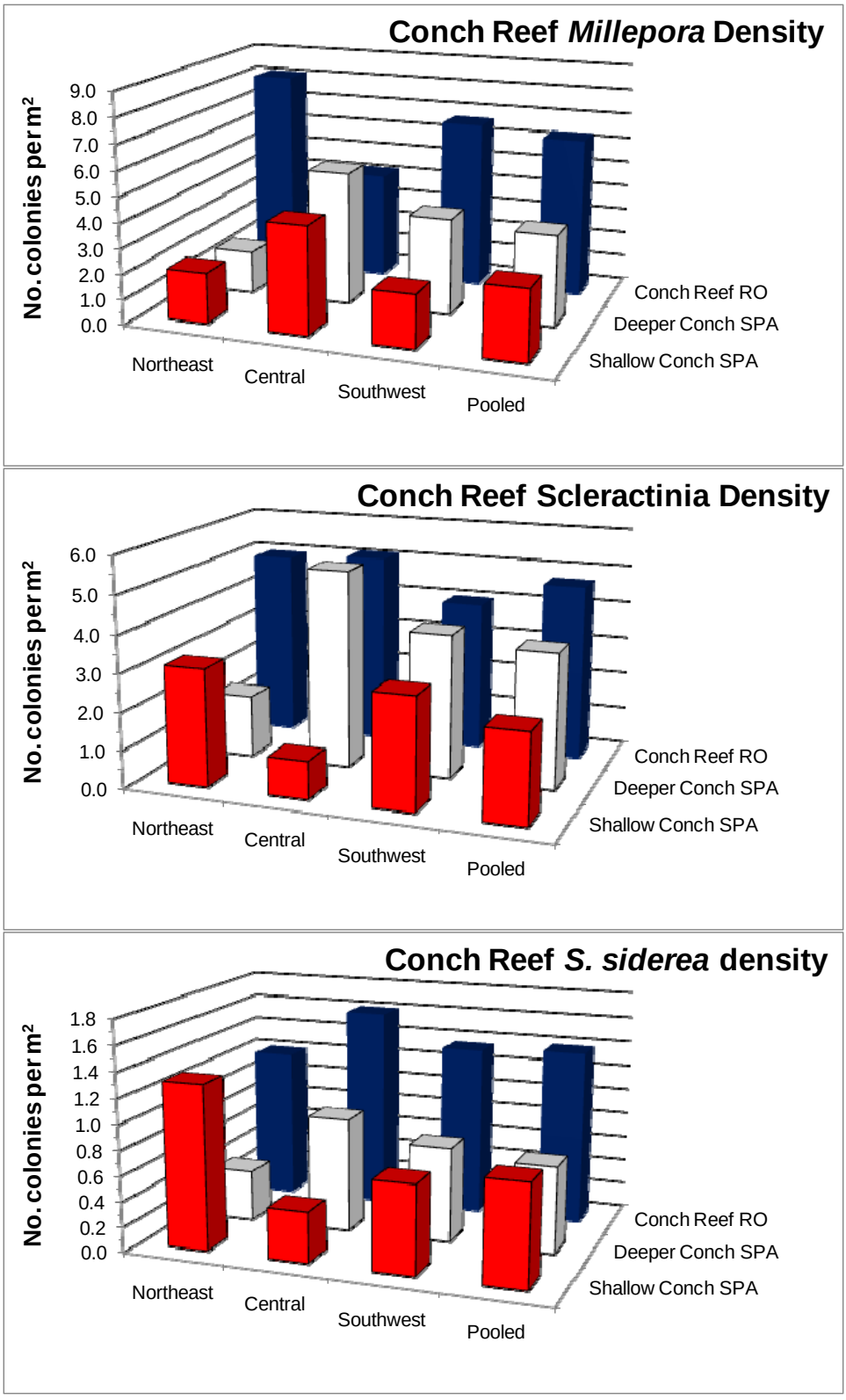


Figure 3-10. Total numbers of scleractinian corals observed as juveniles (< 4 cm) (top), mean density of juvenile scleractinian corals (middle), and mean density of gorgonians (bottom) at Conch Reef SPA and RO at three sites in each of the three depth zones during July-August 2010.

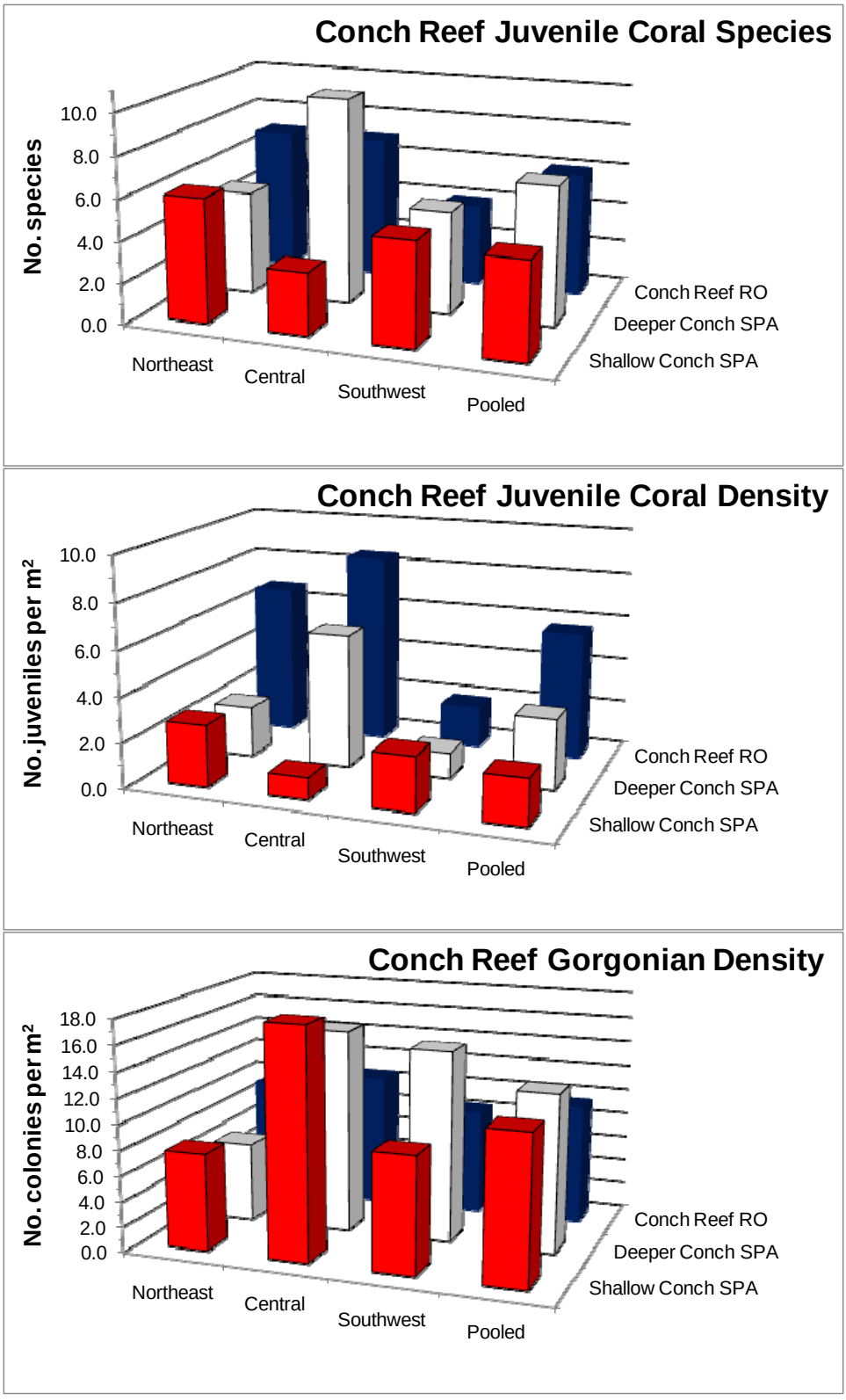


Figure 3-11. Temporal trends in site species richness of sponges, stony corals and gorgonians at Conch Reef, 1999-2010. See Table 3-12 for sample sizes. Error bars represent 95% confidence intervals and dashed lines indicate best-fitted linear trend lines. ns = not significant (P > 0.05).

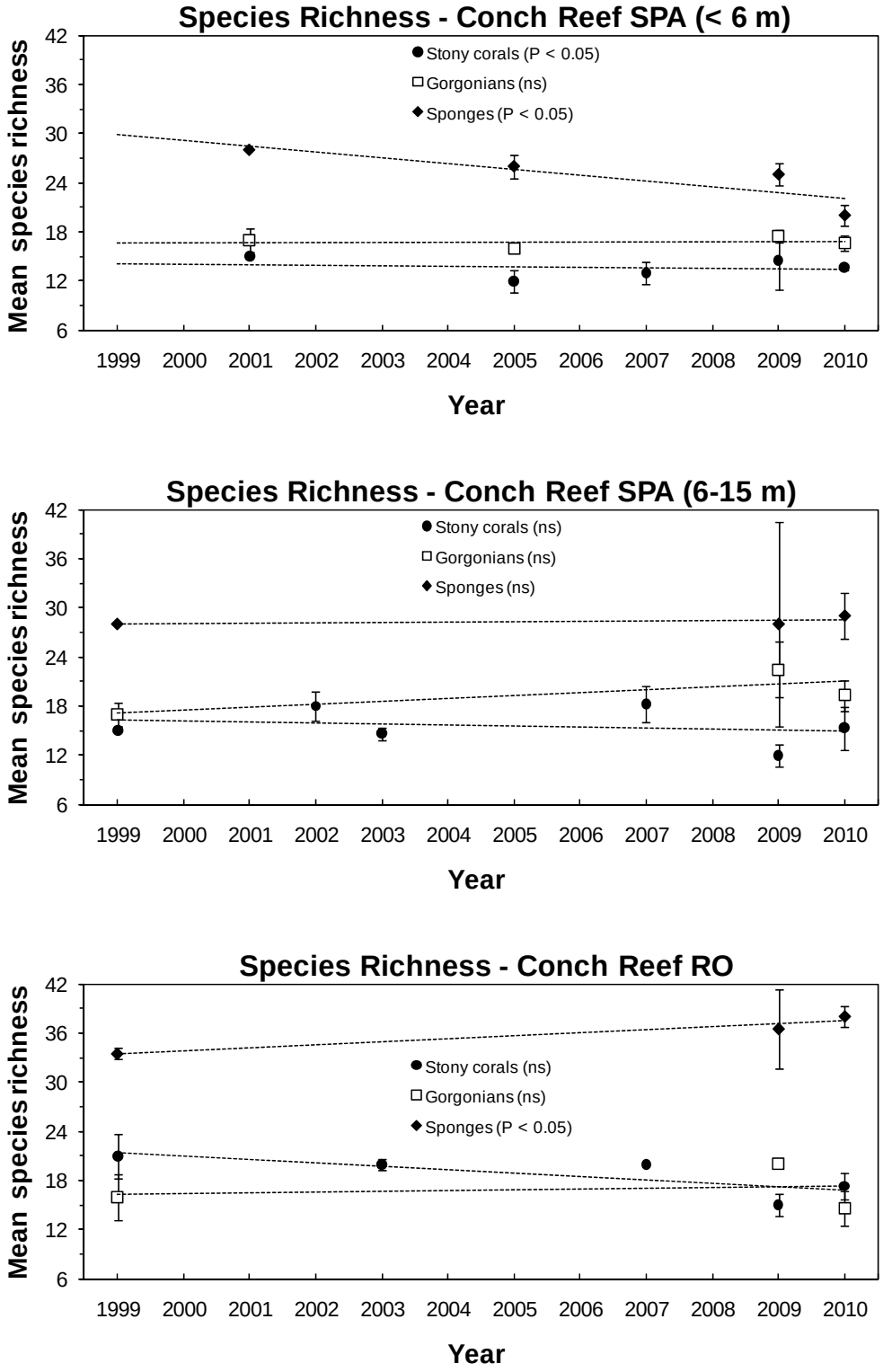
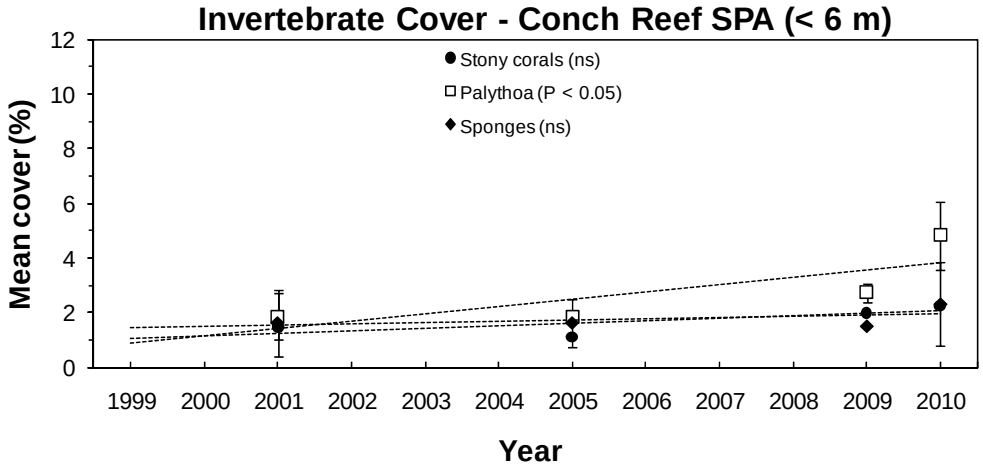
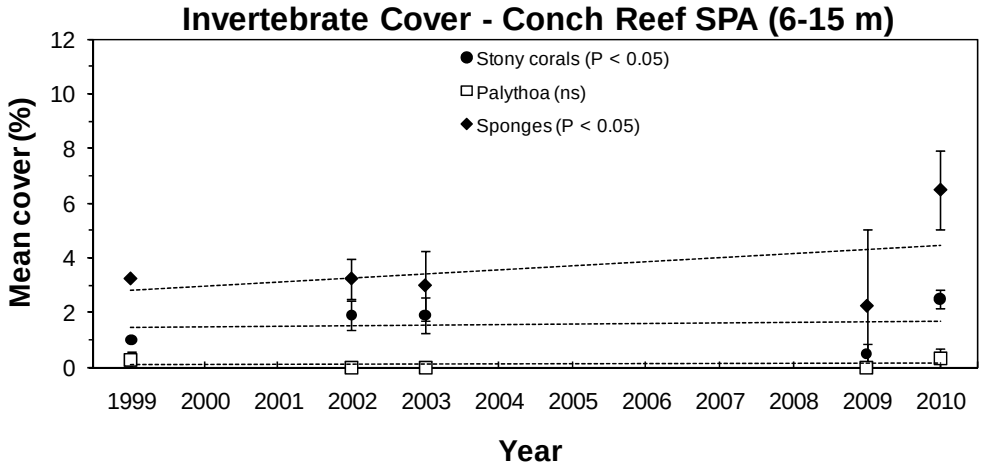


Figure 3-12. Temporal trends in the coverage of stony corals, the colonial zoanthid *Palythoa*, and sponges at Conch Reef, 1999-2010. See Table 3-12 for sample sizes. Error bars represent 95% confidence intervals and dashed lines indicate best-fitted linear trend lines. ns = not significant (P > 0.05).





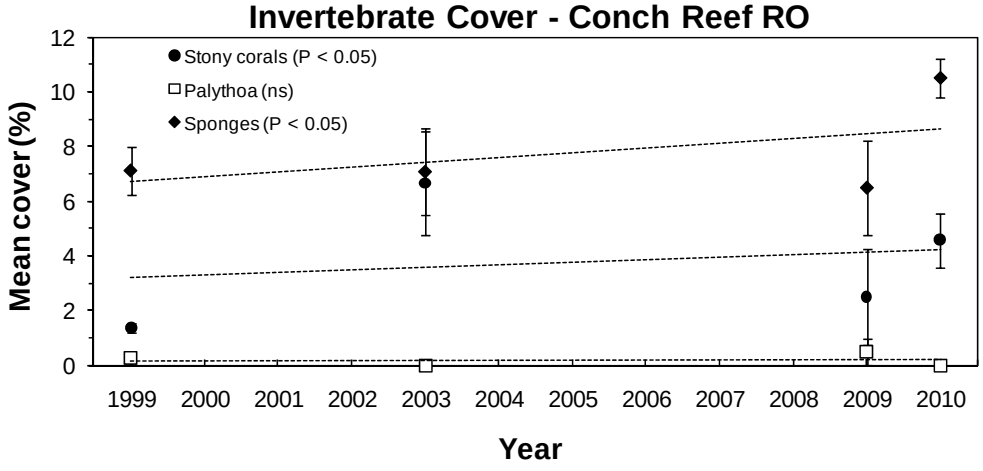


Figure 3-13. Temporal trends in the coverage of crustose coralline algae, turf algal, and macroalgae at Conch Reef, 1999-2010. See Table 3-12 for sample sizes. Error bars represent 95% confidence intervals and dashed lines indicate best-fitted linear trend lines. ns = not significant (P > 0.05).

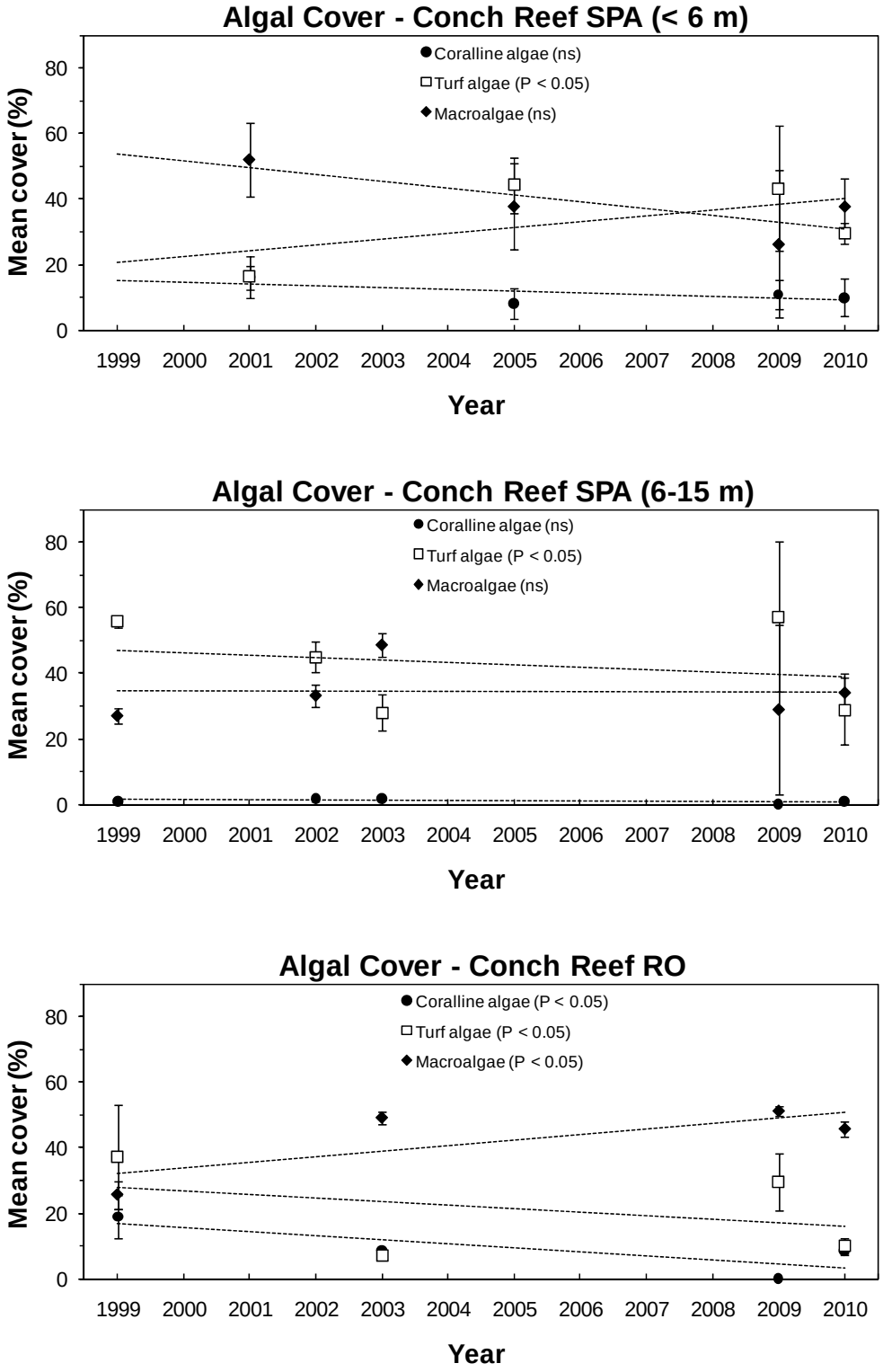


Figure 3-14. Temporal trends in the mean density (no. per m^2) of juvenile corals, gorgonians, and the urchin *Eucidaris tribuloides* at Conch Reef, 1999-2010. See Table 3-12 for sample sizes. Error bars represent 95% confidence intervals and dashed lines indicate best-fitted linear trend lines. The only significant change ($P < 0.05$) was an increase in *E. tribuloides* at shallow Conch Reef SPA.

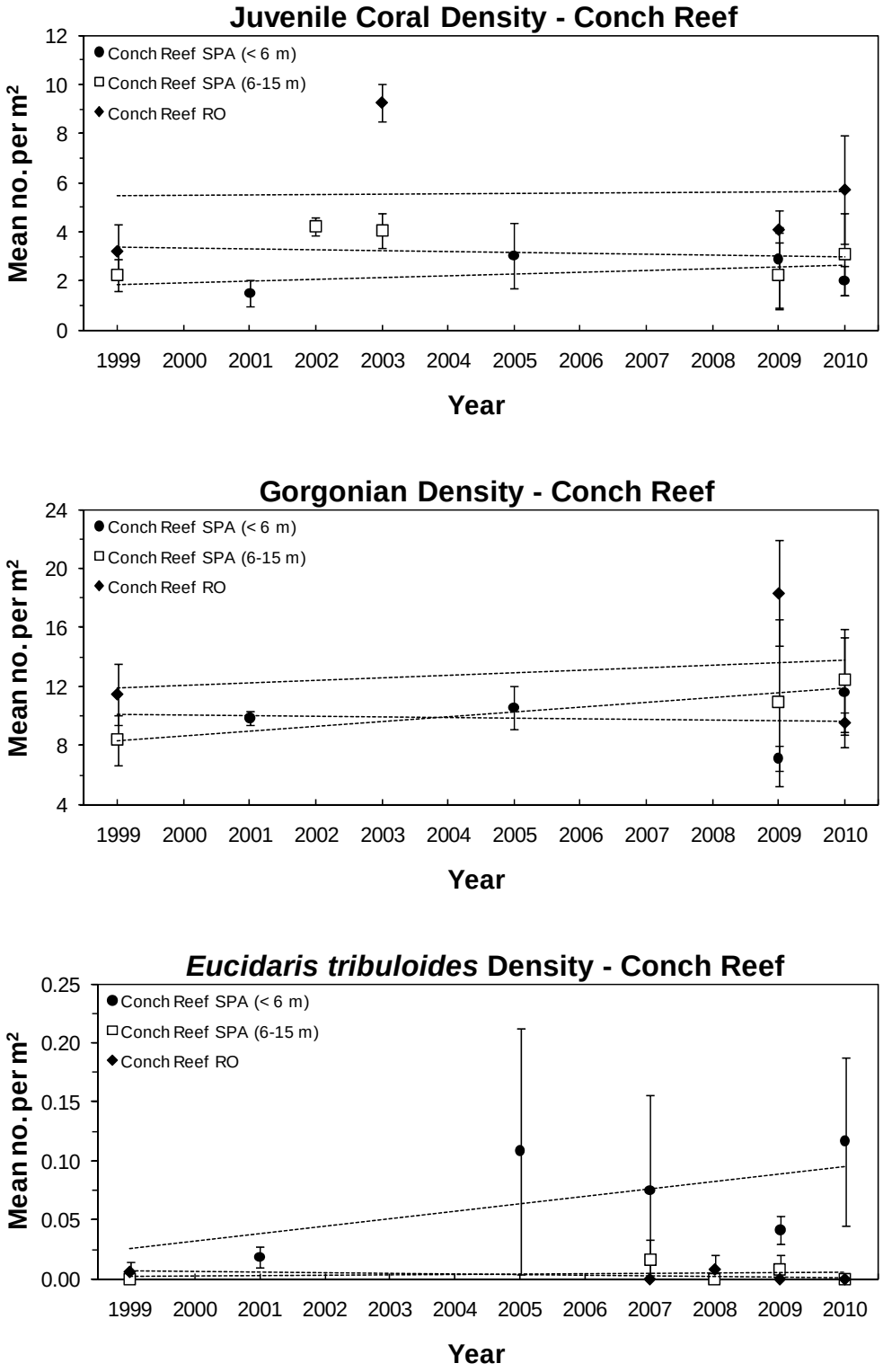


Figure 3-15. Mean densities (no. colonies per m^2) of select brooding corals at Conch Reef SPA (10 m depth) (top) and RO (13-20 m depth) (bottom) during 2002-03 and 2010. See Table 3-12 for sample sizes. Error bars represent 95% confidence intervals. The only significant ($P < 0.05$) temporal change was the increase in density of *Porites astreoides* in Conch Reef SPA.

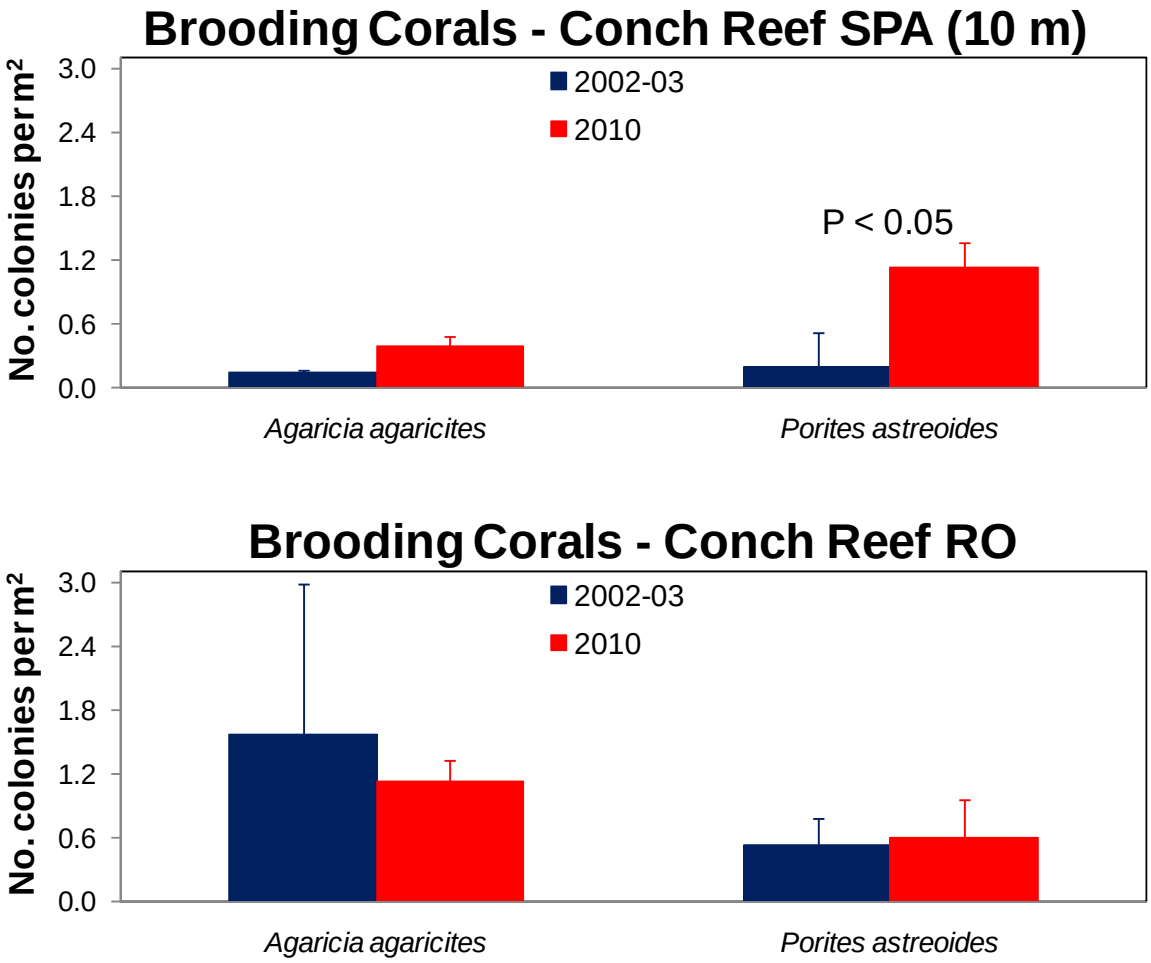


Figure 3-16. Mean densities (no. colonies per m^2) of select broadcast spawning corals at Conch Reef SPA (10 m depth) and RO during 2002-03 and 2010. See Table 3-12 for sample sizes. Error bars represent 95% confidence intervals and size classes are based upon maximum colony diameter. Only two significant ($P < 0.05$) temporal changes were evident, both within Conch Reef RO, as reflected in the decline in total density of *M. cavernosa* and the decline in mean density of *S. siderea* colonies that were 15-50 cm in maximum diameter.

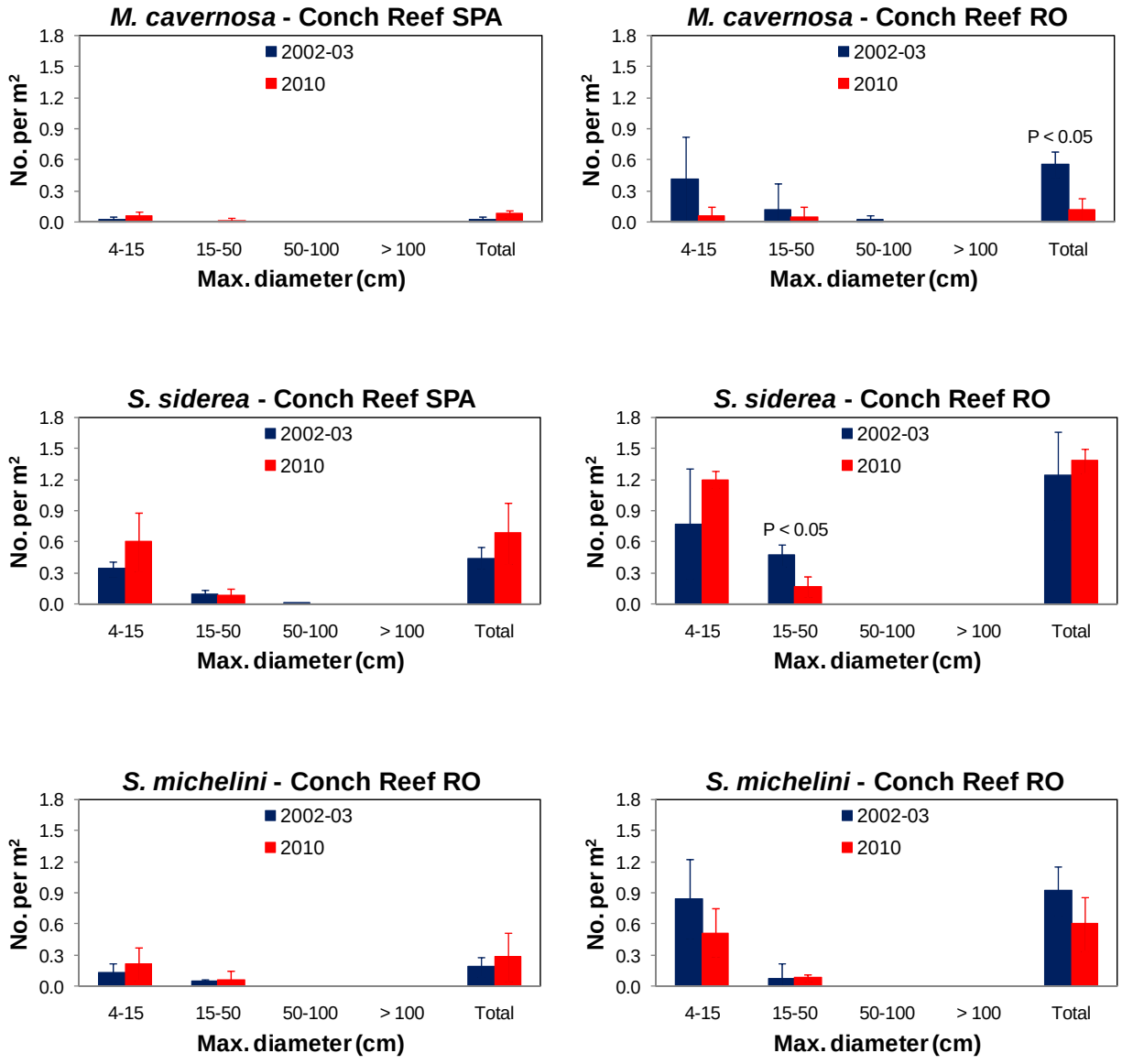


Table 3-1. Transect depth range and mean (± 1 SE) transect depth (m) and maximum vertical relief at Conch Reef Sanctuary Preservation Area (SPA) and Research Only Area (RO) during July-August 2010. Four 15-m transects were surveyed per site, with three sites per depth interval constituting the shallower and deeper areas of the Sanctuary Preservation Area, as well as and Research Only Area.

Site location (site number)	**Min. depth (m)**	**Max. depth (m)**	**Mean depth (m)**	**Max. vertical relief (cm)**
Shallow Conch Reef SPA (< 6 m)				
Northeast (A86)	4.9	6.7	5.9 ± 0.1	79 ± 12
Central (555)	4.3	6.1	5.0 ± 0.2	55 ± 9
Southwest (554)	4.6	5.5	5.0 ± 0.1	67 ± 7
All sites	4.3	6.7	5.3 ± 0.3	67 ± 7
Deeper Conch Reef SPA (6-15 m)				
Northeast (B16)	11.3	11.9	11.7 ± 0.0	29 ± 6
Central (610)	9.8	11.3	10.5 ± 0.2	50 ± 4
Southwest (611)	8.8	10.1	9.4 ± 0.1	47 ± 8
All sites	8.8	11.9	10.5 ± 0.6	42 ± 7
Conch Reef RO				
Northeast (626)	13.4	14.3	13.9 ± 0.1	49 ± 4
Central (625)	12.8	14.3	13.7 ± 0.1	58 ± 6
Southwest (B24)	13.4	14.9	14.2 ± 0.1	80 ± 14
All sites	12.8	14.9	13.9 ± 0.2	62 ± 9

Table 3-2. Species richness of sponges, stony corals (Milleporina and Scleractinia), and gorgonians (Octocorallia) at shallow Conch Reef SPA. Species-level data are the mean ± 1 SE transect frequency of occurrence (%) from surveys of four 15-m x 1-m transects (60 m^2) at each site during July-August 2010.

Species	**Northeast (A86)**	**Central (555)**	**Southwest (554)**	**All sites**
Sponges				
Agelas clathrodes	50 ± 29	25 ± 25	50 ± 29	42 ± 8
A. schmidti	0 ± 0	0 ± 0	25 ± 25	8 ± 8
A. wiedenmayaari	75 ± 25	100 ± 0	100 ± 0	92 ± 8
Amphimedon compressa	100 ± 0	75 ± 25	100 ± 0	92 ± 8
Anthosigmella varians	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Aplysina cauliformis	50 ± 29	25 ± 25	25 ± 25	33 ± 8
A. fistularis	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Callyspongia vaginalis	75 ± 25	50 ± 29	50 ± 29	58 ± 8
Chondrilla nucula	25 ± 25	25 ± 25	75 ± 25	42 ± 17
Cliona deletrix	0 ± 0	0 ± 0	75 ± 25	25 ± 25
Cliona sp.	75 ± 25	25 ± 25	0 ± 0	33 ± 22
Diplastrella megastellata	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Dysidea etheria	0 ± 0	25 ± 25	0 ± 0	8 ± 8
Ectyoplasia ferox	0 ± 0	25 ± 25	0 ± 0	8 ± 8
Haliclona aqueaductus	50 ± 29	25 ± 25	0 ± 0	25 ± 14
Ircinia felix	100 ± 0	100 ± 0	50 ± 29	83 ± 17
I. strobilina	25 ± 25	25 ± 25	25 ± 25	25 ± 0
Monanchora barbadensis	25 ± 25	25 ± 25	0 ± 0	17 ± 8
M. unguifera	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Mycale laevis	75 ± 25	0 ± 0	0 ± 0	25 ± 25
Niphates amorpha	75 ± 25	100 ± 0	25 ± 25	67 ± 22
N. digitalis	100 ± 0	50 ± 29	25 ± 25	58 ± 22
N. erecta	50 ± 29	25 ± 25	0 ± 0	25 ± 14
Oligoceras hemorrhages	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Pseudoaxinella lunaecharta	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Pseudoceratina crassa	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Ptilocaulis sp.	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Rhaphidophlus venosus	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Spirastrella mollis	50 ± 29	50 ± 29	0 ± 0	33 ± 17
Ulosa rüetzleri	75 ± 25	50 ± 29	100 ± 0	75 ± 14
Unknown orange encrusting	25 ± 25	0 ± 0	75 ± 25	33 ± 22
Xestospongia muta	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Total sponge species	22	18	20	32
Stony corals				
Acropora cervicornis	0 ± 0	0 ± 0	75 ± 25	25 ± 25
A. palmata	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Agaricia agaricites	75 ± 25	100 ± 0	75 ± 25	83 ± 8
A. fragilis	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Colpophyllia natans	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Dendrogyra cylindrus	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Dichocoenia stokesi	0 ± 0	25 ± 25	0 ± 0	8 ± 8
Diploria labyrinthiformis	0 ± 0	25 ± 25	0 ± 0	8 ± 8
Eusmilia fastigiata	25 ± 25	25 ± 25	25 ± 25	25 ± 0
Leptoseris cucullata	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Madracis decactis	50 ± 29	25 ± 25	0 ± 0	25 ± 14
Meandrina meandrites	50 ± 29	0 ± 0	0 ± 0	17 ± 17
Millepora alcicornis	100 ± 0	100 ± 0	100 ± 0	100 ± 0
M. complanata	50 ± 29	75 ± 25	75 ± 25	67 ± 8
Montastraea cavernosa	0 ± 0	25 ± 25	0 ± 0	8 ± 8
Porites astreoides	0 ± 0	25 ± 25	100 ± 0	42 ± 30
P. porites f. divaricata	25 ± 25	75 ± 25	25 ± 25	42 ± 17
P. porites f. furcata	25 ± 25	75 ± 25	75 ± 25	58 ± 17
P. porites f. porites	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Siderastrea radians	25 ± 25	75 ± 25	75 ± 25	58 ± 17

Species	Northeast (A86)	Central (555)	Southwest (554)	All sites
S. siderea	75 ± 25	100 ± 0	100 ± 0	92 ± 8
Stephanocoenia michelini	0 ± 0	50 ± 29	25 ± 25	25 ± 14
Total stony coral species	14	14	13	22
Gorgonians				
Briareum asbestinum	50 ± 29	0 ± 0	0 ± 0	17 ± 17
Erythropodium caribaeorum	100 ± 0	75 ± 25	50 ± 29	75 ± 14
Eunicea calyculata	50 ± 29	0 ± 0	50 ± 29	33 ± 17
E. fusca	50 ± 29	100 ± 0	50 ± 29	67 ± 17
E. laciniata	25 ± 25	0 ± 0	0 ± 0	8 ± 8
E. mammosa	50 ± 29	100 ± 0	50 ± 29	67 ± 17
E. succinea	50 ± 29	0 ± 0	50 ± 29	33 ± 17
E. tourneforti	75 ± 25	100 ± 0	100 ± 0	92 ± 8
Gorgonia ventalina	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Muricea elongata	25 ± 25	25 ± 25	0 ± 0	17 ± 8
M. muricata	100 ± 0	100 ± 0	75 ± 25	92 ± 8
Muriceopsis flavida	0 ± 0	75 ± 25	50 ± 29	42 ± 22
Plexaura flexuosa	50 ± 29	50 ± 29	100 ± 0	67 ± 17
P. homomalla	0 ± 0	0 ± 0	25 ± 25	8 ± 8
P. kuna	0 ± 0	0 ± 0	50 ± 29	17 ± 17
Plexaurella dichotoma	25 ± 25	50 ± 29	50 ± 29	42 ± 8
Pseudoplexaura flagellosa	0 ± 0	75 ± 25	25 ± 25	33 ± 22
P. porosa	75 ± 25	50 ± 29	100 ± 0	75 ± 14
Pseudopterogorgia acerosa	75 ± 25	75 ± 25	50 ± 29	67 ± 8
P. americana	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Pterogorgia citrina	25 ± 25	50 ± 29	25 ± 25	33 ± 8
Total gorgonian species	17	15	18	21

Table 3-3. Species richness of sponges, stony corals (Milleporina and Scleractinia), and gorgonians (Octocorallia) at deeper (6-15) Conch Reef SPA. Species-level data are the mean ± 1 SE transect frequency of occurrence (%) from surveys of four 15-m x 1-m transects (60 m^2) at each site during July-August 2010.

Species	**Northeast (B16)**	**Central (610)**	**Southwest (611)**	**All sites**
Sponges				
Agelas clathrodes	50 ± 29	100 ± 0	25 ± 25	58 ± 22
A. schmidti	0 ± 0	0 ± 0	25 ± 25	8 ± 8
A. wiedenmayaari	0 ± 0	75 ± 25	100 ± 0	58 ± 30
Amphimedon compressa	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Anthosigmella varians	25 ± 25	0 ± 0	50 ± 29	25 ± 14
Aplysina archeri	0 ± 0	25 ± 25	0 ± 0	8 ± 8
A. cauliformis	100 ± 0	100 ± 0	100 ± 0	100 ± 0
A. fistularis	75 ± 25	0 ± 0	100 ± 0	58 ± 30
A. lacunosa	25 ± 25	25 ± 25	25 ± 25	25 ± 0
Callyspongia plicifera	0 ± 0	25 ± 25	25 ± 25	17 ± 8
C. vaginalis	50 ± 29	100 ± 0	100 ± 0	83 ± 17
Chondrilla nucula	0 ± 0	25 ± 25	50 ± 29	25 ± 14
Cinachyra sp.	0 ± 0	25 ± 25	0 ± 0	8 ± 8
Cliona deletrix	75 ± 25	0 ± 0	50 ± 29	42 ± 22
Cribochalina vasculum	0 ± 0	25 ± 25	25 ± 25	17 ± 8
Diplastrella megastellata	0 ± 0	0 ± 0	50 ± 29	17 ± 17
Dysidea etheria	25 ± 25	50 ± 29	0 ± 0	25 ± 14
D. fragilis	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Ectyoplasia ferox	0 ± 0	75 ± 25	100 ± 0	58 ± 30
Higginsia strigilata	75 ± 25	0 ± 0	0 ± 0	25 ± 25
Iotrochota birotulata	0 ± 0	25 ± 25	0 ± 0	8 ± 8
Ircinia felix	75 ± 25	100 ± 0	100 ± 0	92 ± 8
I. strobilina	25 ± 25	75 ± 25	100 ± 0	67 ± 22
Monanchora unguifera	0 ± 0	25 ± 25	50 ± 29	25 ± 14
Mycale laevis	0 ± 0	50 ± 29	25 ± 25	25 ± 14
Myrmekioderma sp.	25 ± 25	50 ± 29	0 ± 0	25 ± 14
Neofibularia notilangere	0 ± 0	25 ± 25	50 ± 29	25 ± 14
Niphates amorpha	75 ± 25	75 ± 25	100 ± 0	83 ± 8
N. digitalis	100 ± 0	100 ± 0	100 ± 0	100 ± 0
N. erecta	50 ± 29	100 ± 0	100 ± 0	83 ± 17
Pandaros acanthifolium	0 ± 0	50 ± 29	0 ± 0	17 ± 17
Pseudoaxinella lunaecharta	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Pseudoceratina crassa	50 ± 29	100 ± 0	100 ± 0	83 ± 17
Ptilocaulis sp.	75 ± 25	0 ± 0	75 ± 25	50 ± 25
Rhaphidophlus venosus	75 ± 25	25 ± 25	75 ± 25	58 ± 17
Spheciospongia vesparium	100 ± 0	0 ± 0	25 ± 25	42 ± 30
Spinosella tenerrima	0 ± 0	100 ± 0	50 ± 29	50 ± 29
Spirastrella coccinea	0 ± 0	50 ± 29	0 ± 0	17 ± 17
S. mollis	25 ± 25	25 ± 25	75 ± 25	42 ± 17
Unknown carmine red	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Unknown red squishy	0 ± 0	25 ± 25	0 ± 0	8 ± 8
Verongula rigida	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Xestospongia muta	75 ± 25	100 ± 0	100 ± 0	92 ± 8
Total sponge species	24	31	32	43
Stony corals				
Agaricia agaricites	75 ± 25	100 ± 0	100 ± 0	92 ± 8
A. fragilis	0 ± 0	25 ± 25	25 ± 25	17 ± 8
Colpophyllia natans	0 ± 0	25 ± 25	0 ± 0	8 ± 8
Dichocoenia stokesi	0 ± 0	50 ± 29	50 ± 29	33 ± 17
Diploria labyrinthiformis	25 ± 25	25 ± 25	0 ± 0	17 ± 8
D. strigosa	0 ± 0	25 ± 25	0 ± 0	8 ± 8
Leptoseris cucullata	0 ± 0	25 ± 25	25 ± 25	17 ± 8
Madracis decactis	0 ± 0	75 ± 25	50 ± 29	42 ± 22

Species	Northeast (B16)	Central (610)	Southwest (611)	All sites
M. mirabilis	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Manicina areolata	25 ± 25	75 ± 25	25 ± 25	42 ± 17
Meandrina meandrites	0 ± 0	50 ± 29	0 ± 0	17 ± 17
Millepora alcicornis	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Montastraea cavernosa	75 ± 25	75 ± 25	100 ± 0	83 ± 8
Porites astreoides	100 ± 0	100 ± 0	75 ± 25	92 ± 8
P. porites f. divaricata	0 ± 0	50 ± 29	25 ± 25	25 ± 14
P. porites f. furcata	75 ± 25	50 ± 29	100 ± 0	75 ± 14
P. porites f. porites	0 ± 0	75 ± 25	25 ± 25	33 ± 22
Siderastrea radians	100 ± 0	100 ± 0	100 ± 0	100 ± 0
S. siderea	75 ± 25	100 ± 0	100 ± 0	92 ± 8
Solenastrea bournoni	50 ± 29	0 ± 0	000 ± 0	17 ± 17
Stephanocoenia michelini	75 ± 25	100 ± 0	75 ± 25	83 ± 8
Total stony coral species	11	19	16	21
Gorgonians				
Briareum asbestinum	75 ± 25	100 ± 0	100 ± 0	92 ± 8
Erythropodium caribaeorum	0 ± 0	100 ± 0	100 ± 0	67 ± 33
Eunicea calyculata	0 ± 0	25 ± 25	0 ± 0	8 ± 8
E. fusca	100 ± 0	75 ± 25	100 ± 0	92 ± 8
E. laciniata	25 ± 25	50 ± 29	25 ± 25	33 ± 8
E. mammosa	100 ± 0	75 ± 25	100 ± 0	92 ± 8
E. succinea	75 ± 25	25 ± 25	25 ± 25	42 ± 17
E. tourneforti	25 ± 25	75 ± 25	100 ± 0	67 ± 22
Gorgonia ventalina	75 ± 25	100 ± 0	100 ± 0	92 ± 8
Muricea elongata	100 ± 0	100 ± 0	100 ± 0	100 ± 0
M. muricata	25 ± 25	100 ± 0	100 ± 0	75 ± 25
Muriceopsis flavida	25 ± 25	75 ± 25	100 ± 0	67 ± 22
Plexaura flexuosa	25 ± 25	75 ± 25	50 ± 29	50 ± 14
Plexaurella dichotoma	100 ± 0	75 ± 25	50 ± 29	75 ± 14
P. grisea	25 ± 25	000 ± 0	0 ± 0	8 ± 8
Pseudoplexaura flagellosa	0 ± 0	50 ± 29	25 ± 25	25 ± 14
P. porosa	0 ± 0	75 ± 25	75 ± 25	50 ± 25
Pseudopterogorgia acerosa	100 ± 0	100 ± 0	100 ± 0	100 ± 0
P. americana	100 ± 0	100 ± 0	100 ± 0	100 ± 0
P. bipinnata	50 ± 29	100 ± 0	50 ± 29	67 ± 17
P. rigida	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Pterogorgia citrina	0 ± 0	25 ± 25	100 ± 0	42 ± 30
P. guadalupensis	0 ± 0	25 ± 25	25 ± 25	17 ± 8
Total gorgonian species	17	15	18	21

Table 3-4. Species richness of sponges, stony corals (Milleporina and Scleractinia), and gorgonians (Octocorallia) at Conch Reef RO along the depth contour of the Aquarius Undersea Habitat. Species-level data are the mean ± 1 SE transect frequency of occurrence (%) from surveys of four 15-m x 1-m transects (60 m^2) at each site during July-August 2010.

Species	**Northeast (626)**	**Central (625)**	**Southwest (B24)**	**All sites**
Sponges				
Adocia carbonifera	0 ± 0	0 ± 0	50 ± 29	17 ± 17
Agelas clathrodes	25 ± 25	50 ± 29	50 ± 29	42 ± 8
A. dispar	0 ± 0	25 ± 25	0 ± 0	8 ± 8
A. schmidti	75 ± 25	100 ± 0	75 ± 25	83 ± 8
A. wiedenmayaari	50 ± 29	75 ± 25	100 ± 0	75 ± 14
Amphimedon compressa	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Anthosigmella varians	50 ± 29	100 ± 0	100 ± 0	83 ± 17
Aplysina archeri	0 ± 0	0 ± 0	25 ± 25	8 ± 8
A. cauliformis	100 ± 0	100 ± 0	100 ± 0	100 ± 0
A. fistularis	0 ± 0	0 ± 0	25 ± 25	8 ± 8
A. fulva	100 ± 0	50 ± 29	0 ± 0	50 ± 29
A. lacunosa	75 ± 25	100 ± 0	100 ± 0	92 ± 8
Callyspongia fallax	25 ± 25	0 ± 0	25 ± 25	17 ± 8
C. plicifera	50 ± 29	75 ± 25	25 ± 25	50 ± 14
C. vaginalis	75 ± 25	50 ± 29	100 ± 0	75 ± 14
Chondrilla nucula	50 ± 29	50 ± 29	25 ± 25	42 ± 8
Cliona deletrix	50 ± 29	75 ± 25	75 ± 25	67 ± 8
Diplastrella megastellata	50 ± 29	75 ± 25	75 ± 25	67 ± 8
Ectyoplasia ferox	100 ± 0	100 ± 0	25 ± 25	75 ± 25
Geodia neptuna	50 ± 29	0 ± 0	25 ± 25	25 ± 14
Haliclona aqueaductus	0 ± 0	25 ± 25	25 ± 25	17 ± 8
Iotrochota birotulata	25 ± 25	75 ± 25	25 ± 25	42 ± 17
Ircinia felix	50 ± 29	75 ± 25	100 ± 0	75 ± 14
I. strobilina	100 ± 0	100 ± 0	100 ± 0	100 ± 0
I. variabilis	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Monanchora barbadensis	0 ± 0	25 ± 25	0 ± 0	8 ± 8
M. unguifera	0 ± 0	50 ± 29	0 ± 0	17 ± 17
Mycale laevis	100 ± 0	50 ± 29	25 ± 25	58 ± 22
Myrmekioderma sp.	50 ± 29	25 ± 25	25 ± 25	33 ± 8
Neofibularia notilangere	0 ± 0	50 ± 29	25 ± 25	25 ± 14
Niphates amorpha	50 ± 29	25 ± 25	75 ± 25	50 ± 14
N. digitalis	100 ± 0	100 ± 0	100 ± 0	100 ± 0
N. erecta	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Pandaros acanthifolium	0 ± 0	50 ± 29	25 ± 25	25 ± 14
Pseudoceratina crassa	75 ± 25	75 ± 25	100 ± 0	83 ± 8
Ptilocaulis sp.	100 ± 0	50 ± 29	50 ± 29	67 ± 17
Rhaphidophlus juniperinis	0 ± 0	25 ± 25	0 ± 0	8 ± 8
Spheciospongia vesparium	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Spinosella tenerrima	25 ± 25	50 ± 29	75 ± 25	50 ± 14
Spirastrella coccinea	100 ± 0	25 ± 25	75 ± 25	67 ± 22
S. mollis	50 ± 29	75 ± 25	75 ± 25	67 ± 8
Ulosa rüetzleri	100 ± 0	75 ± 25	100 ± 0	92 ± 8
Unknown brown lumpy	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Unknown olive *Verongula*	50 ± 29	75 ± 25	0 ± 0	42 ± 22
Unknown red squishy	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Verongula gigantea	25 ± 25	0 ± 0	25 ± 25	17 ± 8
V. reiswigi	0 ± 0	0 ± 0	25 ± 25	8 ± 8
V. rigida	50 ± 29	25 ± 25	0 ± 0	25 ± 14
Xestospongia muta	75 ± 25	75 ± 25	100 ± 0	83 ± 8
Total sponge species	24	31	32	43
Stony corals				
Agaricia agaricites	100 ± 0	100 ± 0	100 ± 0	100 ± 0
A. fragilis	0 ± 0	25 ± 25	50 ± 29	25 ± 14

Species	Northeast (626)	Central (625)	Southwest (B24)	All sites
A. lamarcki	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Colpophyllia natans	0 ± 0	25 ± 25	25 ± 25	17 ± 8
Dichocoenia stokesi	50 ± 29	50 ± 29	25 ± 25	42 ± 8
Diploria labyrinthiformis	0 ± 0	25 ± 25	25 ± 25	17 ± 8
Eusmilia fastigiata	25 ± 25	25 ± 25	0 ± 0	17 ± 8
Madracis decactis	75 ± 25	75 ± 25	25 ± 25	58 ± 17
Manicina areolata	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Meandrina meandrites	0 ± 0	25 ± 25	0 ± 0	8 ± 8
Millepora alcicornis	100 ± 0	100 ± 0	100 ± 0	100 ± 0
M. annularis	0 ± 0	25 ± 25	0 ± 0	8 ± 8
M. faveolata	50 ± 29	75 ± 25	50 ± 29	58 ± 8
M. franksi	0 ± 0	25 ± 25	50 ± 29	25 ± 14
M. cavernosa	75 ± 25	50 ± 29	75 ± 25	67 ± 8
Mycetophyllia aliciae	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Mycetophyllia danaana	25 ± 25	0 ± 0	0 ± 0	8 ± 8
Porites astreoides	100 ± 0	100 ± 0	75 ± 25	92 ± 8
P. porites f. divaricata	25 ± 25	75 ± 25	0 ± 0	33 ± 22
P. porites f. furcata	75 ± 25	75 ± 25	50 ± 29	67 ± 8
P. porites f. porites	0 ± 0	25 ± 25	0 ± 0	8 ± 8
Siderastrea radians	50 ± 29	75 ± 25	75 ± 25	67 ± 8
S. siderea	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Stephanocoenia michelini	100 ± 0	100 ± 0	75 ± 25	92 ± 8
Total stony coral species	17	20	15	24
Gorgonians				
Briareum asbestinum	75 ± 25	100 ± 0	100 ± 0	92 ± 8
Erythropodium caribaeorum	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Eunicea calyculata	25 ± 25	0 ± 0	0 ± 0	8 ± 8
E. fusca	75 ± 25	75 ± 25	100 ± 0	83 ± 8
E. laciniata	50 ± 29	100 ± 0	0 ± 0	50 ± 29
E. mammosa	25 ± 25	75 ± 25	0 ± 0	33 ± 22
E. succinea	100 ± 0	50 ± 29	25 ± 25	58 ± 22
E. tourneforti	0 ± 0	0 ± 0	25 ± 25	8 ± 8
Gorgonia ventalina	50 ± 29	100 ± 0	50 ± 29	67 ± 17
Muricea elongata	25 ± 25	75 ± 25	0 ± 0	33 ± 22
M. muricata	25 ± 25	50 ± 29	0 ± 0	25 ± 14
Muriceopsis flavida	50 ± 29	75 ± 25	0 ± 0	42 ± 22
Plexaura flexuosa	75 ± 25	75 ± 25	100 ± 0	83 ± 8
Plexaurella dichotoma	0 ± 0	50 ± 25	25 ± 25	25 ± 14
P. nutans	50 ± 29	0 ± 0	0 ± 0	17 ± 17
Pseudoplexaura porosa	0 ± 0	50 ± 29	0 ± 0	17 ± 17
Pseudopterogorgia acerosa	100 ± 0	100 ± 0	100 ± 0	100 ± 0
P. americana	100 ± 0	100 ± 0	100 ± 0	100 ± 0
P. bipinnata	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Pterogorgia citrina	25 ± 25	0 ± 0	50 ± 29	25 ± 14
Total gorgonian species	17	15	18	21

Table 3-5. Mean ± 1 SE benthic cover (%) of abiotic and biotic components at shallow (< 6 m) Conch Reef SPA along the shoreward ledge and low-relief hard-bottom habitat, as determined from surveys of four 15-m transects per site at three sites from northeast to southwest across the shallow ledge during July-August 2010. A total of 100 points were surveyed per transect at each site.

Bottom type	**Northeast (A86)**	**Central (555)**	**Southwest (554)**	**All sites**
Millepora spp.	1.00 ± 0.00	1.25 ± 0.95	1.75 ± 0.63	1.33 ± 0.22
Acropora cervicornis	0 ± 0	0.00 ± 0.00	0.25 ± 0.25	0.08 ± 0.08
A. palmata	0 ± 0	0.00 ± 0.00	0.25 ± 0.25	0.08 ± 0.08
Agaricia agaricites	0 ± 0	0.00 ± 0.00	0.50 ± 0.29	0.17 ± 0.17
Siderastrea siderea	0.25 ± 0.25	0.75 ± 0.25	0.75 ± 0.25	0.58 ± 0.17
Total scleractinian corals	0.25 ± 0.25	0.75 ± 0.25	1.75 ± 0.63	0.92 ± 0.44
Total stony corals	1.25 ± 0.25	2.00 ± 1.00	3.50 ± 0.96	2.25 ± 0.66
Encrusting gorgonians	0 ± 0	0.50 ± 0.50	0.50 ± 0.29	0.33 ± 0.17
Branching gorgonians	2.50 ± 0.87	5.00 ± 0.41	4.50 ± 2.53	4.00 ± 0.76
Palythoa	4.00 ± 2.12	7.00 ± 4.18	3.50 ± 1.50	4.83 ± 1.09
Sponges	1.25 ± 0.75	0.75 ± 0.48	5.00 ± 2.04	2.33 ± 1.34
Cyanobacteria or diatoms	0 ± 0	0.25 ± 0.25	0.75 ± 0.25	0.33 ± 0.22
Crustose coralline algae	5.75 ± 2.50	4.00 ± 0.82	20.00 ± 5.05	9.92 ± 5.07
Algal turf	24.00 ± 4.36	33.50 ± 3.77	31.50 ± 4.73	29.67 ± 2.89
Halimeda spp.	2.25 ± 1.03	4.00 ± 0.41	3.50 ± 0.87	3.25 ± 0.52
Dictyota spp.	41.50 ± 2.96	32.25 ± 4.37	21.50 ± 1.85	31.75 ± 5.78
Stypopodium zonale	1.50 ± 0.65	0.00 ± 0.00	0.50 ± 0.29	0.67 ± 0.44
Total brown macroalgae	43.00 ± 2.65	32.25 ± 4.37	22.00 ± 1.83	32.42 ± 6.06
Amphiroa and *Galaxaura*	0.25 ± 0.25	0 ± 0	0 ± 0	0.08 ± 0.08
Laurencia intricata	6.25 ± 1.65	0 ± 0	0 ± 0	2.08 ± 2.08
Total macroalgae	51.75 ± 3.71	36.25 ± 4.13	25.50 ± 2.40	37.83 ± 7.62
Total algal cover	81.50 ± 2.06	74.00 ± 4.71	77.75 ± 3.40	77.75 ± 2.17
Bare space	0.25 ± 0.25	0.25 ± 0.25	0 ± 0	0.17 ± 0.08
Rubble	1.50 ± 0.87	0.50 ± 0.29	0 ± 0	0.67 ± 0.44
Sand	1.75 ± 0.85	1.25 ± 0.75	2.25 ± 0.63	1.75 ± 0.29
Sand or silt on hard-bottom	6.00 ± 2.16	8.75 ± 2.93	3.00 ± 1.35	5.92 ± 1.66

Table 3-6. Mean ± 1 SE benthic cover (%) of abiotic and biotic components at deeper (6-15 m depth) Conch Reef SPA in the low-relief spur and groove habitat, as determined from surveys of four 15-m transects per site at three sites from northeast to southwest offshore of the mooring buoys during July-August 2010. A total of 100 points were surveyed per transect at each site.

Bottom type	**Northeast (B16)**	**Central (610)**	**Southwest (611)**	**All sites**
Millepora spp.	1.50 ± 0.50	0.50 ± 0.29	1.25 ± 0.25	1.08 ± 0.30
Aagaricia agaricites	0.25 ± 0.25	0 ± 0	0.50 ± 0.29	0.25 ± 0.14
Madracis mirabilis	0 ± 0	0 ± 0	0.25 ± 0.25	0.08 ± 0.08
Porites astreoides	0 ± 0	0.25 ± 0.25	0 ± 0	0.08 ± 0.08
P. porites porites	0 ± 0	0.25 ± 0.25	0.25 ± 0.25	0.17 ± 0.08
Siderastrea radians	0.25 ± 0.25	0 ± 0	0 ± 0	0.08 ± 0.08
S. siderea	0.50 ± 0.29	1.00 ± 0.41	0.25 ± 0.25	0.58 ± 0.22
Stephanocoenia michelini	0 ± 0	0.00 ± 0	0.50 ± 0.29	0.17 ± 0.17
Total Scleractinia	1.00 ± 0.41	1.50 ± 0.50	1.75 ± 0.25	1.42 ± 0.22
Total stony coral	2.50 ± 0.87	2.00 ± 0.41	3.00 ± 0.41	2.50 ± 0.29
Encrusting gorgonians	0 ± 0	0.75 ± 0.48	0.50 ± 0.29	0.42 ± 0.22
Branching gorgonians	2.25 ± 0.25	2.50 ± 0.29	2.75 ± 0.63	2.50 ± 0.14
Palythoa	0 ± 0	1.00 ± 0	0 ± 0	0.33 ± 0.33
Sponges	4.00 ± 1.35	7.50 ± 1.55	8.00 ± 1.78	6.50 ± 1.26
Cyanobacteria	1.50 ± 0.65	0.25 ± 0.25	0.75 ± 0.75	0.83 ± 0.36
Crustose coralline algae	0.50 ± 0.50	1.50 ± 0.29	0.75 ± 0.25	0.92 ± 0.30
Algal turf	45.50 ± 5.12	15.00 ± 1.87	25.50 ± 2.47	28.67 ± 8.95
Halimeda spp.	3.00 ± 0	3.00 ± 0.58	3.00 ± 0.91	3.00 ± 0.00
Udotea spp.	0.50 ± 0.29	0 ± 0	0 ± 0	0.17 ± 0.17
Dictyota spp.	21.50 ± 4.03	37.75 ± 1.18	29.00 ± 2.27	29.42 ± 4.70
Lobophora variegata	0 ± 0	0.50 ± 0.29	0 ± 0	0.17 ± 0.17
Stypopodium zonale	0 ± 0	0 ± 0	1.50 ± 0.65	0.50 ± 0.50
Total brown macroalgae	21.50 ± 4.03	38.25 ± 1.31	30.50 ± 2.02	30.08 ± 4.84
Amphiroa and *Galaxaura*	0.25 ± 0.25	1.75 ± 0.25	0.50 ± 0.29	0.83 ± 0.46
Total macroalgae	25.25 ± 4.35	43.00 ± 1.22	34.00 ± 2.92	34.08 ± 5.12
Total algal cover	72.75 ± 2.75	59.75 ± 1.03	61.00 ± 1.78	64.50 ± 4.14
Bare space	0 ± 0	0.25 ± 0.25	0 ± 0	0.08 ± 0.08
Rubble	1.75 ± 0.48	2.00 ± 0.00	0.75 ± 0.48	1.50 ± 0.38
Sand	3.50 ± 1.04	4.75 ± 1.44	6.25 ± 1.03	4.83 ± 0.79
Sand or silt on hard-bottom	13.25 ± 3.35	19.50 ± 2.18	17.75 ± 1.80	16.83 ± 1.86

Table 3-7. Mean ± 1 SE benthic cover (%) of abiotic and biotic components in Conch Reef RO in the low-relief spur and groove habitat along the depth contour of the Aquarius Undersea Laboratory, as determined from surveys of four 15-m transects per site at three sites from northeast to southwest during July-August 2010. A total of 100 points were surveyed per transect at each site.

Bottom type	**Northeast (626)**	**Central (625)**	**Southwest (B24)**	**All sites**
Millepora spp.	0.75 ± 0.25	1.75 ± 0.48	2.50 ± 0.65	1.67 ± 0.51
Agaricia agaricites	0.25 ± 0.25	0.50 ± 0.29	0.25 ± 0.25	0.33 ± 0.08
Madracis decactis	0.25 ± 0.25	0 ± 0	0.25 ± 0.25	0.17 ± 0.08
Montastraea annularis	0 ± 0	0.25 ± 0.25	0 ± 0	0.08 ± 0.08
M. cavernosa	0 ± 0	0 ± 0	1.00 ± 0.58	0.33 ± 0.33
M. faveolata	0 ± 0	0.25 ± 0.25	0.50 ± 0.29	0.25 ± 0.14
Porites astreoides	0.50 ± 0.50	0.50 ± 0.29	0 ± 0	0.33 ± 0.17
P. porites furcata	0 ± 0	0.25 ± 0.25	0 ± 0	0.08 ± 0.08
Siderastrea radians	0 ± 0	0 ± 0	0.25 ± 0.25	0.08 ± 0.08
S. siderea	0.50 ± 0.29	0.75 ± 0.25	1.00 ± 0.41	0.75 ± 0.14
Stephanocoenia intersepta	1.00 ± 0.41	0 ± 0	0.50 ± 0.29	0.50 ± 0.29
Total Scleractinia	2.50 ± 1.32	2.50 ± 0.87	3.75 ± 1.11	2.92 ± 0.42
Total stony coral	3.25 ± 1.11	4.25 ± 1.31	6.25 ± 1.65	4.58 ± 0.88
Encrusting gorgonians	4.50 ± 1.04	3.00 ± 1.47	3.00 ± 0.71	3.50 ± 0.50
Branching gorgonians	1.00 ± 0.41	4.75 ± 1.11	1.50 ± 0.65	2.42 ± 1.18
Sponges	9.25 ± 1.25	11.00 ± 1.78	11.25 ± 1.11	10.50 ± 0.63
Cyanobacteria	0 ± 0	5.50 ± 0.96	0.75 ± 0.25	2.08 ± 1.72
Crustose coralline algae	9.75 ± 2.39	6.75 ± 2.17	9.00 ± 0.82	8.50 ± 0.90
Algal turf	5.75 ± 1.11	12.00 ± 1.78	12.50 ± 2.02	10.08 ± 2.17
Halimeda spp.	1.00 ± 0.71	0.25 ± 0.25	0.25 ± 0.25	0.50 ± 0.25
Dictyota spp.	36.50 ± 2.40	42.00 ± 2.16	38.75 ± 2.72	39.08 ± 1.60
Lobophora variegata	10.50 ± 3.23	0 ± 0	3.75 ± 1.38	4.75 ± 3.07
Stypopodium zonale	1.00 ± 0.71	0 ± 0	1.75 ± 1.44	0.92 ± 0.51
Total brown macroalgae	48.00 ± 1.47	42.00 ± 2.16	44.25 ± 3.57	44.75 ± 1.75
Amphiroa and *Galaxaura*	0.25 ± 0.25	0.25 ± 0.25	0.75 ± 0.48	0.42 ± 0.17
Total macroalgae	49.25 ± 1.31	42.50 ± 2.40	45.25 ± 4.07	45.67 ± 1.96
Total algal cover	64.75 ± 1.31	66.75 ± 1.49	67.50 ± 4.77	66.33 ± 0.82
Bare space	0.25 ± 0.25	1.00 ± 0.41	1.25 ± 0.48	0.83 ± 0.30
Rubble	1.75 ± 0.48	0.25 ± 0.25	0 ± 0	0.67 ± 0.55
Sand	5.00 ± 2.80	3.50 ± 1.50	1.25 ± 0.75	3.25 ± 1.09
Sand or silt on hard-bottom	10.25 ± 1.18	5.50 ± 0.87	8.00 ± 1.22	7.92 ± 1.37

Table 3-8. Numbers (N) of colonies (relative abundance, %) and mean ± 1 SE density (no. colonies per m^2) of stony corals at Conch Reef, as determined from surveys of two 10-m x 1-m transects per site at three sites from northeast to southwest during July-August 2010.

Shallow (< 6 m) Conch Reef SPA

Coral species	**Northeast (A86)**		**Central (555)**		**Southwest (554)**		**All sites**	
	N (%)	No. per m^2	N (%)	No. per m^2	N (%)	No. per m^2	N (%)	No. per m^2
M. alcicornis	38 (37.3)	1.90 ± 1.10	69 (65.7)	3.45 ± 1.75	30 (29.7)	1.50 ± 0.00	137 (44.5)	2.28 ± 0.59
M. complanata	2 (2.0)	0.10 ± 0.00	16 (15.2)	0.80 ± 0.70	12 (11.9)	0.60 ± 0.30	30 (9.7)	0.50 ± 0.21
Millepora	40 (39.2)	2.00 ± 1.10	85 (81.0)	4.25 ± 2.45	42 (41.6)	2.10 ± 0.30	167 (54.2)	2.78 ± 0.73
A. cervicornis	0 (0)	0 ± 0	0 (0)	0.00 ± 0	4 (4.0)	0.20 ± 0.00	4 (1.3)	0.07 ± 0.07
A. agaricites	25 (24.5)	1.25 ± 1.15	6 (5.7)	0.30 ± 0.00	20 (19.8)	1.00 ± 0.40	51 (16.6)	0.85 ± 0.28
C. natans	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (1.0)	0.05 ± 0.05	1 (0.3)	0.02 ± 0.02
D. cylindrus	1 (1.0)	0.05 ± 0.05	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (0.3)	0.02 ± 0.02
E. fastigiata	1 (1.0)	0.05 ± 0.05	0 (0)	0 ± 0	1 (1.0)	0.05 ± 0.05	2 (0.6)	0.03 ± 0.02
L. cucullata	1 (1.0)	0.05 ± 0.05	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (0.3)	0.02 ± 0.02
M. decactis	1 (1.0)	0.05 ± 0.05	1 (1.0)	0.05 ± 0.05	0 (0)	0 ± 0	2 (0.6)	0.03 ± 0.02
M. meandrites	2 (2.0)	0.10 ± 0.10	1 (1.0)	0.05 ± 0.05	0 (0)	0 ± 0	3 (1.0)	0.05 ± 0.03
P. astreoides	0 (0)	0 ±0	0 (0)	0 ± 0	17 (16.8)	0.85 ± 0.35	17 (5.5)	0.28 ± 0.28
P. furcata	2 (2.0)	0.10 ± 0.00	2 (1.9)	0.10 ± 0.10	0 (0)	0 ± 0	4 (1.3)	0.07 ± 0.03
P. porites	2 (2.0)	0.10 ± 0	1 (1.0)	0.05 ± 0.05	2 (2.0)	0.10 ± 0.10	5 (1.6)	0.08 ± 0.02
S. siderea	26 (25.5)	1.30 ± 0.40	8 (7.6)	0.40 ± 0.10	14 (13.9)	0.70 ± 0.40	48 (15.6)	0.80 ± 0.26
S. michelini	1 (1.0)	0.05 ± 0.05	1 (1.0)	0.05 ± 0.05	0 (0)	0 ± 0	2 (0.6)	0.03 ± 0.02
Scleractinia	62 (60.8)	3.10 ± 1.90	20 (19.0)	1.00 ± 0.20	59 (58.4)	2.95 ± 0.35	141 (45.8)	2.35 ± 0.68
Total	102 (100)	5.10 ± 0.80	105 (100)	5.25 ± 2.25	101 (100)	5.05 ± 0.05	308 (100)	5.13 ± 0.06

Deeper (6-15 m) Conch Reef SPA

Coral species	**Northeast (B16)**		**Central (610)**		**Southwest (611)**		**All sites**	
	N (%)	No. per m^2	N (%)	No. per m^2	N (%)	No. per m^2	N (%)	No. per m^2
M. alcicornis	33 (62.3)	1.65 ± 0.35	105 (64.8)	5.25 ± 1.15	76 (56.3)	3.80 ± 0.50	214 (61.1)	3.57 ± 1.05
A. agaricites	3 (5.7)	0.15 ± 0.15	6 (3.7)	0.30 ± 0.20	14 (10.4)	0.70 ± 0.00	23 (6.6)	0.38 ± 0.16
A. fragilis	0 (0)	0 ± 0	2 (1.2)	0.10 ± 0.10	0 (0)	0.00 ± 0	2 (0.6)	0.03 ± 0.03
C. natans	0 (0)	0 ± 0	1 (0.6)	0.05 ± 0.05	1 (0.7)	0.05 ± 0.05	2 (0.6)	0.03 ± 0.02
D. stokes	0 (0)	0 ± 0	3 (1.9)	0.15 ± 0.05	1 (0.7)	0.05 ± 0.05	4 (1.1)	0.07 ± 0.04
M. decactis	0 (0)	0 ± 0	1 (0.6)	0.05 ± 0.05	0 (0)	0.00 ± 0	1 (0.3)	0.02 ± 0.02
M. areolata	1 (1.9)	0.05 ± 0.05	0 (0)	0 ± 0	0 (0)	0.00 ± 0	1 (0.3)	0.02 ± 0.02
M. meandrites	0 (0)	0 ± 0	0 (0)	0 ± 0	4 (3.0)	0.20 ± 0.20	4 (1.1)	0.07 ± 0.07
M. cavernosa	2 (3.8)	0.10 ± 0.10	1 (0.6)	0.05 ± 0.05	2 (1.5)	0.10 ± 0	5 (1.4)	0.08 ± 0.02
P. astreoides	2 (3.8)	0.10 ± 0.00	11 (6.8)	0.55 ± 0.25	5 (3.7)	0.25 ± 0.05	18 (5.1)	0.30 ± 0.13
P. furcata	0 (0)	0 ± 0	1 (0.6)	0.05 ± 0.05	0 (0)	0.00 ± 0	1 (0.3)	0.02 ± 0.02
P. porites	1 (1.9)	0.05 ± 0.05	5 (3.1)	0.25 ± 0.15	6 (4.4)	0.30 ± 0.20	12 (3.4)	0.20 ± 0.08
S. radians	1 (1.9)	0.05 ± 0.05	1 (0.6)	0.05 ± 0.05	2 (1.5)	0.10 ± 0	4 (1.1)	0.07 ± 0.02
S. siderea	8 (15.1)	0.40 ± 0.20	18 (11.1)	0.90 ± 0.40	15 (11.1)	0.75 ± 0.05	41 (11.7)	0.68 ± 0.15
S. bournoni	1 (1.9)	0.05 ± 0.05	0 (0)	0 ± 0	0 (0)	0.00 ± 0	1 (0.3)	0.02 ± 0.02
S. michelini	1 (1.9)	0.05 ± 0.05	7 (4.3)	0.35 ± 0.15	9 (6.7)	0.45 ± 0.05	17 (4.9)	0.28 ± 0.12
Scleractinia	19 (35.8)	0.95 ± 0.15	57 (35.2)	2.85 ± 1.45	59 (43.7)	2.95 ± 0.05	135 (38.6)	2.25 ± 0.65
Total	53 (100)	2.60 ± 0.50	162 (100)	8.10 ± 0.30	135 (100)	6.75 ± 0.55	350 (100)	5.82 ± 1.65

Conch Reef RO

Coral species	**Northeast (626)**		**Central (625)**		**Southwest (B24)**		**All sites**	
	N (%)	No. per m^2	N (%)	No. per m^2	N (%)	No. per m^2	N (%)	No. per m^2
M. alcicornis	162 (62.1)	8.10 ± 0.50	84 (45.2)	4.20 ± 0.90	133	6.65 ± 0.55	379 (57.4)	6.32 ± 1.14
A. agaricites	26 (10.0)	1.30 ± 0.20	23 (12.4)	1.15 ± 0.35	14 (6.6)	0.70 ± 0.20	63 (9.5)	1.05 ± 0.18
A. fragilis	0 (0)	0 ± 0	1 (0.5)	0.05 ± 0.05	0 (0)	0 ± 0	1 (0.2)	0.02 ± 0.02
D. stokes	2 (0.8)	0.10 ± 0.1	1 (0.5)	0.05 ± 0.05	0 (0)	0 ± 0	3 (0.5)	0.05 ± 0.03
D. labyrinthiformis	0 (0)	0 ± 0	1 (0.5)	0.05 ± 0.05	1 (0.5)	0.05 ± 0.05	2 (0.3)	0.03 ± 0.02
D. strigosa	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (0.5)	0.05 ± 0.05	1 (0.2)	0.02 ± 0.02
E. fastigiata	1 (0.4)	0.05 ± 0.05	1 (0.5)	0.05 ± 0.05	0 (0)	0 ± 0	2 (0.3)	0.03 ± 0.02
M. decactis	1 (0.4)	0.05 ± 0.05	1 (0.5)	0.05 ± 0.05	5 (2.3)	0.25 ± 0.15	7 (1.1)	0.12 ± 0.07
M. areolata	2 (0.8)	0.10 ± 0.10	0 (0)	0 ± 0	0 (0)	0 ± 0	2 (0.3)	0.03 ± 0.03
M. annularis	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (0.5)	0.05 ± 0.05	1 (0.2)	0.02 ± 0.02
M. faveolata	1 (0.4)	0.05 ± 0.05	0 (0)	0 ± 0	2 (0.9)	0.10 ± 0	3 (0.5)	0.05 ± 0.03
M. cavernosa	3 (1.1)	0.15 ± 0.05	0 (0)	0 ± 0	4 (1.9)	0.20 ± 0.20	7 (1.1)	0.12 ± 0.06
M. danaana	1 (0.4)	0.05 ± 0.05	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (0.2)	0.02 ± 0.02
P. astreoides	19 (7.3)	0.95 ± 0.45	21 (11.3)	1.05 ± 0.15	13 (6.1)	0.65 ± 0.05	53 (8.0)	0.88 ± 0.12
P. porites	1 (0.4)	0.05 ± 0.05	10 (5.4)	0.50 ± 0.10	0 (0)	0 ± 0	11 (1.7)	0.18 ± 0.16
Scolymia sp.	0 (0)	0 ± 0	1 (0.5)	0.05 ± 0.05	0 (0)	0 ± 0	1 (0.2)	0.02 ± 0.02
S. radians	1 (0.4)	0.05 ± 0.05	2 (1.1)	0.10 ± 0.00	1 (0.5)	0.05 ± 0.05	4 (0.6)	0.07 ± 0.02
S. siderea	24 (9.2)	1.20 ± 0.20	32 (17.2)	1.60 ± 0.10	27 (12.7)	1.35 ± 0.05	83 (12.6)	1.38 ± 0.12
S. michelini	17 (6.5)	0.85 ± 0.05	8 (4.3)	0.40 ± 0.00	11 (5.2)	0.55 ± 0.05	36 (5.5)	0.60 ± 0.13
Scleractinia	99 (37.9)	4.95 ± 0.85	102 (54.8)	5.10 ± 0.80	80 (37.6)	4.00 ± 0.40	281 (42.6)	4.68 ± 0.34
Total	261 (100)	13.05 ± 1.35	186 (100)	9.30 ± 1.70	213 (100)	10.65 ± 0.95	660 (100)	11.00 ± 1.10

Table 3-9. Numbers (N) of colonies (relative abundance, %) and mean ± 1 SE density (no. colonies per m^2) of larger scleractinian coral species by size class (max. diameter, cm) at shallow (< 6 m) Conch Reef SPA, deeper (6-15 m) Conch Reef SPA, and Conch Reef RO along the depth contour of the Aquarius Undersea HabitaConch Reef, as determined from surveys of two 10-m x 1-m transects per site at three sites from northeast to southwest during July-August 2010. Data represent pooled values in each depth zone from surveys of 60 m^2 of substratum.

Coral species	**Conch Reef SPA (< 6 m)**		**Conch Reef SPA (6-15 m)**		**Conch Reef RO**	
	N (%)	No. per m^2	N (%)	No. per m^2	N (%)	No. per m^2
A. cervicornis						
4-15 cm	1 (25.0)	0.02 ± 0.02	0 (0)	0 ± 0	0 (0)	0 ± 0
15-50 cm	3 (75.0)	0.05 ± 0.05	0 (0)	0 ± 0	0 (0)	0 ± 0
50-100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
> 100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
C. natans						
4-15 cm	0 (0)	0 ± 0	2 (100)	0.03 ± 0.02	0 (0)	0 ± 0
15-50 cm	1	0.02 ± 0.02	0 (0)	0 ± 0	0 (0)	0 ± 0
50-100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
> 100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
D. cylindrus						
4-15 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
15-50 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
50-100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
> 100 cm	1 (100)	0.02 ± 0.02	0 (0)	0 ± 0	0 (0)	0 ± 0
D. labyrinthiformis						
4-15 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (50)	0.02 ± 0.02
15-50 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (50)	0.02 ± 0.02
50-100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
> 100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
D. strigosa						
4-15 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
15-50 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (100)	0.02 ± 0.02
50-100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
> 100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
M. annularis						
4-15 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
15-50 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (100)	0.02 ± 0.02
50-100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
> 100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
M. faveolata						
4-15 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (33.3)	0.02 ± 0.02
15-50 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (33.3)	0.02 ± 0.02
50-100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (33.3)	0.02 ± 0.02
> 100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
M. cavernosa						
4-15 cm	0 (0)	0 ± 0	4 (80)	0.07 ± 0.02	4 (57.1)	0.07 ± 0.04
15-50 cm	0 (0)	0 ± 0	1 (20)	0.02 ± 0.02	3 (42.9)	0.05 ± 0.05
50-100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
> 100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0

Coral species	Conch Reef SPA (< 6 m)		Conch Reef SPA (6-15 m)		Conch Reef RO	
	N (%)	No. per m^2	N (%)	No. per m^2	N (%)	No. per m^2
S. siderea						
4-15 cm	41 (85.4)	0.68 ± 0.25	36 (87.8)	0.60 ± 0.14	72 (87.8)	1.20 ± 0.14
15-50 cm	7 (14.6)	0.12 ± 0.02	5 (12.2)	0.08 ± 0.03	10 (12.2)	0.17 ± 0.04
50-100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
> 100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
S. bournoni						
4-15 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	31 (86.1)	0.52 ± 0.12
15-50 cm	0 (0)	0 ± 0	1 (100)	0.02 ± 0.02	5 (13.9)	0.08 ± 0.02
50-100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
> 100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
S. michelini						
4-15 cm	1 (50)	0.02 ± 0.02	13 (76.5)	0.22 ± 0.08	31 (86.1)	0.52 ± 0.12
15-50 cm	1 (50)	0.02 ± 0.02	4 (23.5)	0.07 ± 0.04	5 (13.9)	0.08 ± 0.02
50-100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0
> 100 cm	0 (0)	0 ± 0	0 (0)	0 ± 0	0 (0)	0 ± 0

Table 3-10. Numbers (N) of juveniles (relative abundance, %) and mean ± 1 SE density (no. juveniles per m^2) of juvenile (< 4 cm max. diameter) scleractinian corals at shallow (< 6 m) Conch Reef SPA, deeper (6-15 m) Conch Reef SPA, and Conch Reef RO along the depth contour of the Aquarius Undersea Habitat, as determined from surveys of ten 0.65-cm x 0.48 cm quadrats (3.12 m^2) along each of two 15-m transects per site at three sites from northeast to southwest in each depth interval July-August 2010.

Shallow (< 6 m) Conch Reef SPA

Coral species	**Northeast (A86)**		**Central (555)**		**Southwest (554)**		**All sites**	
	N (%)	No. per m^2	N (%)	No. per m^2	N (%)	No. per m^2	N (%)	No. per m^2
A. agaricites	7 (41.2)	1.12 ± 0.80	0 (0)	0 ± 0	11 (73.3)	1.76 ± 1.44	18 (47.4)	0.96 ± 0.52
Favia fragum	1 (5.9)	0.16 ± 0.16	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (2.6)	0.05 ± 0.05
M. cavernosa	1 (5.9)	0.16 ± 0.16	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (2.6)	0.05 ± 0.05
P. astreoides	1 (5.9)	0.16 ± 0.16	2 (33.3)	0.32 ± 0.32	1 (6.7)	0.16 ± 0.16	4 (10.5)	0.21 ± 0.05
S. radians	5 (29.4)	0.80 ± 0.16	1 (16.7)	0.16 ± 0.16	1 (6.7)	0.16 ± 0.16	7 (18.4)	0.37 ± 0.21
S. siderea	0 (0)	0 ± 0	3 (50.0)	0.48 ± 0.16	1 (6.7)	0.16 ± 0.16	4 (10.5)	0.21 ± 0.14
S. michelini	2 (11.8)	0.32 ± 0.32	0 (0)	0 ± 0	1 (6.7)	0.16 ± 0.16	3 (7.9)	0.16 ± 0.09
Total juveniles	17 (100)	2.72 ± 1.12	6 (100)	0.96 ± 0.32	15 (100)	2.40 ± 1.76	38 (100)	2.72 ± 1.12

Deeper (6-15 m) Conch Reef SPA

Coral species	**Northeast (B16)**		**Central (610)**		**Southwest (611)**		**All sites**	
	N (%)	No. per m^2	N (%)	No. per m^2	N (%)	No. per m^2	N (%)	No. per m^2
A. agaricites	0 (0)	0 ± 0	4 (10.8)	0.64 ± 0.32	1 (14.3)	0.16 ± 0.16	5 (8.6)	0.27 ± 0.19
L. cucullata	0 (0)	0 ± 0	2 (5.4)	0.32 ± 0.32	0 (0)	0 ± 0	2 (3.4)	0.11 ± 0.11
M. areolata	0 (0)	0 ± 0	2 (5.4)	0.32 ± 0.32	0 (0)	0 ± 0	2 (3.4)	0.11 ± 0.11
M.cavernosa	2 (14.3)	0.32 ± 0.32	2 (5.4)	0.32 ± 0.32	2 (28.6)	0.32 ± 0.32	6 (10.3)	0.32 ± 0.00
P. astreoides	4 (28.6)	0.64 ± 0.32	8 (21.6)	1.28 ± 0.32	0 (0)	0 ± 0	12 (20.7)	0.64 ± 0.37
P. porites f. porites	1 (7.1)	0.16 ± 0.16	3 (8.1)	0.48 ± 0.48	0 (0)	0 ± 0	4 (6.9)	0.21 ± 0.14
Scolymia spp.	0 (0)	0 ± 0	1 (2.7)	0.16 ± 0.16	0 (0)	0 ± 0	1 (1.7)	0.05 ± 0.05
S. radians	6 (42.9)	0.96 ± 0.00	9 (24.3)	1.44 ± 1.12	2 (28.6)	0.32 ± 0.32	17 (29.3)	0.91 ± 0.32
S. siderea	1 (7.1)	0.16 ± 0.16	4 (10.8)	0.64 ± 0.32	1 (14.3)	0.16 ± 0.16	6 (10.3)	0.32 ± 0.16
S. michelini	0 (0)	0 ± 0	2 (5.4)	0.32 ± 0.00	1 (14.3)	0.16 ± 0.16	3 (5.2)	0.16 ± 0.09
Total	14 (100)	2.03 ± 0.54	37 (100)	5.93 ± 0.48	7 (100)	1.12 ± 0.48	58 (100)	3.10 ± 1.45

Conch Reef RO

Coral species	**Northeast (626)**		**Central (625)**		**Southwest (B24)**		**All sites**	
	N (%)	No. per m^2	N (%)	No. per m^2	N (%)	No. per m^2	N (%)	No. per m^2
A. agaricites	7 (16.7)	1.12 ± 0.16	3 (5.7)	0.48 ± 0.48	2 (16.7)	0.32 ± 0	12 (11.2)	0.64 ± 0.24
D. stokesi	2 (4.8)	0.32 ± 0.32	0 (0)	0 ± 0	0 (0)	0 ± 0	2 (1.9)	0.11 ± 0.11
M. faveolata	1 (2.4)	0.16 ± 0.16	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (0.9)	0.05 ± 0.05
M. cavernosa	1 (2.4)	0.16 ± 0.16	7 (13.2)	1.12 ± 0.16	1 (8.3)	0.16 ± 0.16	9 (8.4)	0.48 ± 0.32
P. astreoides	10 (23.8)	1.60 ± 0.32	8 (15.1)	1.28 ± 0.32	3 (25)	0.48 ± 0.16	21 (19.6)	1.12 ± 0.33
P. porites f. porites	0 (0)	0 ± 0	1 (1.9)	0.16 ± 0.16	0 (0)	0 ± 0	1 (0.9)	0.05 ± 0.05
S. radians	0 (0)	0 ± 0	3 (5.7)	0.48 ± 0.48	0 (0)	0 ± 0	3 (2.8)	0.16 ± 0.16
S. siderea	16 (38.1)	2.56 ± 0.96	27 (50.9)	4.33 ± 2.40	6 (50)	0.96 ± 0.64	49 (45.8)	2.62 ± 0.97
S. michelini	5 (11.9)	0.80 ± 0.48	4 (7.5)	0.64 ± 0.64	0 (0)	0 ± 0	9 (8.4)	0.48 ± 0.24
Total	42 (100)	6.73 ± 0.32	53 (100)	8.49 ± 4.01	12 (100)	1.92 ± 0.32	107 (100)	5.72 ± 1.96

Table 3-11. Numbers (N) of colonies (relative abundance, %) and mean ± 1 SE density (no. colonies per m^2) of gorgonians (Octocorallia) at shallow (< 6 m) Conch Reef SPA, deeper (6-15 m) Conch Reef SPA, and Conch Reef RO along the depth contour of the Aquarius Undersea Habitat, as determined from surveys of two 8-m x 1-m belt transects per site at three sites from northeast to southwest in each depth interval July-August 2010.

Shallow (< 6 m) Conch Reef SPA

Species	**Northeast (A86)**		**Central (555)**		**Southwest (554)**		**All sites**	
	N (%)	No. per m^2	N	No. per m^2	N	No. per m^2	N	No. per m^2
B. asbestinum	1 (0.8)	0.06 ± 0.06	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (0.2)	0.02 ± 0.02
E. caribaeorum	11 (9.0)	0.69 ± 0.44	7 (2.4)	0.44 ± 0.19	6 (4.1)	0.38 ± 0.38	24 (4.3)	0.50 ± 0.10
E. calyculata	1 (0.8)	0.06 ± 0.06	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (0.2)	0.02 ± 0.02
E. fusca	4 (3.3)	0.25 ± 0.25	4 (1.4)	0.25 ± 0.00	0 (0)	0 ± 0	8 (1.4)	0.17 ± 0.08
E. mammosa	3 (2.5)	0.19 ± 0.06	19 (6.6)	1.19 ± 0.19	2 (1.4)	0.13 ± 0.00	24 (4.3)	0.50 ± 0.34
E. succinea	1 (0.8)	0.06 ± 0.06	0 (0)	0 ± 0	1 (0.7)	0.06 ± 0.06	2 (0.4)	0.04 ± 0.02
E. tourneforti	3 (2.5)	0.19 ± 0.06	2 (0.7)	0.13 ± 0.00	2 (1.4)	0.13 ± 0.00	7 (1.3)	0.15 ± 0.02
G. ventalina	13 (10.7)	0.81 ± 0.69	161 (55.7)	10.06 ± 5.69	68 (46.6)	4.25 ± 2.25	242 (43.4)	5.04 ± 2.70
M. elongata	1 (0.8)	0.06 ± 0.06	2 (0.7)	0.13 ± 0.13	0 (0)	0 ± 0	3 (0.5)	0.06 ± 0.04
M. muricata	4 (3.3)	0.25 ± 0.13	9 (3.1)	0.56 ± 0.06	0 (0)	0 ± 0	13 (2.3)	0.27 ± 0.16
M. flavida	0 (0)	0 ± 0	2 (0.7)	0.13 ± 0.13	2 (1.4)	0.13 ± 0.00	4 (0.7)	0.08 ± 0.04
P. flexuosa	2 (1.6)	0.13 ± 0.13	1 (0.3)	0.06 ± 0.06	2 (1.4)	0.13 ± 0.13	5 (0.9)	0.10 ± 0.02
P. homomalla	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (0.7)	0.06 ± 0.06	1 (0.2)	0.02 ± 0.02
P. kuna	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (0.7)	0.06 ± 0.06	1 (0.2)	0.02 ± 0.02
P. dichotoma	1 (0.8)	0.06 ± 0.06	0 (0)	0 ± 0	2 (1.4)	0.13 ± 0.00	3 (0.5)	0.06 ± 0.04
P. flagellosa	0 (0)	0 ± 0	2 (0.7)	0.13 ± 0.00	0 (0)	0 ± 0	2 (0.4)	0.04 ± 0.04
P. porosa	2 (1.6)	0.13 ± 0.00	2 (0.7)	0.13 ± 0.13	2 (1.4)	0.13 ± 0.00	6 (1.1)	0.13 ± 0.00
P. acerosa	2 (1.6)	0.13 ± 0.00	4 (1.4)	0.25 ± 0.13	3 (2.1)	0.19 ± 0.19	9 (1.6)	0.19 ± 0.04
P. americana	73 (59.8)	4.56 ± 1.69	71 (24.6)	4.44 ± 0.69	53 (36.3)	3.31 ± 1.94	197 (35.4)	4.10 ± 0.40
P. citrina	0 (0)	0 ± 0	3 (1.0)	0.19 ± 0.19	1 (0.7)	0.06 ± 0.06	4 (0.7)	0.08 ± 0.06
Total	122 (100)	7.63 ± 1.63	289 (100)	18.06 ± 6.56	146 (100)	9.13 ± 4.38	557 (100)	11.60 ± 3.26

Deeper (6-15 m) Conch Reef SPA

Species	**Northeast (B16)**		**Central (610)**		**Southwest (611)**		**All sites**	
	N (%)	No. per m^2	N	No. per m^2	N	No. per m^2	N	No. per m^2
B. asbestinum	1 (1.0)	0.06 ± 0.06	4 (1.6)	0.25 ± 0.13	2 (0.8)	0.13 ± 0.13	7 (1.2)	0.15 ± 0.06
E. caribaeorum	0 (0.0)	0 ± 0	15 (5.9)	0.94 ± 0.06	28 (11.7)	1.75 ± 1.13	43 (7.2)	0.90 ± 0.51
E. fusca	8 (8.0)	0.50 ± 0.38	17 (6.6)	1.06 ± 0.19	16 (6.7)	1.00 ± 0.25	41 (6.9)	0.85 ± 0.18
E. laciniata	1 (1.0)	0.06 ± 0.06	1 (0.4)	0.06 ± 0.06	0 (0)	0 ± 0	2 (0.3)	0.04 ± 0.02
E. mammosa	5 (5.0)	0.31 ± 0.19	0 (0)	0 ± 0	2 (0.8)	0.13 ± 0.00	7 (1.2)	0.15 ± 0.09
E. succinea	1 (1.0)	0.06 ± 0.06	3 (1.2)	0.19 ± 0.19	0 (0)	0 ± 0	4 (0.7)	0.08 ± 0.06
E. tourneforti	0 (0)	0 ± 0	3 (1.2)	0.19 ± 0.06	1 (0.4)	0.06 ± 0.06	4 (0.7)	0.08 ± 0.06
G. ventalina	4 (4.0)	0.25 ± 0.25	19 (7.4)	1.19 ± 0.06	10 (4.2)	0.63 ± 0.38	33 (5.5)	0.69 ± 0.27
M. elongata	3 (3.0)	0.19 ± 0.06	14 (5.5)	0.88 ± 0.13	6 (2.5)	0.38 ± 0.13	23 (3.9)	0.48 ± 0.21
M. muricata	1 (1.0)	0.06 ± 0.06	5 (2.0)	0.31 ± 0.06	5 (2.1)	0.31 ± 0.19	11 (1.8)	0.23 ± 0.08
M. flavida	1 (1.0)	0.06 ± 0.06	1 (0.4)	0.06 ± 0.06	2 (0.8)	0.13 ± 0.13	4 (0.7)	0.08 ± 0.02
P. flexuosa	1 (1.0)	0.06 ± 0.06	1 (0.4)	0.06 ± 0.06	3 (1.3)	0.19 ± 0.06	5 (0.8)	0.10 ± 0.04
P. dichotoma	10 (10.0)	0.63 ± 0.13	3 (1.2)	0.19 ± 0.06	0 (0)	0 ± 0	13 (2.2)	0.27 ± 0.19
P. porosa	0 (0)	0 ± 0	4 (1.6)	0.25 ± 0.13	6 (2.5)	0.38 ± 0.13	10 (1.7)	0.21 ± 0.11
P. acerosa	13 (13.0)	0.81 ± 0.31	21 (8.2)	1.31 ± 0.31	35 (14.6)	2.19 ± 0.19	69 (11.6)	1.44 ± 0.40
P. americana	50 (50.0)	3.13 ± 0.13	136 (53.1)	8.50 ± 0.38	119 (49.6)	7.44 ± 1.31	305 (51.2)	6.35 ± 1.64
P. bipinnata	1 (1.0)	0.06 ± 0.06	4 (1.6)	0.25 ± 0.13	4 (1.7)	0.25 ± 0.25	9 (1.5)	0.19 ± 0.06
P. citrina	0 (0)	0 ± 0	5 (2.0)	0.31 ± 0.31	1 (0.4)	0.06 ± 0.06	6 (1.0)	0.13 ± 0.10
Total	100	6.25 ± 1.13	256 (100)	16.00 ± 1.25	240 (100)	15.00 ± 0.50	596 (100)	12.42 ± 3.10

Conch Reef RO

Species	**Northeast (626)**		**Central (625)**		**Southwest (B24)**		**All sites**	
	N (%)	No. per m^2	N	No. per m^2	N	No. per m^2	N	No. per m^2
B. asbestinum	7 (4.6)	0.44 ± 0.06	4 (2.4)	0.25 ± 0.13	6 (4.5)	0.38 ± 0.13	17 (3.7)	0.35 ± 0.06
E. caribaeorum	28 (18.4)	1.75 ± 0.38	23 (13.5)	1.44 ± 0.19	30 (22.4)	1.88 ± 0.63	81 (17.8)	1.69 ± 0.13
E. fusca	3 (2.0)	0.19 ± 0.06	8 (4.7)	0.50 ± 0.25	2 (1.5)	0.13 ± 0.00	13 (2.9)	0.27 ± 0.12
E. laciniata	3 (2.0)	0.19 ± 0.06	2 (1.2)	0.13 ± 0.00	0 (0)	0 ± 0	5 (1.1)	0.10 ± 0.06
E. mammosa	1 (0.7)	0.06 ± 0.06	2 (1.2)	0.13 ± 0.00	0 (0)	0 ± 0	3 (0.7)	0.06 ± 0.04
E. succinea	1 (0.7)	0.06 ± 0.06	2 (1.2)	0.13 ± 0.00	0 (0)	0 ± 0	3 (0.7)	0.06 ± 0.04
E. tourneforti	0 (0)	0 ± 0	0 (0)	0 ± 0	1 (0.7)	0.06 ± 0.06	1 (0.2)	0.02 ± 0.02
G. ventalina	2 (1.3)	0.13 ± 0.13	13 (7.6)	0.81 ± 0.31	5 (3.7)	0.31 ± 0.31	20 (4.4)	0.42 ± 0.21
M. elongata	0 (0)	0 ± 0	2 (1.2)	0.13 ± 0.00	0 (0)	0 ± 0	2 (0.4)	0.04 ± 0.04
M. muricata	1 (0.7)	0.06 ± 0.06	2 (1.2)	0.13 ± 0.00	0 (0)	0 ± 0	3 (0.7)	0.06 ± 0.04
M. flavida	1 (0.7)	0.06 ± 0.06	3 (1.8)	0.19 ± 0.06	0 (0)	0 ± 0	4 (0.9)	0.08 ± 0.06
P. flexuosa	1 (0.7)	0.06 ± 0.06	6 (3.5)	0.38 ± 0.00	2 (1.5)	0.13 ± 0.13	9 (2.0)	0.19 ± 0.10
P. dichotoma	0 (0)	0 ± 0	1 (0.6)	0.06 ± 0.06	0 (0)	0 ± 0	1 (0.2)	0.02 ± 0.02
P. porosa	0 (0)	0 ± 0	2 (1.2)	0.13 ± 0.00	0 (0)	0 ± 0	2 (0.4)	0.04 ± 0.04
P. acerosa	25 (16.4)	1.56 ± 0.56	19 (11.2)	1.19 ± 0.06	13 (9.7)	0.81 ± 0.31	57 (12.5)	1.19 ± 0.22
P. americana	79 (52.0)	4.94 ± 0.31	61 (35.9)	3.81 ± 0.69	53 (39.6)	3.31 ± 0.81	193 (42.3)	4.02 ± 0.48
P. bipinnata	0 (0)	0 ± 0	20 (11.8)	1.25 ± 0.38	22 (16.4)	1.38 ± 1.00	42 (9.2)	0.88 ± 0.44
Total	152 (100)	9.50 ± 1.50	170 (100)	10.63 ± 1.13	134 (100)	8.38 ± 3.38	456 (100)	9.50 ± 0.65

Table 3-12. Benthic sampling effort at Conch Reef SPA and RO during 1999-2010. Number of transects and area reflects pooled values for each depth range.

Variables	**Year**	**Conch Reef SPA (< 6 m)**		**Conch Reef SPA (6-15 m)**		**Conch Reef RO**	
		Sites/transects	Area (m^2)	Sites/transects	Area (m^2)	Sites/transects	Area (m^2)
Species richness	1999			2 (8)	160	2 (8)	160
(no. species per site)	2001	2 (8)	160				
	2002			3 (12)	120	3 (12)	120
	2003			3 (12)	240	6 (24)	480
	2005	2 (8)	120				
	2009	2 (8)	120	2 (8)	120	2 (8)	120
	2010	3 (12)	180	3 (12)	180	3 (12)	180
Benthic cover	1999			2 (8)		2 (8)	
(100 points per transect)	2001	2 (8)					
	2002			3 (12)		3 (12)	
	2003			3 (12)		6 (24)	
	2005	2 (8)					
	2009	2 (8)		2 (8)		2 (8)	
	2010	3 (12)		3 (12)		3 (12)	
Coral density and size	1999			2 (4)	40	2 (4)	40
	2001	2 (4)	40				
	2005	2 (4)	40				
	2009	2 (4)	40				
	2010	3 (6)	60	3 (6)	60	3 (6)	60
Juvenile coral density	1999			2 (4)	12.48	2 (4)	12.48
	2001	2 (4)	12.48				
	2002	3 (6)	18.72			3 (6)	18.72
	2003	3 (6)	18.72	3 (6)	18.72	3 (6)	18.72
	2005	2 (4)	12.48				
	2009	2 (4)	12.48				
	2010	3 (6)	18.72	3 (6)	18.72	3 (6)	18.72
Gorgonian density	1999			2 (4)	40	2 (4)	40
	2001	2 (4)	40				
	2005	2 (4)	32				
	2009	2 (4)	32				
	2010	3 (6)	48	3 (6)	48	3 (6)	48
Other cnidarians	1999			2 (8)	160	2 (8)	160
	2001	2 (8)	160				
	2005	2 (8)	120				
	2008			2 (8)	120	2 (8)	120
	2009	2 (8)	120				
	2010	3 (12)	180	3 (12)	180	3 (12)	180
Urchin density and size	1999			2 (8)	160	2 (8)	160
	2001	2 (8)	160				
	2005	2 (8)	120				
	2007	2 (8)	120	2 (8)	120	2 (8)	120
	2008			2 (8)	120	2 (8)	120
	2009	2 (8)	120	2 (8)	120	2 (8)	120
	2010	3 (12)	180	3 (12)	180	3 (12)	180
Marine debris	2001	2 (8)	800				
	2008			2 (8)	480	2 (8)	480
	2009						
	2010	3 (12)	180	3 (12)	180	3 (12)	180

IV. Distribution and Abundance of *Acropora* Corals

Background

The declines in abundance of two of the principal Caribbean reef-building corals, staghorn coral (*Acropora cervicornis*) and elkhorn coral (*A. palmata*), are often-cited examples of the changes that have occurred on wider Caribbean reefs, including the Florida Keys, during the past several decades (Bruckner 2002; Gardner et al. 2003). The causes of these declines, which began in the late 1970s, include regional phenomena such as coral bleaching and disease, especially white band disease (Gladfelter 1982; Aronson and Precht 2001), as well as more localized effects from storms, cold fronts, and predation by corallivorous snails and damselfishes (Miller et al. 2002). Both coral species were under consideration for addition to the U.S. Endangered Species List (ESA) as of the early 1990s and were formally determined to be "threatened" on the ESA based upon range-wide population declines and poor recovery (*Acropora* Biological Review Team 2005).

Increased awareness of the fragility of Atlantic *Acropora* corals and the potential for further population decline, as well as recovery at some locations, stresses the need to gather information on habitat distribution, colony size, density, and population abundance estimates for wider Caribbean reefs. Population assessments of *A. palmata* in the U.S. Virgin Islands (Mayor et al. 2006), southern Caribbean (Zubillaga et al. 2008), at Looe Key in the Florida Keys (Miller et al. 2002) and by our program Keys-wide in 2007 and 2008 (see 2007 and 2008 Quick Look Reports at http://people.uncw.edu/millers) are recent examples. While some recovery is apparent in localized areas, populations of both species remain well-below historical levels, including those in the Florida Keys (Dustan and Halas 1987; Porter and Meier 1992). Moreover, localized and regional threats may inhibit population recovery (*Acropora* Biological Review Team 2005).

To document the current population status of stony corals, including *Acropora* spp., we conducted an assessment of the spatial distribution, colony abundance, size, and condition of these two corals in the upper Florida Keys during 2010. This effort is similar to the 2006 and 2007 field surveys, except that we were limited in 2010 to the geographic area between SW of Crocker Reef northwards to Turtle Reef (similar to 2006). Nevertheless, these efforts contribute to a temporal record dating back to 1999 on the abundance, size, and condition of *Acropora* corals. Using a stratified random sampling design, the goals of the 2010 surveys were to assess patterns in habitat distribution, colony abundance, size, and condition of *Acropora* corals in multiple habitat types, both inside and outside of FKNMS no-take zones. The data were used to construct population abundance estimates by size class and by habitat to provide comparisons to similar data collected in 2006 and 2007.

2010 *Acropora cervicornis* Survey Results

Both *Acropora* coral species surveyed in the upper Florida Keys during 2010 exhibited distribution and abundance patterns that were mostly similar to 2007-2009. While *Acropora cervicornis* (Figure 4-1) was encountered in all of the habitats sampled, frequency of occurrence and density continue to be greatest on patch reefs. Table 4-1 shows presence-absence and mean transect frequency of occurrence data, while Table 4-2 lists site-level mean densities, total surface area, and mean size. Figures 4-2 to 4-4 illustrate the spatial distribution of *A. cervicornis* densities in the upper Florida Keys, while Figures 4-5 and 4-6 illustrate mean colony densities by site for each of the habitats sampled. Overall, *A. cervicornis* was encountered within transects at 14 out of the 120 sites (12%) and in all of the habitats surveyed (Table 4-1). Mean (± 1 SE) transect frequency of occurrence was greater on offshore patch reefs (9% ± 3%) and shallow (< 6 m) hard-bottom (8% ± 6%) and relatively low (5% ± 3%) on mid-channel patch reefs. From 84 transects surveyed at 21 mid-channel patch reefs, colonies were only found at three sites (14%) and only in reference areas. On the 17 offshore patch reefs sampled, *A. cervicornis* was present at three out of 17 sites (18%) and only found in reference sites. Staghorn coral was especially prevalent at a few patch reefs inshore of Conch Reef. As in previous years, frequency of occurrence of *A. cervicornis* was relatively low (< 5% of transects) on shallow spur and groove and deeper fore-reef habitats (Table 4-1).

A total of 131 colonies of *Acropora cervicornis* were surveyed in 480 belt transects (15-m x 1-m) among the 120 upper Keys sites, yielding a total surface area of 30,920 cm^2 (Table 4-2). On mid-channel patch reefs, 21 colonies were encountered (16% of total), yielding a mean density of 0.021 ± 0.017 colonies per m^2 and a total surface area of 5,564 cm^2. One mid-channel patch reef (site A73) west of Conch Reef contained several colonies. As in previous years, offshore patch reefs yielded the greatest densities of staghorn corals (66 colonies or 50%), even though offshore patch reefs represented only 14% of the total sampling effort in 2010 (Figure 4-2 to 4-4). Mean colony density on offshore patch reefs was 0.065 ± 0.039 per m^2, with a total colony surface area of 5,560 cm^2 among all colonies. Two sites inshore of Conch Reef (A801 and A802) and one site NW of French Reef on White Bank (643) contained several patches of staghorn corals (Figure 4-5). Shallow (< 6 m) hard-bottom sites also yielded relatively high numbers of larger colonies (Table 4-2). Other habitats such as back-reef rubble, shallow spur and groove, and deeper fore-reef habitats yielded relatively low densities of staghorn corals (Figure 4-6).

In addition to density and size assessments, the sampled staghorn colonies were also assessed for condition as related to evidence of bleaching, disease, predation, and overgrowth. Out of the 131 colonies

counted and measured in the upper Keys during 2010, a total of 21 colonies (16%) exhibited symptoms of bleaching (paling, partial or total bleaching) from late June to late August. Bleaching prevalence was relatively high in most of the habitats sampled, particularly on back-reef rubble sites (100% of colonies), high-relief spur and groove (36%), shallow hard-bottom (23%), mid-channel patch reefs (19%). Of the 131 *Acropora cervicornis* colonies sampled, none were observed with any evident signs of disease such as white-band disease. Overgrowth that was causing obvious tissue abrasion and partial mortality was documented on only four colonies (3%). Predation by *Coralliophila* snails, fireworms (*Hermodice caruncullata*), or damselfishes (Pomacentridae) affected ~8% of the colonies assessed during 2010. The proportion of colonies with obvious signs of predation was greatest on back-reef rubble sites (67%), shallow hard-bottom (23%), and offshore patch reefs (6%).

2010 *Acropora palmata* Survey Results

Acropora palmata (Figure 4-7) was encountered at 13 of the 120 upper Keys sites (11%) (Table 4-1). Table 4-1 provides presence-absence and mean transect frequency of occurrence, while Table 4-3 lists site-level mean colony densities, total surface area, and mean colony sizes. Figures 4-8 to 4-10 illustrate site-level densities across the upper Florida Keys study area and Figures 4-11 and 4-12 illustrate mean site-level densities by habitat type. Elkhorn coral colonies were found only in three of the habitats surveyed: back-reef rubble, shallow hard-bottom, and high-relief spur and groove. Mean transect frequency of occurrence was low (2%) in two of these habitats. In back-reef rubble zones, *A. palmata* was only encountered at one out of 12 sites (8%); the one site is located in the back reef of Pickles Reef. On shallow hard-bottom, *A. palmata* was only found at one out of 12 sites (8%); the one site is at shallow Conch Reef SPA near mooring buoy C1 (site 554) (Table 4-3). As in previous years, high-relief spur and groove reefs yielded the greatest transect frequency of occurrence. *A. palmata* was found on 19% ± 5% of the 96 transects sampled at 24 sites. Elkhorn coral was encountered at 11 of the 24 high-relief spur and groove sites (46%), seven of which are in no-take zones (Molasses Reef SPA, Grecian Rocks SPA, Dry Rocks SPA, Elbow Reef SPA, Carysfort/S. Carysfort SPA), while the remaining sites are reference areas such as Sand Island, Little Grecian, North-North Dry Rocks, and Turtle Reef (Figures 4-8 to 4-10).

A total of 129 *Acropora palmata* colonies were surveyed from 480 belt transects (15-m x 1-m), with a total surface area of 180,259 cm^2 measured among all colonies (Table 4-3). In back-reef rubble zones, two colonies (2% of the total) were encountered among all sites, yielding an overall habitat-level mean density of 0.003 ± 0.003 colonies per m^2 and a total surface area of 859 cm^2 (Table 4-3). On shallow hard-bottom, a total of five colonies from one site (site 554 at Conch Reef SPA) were encountered (4% of the total), with a mean density of 0.007 ± 0.007 colonies per m^2 and a total surface area of 495 cm^2. High-

relief spur and groove reefs yielded the most elkhorn corals and the greatest sizes. A total of 122 colonies were found (95% of total) on high-relief spur and groove reefs, even though only 20% of the total sampling effort was devoted to this habitat type. The mean colony density (0.085 ± 0.030 per m^2) and total surface area of 178,905 cm^2 were substantially greater than in other habitats. A maximum site-level density of 0.500 ± 0.250 colonies per m^2 was recorded at Sand Island (711), just north of Molasses Reef SPA, but relatively high densities and/or large colonies were also recorded at Grecian Rocks, Elbow Reef, and South Carysfort Reef.

In contrast to its congener, only three out of the 129 (2%) *Acropora palmata* colonies sampled during late June to late August exhibited any symptoms of bleaching such as paling, partial bleaching, or total bleaching. None of the elkhorn corals sampled exhibited any symptoms of disease. Active colony overgrowth by other organisms such as macroalgae was documented on four out of 131 colonies (3%). Predation by corallivorous snails, fireworms, and/or damselfishes was documented on ten out of 129 colonies (8%). On high-relief spur and groove reefs, where most (122) colonies were encountered, eight colonies (7%) exhibited obvious signs of predation.

Discussion

Results from the 2010 sampling effort add to a growing spatial and temporal data set on the status and changes in Florida Keys *Acropora palmata* and *A. cervicornis* populations. Subsequent analyses will yield domain-wide abundance estimates, structured by colony size that will provide for estimates of population size by habitat, region, and for individual no-take marine reserves. While earlier Keys-wide sampling in previous years was not optimized for *Acropora* corals, the benthic data still provide important opportunities to compare populations across multiple habitat types, including managed areas in the FKNMS. What is apparent from the *Acropora* surveys is that the distribution and abundance patterns of these two species are clearly different, perhaps necessitating different management approaches. Although 24 high-relief spur and groove sites were sampled in 2010, the results indicate that significant *A. palmata* stands remain at only a handful of sites, namely South Carysfort Reef, Elbow Reef, Grecian Rocks, and Sand Island. Although most of these sites are already within existing FKNMS no-take zones, predation by snails and damselfishes is still prevalent. In contrast, the distribution pattern of *A. cervicornis* reflects the importance of patch reefs to the possible recovery of this species. While there are over 5,000 patch reef sites on the south Florida shelf, staghorn is currently very patchily distributed, and the factors responsible for this pattern are not well known. In addition, patch reefs closer to shore are more susceptible to both hyper- and hypothermal events, best exemplified by the January 2010 cold-front, which apparently impacted many nearshore reefs, including those that support staghorn corals.

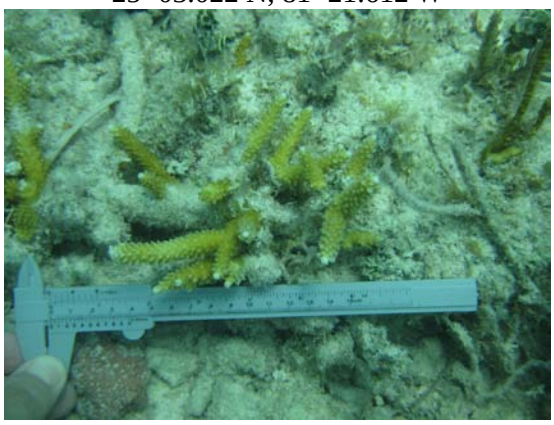
Figure 4-1. Examples of *Acropora cervicornis* in hard-bottom and coral reef habitats in the upper Florida Keys National Marine Sanctuary observed during June-August 2010.

Mid-channel patch reef, 3.0-4.0 m
Site #A73, West of Conch Reef
24° 57.529 N, 80° 29.427 W

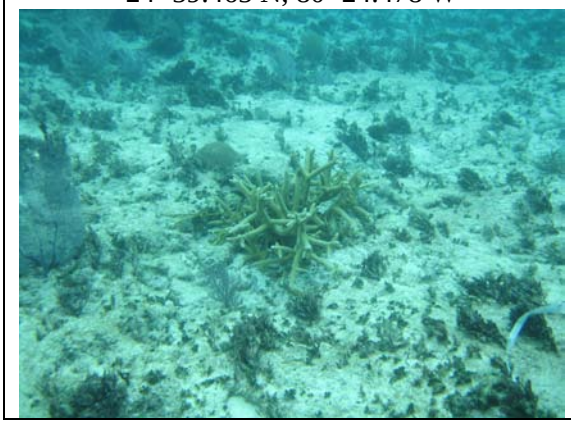
Mid-channel patch reef, 1.5-3.0 m
Site #633, Basin Hill Shoals
25° 13.250 N, 80° 15.618 W

Mid-channel patch reef, 2.1-3.7 m
Site #637, West of Turtle Rocks
25° 17.210 N, 80° 13.425 W

Offshore patch reef, 4.3-4.9 m
Site #643, White Bank (NW of French Reef)
25° 03.022 N, 81° 21.612 W



High-relief spur and groove, 3.7-4.6 m
Site #696, NE Pickles Reef
24° 59.465 N, 80° 24.478 W



Low-relief hard-bottom, 4.6-6.1 m
Site #555, Conch Reef C2
24° 57.292 N, 80° 27.504 W

Figure 4-2. Staghorn coral (*Acropora cervicornis*) presence-absence and colony density (no. of colonies/m^2) in the Florida Keys from the southern BNP boundary south to Carysfort/S. Carysfort Reef SPA surveyed during June-August 2010.

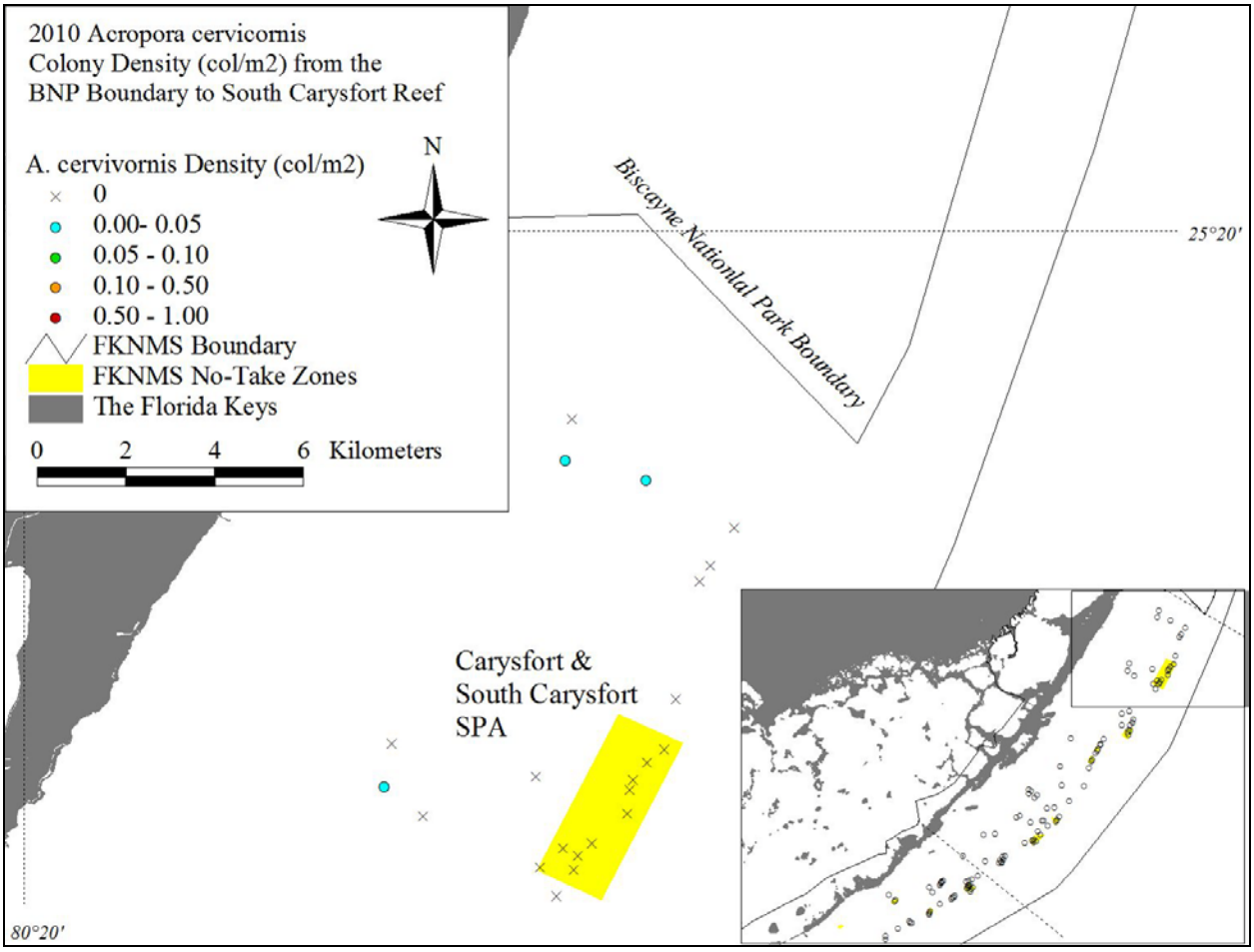


Figure 4-3. Staghorn coral (*Acropora cervicornis*) presence-absence and colony density (no. of colonies/m^2) in the Florida Keys from Elbow Reef SPA to Pickles Reef surveyed during June-August 2010.

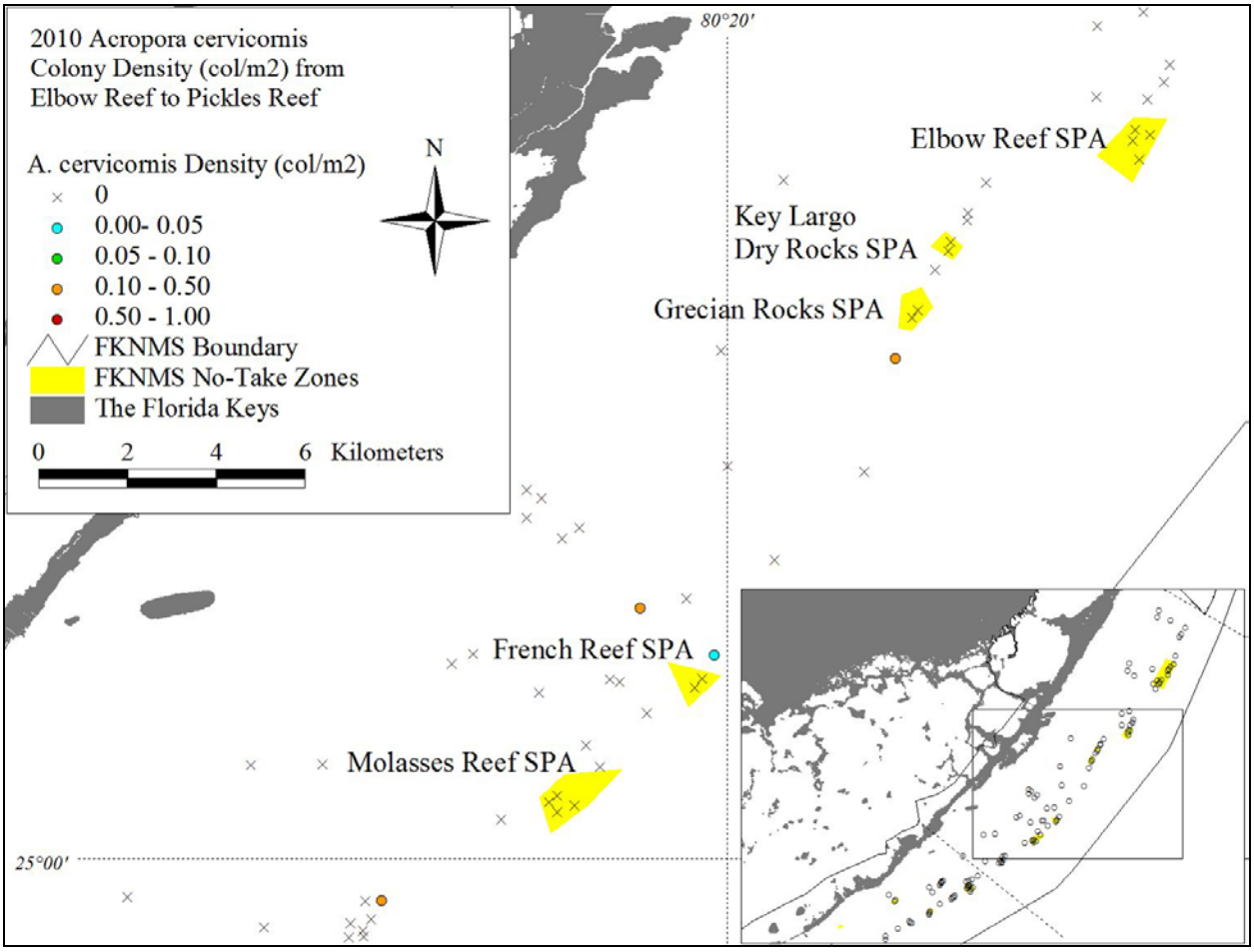


Figure 4-4. Staghorn coral (*Acropora cervicornis*) presence-absence and colony density (no. of colonies/m^2) in the Florida Keys from Conch Reef SPA to Crocker Reef surveyed during June-August 2010.

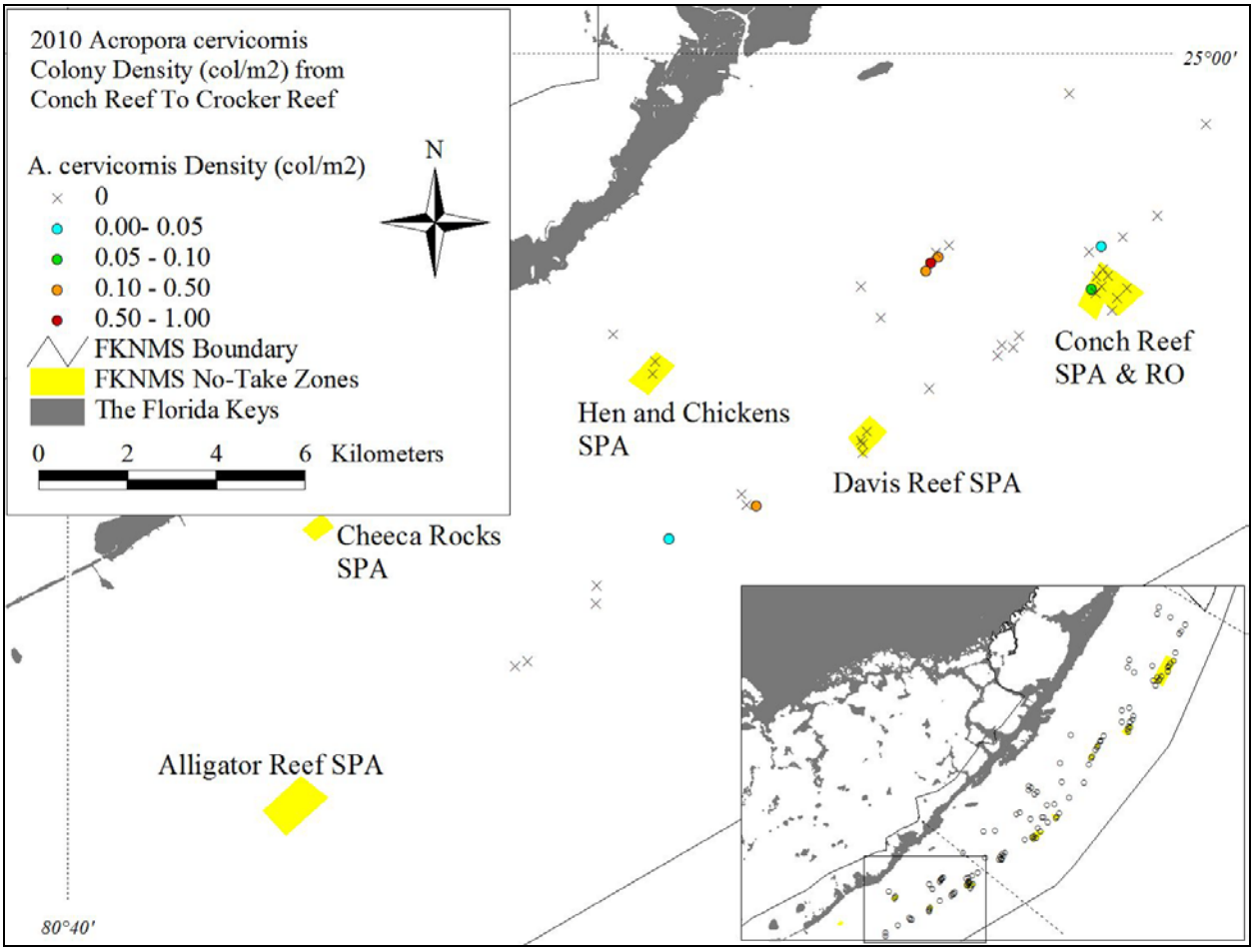


Figure 4-5. Mean (+ 1 SE) densities (no. colonies per m^2) of staghorn corals (*Acropora cervicornis*) on inshore and mid-channel patch reefs (top), offshore patch reefs (middle), and back reef rubble habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.

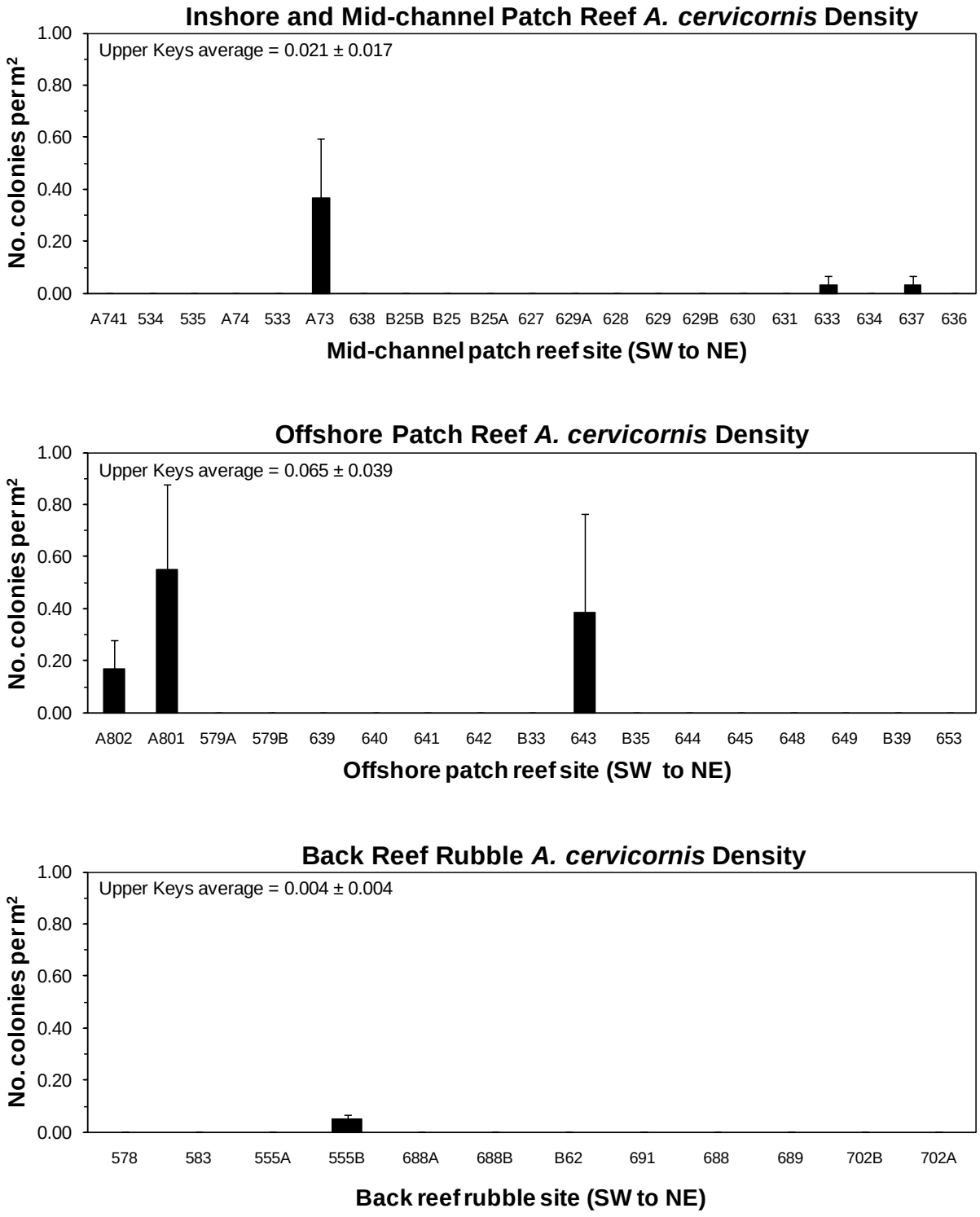
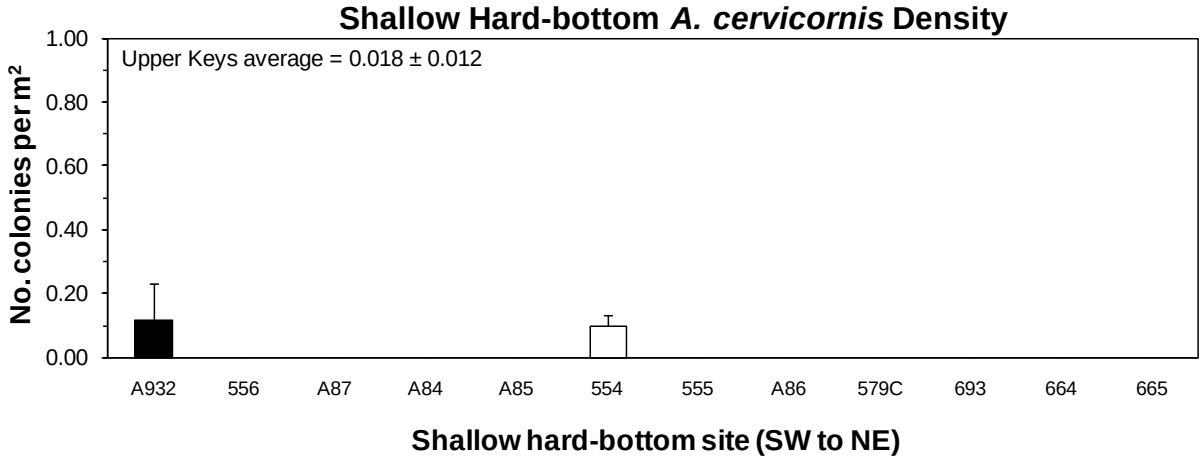
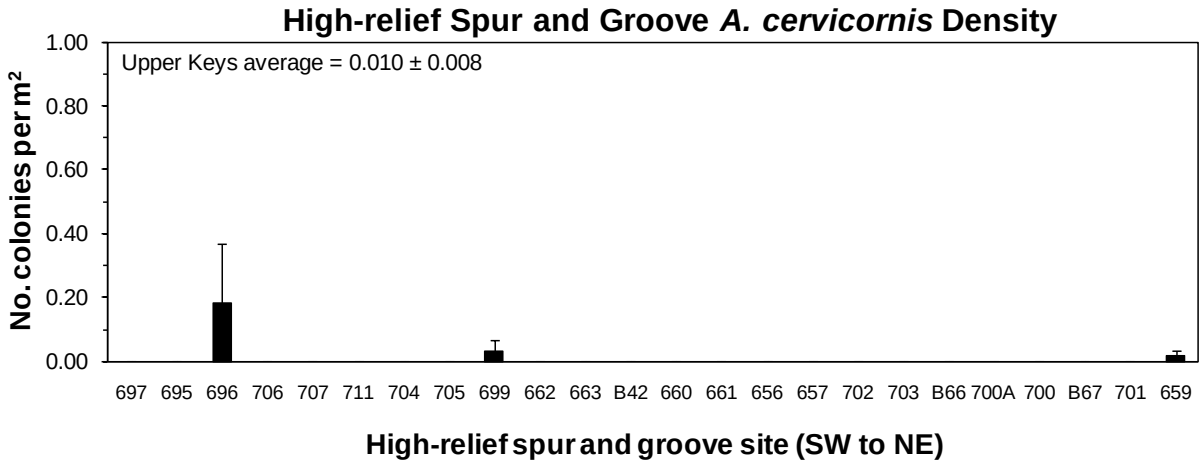


Figure 4-6. Mean (+ 1 SE) densities (no. colonies per m^2) of staghorn corals (*Acropora cervicornis*) on shallow (< 6 m) hard-bottom (top), high-relief spur and groove reefs (middle) and deeper (6-15 m) fore reef habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.





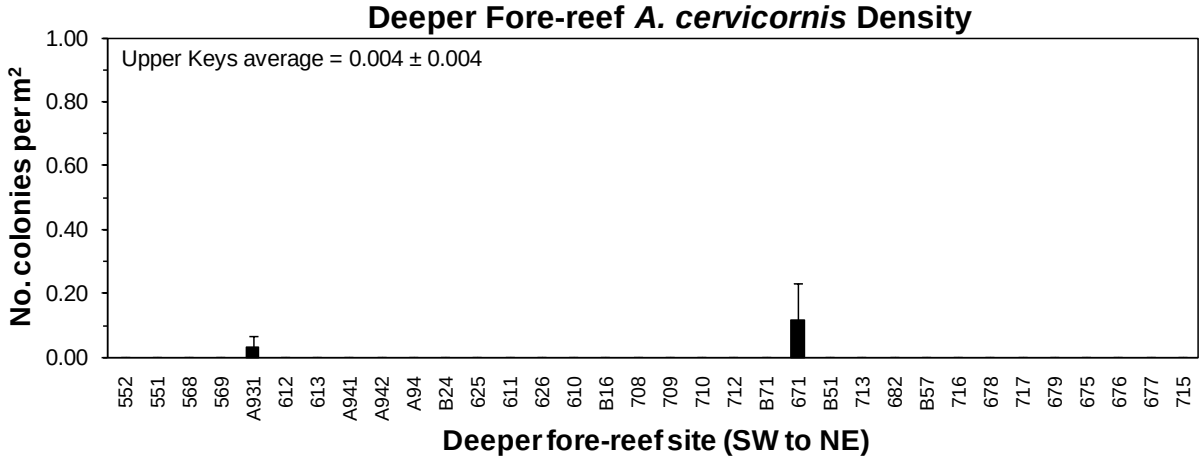
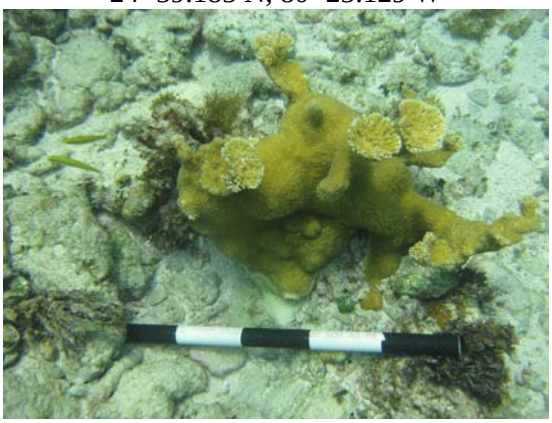


Figure 4-7. Examples of *Acropora palmata* in hard-bottom and coral reef habitats in the upper Florida Keys National Marine Sanctuary observed during June-August 2010.

Back reef rubble, 2.4-2.7 m
Site #688A, Pickles Reef
24° 59.185 N, 80° 25.129 W



High-relief spur and groove, 2.4-5.5 m
Site #701, Carysfort Reef C5
25° 13.332 N, 80° 12.603 W

High-relief spur and groove, 3.0-5.2 m
Site #711, Sand Island
25° 01.089 N, 80° 22.099 W

High-relief spur and groove, 2.7-5.2 m
Site #B42, Little Grecian Rocks
25° 07.112 N, 80° 18.028 W

High-relief spur and groove, 2.7-4.6 m
Site #662, Grecian Rocks SPA
25° 06.532 N, 80° 18.312 W

High-relief spur and groove, 5.2-7.9 m
Site #703, Elbow Reef SPA
25° 08.752 N, 80° 15.421 W

Figure 4-8. Elkhorn coral (*Acropora palmata*) presence-absence and colony density (no. of colonies/m^2) in the Florida Keys from the southern BNP boundary south to Carysfort/S. Carysfort Reef SPA surveyed during June-August 2010.

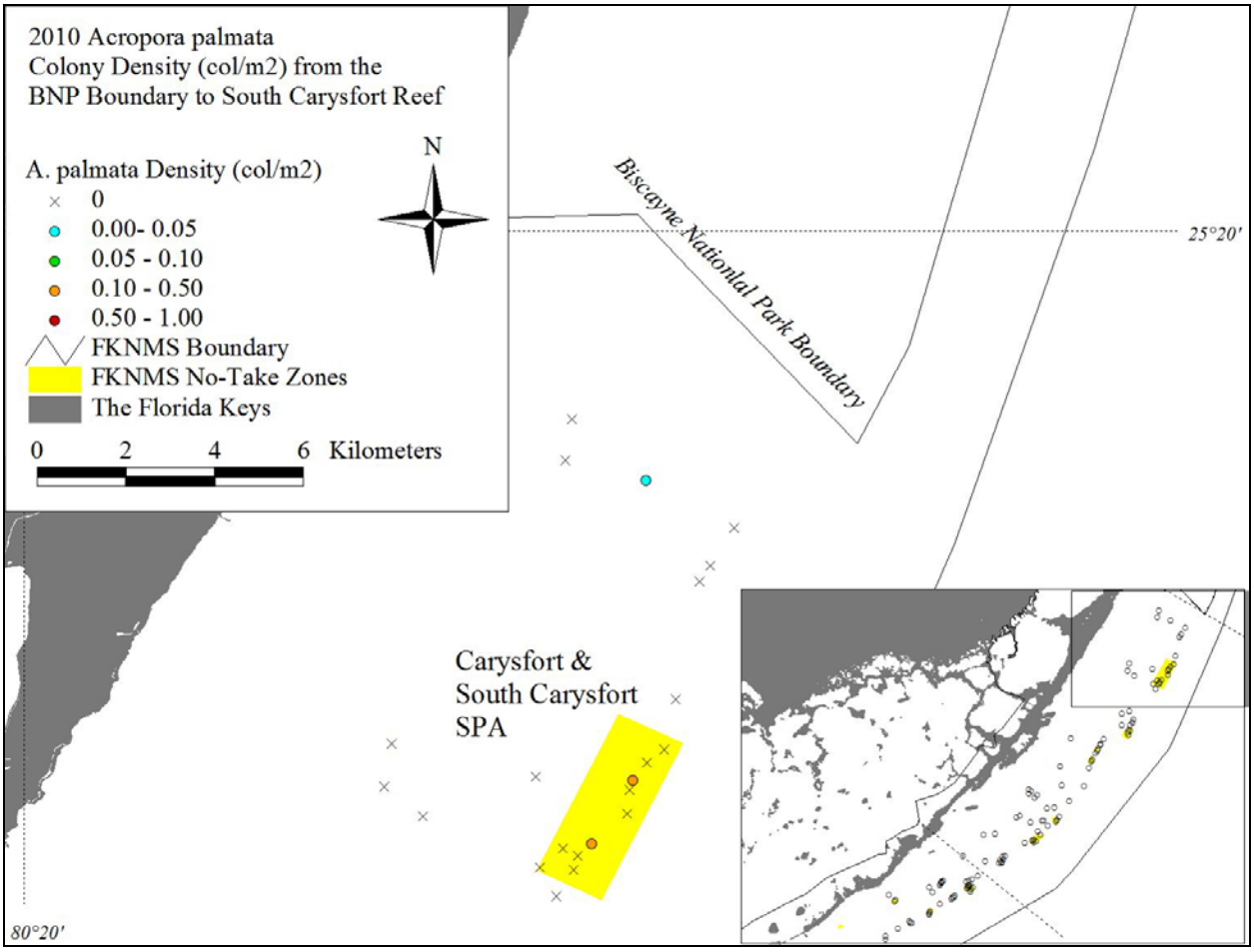


Figure 4-9. Elkhorn coral (*Acropora palmata*) presence-absence and colony density (no. of colonies/m^2) in the Florida Keys from Elbow Reef SPA to Pickles Reef surveyed during June-August 2010.

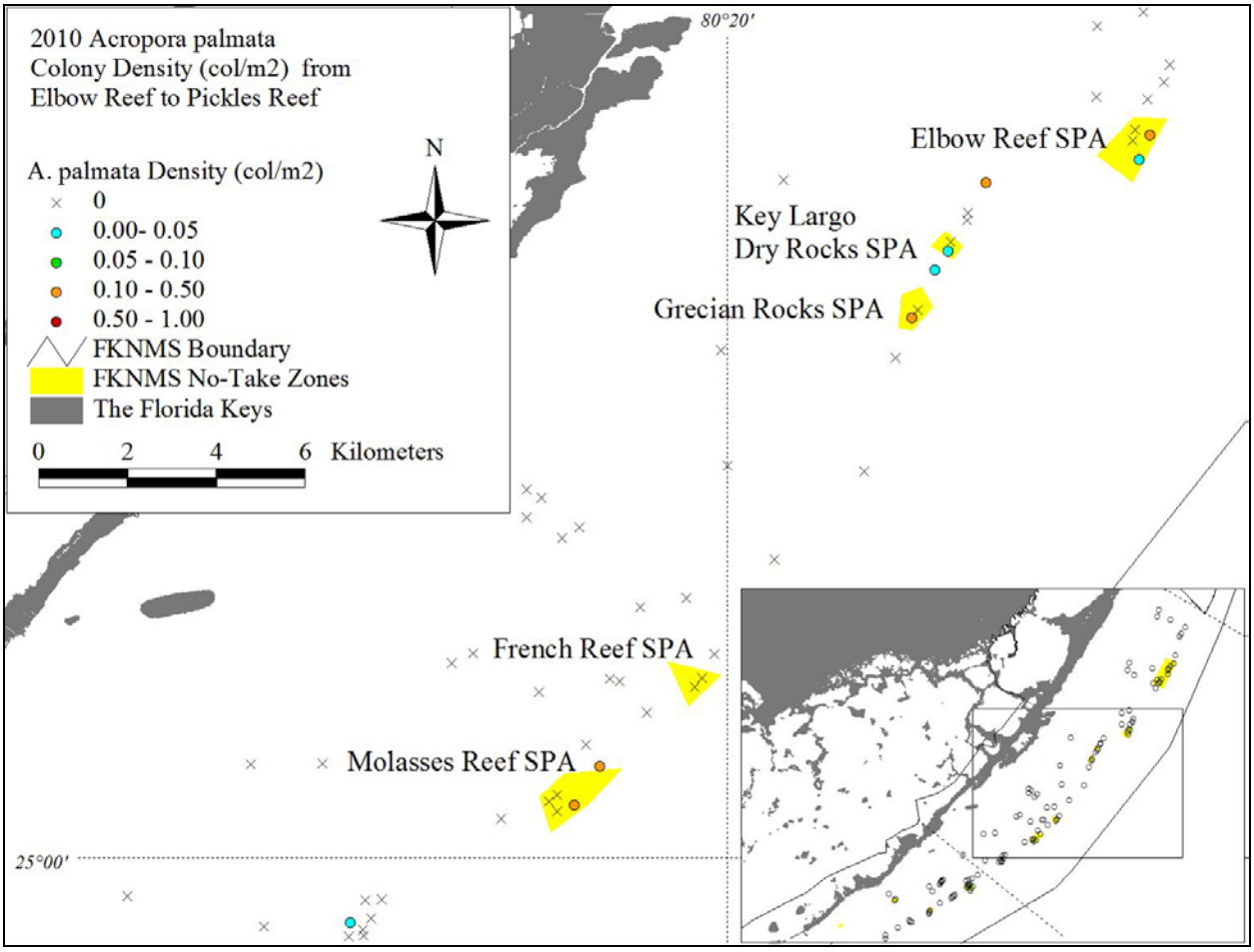


Figure 4-10. Elkhorn coral (*Acropora palmata*) presence-absence and colony density (no. of colonies/m^2) in the Florida Keys from Conch Reef SPA to Crocker Reef surveyed during June-August 2010.

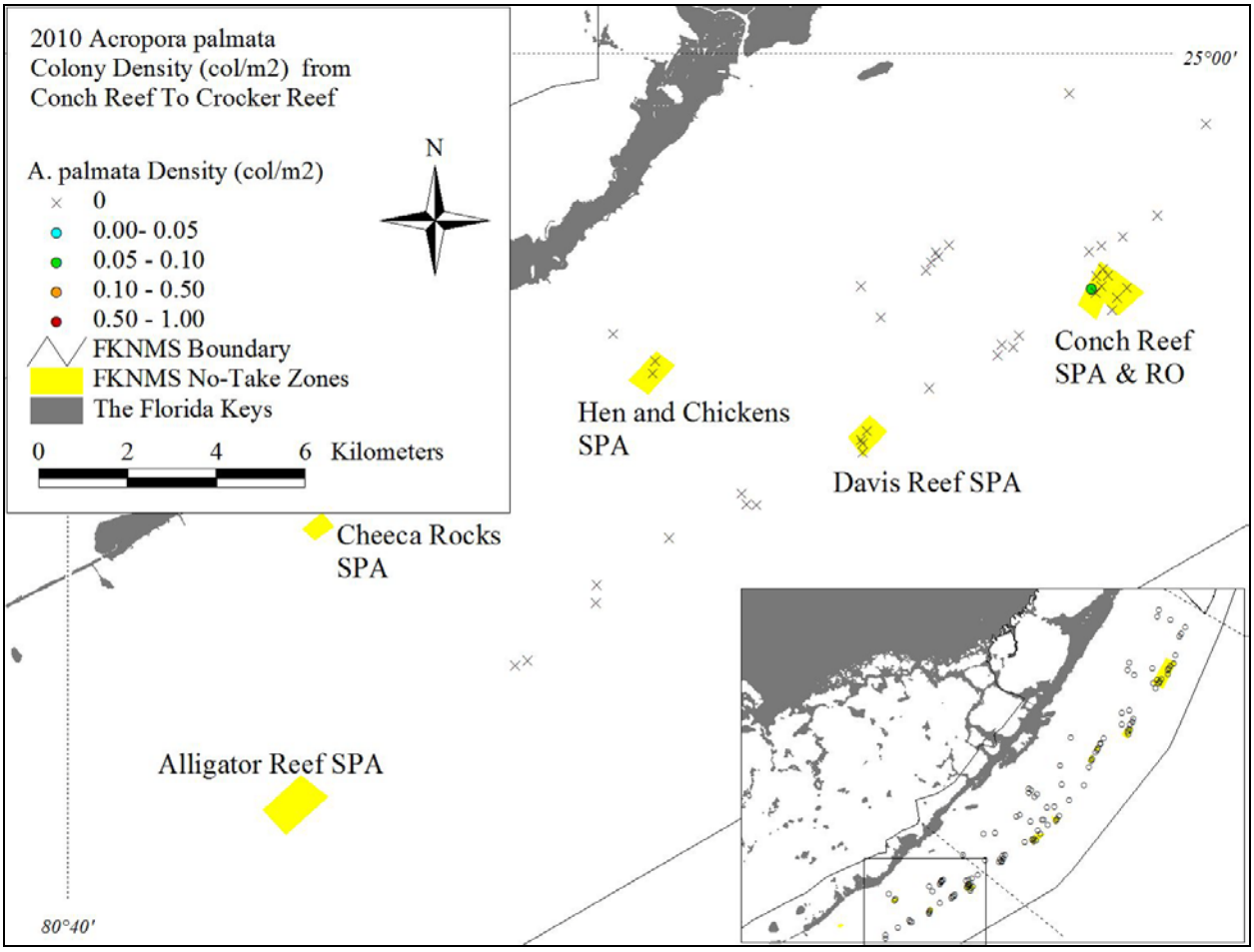


Figure 4-11. Mean (+ 1 SE) densities (no. colonies per m^2) of elkhorn corals (*Acropora palmata*) on inshore and mid-channel patch reefs (top), offshore patch reefs (middle), and back reef rubble habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.

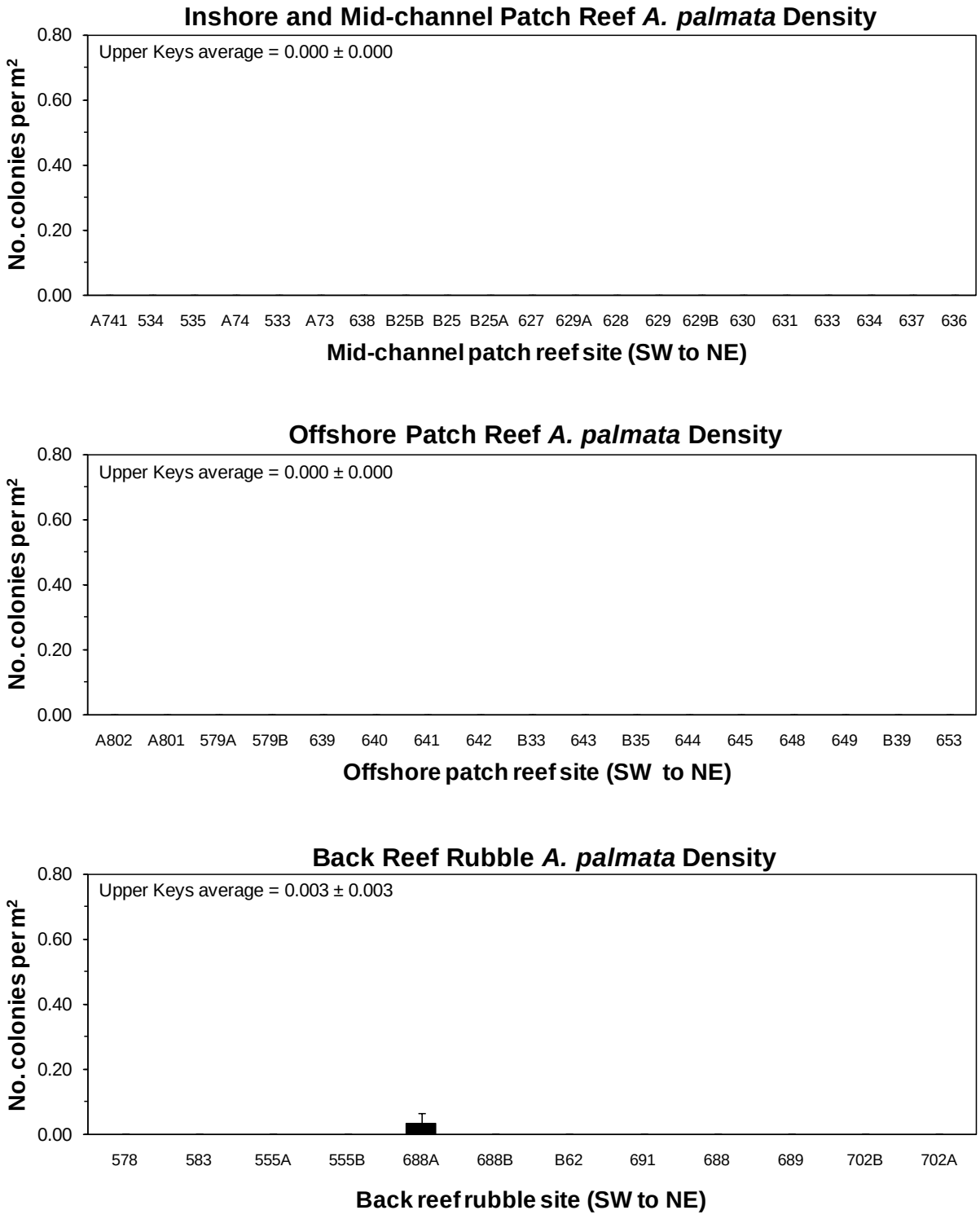


Figure 4-12. Mean (+ 1 SE) densities (no. colonies per m^2) of elkhorn corals (*Acropora palmata*) on shallow (< 6 m) hard-bottom (top), high-relief spur and groove reefs (middle) and deeper (6-15 m) fore reef habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.

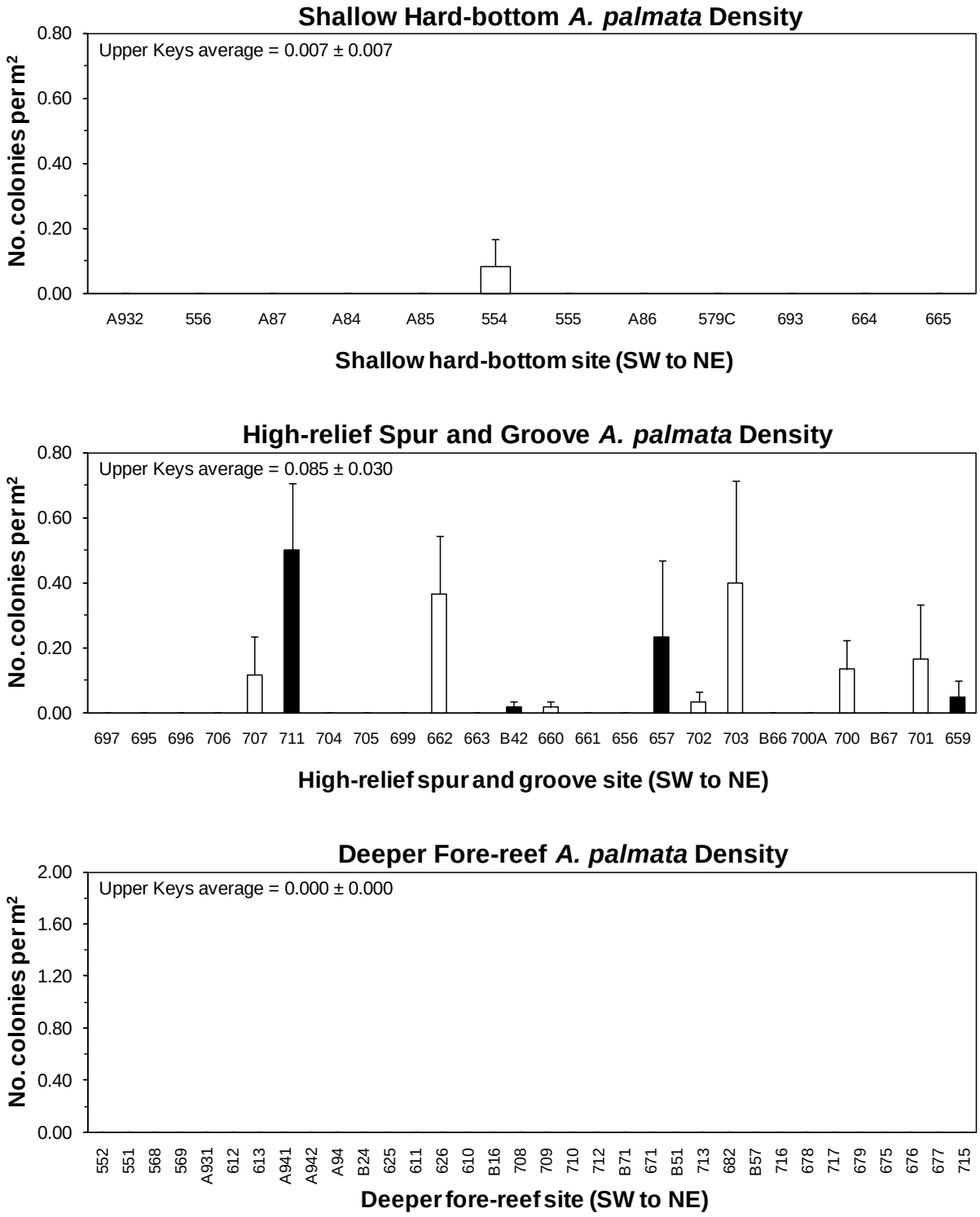


Table 4-1. Presence-absence and mean ± 1 SE transect frequencies (%) for staghorn (*Acropora cervicornis*) and elkhorn (*A. palmata*) corals in the upper Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-August 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	***Acropora cervicornis***		***Acropora palmata***	
	Present	**Transect frequency (%)**	**Present**	**Transect frequency (%)**
Inshore and mid-channel patch reefs				
Middle Florida Keys				
A741 – Tavernier Rocks		0 ± 0		0 ± 0
534 – Hen and Chickens SPA**		0 ± 0		0 ± 0
535 – Hen and Chickens SPA**		0 ± 0		0 ± 0
A74 – West of Conch Reef		0 ± 0		0 ± 0
533 – West of Conch Reef		0 ± 0		0 ± 0
A73 – West of Conch Reef	**	50 ± 29		0 ± 0
Middle Florida Keys Total (6)	**	8 ± 8		0 ± 0
Upper Florida Keys				
638 – Inshore of Pickles Reef		0 ± 0		0 ± 0
B25B – Inshore of Molasses Reef		0 ± 0		0 ± 0
B25 – Inshore of Molasses Reef		0 ± 0		0 ± 0
B25A – Inshore of Molasses Reef		0 ± 0		0 ± 0
627 – Mosquito Bank		0 ± 0		0 ± 0
629A – Mosquito Bank		0 ± 0		0 ± 0
628 – Mosquito Bank		0 ± 0		0 ± 0
629 – Mosquito Bank		0 ± 0		0 ± 0
629B – Mosquito Bank		0 ± 0		0 ± 0
630 – SE of Cannon Patch Reef		0 ± 0		0 ± 0
631 – Marker 33		0 ± 0		0 ± 0
633 – Basin Hill Shoals	**	25 ± 25		0 ± 0
634 – Basin Hill Shoals		0 ± 0		0 ± 0
637 – West of Turtle Rocks	**	25 ± 25		0 ± 0
636 – West of Turtle Rocks		0 ± 0		0 ± 0
Upper Florida Keys Total (15)	**	3 ± 2		0 ± 0
Mid-channel Patch Reef Total (21)	****	**5 ± 3**		**0 ± 0**
Offshore patch reefs				
Middle Florida Keys				
A802 – Inshore of Conch Reef		0 ± 0		0 ± 0
A801 – Inshore of Conch Reef	**	75 ± 25		0 ± 0
579A – Inshore of Conch Reef		0 ± 0		0 ± 0
579B – Inshore of Conch Reef		0 ± 0		0 ± 0
Middle Florida Keys Total (4)	**	19 ± 19		0 ± 0
Upper Florida Keys				
639 – Inshore of Pickles Reef		0 ± 0		0 ± 0
640 – White Bank (West of Molasses)		0 ± 0		0 ± 0
641 – White Bank (West of Molasses)		0 ± 0		0 ± 0
642 – SE of White Bank Dry Rocks		0 ± 0		0 ± 0
B33 – East of White Bank Dry Rocks		0 ± 0		0 ± 0
643 – White Bank (NW of French)	**	25 ± 25		0 ± 0
B35 – West of Elbow Reef		0 ± 0		0 ± 0
644 – Watson's Reef		0 ± 0		0 ± 0
645 – Watson's Reef		0 ± 0		0 ± 0
648 – East of Basin Hill Shoals		0 ± 0		0 ± 0
649 – West of Carysfort Reef		0 ± 0		0 ± 0
B39 – Carysfort Reef SPA**		0 ± 0		0 ± 0
653 – Carysfort Reef SPA**		0 ± 0		0 ± 0

Site number/site location	*Acropora cervicornis*		*Acropora palmata*	
	Present	**Transect frequency (%)**	**Present**	**Transect frequency (%)**
Upper Florida Keys Total (13)	**	2 ± 2		0 ± 0
Offshore Patch Reef Total (17)	****	**6 ± 5**		**0 ± 0**
Back reef rubble				
Middle Florida Keys				
578 – Crocker Reef		0 ± 0		0 ± 0
583 – Crocker Reef		0 ± 0		0 ± 0
555A – Conch Reef		0 ± 0		0 ± 0
555B – Conch Reef	**	75 ± 25		0 ± 0
Middle Florida Keys Total (4)	**	19 ± 19		0 ± 0
Upper Florida Keys				
688A – Pickles Reef		0 ± 0	**	25 ± 25
688B – Pickles Reef		0 ± 0		0 ± 0
B62 – Molasses Reef SPA**		0 ± 0		0 ± 0
691 – Molasses Reef SPA**		0 ± 0		0 ± 0
688 – Sand Island		0 ± 0		0 ± 0
689 – Inshore of Dixie Shoal		0 ± 0		0 ± 0
702B – Elbow Reef SPA**		0 ± 0		0 ± 0
702A – Elbow Reef SPA**		0 ± 0		0 ± 0
Upper Florida Keys Total (8)		0 ± 0	**	3 ± 3
Back Reef Rubble Total (12)	****	**6 ± 6**	****	**2 ± 2**
Low-relief hard-bottom (< 6 m)				
Middle Florida Keys				
A932 – Crocker Reef	**	25 ± 25		0 ± 0
556 – Davis Reef SPA**		0 ± 0		0 ± 0
A87 – Davis Reef SPA**		0 ± 0		0 ± 0
A84 – Little Conch Reef		0 ± 0		0 ± 0
A85 – Little Conch Reef		0 ± 0		0 ± 0
554 – Conch Reef C1**	**	75 ± 25	**	25 ± 25
555 – Conch Reef C2**		0 ± 0		0 ± 0
A86 – Conch Reef C3**		0 ± 0		0 ± 0
579C – NE of Conch Reef		0 ± 0		0 ± 0
Middle Florida Keys Total (9)	**	11 ± 8	**	3 ± 3
Upper Florida Keys				
693 – Little Pickles Reef		0 ± 0		0 ± 0
664 – North of French Reef		0 ± 0		0 ± 0
665 – Inshore of Dixie Shoal		0 ± 0		0 ± 0
Upper Florida Keys Total (3)		0 ± 0		0 ± 0
Shallow Hard-bottom Total (17)	****	**8 ± 6**	****	**2 ± 2**
High-relief spur & groove				
Upper Florida Keys		0 ± 0		0 ± 0
697 – Pickles Reef P1		0 ± 0		0 ± 0
695 – Pickles Reef P3		0 ± 0		0 ± 0
696 – NE Pickles Reef	**	25 ± 25		0 ± 0
706 – Molasses Reef SPA**		0 ± 0	**	25 ± 25
707 – Molasses Reef SPA**		0 ± 0	**	75 ± 25
711 – Sand Island		0 ± 0		0 ± 0
704 – French Reef SPA**		0 ± 0		0 ± 0
705 – French Reef SPA**		0 ± 0		0 ± 0
699 – North of French Reef	**	25 ± 25	**	50 ± 29
662 – Grecian Rocks SPA**		0 ± 0		0 ± 0
663 – Grecian Rocks SPA**		0 ± 0	**	25 ± 25
B42 – Little Grecian Rocks		0 ± 0		0 ± 0

Site number/site location	*Acropora cervicornis*		*Acropora palmata*	
	Present	**Transect frequency (%)**	**Present**	**Transect frequency (%)**
660 – Key Largo Dry Rocks**		0 ± 0	**	25 ± 25
661 – Key Largo Dry Rocks**		0 ± 0		0 ± 0
656 – North Dry Rocks		0 ± 0		0 ± 0
657 – North-North Dry Rocks		0 ± 0	**	25 ± 25
702 – Elbow Reef SPA**		0 ± 0	**	25 ± 25
703 – Elbow Reef SPA**		0 ± 0	**	75 ± 25
B66 – South of S. Carysfort		0 ± 0		0 ± 0
700A – South Carysfort Reef**		0 ± 0		0 ± 0
700 – South Carysfort Reef**		0 ± 0	**	75 ± 25
B67 – Carysfort Reef C2**		0 ± 0		0 ± 0
701 – Carysfort Reef C5**		0 ± 0	**	25 ± 25
659 – Turtle Reef	**	25 ± 25	**	25 ± 25
Upper Florida Keys Total (24)	**	3 ± 2	**	19 ± 5
High-relief Spur & Groove Total (42)	****	**3 ± 2**	****	**19 ± 5**
Deeper Fore-reef (6-15 m)				
Middle Florida Keys				
552 – SW of Crocker Reef		0 ± 0		0 ± 0
551 – SW of Crocker Reef		0 ± 0		0 ± 0
568 – SW of Crocker Reef		0 ± 0		0 ± 0
569 – SW of Crocker Reef		0 ± 0		0 ± 0
A931 – SW of Crocker Reef	**	25 ± 25		0 ± 0
612 – Davis Reef SPA**		0 ± 0		0 ± 0
613 – Davis Reef SPA**		0 ± 0		0 ± 0
A941 – North of Davis Reef		0 ± 0		0 ± 0
A942 – Little Conch Reef		0 ± 0		0 ± 0
A94 – Little Conch Reef		0 ± 0		0 ± 0
B24 – Conch Reef RO**		0 ± 0		0 ± 0
625 – Conch Reef RO**		0 ± 0		0 ± 0
611 – Conch Reef SPA**		0 ± 0		0 ± 0
626 – Conch Reef RO**		0 ± 0		0 ± 0
610 – Conch Reef SPA**		0 ± 0		0 ± 0
B16 – Conch Reef SPA**		0 ± 0		0 ± 0
Middle Florida Keys Total (16)	**	2 ± 2		0 ± 0
Upper Florida Keys				
708 – NE of Conch Reef		0 ± 0		0 ± 0
709 – Pickles Reef		0 ± 0		0 ± 0
710 – SW of Molasses Reef SPA		0 ± 0		0 ± 0
712 – SW of French Reef		0 ± 0		0 ± 0
B71 – Dixie Shoal		0 ± 0		0 ± 0
671 – South of Grecian Rocks	**	25 ± 25		0 ± 0
B51 – East of Dry Rocks		0 ± 0		0 ± 0
713 – North of Elbow Reef		0 ± 0		0 ± 0
682 – North of Elbow Reef		0 ± 0		0 ± 0
B57 – SE of Watson's Reef		0 ± 0		0 ± 0
716 – South Carysfort Reef**		0 ± 0		0 ± 0
678 – North Carysfort Reef**		0 ± 0		0 ± 0
717 – North Carysfort Reef**		0 ± 0		0 ± 0
679 – North Carysfort Reef**		0 ± 0		0 ± 0
675 – North of Carysfort Reef		0 ± 0		0 ± 0
676 – North of Carysfort Reef		0 ± 0		0 ± 0
677 – North of Carysfort Reef		0 ± 0		0 ± 0
715 – North of Carysfort Reef		0 ± 0		0 ± 0
Upper Florida Keys Total (18)	**	1 ± 1		0 ± 0
Deeper Fore-reef Total (34)	****	**1 ± 1**		**0 ± 0**

Table 4-2. Mean (± 1 SE) densities (no. colonies per m^2), numbers of colonies sampled, total colony tissue surface area, and mean (± 1 SE) colony (ramet) surface area size of *Acropora cervicornis* in the upper Florida Keys, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-August 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	No. colonies per m^2	N	Total surface area (cm^2)	Mean size (cm^2)
Inshore and mid-channel patch reefs				
Middle Florida Keys				
A741 – Tavernier Rocks	0 ± 0	0	0	
534 – Hen and Chickens SPA**	0 ± 0	0	0	
535 – Hen and Chickens SPA**	0 ± 0	0	0	
A74 – West of Conch Reef	0 ± 0	0	0	
533 – West of Conch Reef	0 ± 0	0	0	
A73 – West of Conch Reef	0.367 ± 0.227	22	4,692	224 ± 27
Middle Florida Keys Total (6)	0.061 ± 0.061	22	4,692	224 ± 27
Upper Florida Keys				
638 – Inshore of Pickles Reef	0 ± 0	0	0	
B25B – Inshore of Molasses Reef	0 ± 0	0	0	
B25 – Inshore of Molasses Reef	0 ± 0	0	0	
B25A – Inshore of Molasses Reef	0 ± 0	0	0	
627 – Mosquito Bank	0 ± 0	0	0	
629A – Mosquito Bank	0 ± 0	0	0	
628 – Mosquito Bank	0 ± 0	0	0	
629 – Mosquito Bank	0 ± 0	0	0	
629B – Mosquito Bank	0 ± 0	0	0	
630 – SE of Cannon Patch Reef	0 ± 0	0	0	
631 – Marker 33	0 ± 0	0	0	
633 – Basin Hill Shoals	0.033 ± 0.033	2	499	250 ± 0
634 – Basin Hill Shoals	0 ± 0	0	0	
637 – West of Turtle Rocks	0.033 ± 0.033	2	373	186 ± 0
636 – West of Turtle Rocks	0 ± 0	0	0	
Upper Florida Keys Total (15)	0.004 ± 0.004	4	872	218 ± 32
Mid-channel Patch Reef Total (21)	**0.021 ± 0.017**	**26**	**5,564**	**220 ± 18**
Offshore patch reefs				
Middle Florida Keys				
A802 – Inshore of Conch Reef	0.167 ± 0.111	10	508	64 ± 23
A801 – Inshore of Conch Reef	0.550 ± 0.328	33	4,629	420 ± 257
579A – Inshore of Conch Reef	0 ± 0	0	0	
579B – Inshore of Conch Reef	0 ± 0	0	0	
Middle Florida Keys Total (4)	0.179 ± 0.130	0	5,137	242 ± 178
Upper Florida Keys				
639 – Inshore of Pickles Reef	0 ± 0	0	0	
640 – White Bank (West of Molasses)	0 ± 0	0	0	
641 – White Bank (West of Molasses)	0 ± 0	0	0	
642 – SE of White Bank Dry Rocks	0 ± 0	0	0	
B33 – East of White Bank Dry Rocks	0 ± 0	0	0	
643 – White Bank (NW of French)	0.383 ± 0.383	23	422	25 ± 0
B35 – West of Elbow Reef	0 ± 0	0	0	
644 – Watson's Reef	0 ± 0	0	0	
645 – Watson's Reef	0 ± 0	0	0	
648 – East of Basin Hill Shoals	0 ± 0	0	0	
649 – West of Carysfort Reef	0 ± 0	0	0	
B39 – Carysfort Reef SPA**	0 ± 0	0	0	
653 – Carysfort Reef SPA**	0 ± 0	0	0	

Site number/site location	No. colonies per m^2	N	Total surface area (cm^2)	Mean size (cm^2)
Upper Florida Keys Total (13)	0.029 ± 0.029	23	565	25 ± 0
Offshore Patch Reef Total (17)	**0.065 ± 0.039**	**66**	**5,702**	**169 ± 26**
Back reef rubble				
Middle Florida Keys				
578 – Crocker Reef	0 ± 0	0	0	
583 – Crocker Reef	0 ± 0	0	0	
555A – Conch Reef	0 ± 0	0	0	
555B – Conch Reef	0.050 ± 0.017	3	594	198 ± 79
Middle Florida Keys Total (4)	0.013 ± 0.013	3	594	198 ± 79
Upper Florida Keys				
688A – Pickles Reef	0 ± 0	0	0	
688B – Pickles Reef	0 ± 0	0	0	
B62 – Molasses Reef SPA**	0 ± 0	0	0	
691 – Molasses Reef SPA**	0 ± 0	0	0	
688 – Sand Island	0 ± 0	0	0	
689 – Inshore of Dixie Shoal	0 ± 0	0	0	
702B – Elbow Reef SPA**	0 ± 0	0	0	
702A – Elbow Reef SPA**	0 ± 0	0	0	
Upper Florida Keys Total (8)	0 ± 0	0	0	
Back Reef Rubble Total (12)	**0.004 ± 0.004**	**3**	**594**	**198 ± 79**
Low-relief hard-bottom (< 6 m)				
Middle Florida Keys				
A932 – Crocker Reef	0.117 ± 0.117	7	2,771	396 ± 0
556 – Davis Reef SPA**	0 ± 0	0	0	
A87 – Davis Reef SPA**	0 ± 0	0	0	
A84 – Little Conch Reef	0 ± 0	0	0	
A85 – Little Conch Reef	0 ± 0	0	0	
554 – Conch Reef C1**	0.100 ± 0.033	6	4,406	734 ± 310
555 – Conch Reef C2**	0 ± 0	0	0	
A86 – Conch Reef C3**	0 ± 0	0	0	
579C – NE of Conch Reef	0 ± 0	0	0	
Middle Florida Keys Total (9)	0.024 ± 0.016	13	7,177	565 ± 169
Upper Florida Keys				
693 – Little Pickles Reef	0 ± 0	0	0	
664 – North of French Reef	0 ± 0	0	0	
665 – Inshore of Dixie Shoal	0 ± 0	0	0	
Upper Florida Keys Total (3)	0 ± 0	0	0	
Shallow Hard-bottom Total (17)	**0.018 ± 0.012**	**0**	**0**	**565 ± 169**
High-relief spur & groove				
Upper Florida Keys				
697 – Pickles Reef P1	0 ± 0	0	0	
695 – Pickles Reef P3	0 ± 0	0	0	
696 – NE Pickles Reef	0.183 ± 0.183	11	9.490	863 ± 0
706 – Molasses Reef SPA**	0 ± 0	0	0	
707 – Molasses Reef SPA**	0 ± 0	0	0	
711 – Sand Island	0 ± 0	0	0	
704 – French Reef SPA**	0 ± 0	0	0	
705 – French Reef SPA**	0 ± 0	0	0	
699 – North of French Reef	0.033 ± 0.033	2	286	143 ± 0
662 – Grecian Rocks SPA**	0 ± 0	0	0	
663 – Grecian Rocks SPA**	0 ± 0	0	0	
B42 – Little Grecian Rocks	0 ± 0	0	0	
660 – Key Largo Dry Rocks**	0 ± 0	0	0	

Site number/site location	No. colonies per m^2	N	Total surface area (cm^2)	Mean size (cm^2)
661 – Key Largo Dry Rocks**	0 ± 0	0	0	
656 – North Dry Rocks	0 ± 0	0	0	
657 – North-North Dry Rocks	0 ± 0	0	0	
702 – Elbow Reef SPA**	0 ± 0	0	0	
703 – Elbow Reef SPA**	0 ± 0	0	0	
B66 – South of S. Carysfort	0 ± 0	0	0	
700A – South Carysfort Reef**	0 ± 0	0	0	
700 – South Carysfort Reef**	0 ± 0	0	0	
B67 – Carysfort Reef C2**	0 ± 0	0	0	
701 – Carysfort Reef C5**	0 ± 0	0	0	
659 – Turtle Reef	0.017 ± 0.017	1	1,248	1,248
Upper Florida Keys Total (24)	0.010 ± 0.008	14	11,023	751 ± 324
High-relief Spur & Groove Total (42)	**0.010 ± 0.0080**	**14**	**11,023**	**751 ± 324**
Deeper Fore-reef (6-15 m)				
Middle Florida Keys				
552 – SW of Crocker Reef	0 ± 0	0	0	
551 – SW of Crocker Reef	0 ± 0	0	0	
568 – SW of Crocker Reef	0 ± 0	0	0	
569 – SW of Crocker Reef	0 ± 0	0	0	
A931 – SW of Crocker Reef	0.033 ± 0.033	2	116	58 ± 0
612 – Davis Reef SPA**	0 ± 0	0	0	
613 – Davis Reef SPA**	0 ± 0	0	0	
A941 – North of Davis Reef	0 ± 0	0	0	
A942 – Little Conch Reef	0 ± 0	0	0	
A94 – Little Conch Reef	0 ± 0	0	0	
B24 – Conch Reef RO**	0 ± 0	0	0	
625 – Conch Reef RO**	0 ± 0	0	0	
611 – Conch Reef SPA**	0 ± 0	0	0	
626 – Conch Reef RO**	0 ± 0	0	0	
610 – Conch Reef SPA**	0 ± 0	0	0	
B16 – Conch Reef SPA**	0 ± 0	0	0	
Middle Florida Keys Total (16)	0.002 ± 0.002	2	116	58 ± 0
Upper Florida Keys				
708 – NE of Conch Reef	0 ± 0	0	0	
709 – Pickles Reef	0 ± 0	0	0	
710 – SW of Molasses Reef SPA	0 ± 0	0	0	
712 – SW of French Reef	0 ± 0	0	0	
B71 – Dixie Shoal	0 ± 0	0	0	
671 – South of Grecian Rocks	0.117 ± 0.117	7	886	127 ± 0
B51 – East of Dry Rocks	0 ± 0	0	0	
713 – North of Elbow Reef	0 ± 0	0	0	
682 – North of Elbow Reef	0 ± 0	0	0	
B57 – SE of Watson's Reef	0 ± 0	0	0	
716 – South Carysfort Reef**	0 ± 0	0	0	
678 – North Carysfort Reef**	0 ± 0	0	0	
717 – North Carysfort Reef**	0 ± 0	0	0	
679 – North Carysfort Reef**	0 ± 0	0	0	
675 – North of Carysfort Reef	0 ± 0	0	0	
676 – North of Carysfort Reef	0 ± 0	0	0	
677 – North of Carysfort Reef	0 ± 0	0	0	
715 – North of Carysfort Reef	0 ± 0	0	0	
Upper Florida Keys Total (18)	0.006 ± 0.006	7	886	127 ± 0
Deeper Fore-reef Total (34)	**0.004 ± 0.004**	**9**	**1,002**	**92 ± 34**

Table 4-3. Mean (± 1 SE) densities (no. colonies per m^2), numbers of colonies sampled, total colony tissue surface area, and mean (± 1 SE) colony (ramet) surface area size of *Acropora palmata* in the upper Florida Keys, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-August 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	No. colonies per m^2	N	Total surface area (cm^2)	Mean size (cm^2)
Inshore and mid-channel patch reefs				
Middle Florida Keys				
A741 – Tavernier Rocks	0 ± 0	0	0	
534 – Hen and Chickens SPA**	0 ± 0	0	0	
535 – Hen and Chickens SPA**	0 ± 0	0	0	
A74 – West of Conch Reef	0 ± 0	0	0	
533 – West of Conch Reef	0 ± 0	0	0	
A73 – West of Conch Reef	0 ± 0	0	0	
Middle Florida Keys Total (6)	0 ± 0	0	0	
Upper Florida Keys				
638 – Inshore of Pickles Reef	0 ± 0	0	0	
B25B – Inshore of Molasses Reef	0 ± 0	0	0	
B25 – Inshore of Molasses Reef	0 ± 0	0	0	
B25A – Inshore of Molasses Reef	0 ± 0	0	0	
627 – Mosquito Bank	0 ± 0	0	0	
629A – Mosquito Bank	0 ± 0	0	0	
628 – Mosquito Bank	0 ± 0	0	0	
629 – Mosquito Bank	0 ± 0	0	0	
629B – Mosquito Bank	0 ± 0	0	0	
630 – SE of Cannon Patch Reef	0 ± 0	0	0	
631 – Marker 33	0 ± 0	0	0	
633 – Basin Hill Shoals	0 ± 0	0	0	
634 – Basin Hill Shoals	0 ± 0	0	0	
637 – West of Turtle Rocks	0 ± 0	0	0	
636 – West of Turtle Rocks	0 ± 0	0	0	
Upper Florida Keys Total (15)	0 ± 0	0	0	
Mid-channel Patch Reef Total (21)	**0 ± 0**	**0**	**0**	
Offshore patch reefs				
Middle Florida Keys				
A802 – Inshore of Conch Reef	0 ± 0	0	0	
A801 – Inshore of Conch Reef	0 ± 0	0	0	
579A – Inshore of Conch Reef	0 ± 0	0	0	
579B – Inshore of Conch Reef	0 ± 0	0	0	
Middle Florida Keys Total (4)	0 ± 0	0	0	
Upper Florida Keys				
639 – Inshore of Pickles Reef	0 ± 0	0	0	
640 – White Bank (West of Molasses)	0 ± 0	0	0	
641 – White Bank (West of Molasses)	0 ± 0	0	0	
642 – SE of White Bank Dry Rocks	0 ± 0	0	0	
B33 – East of White Bank Dry Rocks	0 ± 0	0	0	
643 – White Bank (NW of French)	0 ± 0	0	0	
B35 – West of Elbow Reef	0 ± 0	0	0	
644 – Watson's Reef	0 ± 0	0	0	
645 – Watson's Reef	0 ± 0	0	0	
648 – East of Basin Hill Shoals	0 ± 0	0	0	
649 – West of Carysfort Reef	0 ± 0	0	0	
B39 – Carysfort Reef SPA**	0 ± 0	0	0	
653 – Carysfort Reef SPA**	0 ± 0	0	0	

Site number/site location	No. colonies per m^2	N	Total surface area (cm^2)	Mean size (cm^2)
Upper Florida Keys Total (13)	0 ± 0	0	0	
Offshore Patch Reef Total (17)	**0 ± 0**	**0**	**0**	
Back reef rubble				
Middle Florida Keys				
578 – Crocker Reef	0 ± 0	0	0	
583 – Crocker Reef	0 ± 0	0	0	
555A – Conch Reef	0 ± 0	0	0	
555B – Conch Reef	0 ± 0	0	0	
Middle Florida Keys Total (4)	0 ± 0	0	0	
Upper Florida Keys				
688A – Pickles Reef	0.033 ± 0.033	2	859	429 ± 0
688B – Pickles Reef	0 ± 0	0	0	
B62 – Molasses Reef SPA**	0 ± 0	0	0	
691 – Molasses Reef SPA**	0 ± 0	0	0	
688 – Sand Island	0 ± 0	0	0	
689 – Inshore of Dixie Shoal	0 ± 0	0	0	
702B – Elbow Reef SPA**	0 ± 0	0	0	
702A – Elbow Reef SPA**	0 ± 0	0	0	
Upper Florida Keys Total (8)	0.004 ± 0.004	2	859	429 ± 0
Back Reef Rubble Total (12)	**0.004 ± 0.004**	**2**	**859**	**429 ± 0**
Low-relief hard-bottom (< 6 m)				
Middle Florida Keys				
A932 – Crocker Reef	0 ± 0	0	0	
556 – Davis Reef SPA**	0 ± 0	0	0	
A87 – Davis Reef SPA**	0 ± 0	0	0	
A84 – Little Conch Reef	0 ± 0	0	0	
A85 – Little Conch Reef	0 ± 0	0	0	
554 – Conch Reef C1**	0 ± 0	0	0	
555 – Conch Reef C2**	0 ± 0	0	0	
A86 – Conch Reef C3**	0 ± 0	0	0	
579C – NE of Conch Reef	0 ± 0	0	0	
Middle Florida Keys Total (9)	0 ± 0	0	0	
Upper Florida Keys				
693 – Little Pickles Reef	0 ± 0	0	0	
664 – North of French Reef	0 ± 0	0	0	
665 – Inshore of Dixie Shoal	0 ± 0	0	0	
Upper Florida Keys Total (3)	0 ± 0	0	0	
Shallow Hard-bottom Total (17)	**0 ± 0**	**0**	**0**	**0 ± 0**
High-relief spur & groove				
Upper Florida Keys				
697 – Pickles Reef P1	0 ± 0	0	0	
695 – Pickles Reef P3	0 ± 0	0	0	
696 – NE Pickles Reef	0 ± 0	0	0	
706 – Molasses Reef SPA**	0 ± 0	0	0	
707 – Molasses Reef SPA**	0.117 ± 0.117	7	1,407	201 ± 0
711 – Sand Island	0.500 ± 0.205	30	26,818	728 ± 290
704 – French Reef SPA**	0 ± 0	0	0	
705 – French Reef SPA**	0 ± 0	0	0	
699 – North of French Reef	0 ± 0	0	0	
662 – Grecian Rocks SPA**	0.367 ± 0.177	22	65,071	3,711 ± 1,096
663 – Grecian Rocks SPA**	0 ± 0	0	0	
B42 – Little Grecian Rocks	0.017 ± 0.017	1	6,379	6,379
660 – Key Largo Dry Rocks**	0.017 ± 0.017	1	26	26

Site number/site location	No. colonies per m^2	N	Total surface area (cm^2)	Mean size (cm^2)
661 – Key Largo Dry Rocks**	0 ± 0	0	0	
656 – North Dry Rocks	0 ± 0	0	0	
657 – North-North Dry Rocks	0.233 ± 0.233	14	5,230	374 ± 0
702 – Elbow Reef SPA**	0.033 ± 0.0333	2	16,852	8,426 ± 0
703 – Elbow Reef SPA**	0.400 ± 0.314	24	43,395	6,238 ± 4,236
B66 – South of S. Carysfort	0 ± 0	0	0	
700A – South Carysfort Reef**	0 ± 0	0	0	
700 – South Carysfort Reef**	0.133 ± 0.090	8	4,428	1,080 ± 586
B67 – Carysfort Reef C2**	0 ± 0	0	0	
701 – Carysfort Reef C5**	0.167 ± 0.167	10	8,987	899 ± 0
659 – Turtle Reef	0.050 ± 0.050	3	312	104 ± 0
Upper Florida Keys Total (24)	0.085 ± 0.030	122	178,905	2,560 ± 929
High-relief Spur & Groove Total (42)	**0.085 ± 0.030**	**122**	**178,905**	**2,560 ± 929**
Deeper Fore-reef (6-15 m)				
Middle Florida Keys				
552 – SW of Crocker Reef	0 ± 0	0	0	
551 – SW of Crocker Reef	0 ± 0	0	0	
568 – SW of Crocker Reef	0 ± 0	0	0	
569 – SW of Crocker Reef	0 ± 0	0	0	
A931 – SW of Crocker Reef	0 ± 0	0	0	
612 – Davis Reef SPA**	0 ± 0	0	0	
613 – Davis Reef SPA**	0 ± 0	0	0	
A941 – North of Davis Reef	0 ± 0	0	0	
A942 – Little Conch Reef	0 ± 0	0	0	
A94 – Little Conch Reef	0 ± 0	0	0	
B24 – Conch Reef RO**	0 ± 0	0	0	
625 – Conch Reef RO**	0 ± 0	0	0	
611 – Conch Reef SPA**	0 ± 0	0	0	
626 – Conch Reef RO**	0 ± 0	0	0	
610 – Conch Reef SPA**	0 ± 0	0	0	
B16 – Conch Reef SPA**	0 ± 0	0	0	
Middle Florida Keys Total (16)	0 ± 0	0	0	
Upper Florida Keys				
708 – NE of Conch Reef	0 ± 0	0	0	
709 – Pickles Reef	0 ± 0	0	0	
710 – SW of Molasses Reef SPA	0 ± 0	0	0	
712 – SW of French Reef	0 ± 0	0	0	
B71 – Dixie Shoal	0 ± 0	0	0	
671 – South of Grecian Rocks	0 ± 0	0	0	
B51 – East of Dry Rocks	0 ± 0	0	0	
713 – North of Elbow Reef	0 ± 0	0	0	
682 – North of Elbow Reef	0 ± 0	0	0	
B57 – SE of Watson's Reef	0 ± 0	0	0	
716 – South Carysfort Reef**	0 ± 0	0	0	
678 – North Carysfort Reef**	0 ± 0	0	0	
717 – North Carysfort Reef**	0 ± 0	0	0	
679 – North Carysfort Reef**	0 ± 0	0	0	
675 – North of Carysfort Reef	0 ± 0	0	0	
676 – North of Carysfort Reef	0 ± 0	0	0	
677 – North of Carysfort Reef	0 ± 0	0	0	
715 – North of Carysfort Reef	0 ± 0	0	0	
Upper Florida Keys Total (18)	0 ± 0	0	0	
Deeper Fore-reef Total (34)	**0 ± 0**	**0**	**0**	

V. Urchin Abundance and Size

Background

The 1983-84 mass mortality of the long-spined sea urchin *Diadema antillarum* represents a spatially expansive and prolonged disturbances to coral reef ecosystems in the wider Caribbean region (Carpenter 1988; Lessios 1988, 2005). Prior to the mass mortality event, *D. antillarum* attained high (>20 per m^2) densities on many Caribbean reefs (Lessios 1988), but after the disease epidemic, abundances declined by several orders of magnitude and have largely remained in this state for over two decades (Lessios 2005; Weil et al. 2005; Debrot and Nagelkerken 2006). Together with physical impacts from storms, coral disease outbreaks, and severe bleaching episodes (Gardner et al. 2003), the reduction in urchin densities changed coral-algal dominance patterns (Carpenter 1988; Lessios 1988). In the Florida Keys, the few historical data available prior to 1983-84 indicate that *D. antillarum* densities were lower (up to 4 to 5 per m^2) (Kier and Grant 1965; Bauer 1976, 1980) than values reported for the Caribbean. Historical densities of a few individuals per m^2, however, are still one to two orders of magnitude greater than current densities in the Florida Keys. A general trend of greater algal cover was reported after the urchin mortality at several Florida Keys offshore reefs in the late 1980s and early 1990s (Jaap et al. 1988; Porter and Meier 1992). However, identifying clear relationships between grazing and algae – and ultimately coral recovery – remains problematic for at least two reasons: 1) few (if any) specifically designed before-and-after studies were conducted in the Florida Keys related to urchin decline, and 2) the regional die-off of *Acropora* corals from white-band disease occurred at the same time, which opened up large amounts of dead coral substrate for algal recruitment. In contrast to the Caribbean, seven years after the 1983-84 event a second disease event in the Florida Keys, after initially modest recovery to 0.30-0.58 individuals per m^2, once again depressed *D. antillarum* densities to < 0.01 individuals per m^2 (Forcucci 1994). With the exception of a few shallow-water areas in the Dry Tortugas (Chiappone et al. 2001), large-scale surveys of urchin densities across the south Florida during 1999-2001 confirm the continued pattern of poor recovery (Chiappone et al. 2002a,b).

Since the mass mortality, several investigators have reported limited or moderate recovery of *Diadema antillarum* populations for some Caribbean reef areas (Lessios 2005; Carpenter and Edmunds 2006; Debrot and Nagelkerken 2006), but recovery in the Florida Keys appears to be occurring slower (Chiappone et al. 2002a, in press; Lazar et al. 2005). Still, beginning in 2005 up to and including 2010, we have documented small increases in the frequency of occurrence, density, and the sizes of *D. antillarum* from surveys of hundreds of sites across the south Florida shelf. While some have suggested that *D. antillarum* recovery will help to promote coral recruitment and a return to pre-mortality baseline reef conditions (Carpenter and Edmunds 2006; Macia et al. 2007; Myhre and Acevedo-Gutierrez 2007),

diseases, bleaching episodes, and overfishing may counteract any positive influences of increased urchin grazing. Despite these uncertainties, and because of these uncertainties, there is keen interest in the spatial and temporal patterns of *D. antillarum* recovery in the Florida Keys. In addition, the slow and incomplete recovery of this urchin raises the question of what factors currently limit population recovery (Miller et al. in press).

Beginning in 1999, we have conducted intermittent, large-scale surveys of urchin density and size structure in a diversity of habitats across the south Florida shelf encompassing hundreds of sites (Chiappone et al. 2001, 2002a, b). We have recently described the population status of *Diadema antillarum* based upon surveys of 235 sites along ~200 km of the Florida reef tract during 2007 (Chiappone et al. 2009). Additional surveys were conducted Keyswide in 2008 (145 sites) and 2009 (160 sites). Below is a summary of the 2010 results for transect frequency of occurrence, density and sizes of all urchins encountered in surveys of 120 sites in the upper Florida Keys. To our knowledge, these are the only large-scale, repeated, surveys being conducted for urchins in the Sanctuary.

2010 Survey Results

During June-August, a total of 7,200 m^2 of benthic habitat among 120 sites was surveyed in the upper Florida Keys for urchin abundance and test sizes. Five species were encountered within transects: *Diadema antillarum*, *Echinometra lucunter*, *E. viridis*, *Eucidaris tribuloides*, and *Tripneustes ventricosus* (Figure 5-1). No individuals of *Lytechinus variegatus* or other species, except those above, were encountered. Tables 5-1 to 5-5 summarize site-level densities for each species and Table 5-6 provides the mean and ranges in test diameters (TD) by habitat and for the entire sampling effort. Of the five urchin species and 836 individuals encountered, the most abundant were *E. tribuloides* (455 individuals, 54.4% of all urchins) and *E. viridis* (261 individuals, 31.2%), followed by *D. antillarum* (75 individuals, 9.0%), *E. lucunter* (35 individuals, 4.2%), and *T. ventricosus* (10 individuals, 1.2%).

A total of 75 *Diadema antillarum* were recorded, with individuals distributed among all of the habitats sampled, albeit at different densities and sizes (Table 5-1). The maximum site-level density of 0.133 individuals per m^2 was recorded from the back-reef rubble zone at Conch Reef (site 555A). We have noticed since 2001 an increase in the number of sites where *D. antillarum* is found and a trend towards larger test sizes, especially on patch reefs. Figures 5-2 to 5-4 illustrate the spatial distribution of *D. antillarum* densities throughout the upper Florida Keys study area. Proportional station frequencies and habitat-level mean (± 1 SE) densities were greatest in back-reef rubble zones (25% ± 10% of transects, 0.029 ± 0.014 individuals per m^2) and offshore patch reefs (21% ± 6% of transects, 0.020 ± 0.007 per m^2),

followed by high-relief spur and groove (13% ± 4% of transects, 0.010 ± 0.004 per m^2) (Table 5-1). Among all habitats sampled, densities tended to be lower in no-take zones compared to reference areas, a trend evident since 2007 (Figures 5-5 and 5-6). On deeper (7-15 m) fore-reef habitats, *D. antillarum* continues to be absent at most locations (Figure 5-6). *D. antillarum* test sizes ranged from 0.4 to 10.0 cm and averaged 4.1 ± 0.3 cm; this is slightly smaller than the mean size found Keyswide in 2009, at least partly due to the inclusion of back-reef rubble sites in 2010. The size range (0.6-2.5 cm) and mean test diameter in rubble zones (1.5 ± 0.1 cm) indicates the predominance of recently settled recruits in this habitat. If the back-reef rubble sites are excluded, the mean size for all other habitats was 5.1 ± 0.4 cm, which is slightly greater than the 2009 average, ~1.5 cm larger on average than the 3.6 ± 0.1 cm documented in 2007 (Table 5-6), and over 3 cm greater than that reported in 1999-2001 (Chiappone et al. 2002a,b). The test sizes of the individuals in 2010 indicate a mixed distribution, with not only abundant recruits (35% of individuals), but also a large proportion (39%) of individuals greater than 5.0 cm TD (Figure 5-7). Patch reefs and shallow hard-bottom sites yielded the largest average size and maximum size, while back reef rubble sites and the deeper fore-reef yielded the lowest average test diameter (Figure 5-7, Table 5-6).

Two species of *Echinometra* were encountered during the 2010 surveys. *E. lucunter* was the less abundant of the two species (35 individuals) and was found among all habitats except shallow (< 6 m) hard-bottom and the deeper (6-15 m) fore-reef (Table 5-2). Back-reef rubble sites yielded 69% of all individuals, with the balance recorded from patch reefs and high-relief spur and groove. *E. lucunter* test sizes ranged from 0.7 to 3.0 cm and averaged 1.4 ± 0.1 cm. The size range (0.7-2.5 cm) and mean test diameter in rubble zones (1.1 ± 0.1 cm) indicates the predominance of recently settled recruits in this habitat (Table 5-6). Mean and maximum test diameters were greater on mid-channel and offshore patch reefs compared to rubble and high-relief spur and groove habitats.

Echinometra viridis was widely distributed among the habitats sampled, but exhibited habitat-specific patterns of abundance as documented in previous years (Table 5-3). *E. viridis* was especially abundant on mid-channel patch reefs, with 191 (73%) of the 261 individuals recorded from this habitat. Densities were especially high (> 1 individual per m^2) on patch reefs in the Basin Hill Shoals area west of Carysfort Reef (Table 5-3). Figures 5-8 to 5-10 illustrate the spatial distribution of *E. viridis* densities throughout the upper Florida Keys study area and clearly demonstrate relatively high densities on inshore and mid-channel patch reefs. A mean (± 1 SE) habitat-level density of 0.152 ± 0.081 individuals per m^2 was recorded from mid-channel patch reefs, which was at least one order of magnitude greater than the other sampled habitats. Site-level densities of *E. viridis* were as high as 1.333 individuals per m^2 (Figure 5-11

and 5-12). The test diameter (TD) of individuals ranged from 0.3 cm to 5.0 cm and averaged 2.6 ± 0.1 cm among the 120 sites (Table 5-6). The combined size distribution indicated a modal size class of 2.0-2.9 cm. Inshore and mid-channel patch reefs yielded the largest average and maximum sizes compared to other habitats (Table 5-6 and Figure 5-13).

Eucidaris tribuloides was recorded from all habitats sampled, exhibited a habitat distribution pattern similar to historical surveys during 1999-2009 (Table 5-4), and was the most abundant (455 individuals) urchin species surveyed in the upper Keys during 2010. The greatest site-level density estimate of 1.167 ± 0.362 individuals/m^2 was recorded from a back reef rubble site at Pickles Reef (site 688B) (Table 5-4). Figures 5-14 to 5-16 illustrate the spatial distribution of *E. tribuloides* densities throughout the upper Florida Keys study area. Back-reef rubble zones (56% ± 12% of transects, 0.258 ± 0.110 individuals per m^2) and shallow (< 6 m) hard-bottom sites (71% ± 10% of transects, 0.115 ± 0.032 individuals per m^2) yielded the greatest transect frequencies and densities (Table 5-4, Figures 5-17 and 5-18), followed by offshore patch reefs and high-relief spur and groove. For the 455 individuals encountered, test diameters ranged from 0.5 cm to 4.5 cm, averaged 2.1 cm (Table 5-6), and showed two modal size classes below 3.0 cm (Figure 5-19). A slightly larger average size was recorded from patch reefs compared to other habitats, especially back-reef rubble zones where recently settled juveniles predominated (Table 5-6 and Figure 5-19).

Tripneustes ventricosus was the least abundant urchin encountered in 2010, which is expected since the sampling effort did not include seagrass habitats. A total of 10 individuals were recorded from the 120 upper Keys sites, with a maximum site-level density of 0.067 ± 0.067 individuals per m^2 recorded from a mid-channel patch reef (site A74) west of Conch Reef (Table 5-5). *T. ventricosus* was found in all habitats except shallow (< 6 m) hard-bottom, but was most commonly observed on mid-channel and offshore patch reefs. The size range of the 10 individuals sampled ranged from 2 to 10 cm, with a mean size of 7.4 ± 0.8 cm. Larger individuals were found on patch reefs compared to other habitats.

Discussion

Large-scale surveys encompassing hundreds of sites in the Florida Keys since 1999 indicate that the *Diadema antillarum* population continues to persist at densities well below values reported before the Caribbean-wide mass mortality in 1983-84 and the Florida Keys mortality event in 1991 (Kier and Grant 1965; Bauer 1980; Forcucci 1994). Despite this pattern, the Florida Keys population continues to exhibit an increase in the proportion of sites with *D. antillarum* present, as well as an increase in mean test size, with a greater proportion of larger individuals present. In addition, recruitment continues to occur

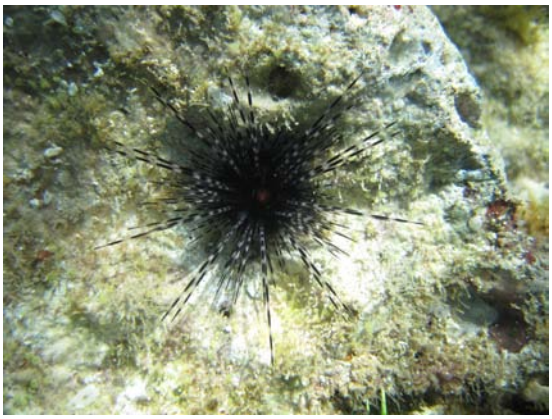
predominately in back-reef rubble zones. Earlier reports and recent observations indicate that other urchin species show density and habitat distribution patterns similar to pre-1983 observations, indicating that other urchin species have apparently not compensated for the loss of *D. antillarum* (Chiappone et al. 2002a). In areas with relatively high (> 0.1 individuals/m^2) and larger (> 5 cm TD) *D. antillarum*, there are obvious effects of grazing on the substratum, particularly the removal of turf and macroalgae and exposure of the substratum (Chiappone et al. 2001). It remains unclear whether or not increasing urchin densities and sizes will lead to other changes to the benthos such as increased coral or urchin recruitment.

The slow and prolonged recovery of *Diadema antillarum* in the Florida Keys, especially compared to several recent studies in other Caribbean reef areas, raises several questions pertaining to factors that may inhibit recovery (Lessios 1988). Possible causes of slow recovery include poor larval survivorship, lack of adult conspecifics and hence protection from predators, suitable recruitment sites, and inter-specific competition. The sources of urchin larvae to the south Florida shelf are not known, but may include both local and regional sources (Lee et al. 1994). Nonetheless, it is apparent that *D. antillarum* have continually recruited to benthic habitats, especially rubble zones, but the fate of these recently settled juveniles is unknown (Chiappone et al. 2002a). A recent study of *D. antillarum* larval settlement rates in the Florida Keys, however, indicate that low larval supply may be one factor limiting recovery (Miller et al. in press). The predominance of relatively small test sizes from 1999-2005 indicated that recently settled individuals may have poor survivorship into larger size classes, perhaps due to predation or physical disturbance from storms. However, since 2005, there has been a notable shift in the size distribution towards larger individuals in the population. Because *D. antillarum* was historically significant as a grazer, it is anticipated that continued recovery will influence patterns in benthic community structure throughout the Florida Keys.

Figure 5-1. Urchin species surveyed for density and size (test diameter) in the Florida Keys during 2010. Not shown is *Lytechinus variegatus* (variegated urchin).

Diadema antillarum

Juvenile *Diadema antillarum*



Echinometra lucunter

Echinometra viridis

Eucidaris tribuloides

Tripneustes ventricosus

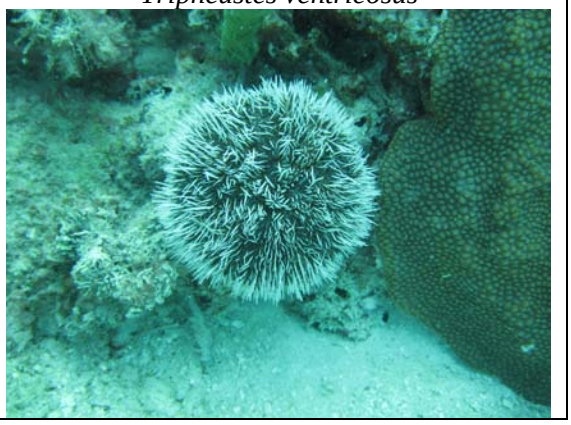


Figure 5-2. Densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) in the upper Florida Keys National Marine Sanctuary from the southern BNP boundary to Carysfort/S. Carysfort SPA.

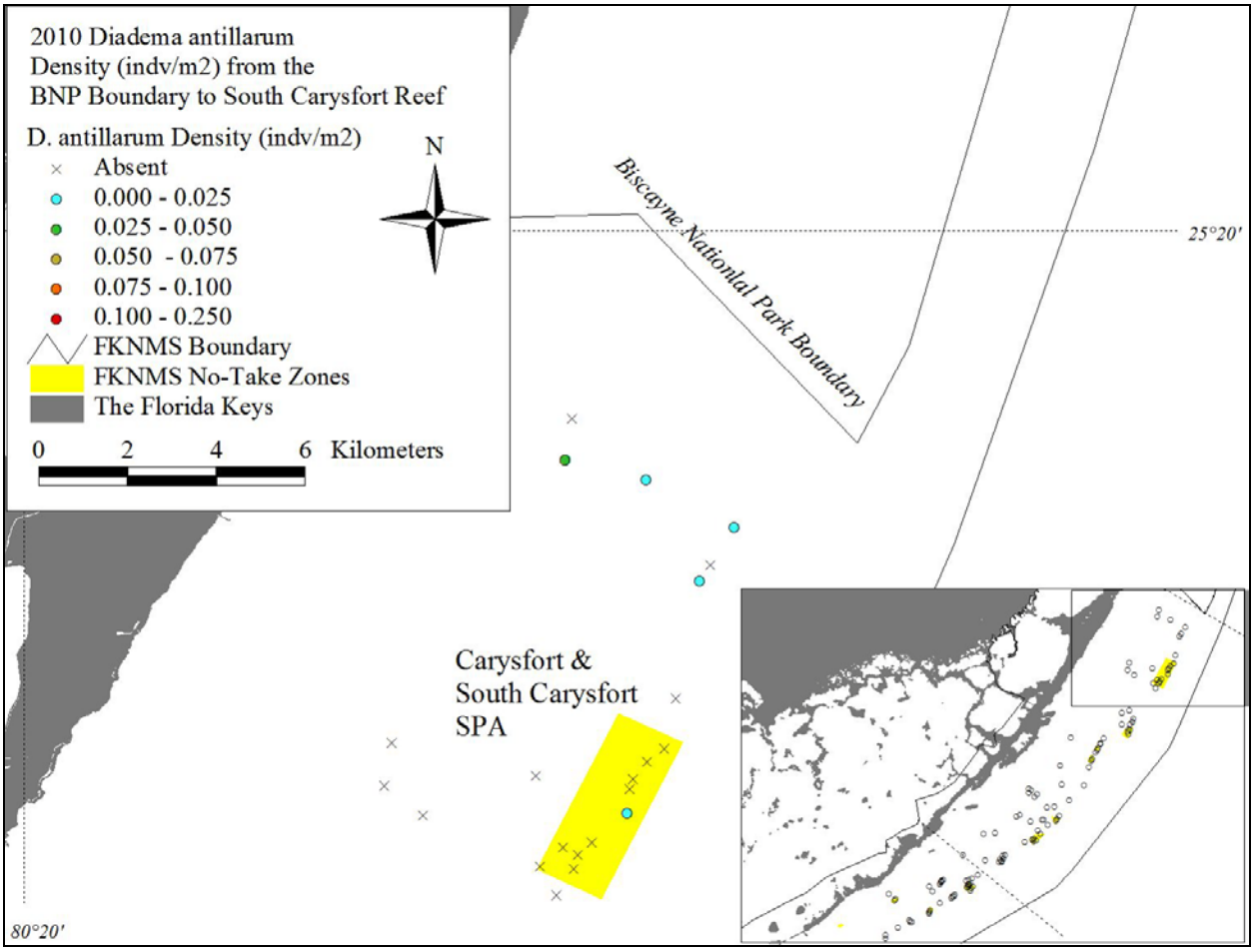


Figure 5-3. Densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) in the upper Florida Keys National Marine Sanctuary from Elbow Reef to Pickles Reef surveyed during June-August 2010.

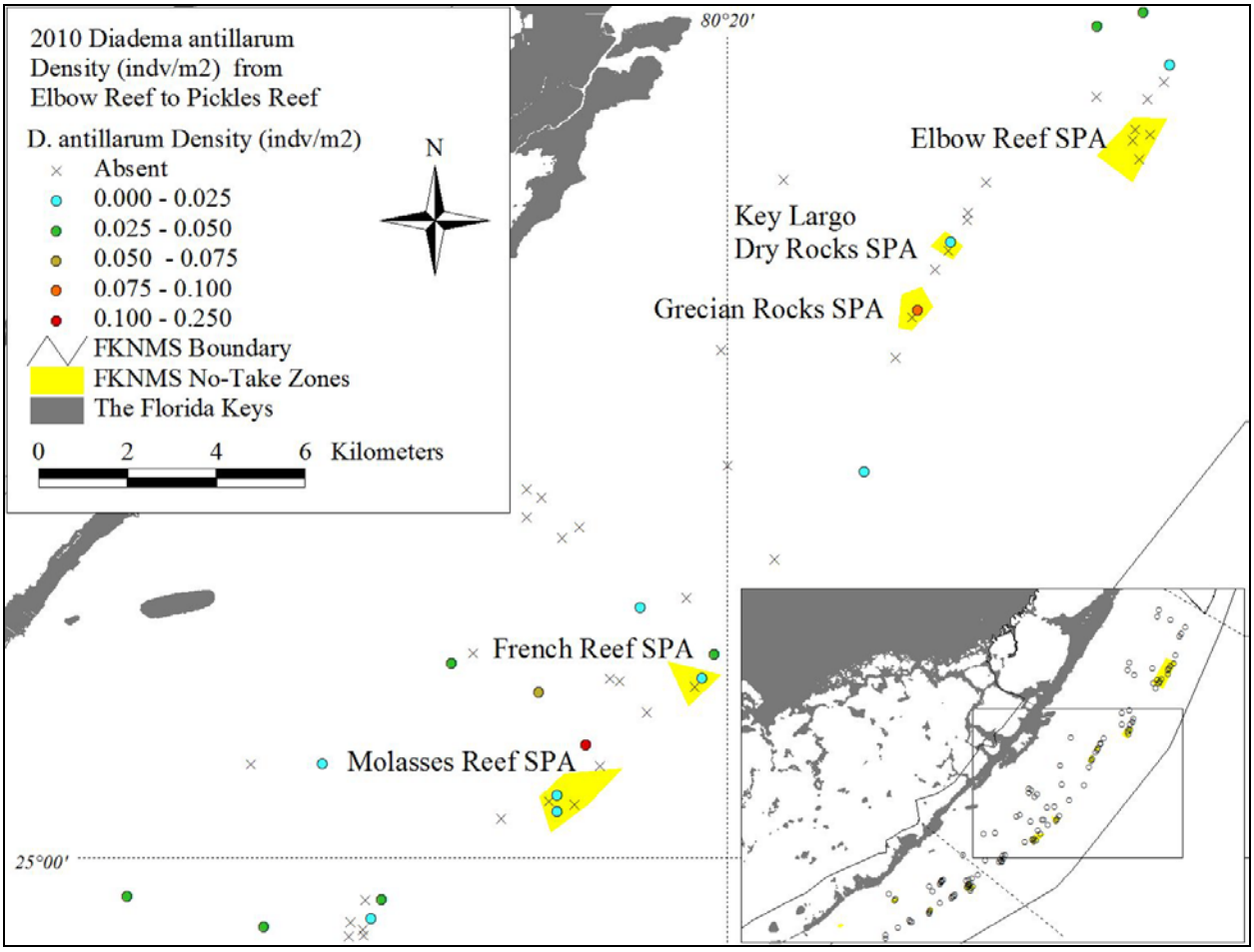


Figure 5-4. Densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) in the upper Florida Keys National Marine Sanctuary from Conch Reef SPA to Crocker Reef surveyed during June-August 2010.

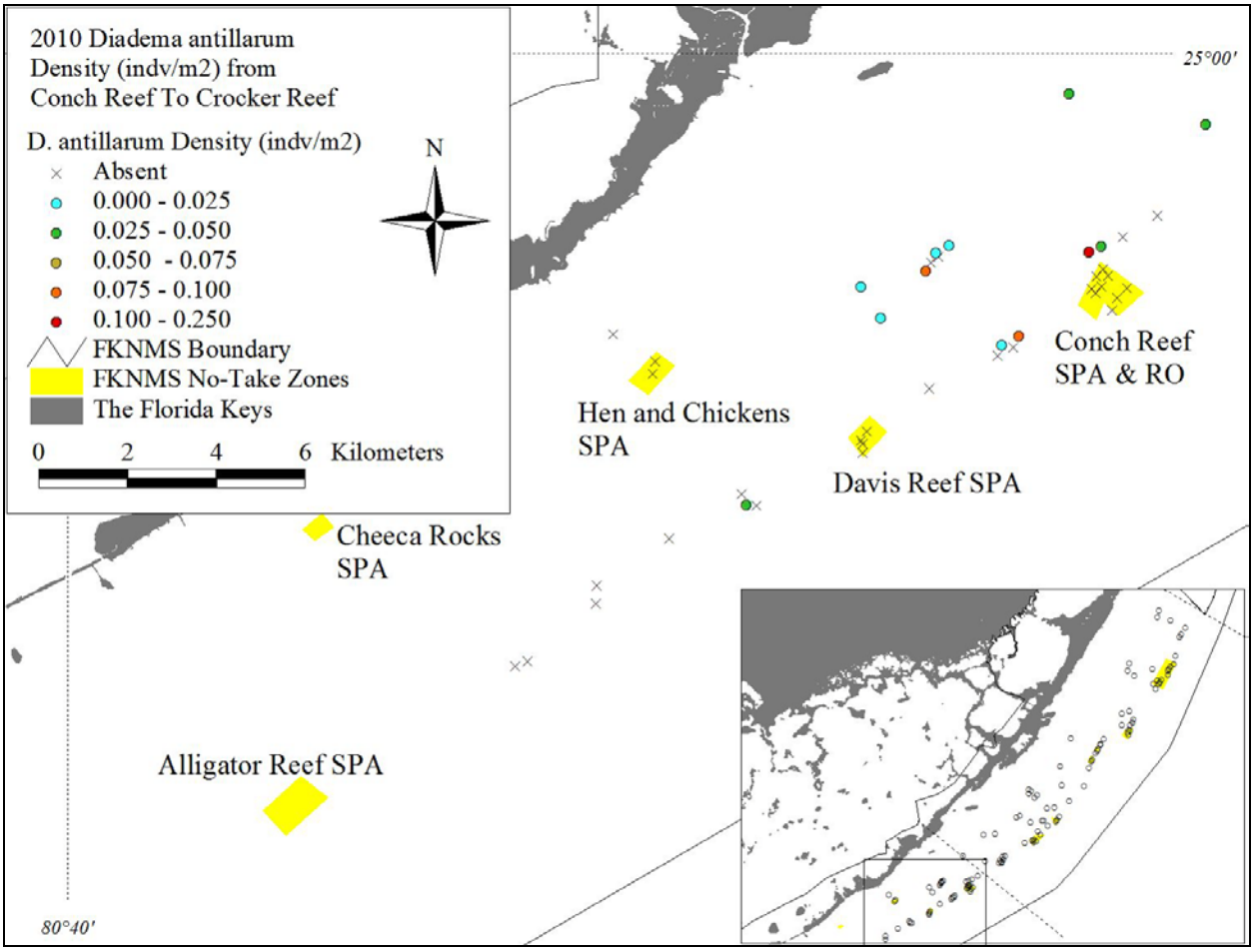
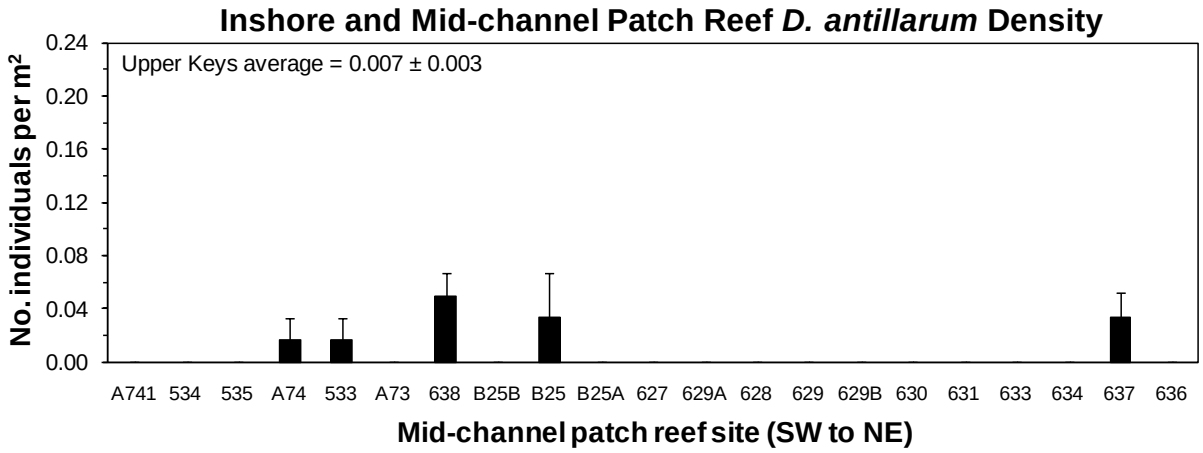
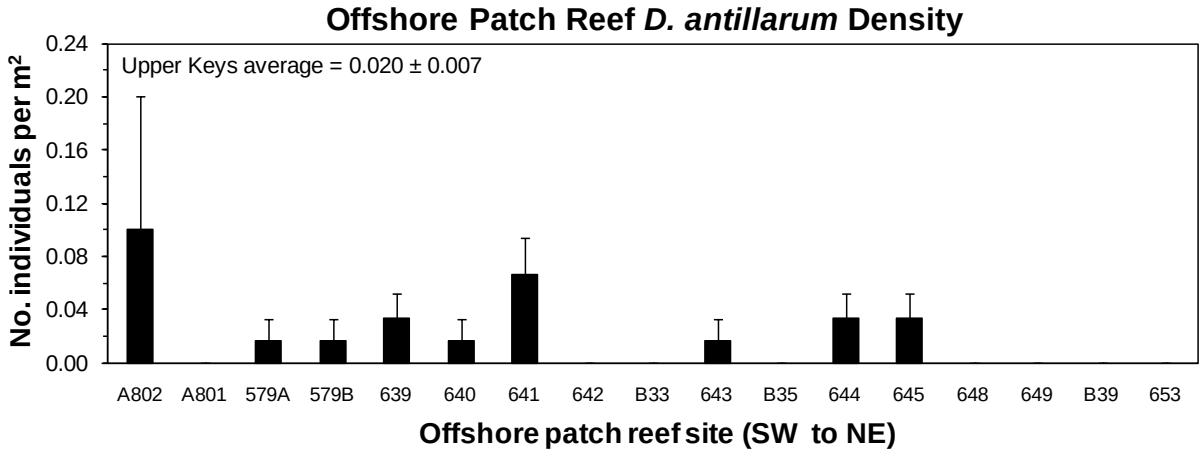


Figure 5-5. Mean (+ 1 SE) densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) on inshore and mid-channel patch reefs (top), offshore patch reefs (middle), and back reef rubble habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.





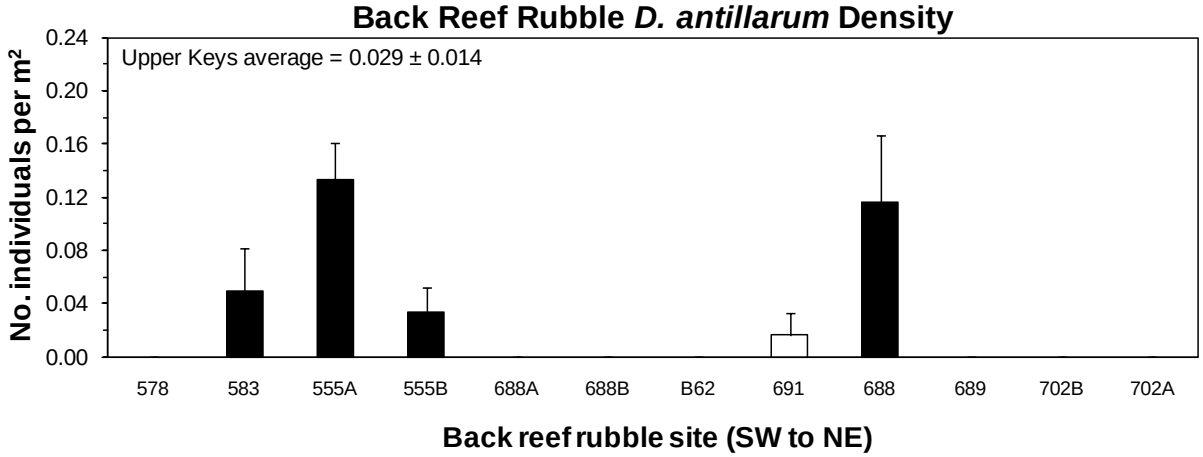


Figure 5-6. Mean (+ 1 SE) densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) on shallow (< 6 m) hard-bottom (top), high-relief spur and groove reefs (middle) and deeper (6-15 m) fore reef habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.

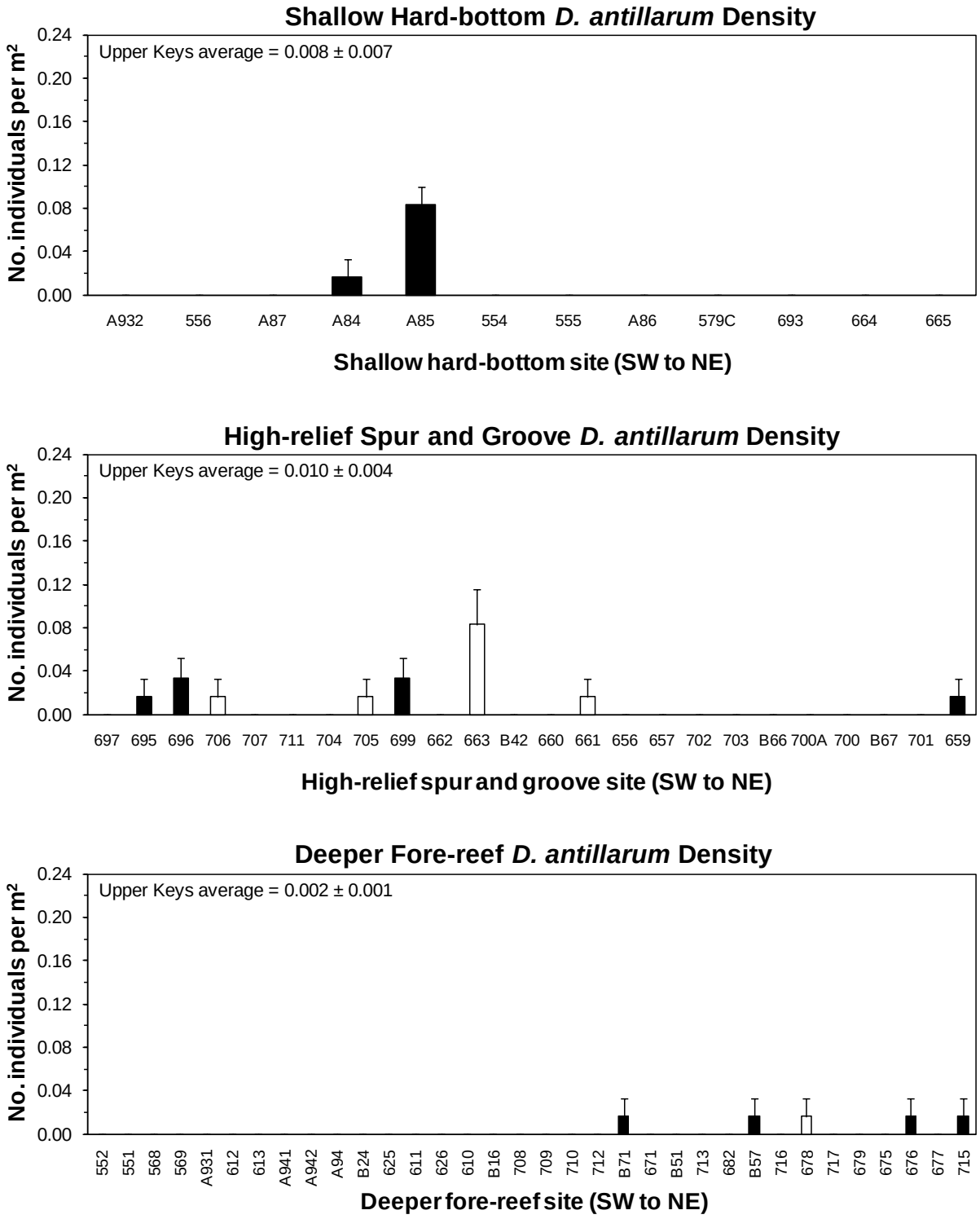


Figure 5-7. Distribution of urchin test diameter sizes (top) and mean (± 1 SE) (filled circles) and maximum sizes (open circles) across habitats (bottom) for *Diadema antillarum* in the upper Florida Keys National Marine Sanctuary, as determined from surveys at 120 sites during June-August 2010. Habitat abbreviations in the bottom figure are: MPR = inshore and mid-channel patch reefs, OPR = offshore patch reefs, BRR = back reef rubble, SHB = shallow (< 6 m) hard-bottom, HSG = high-relief and groove, and DFR = deeper (6-15 m) fore-reef habitats.

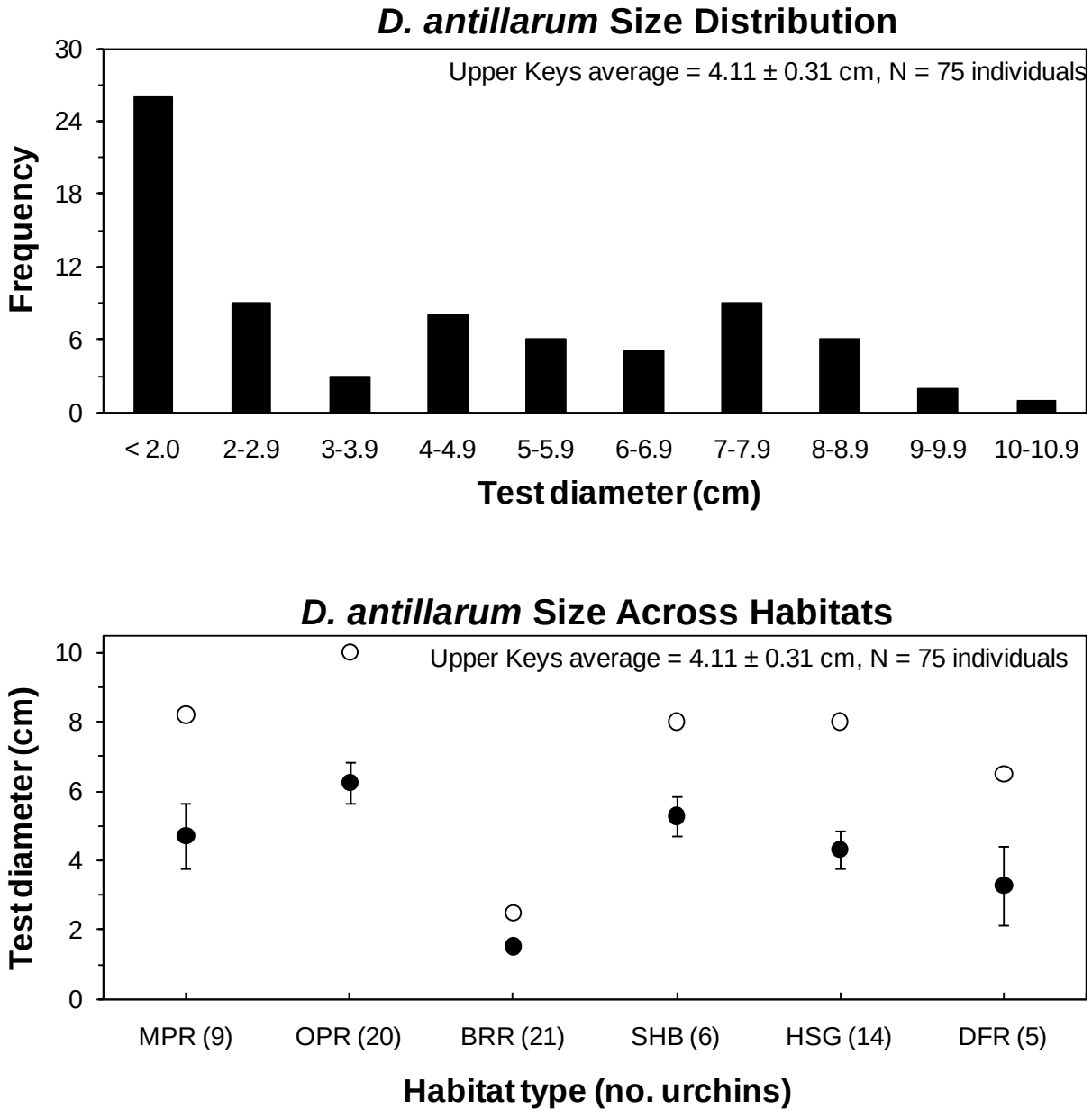


Figure 5-8. Densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) in the upper Florida Keys National Marine Sanctuary from the southern BNP boundary to Carysfort/S. Carysfort SPA surveyed during June-August 2010.

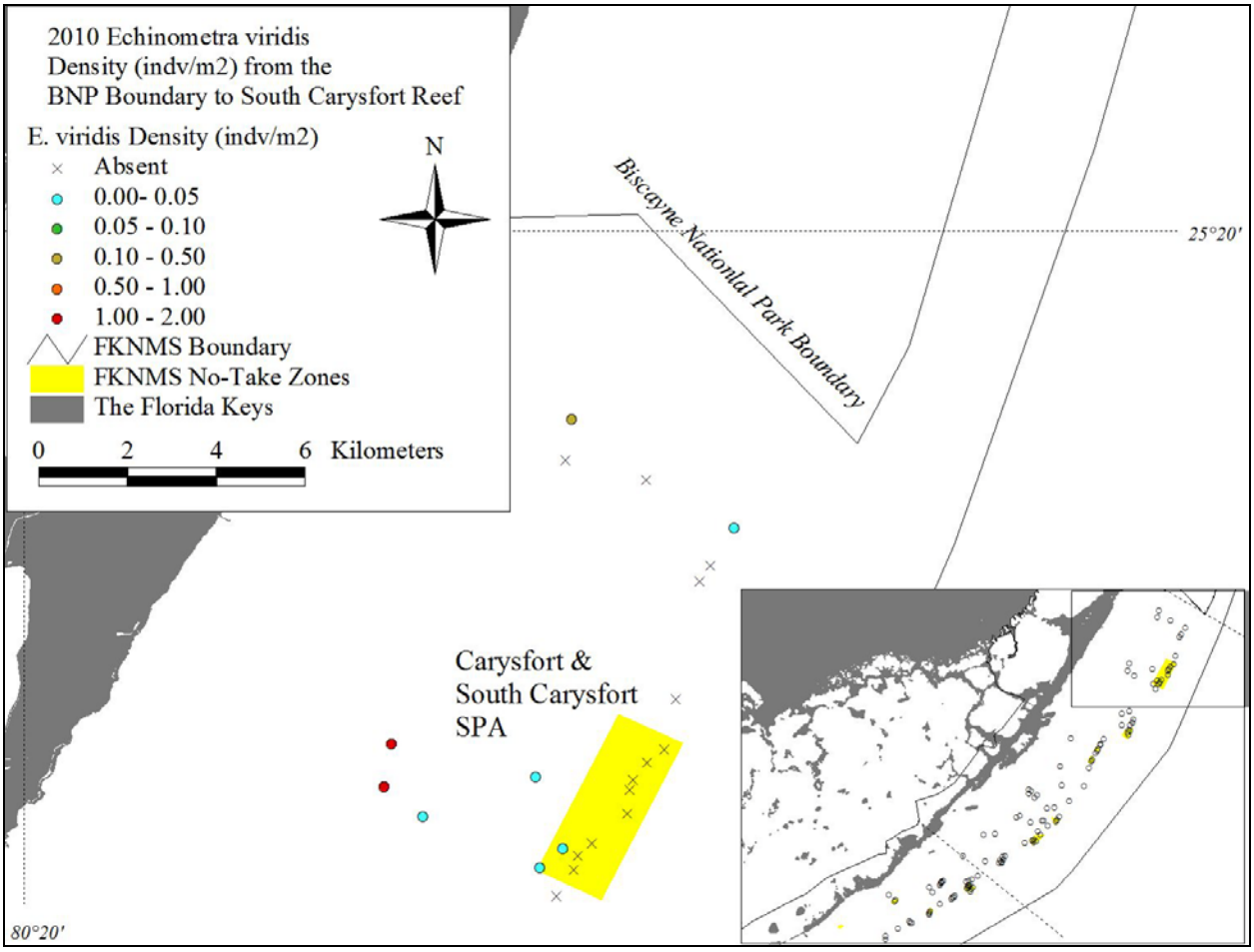


Figure 5-9. Densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) in the upper Florida Keys National Marine Sanctuary from Elbow Reef to Pickles Reef (bottom) surveyed during June-August 2010.

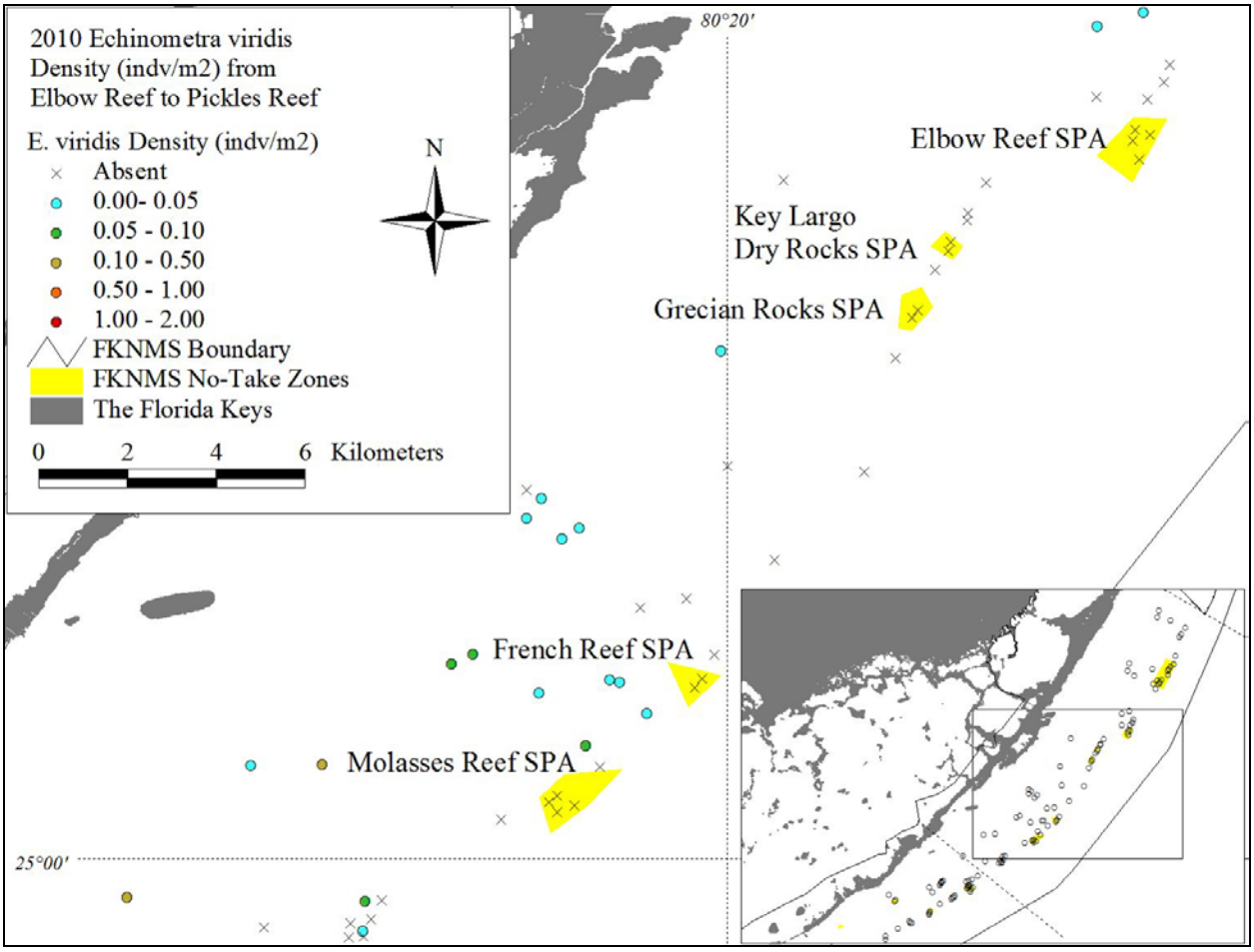


Figure 5-10. Densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) in the upper Florida Keys National Marine Sanctuary from Conch Reef SPA to Crocker Reef surveyed during June-August 2010.

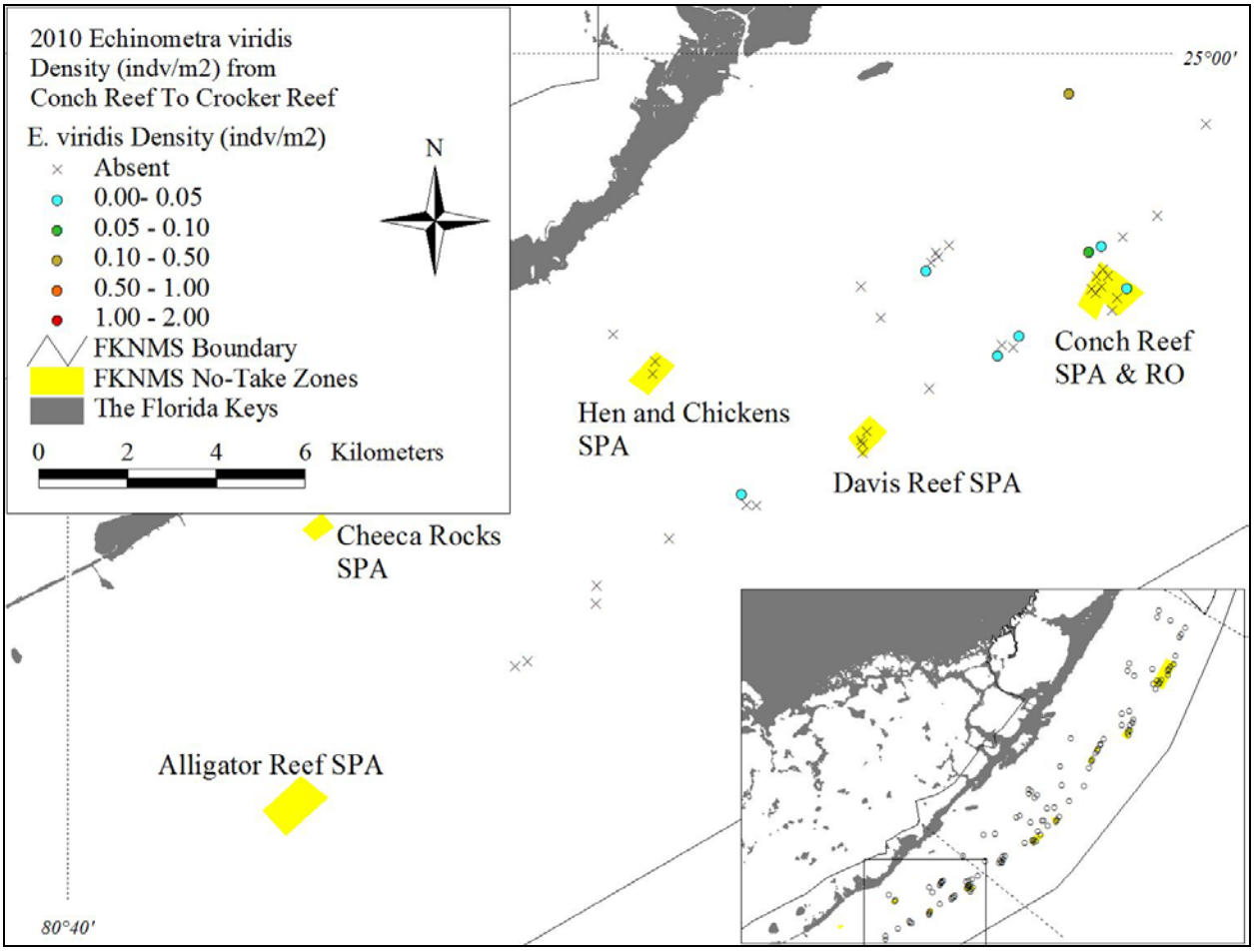
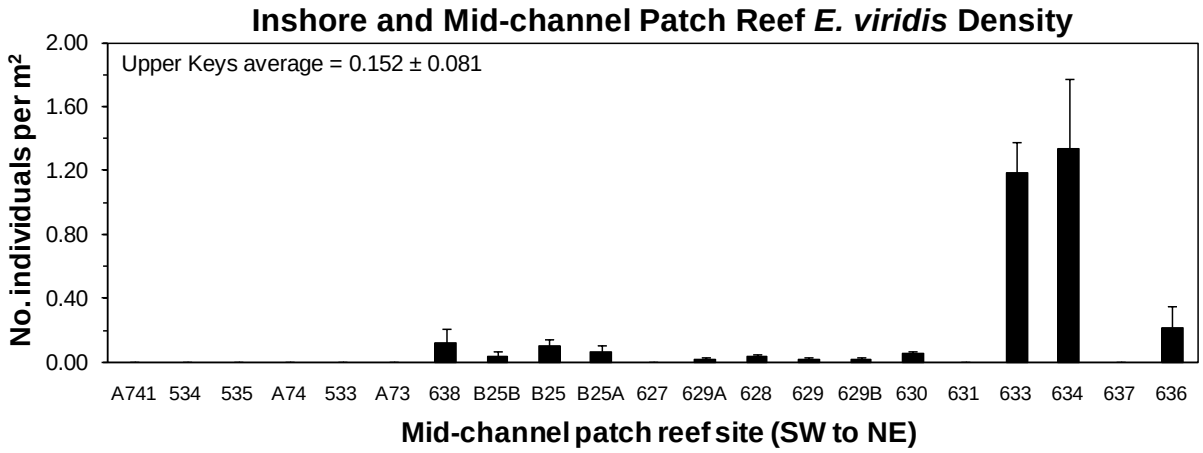
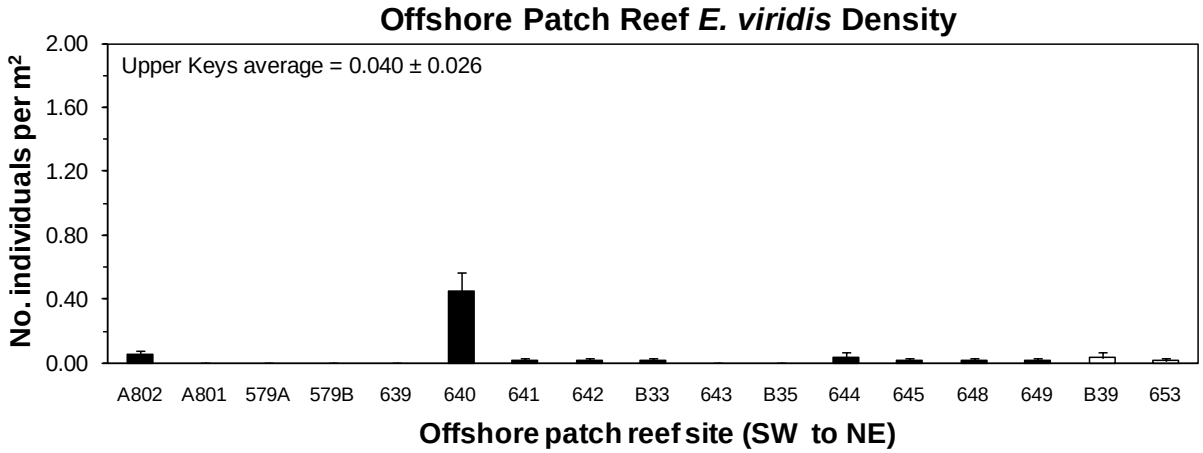


Figure 5-11. Mean (+ 1 SE) densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) on inshore and mid-channel patch reefs (top), offshore patch reefs (middle), and back reef rubble habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.





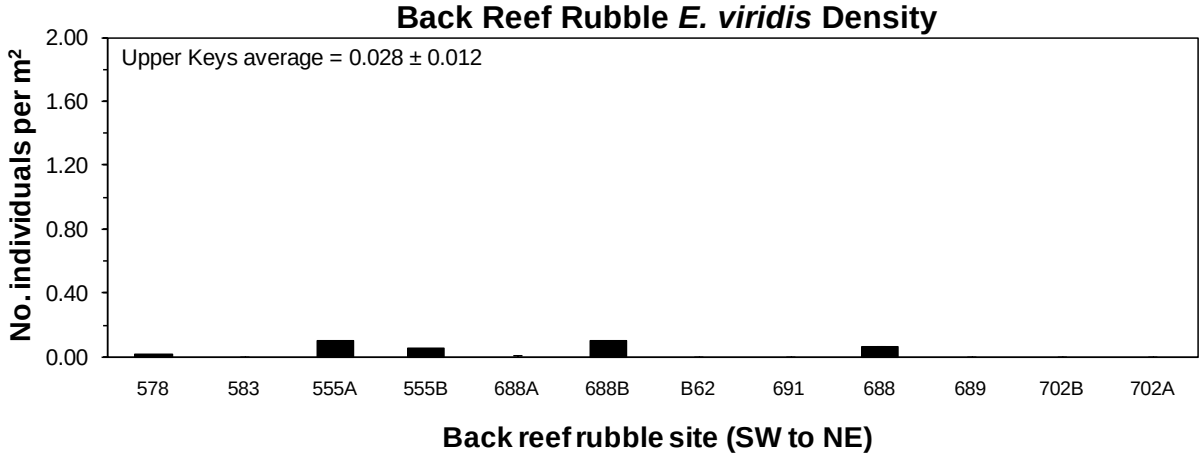


Figure 5-12. Mean (+ 1 SE) densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) on shallow (< 6 m) hard-bottom (top), high-relief spur and groove reefs (middle) and deeper (6-15 m) fore reef habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.

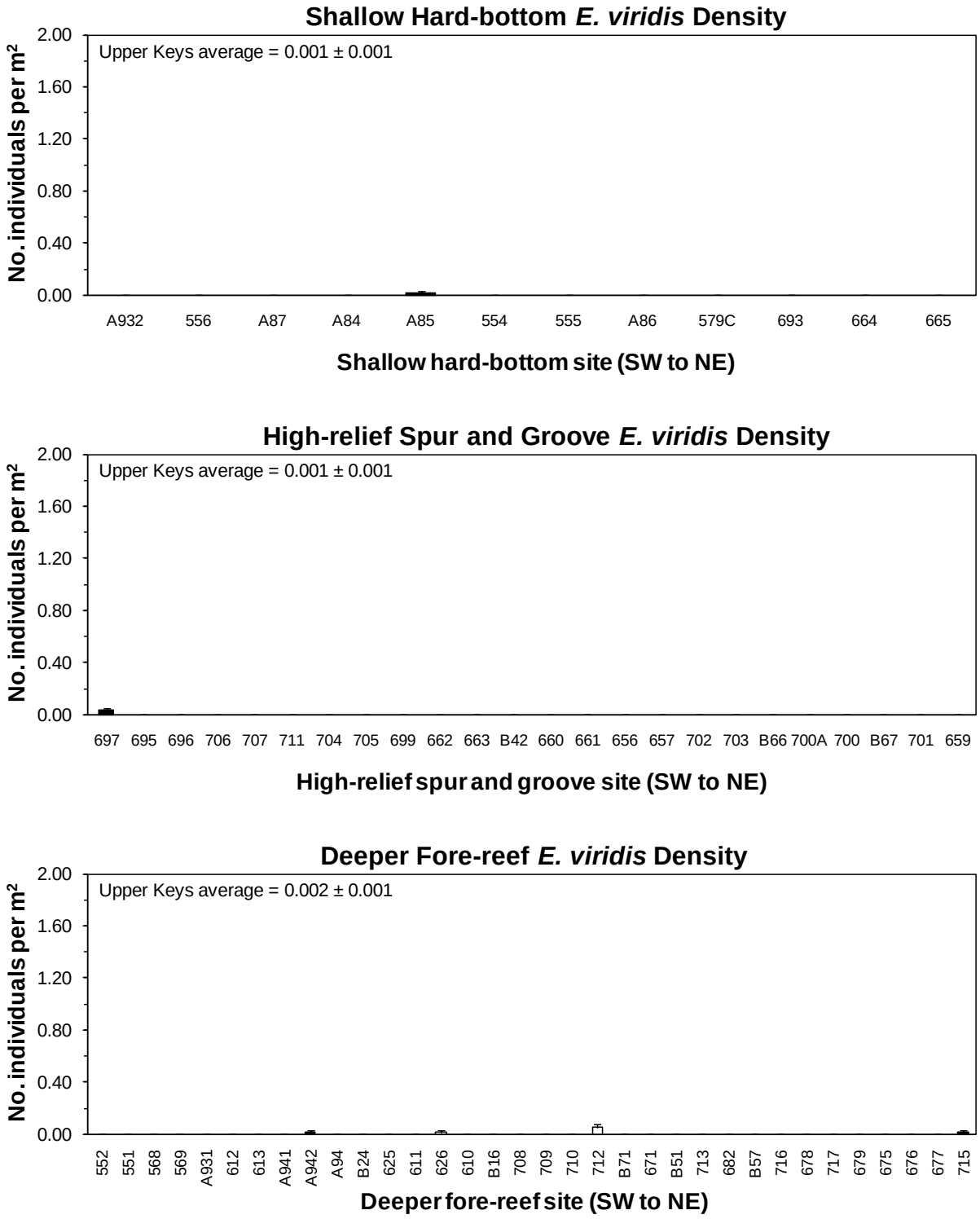


Figure 5-13. Distribution of urchin test diameter sizes (top) and mean (± 1 SE) (filled circles) and maximum sizes (open circles) across habitats (bottom) for *Echinometra viridis* in the upper Florida Keys National Marine Sanctuary, as determined from surveys at 120 sites during June-August 2010. Habitat abbreviations in the bottom figure are: MPR = inshore and mid-channel patch reefs, OPR = offshore patch reefs, BRR = back reef rubble, SHB = shallow (< 6 m) hard-bottom, HSG = high-relief and groove, and DFR = deeper (6-15 m) fore-reef habitats.

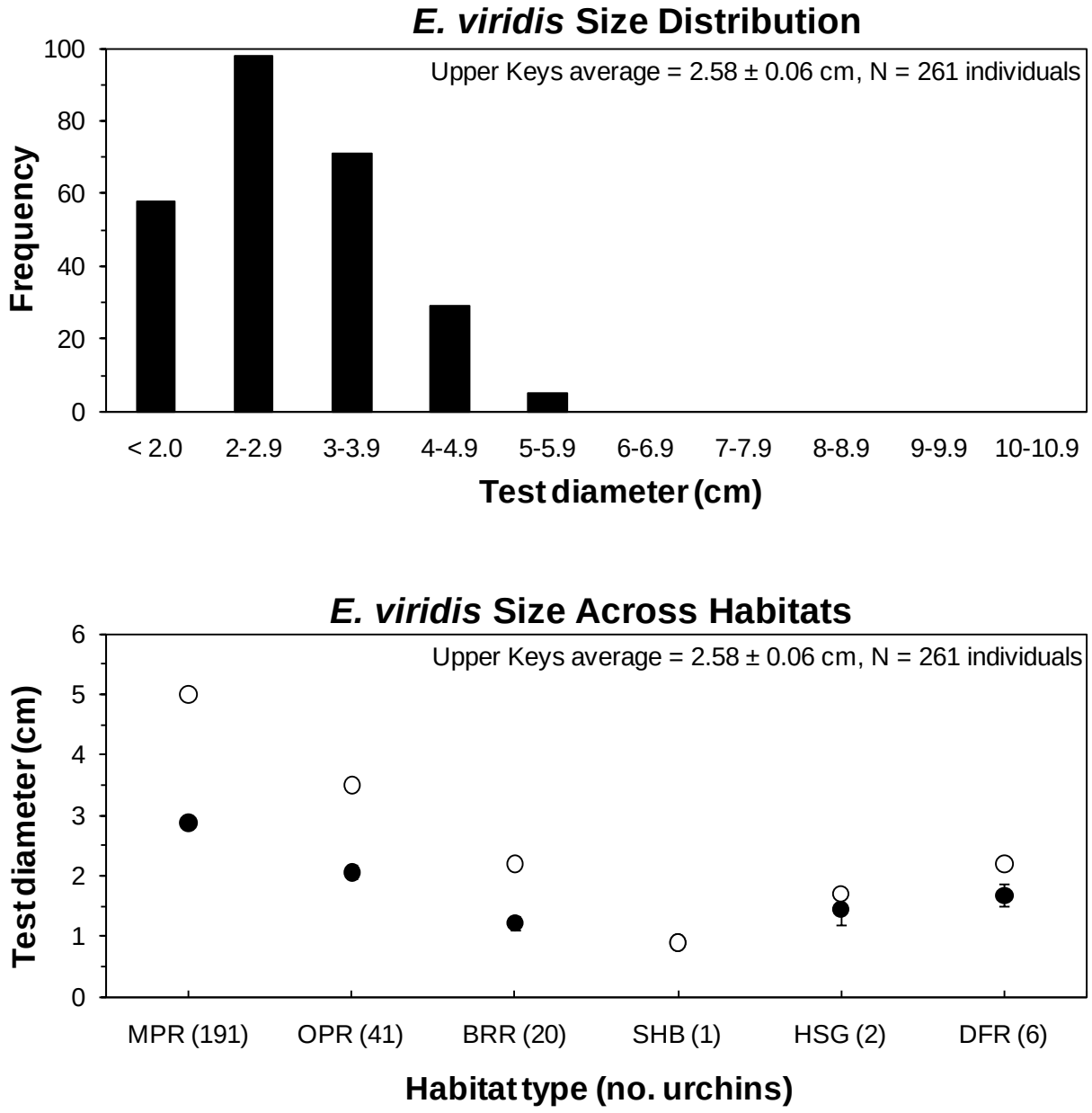


Figure 5-14. Densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) in the upper Florida Keys National Marine Sanctuary from the southern BNP boundary to Carysfort/S. Carysfort SPA surveyed during June-August 2010.

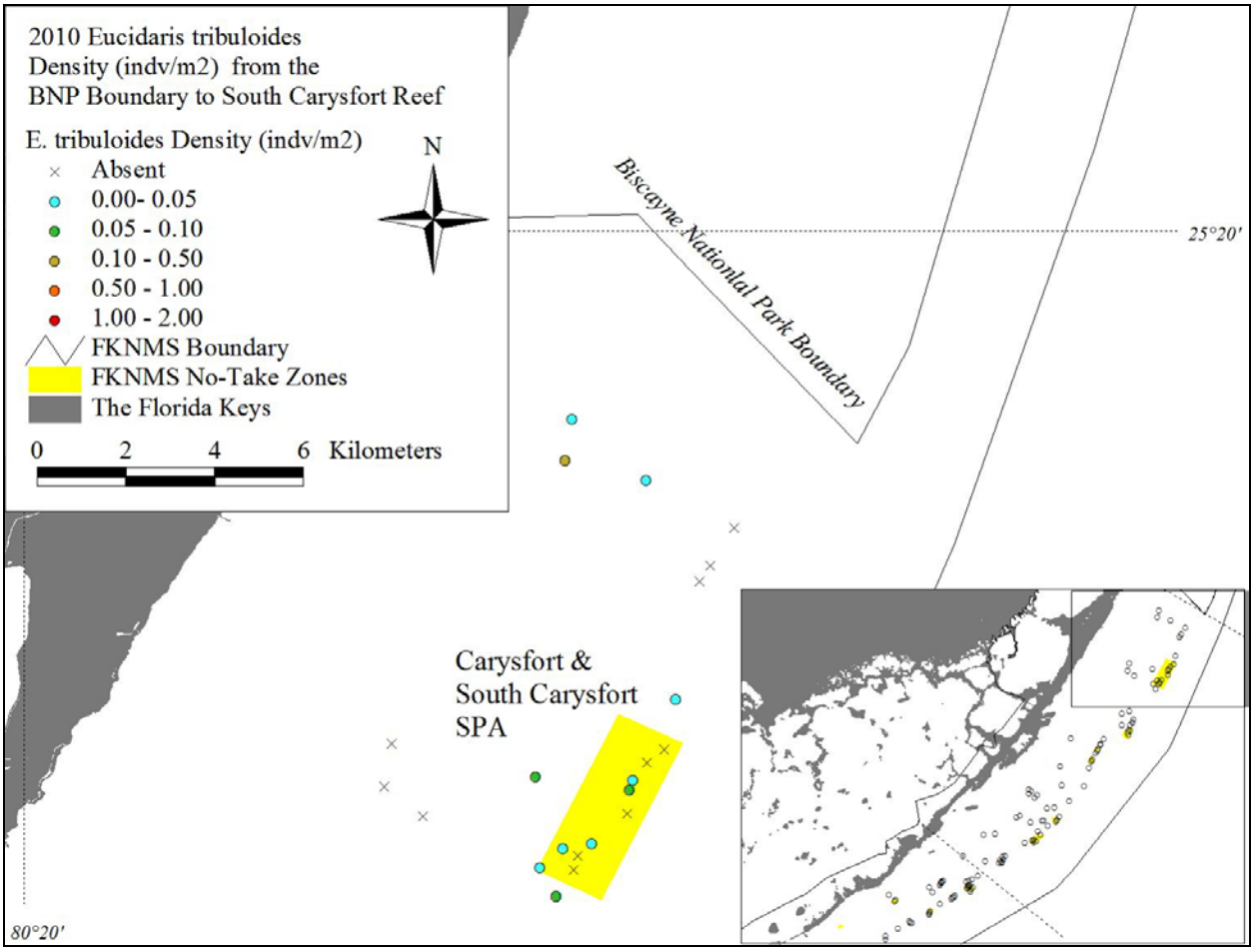


Figure 5-15. Densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) in the upper Florida Keys National Marine Sanctuary from Elbow Reef to Pickles Reef (bottom) surveyed during June-August 2010.

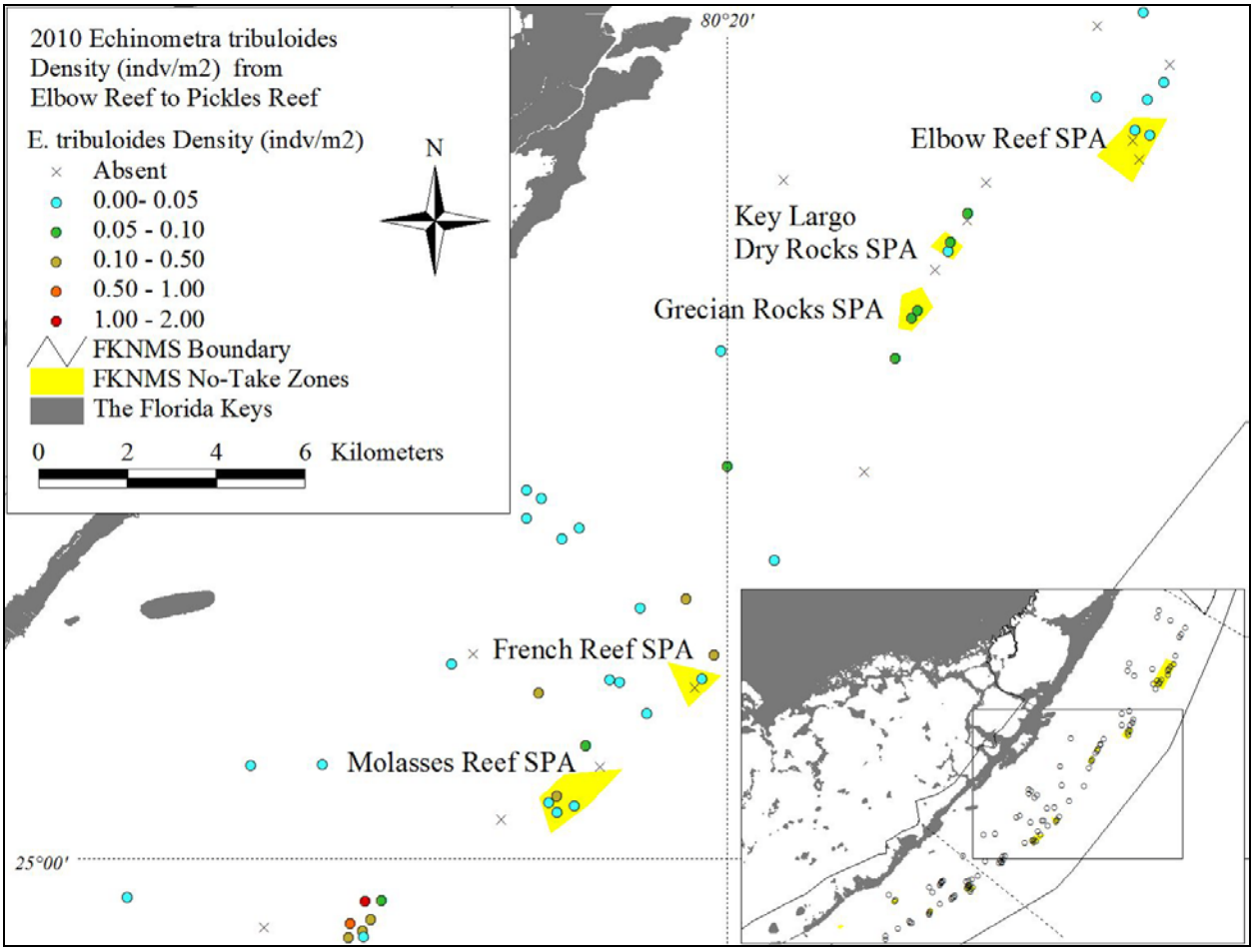


Figure 5-16. Densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) in the upper Florida Keys National Marine Sanctuary from Conch Reef SPA to Crocker Reef surveyed during June-August 2010.

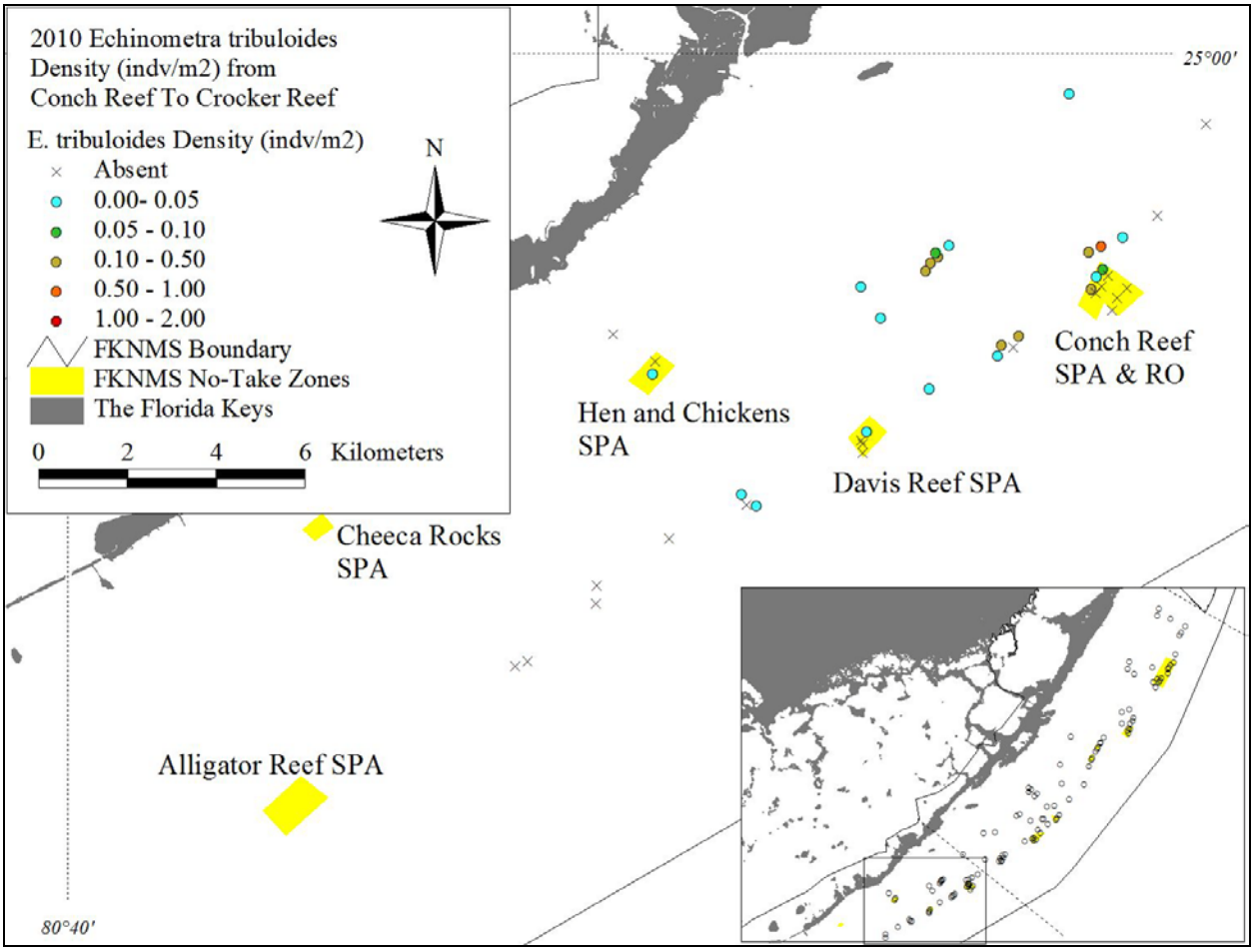
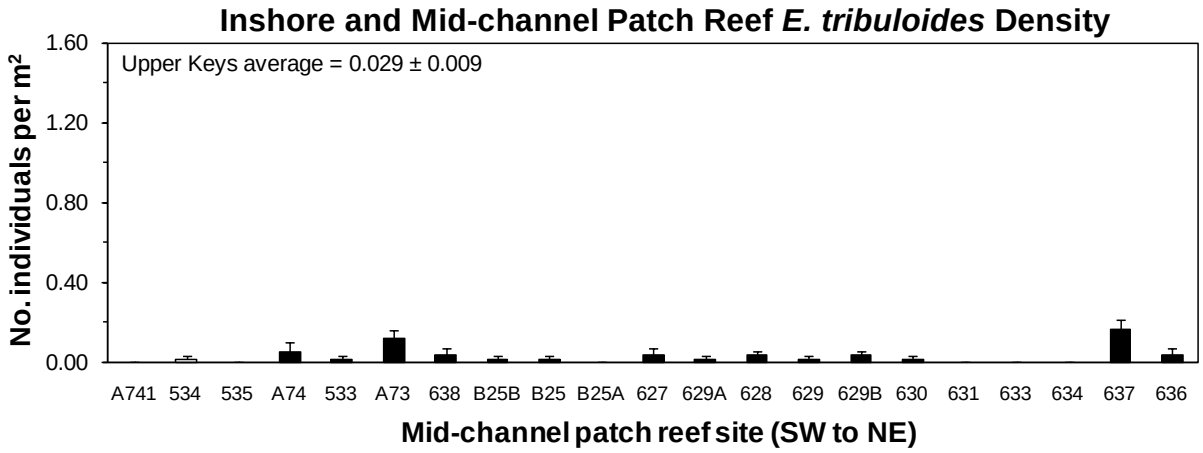
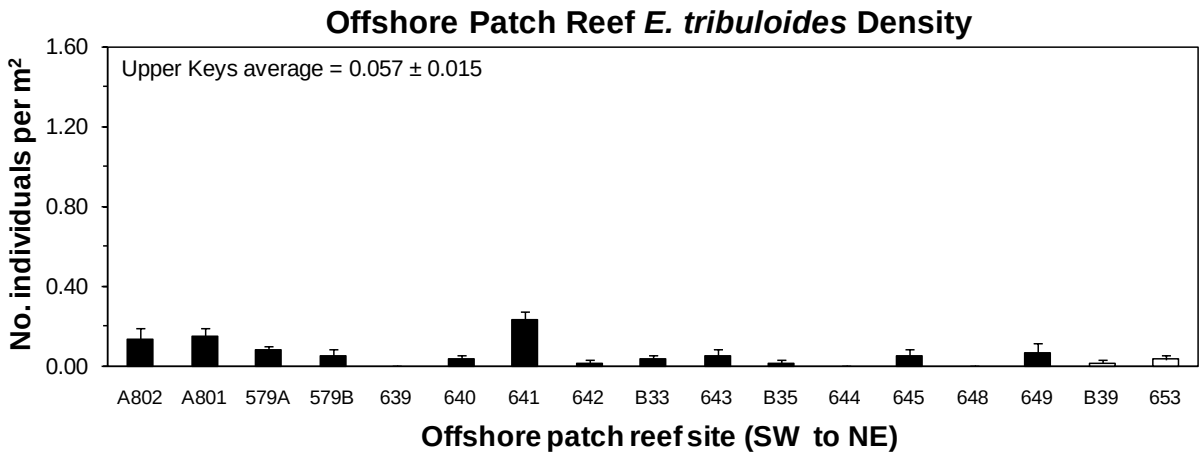


Figure 5-17. Mean (+ 1 SE) densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) on inshore and mid-channel patch reefs (top), offshore patch reefs (middle), and back reef rubble habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.





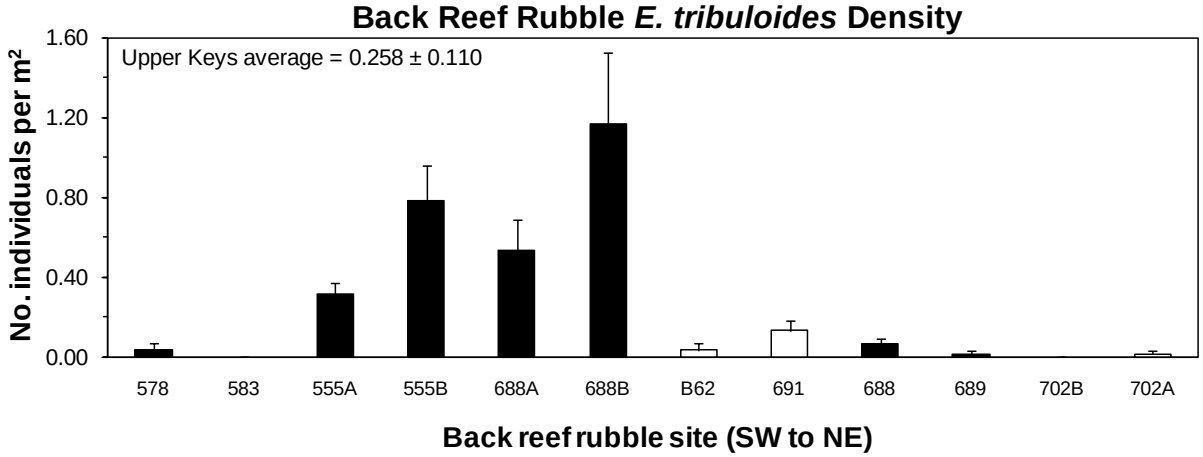
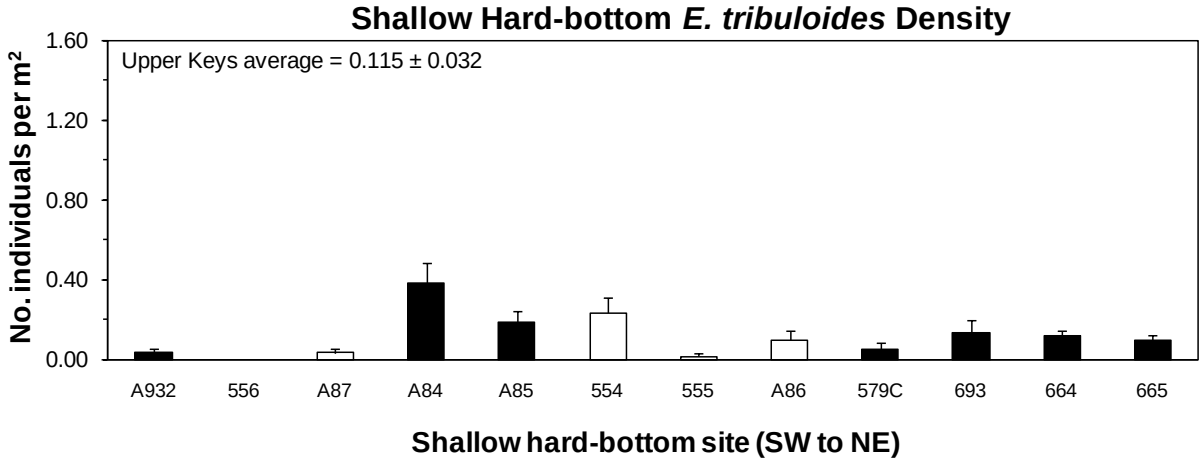
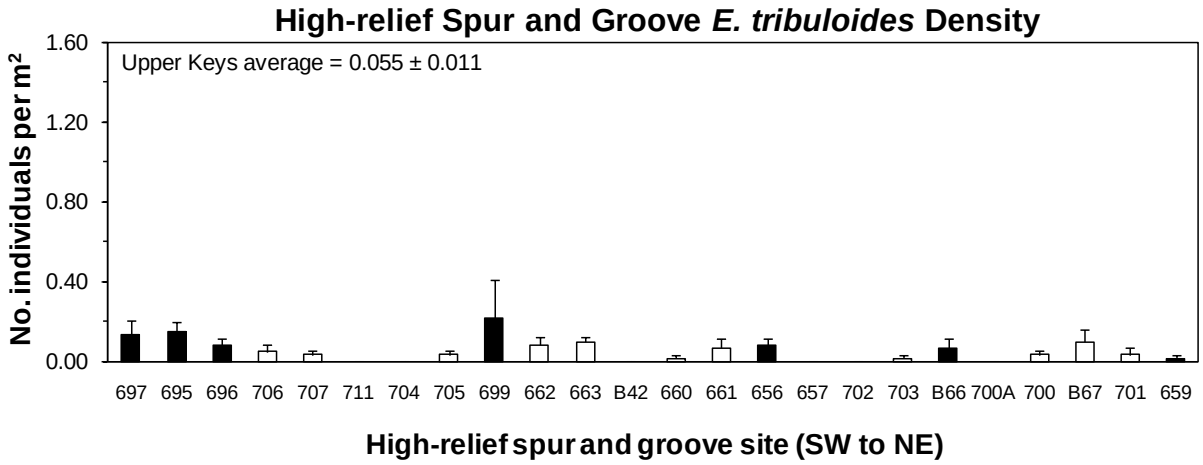


Figure 5-18. Mean (+ 1 SE) densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) on shallow (< 6 m) hard-bottom (top), high-relief spur and groove reefs (middle) and deeper (6-15 m) fore reef habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.





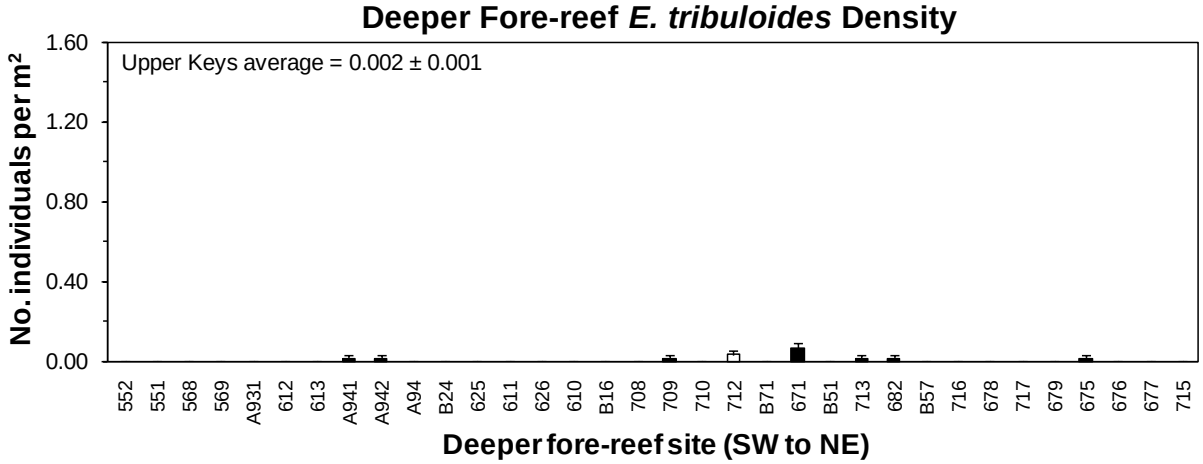


Figure 5-19. Distribution of urchin test diameter sizes (top) and mean (± 1 SE) (filled circles) and maximum sizes (open circles) across habitats (bottom) for *Eucidaris tribuloides* in the upper Florida Keys National Marine Sanctuary, as determined from surveys at 120 sites during June-August 2010. Habitat abbreviations in the bottom figure are: MPR = inshore and mid-channel patch reefs, OPR = offshore patch reefs, BRR = back reef rubble, SHB = shallow (< 6 m) hard-bottom, HSG = high-relief and groove, and DFR = deeper (6-15 m) fore-reef habitats.

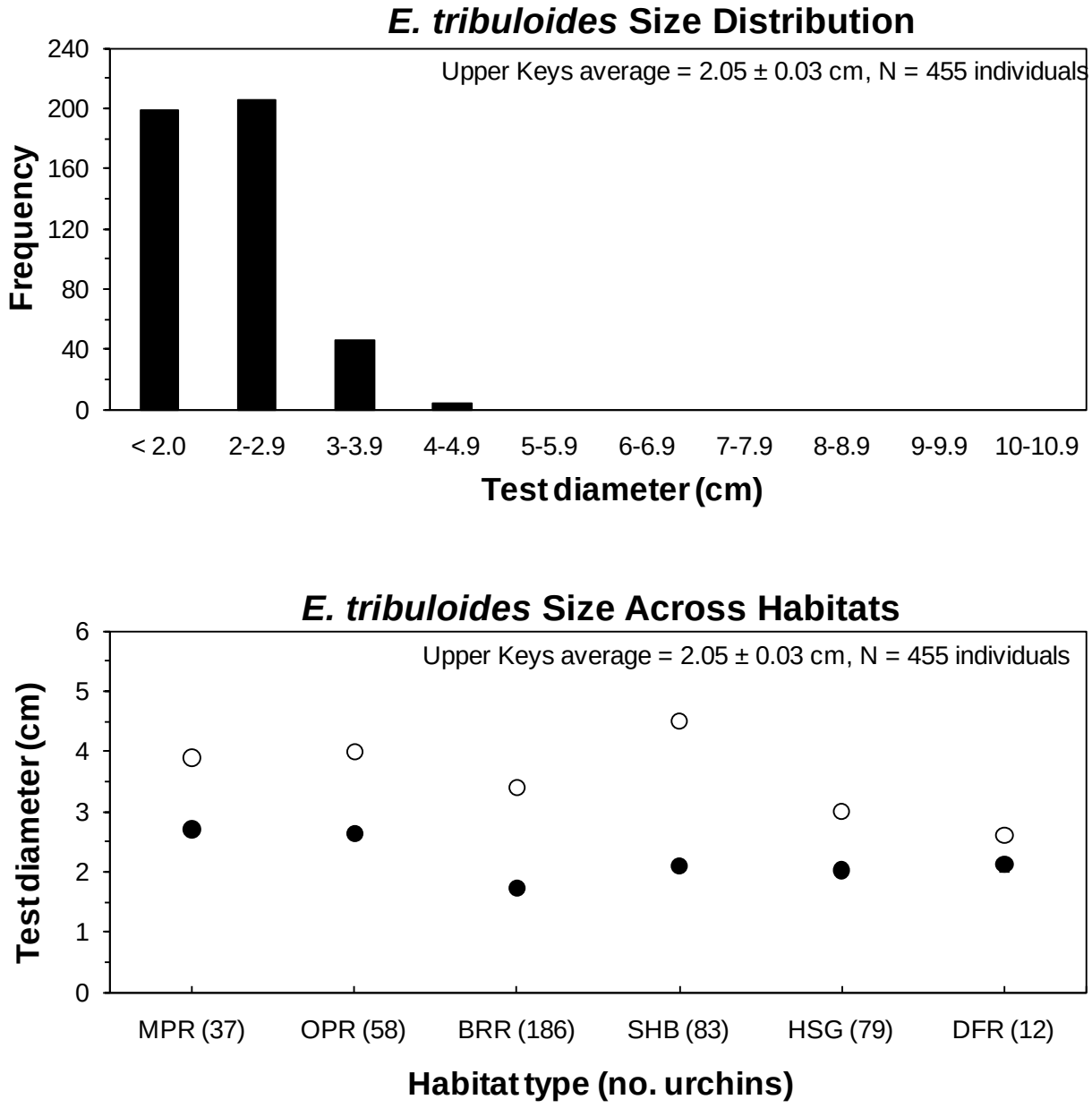


Table 5-1. Mean ± 1 SE transect frequencies (%), densities (no. individuals per m^2), numbers of individuals (N), and test diameters of *Diadema antillarum* in the upper Florida Keys, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-August 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
Inshore and mid-channel patch reefs				
Middle Florida Keys				
A741 – Tavernier Rocks	0 ± 0	0	0 ± 0	
534 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
535 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
A74 – West of Conch Reef	25 ± 25	1	0.017 ± 0.017	5.7
533 – West of Conch Reef	25 ± 25	1	0.017 ± 0.017	7.2
A73 – West of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (6)	**8 ± 5**	**2**	**0.006 ± 0.004**	6.5 ± 0.8
Upper Florida Keys				
638 – Inshore of Pickles Reef	75 ± 25	3	0.050 ± 0.017	
B25B – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
B25 – Inshore of Molasses Reef	25 ± 25	2	0.033 ± 0.033	4.9 ± 3.4
B25A – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
627 – Mosquito Bank	0 ± 0	0	0 ± 0	
629A – Mosquito Bank	0 ± 0	0	0 ± 0	
628 – Mosquito Bank	0 ± 0	0	0 ± 0	
629 – Mosquito Bank	0 ± 0	0	0 ± 0	
629B – Mosquito Bank	0 ± 0	0	0 ± 0	
630 – SE of Cannon Patch Reef	0 ± 0	0	0 ± 0	
631 – Marker 33	0 ± 0	0	0 ± 0	
633 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
634 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
637 – West of Turtle Rocks	50 ± 29	2	0.033 ± 0.019	7.0 ± 0.9
636 – West of Turtle Rocks	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (15)	10 ± 6	7	0.008 ± 0.004	4.2 ± 1.2
Mid-channel Patch Reef Total (21)	**10 ± 4**	**9**	**0.007 ± 0.003**	4.7 ± 0.9
Offshore patch reefs				
Middle Florida Keys				
A802 – Inshore of Conch Reef	25 ± 25	6	0.100 ± 0.100	7.8 ± 0.2
A801 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579A – Inshore of Conch Reef	25 ± 25	1	0.017 ± 0.017	6.4
579B – Inshore of Conch Reef	25 ± 25	1	0.017 ± 0.017	6.0
Middle Florida Keys Total (4)	19 ± 6	8	0.033 ± 0.023	7.4 ± 0.3
Upper Florida Keys				
639 – Inshore of Pickles Reef	50 ± 29	2	0.033 ± 0.019	
640 – White Bank (West of Molasses)	25 ± 25	1	0.017 ± 0.017	1.2
641 – White Bank (West of Molasses)	75 ± 25	4	0.067 ± 0.027	4.0 ± 1.0
642 – SE of White Bank Dry Rocks	0 ± 0	0	0 ± 0	
B33 – East of White Bank Dry Rocks	0 ± 0	0	0 ± 0	
643 – White Bank (NW of French)	25 ± 25	1	0.017 ± 0.017	5.0
B35 – West of Elbow Reef	0 ± 0	0	0 ± 0	
644 – Watson's Reef	50 ± 29	2	0.033 ± 0.019	9.1 ± 0.0
645 – Watson's Reef	50 ± 29	2	0.033 ± 0.019	5.4 ± 4.7
648 – East of Basin Hill Shoals	0 ± 0	0	0 ± 0	
649 – West of Carysfort Reef	0 ± 0	0	0 ± 0	
B39 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	
653 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (13)	21 ± 7	12	0.015 ± 0.006	5.5 ± 0.9

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
Offshore Patch Reef Total (17)	**21 ± 6**	**20**	**0.020 ± 0.007**	**6.3 ± 0.6**
Back reef rubble				
Middle Florida Keys				
578 – Crocker Reef	0 ± 0	0	0 ± 0	
583 – Crocker Reef	50 ± 29	3	0.050 ± 0.032	1.5 ± 0.1
555A – Conch Reef	100 ± 0	8	0.133 ± 0.027	1.6 ± 0.2
555B – Conch Reef	50 ± 29	2	0.033 ± 0.019	1.3 ± 0.4
Middle Florida Keys Total (4)	50 ± 20	13	0.054 ± 0.028	1.5 ± 0.1
Upper Florida Keys				
688A – Pickles Reef	0 ± 0	0	0 ± 0	
688B – Pickles Reef	0 ± 0	0	0 ± 0	
B62 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
691 – Molasses Reef SPA**	25 ± 25	1	0.017 ± 0.017	2.0
688 – Sand Island	75 ± 25	7	0.117 ± 0.050	1.5 ± 0.2
689 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
702B – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
702A – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (8)	13 ± 9	8	0.017 ± 0.014	1.6 ± 0.2
Back Reef Rubble Total (12)	**25 ± 10**	**21**	**0.029 ± 0.014**	**1.5 ± 0.2**
Low-relief hard-bottom (< 6 m)				
Middle Florida Keys				
A932 – Crocker Reef	0 ± 0	0	0 ± 0	
556 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A87 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A84 – Little Conch Reef	25 ± 25	1	0.017 ± 0.017	4.5
A85 – Little Conch Reef	100 ± 0	5	0.083 ± 0.017	5.4 ± 0.6
554 – Conch Reef C1**	0 ± 0	0	0 ± 0	
555 – Conch Reef C2**	0 ± 0	0	0 ± 0	
A86 – Conch Reef C3**	0 ± 0	0	0 ± 0	
579C – NE of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (9)	14 ± 11	6	0.011 ± 0.009	5.3 ± 0.6
Upper Florida Keys				
693 – Little Pickles Reef	0 ± 0	0	0 ± 0	
664 – North of French Reef	0 ± 0	0	0 ± 0	
665 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (3)	0 ± 0	0	0 ± 0	
Shallow Hard-bottom Total (17)	**10 ± 8**	**6**	**0.008 ± 0.007**	**5.3 ± 0.6**
High-relief spur & groove				
Upper Florida Keys				
697 – Pickles Reef P1	0 ± 0	0	0 ± 0	
695 – Pickles Reef P3	25 ± 25	1	0.017 ± 0.017	
696 – NE Pickles Reef	50 ± 29	2	0.033 ± 0.019	
706 – Molasses Reef SPA**	25 ± 25	1	0.017 ± 0.017	2.7
707 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
711 – Sand Island	0 ± 0	0	0 ± 0	
704 – French Reef SPA**	0 ± 0	0	0 ± 0	
705 – French Reef SPA**	25 ± 25	1	0.017 ± 0.017	4.0
699 – North of French Reef	50 ± 29	2	0.033 ± 0.019	3.2 ± 0.7
662 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	
663 – Grecian Rocks SPA**	75 ± 25	5	0.083 ± 0.032	4.3 ± 1.0
B42 – Little Grecian Rocks	0 ± 0	0	0 ± 0	
660 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	
661 – Key Largo Dry Rocks**	25 ± 25	1	0.017 ± 0.017	3.9

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
656 – North Dry Rocks	0 ± 0	0	0 ± 0	
657 – North-North Dry Rocks	0 ± 0	0	0 ± 0	
702 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
703 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
B66 – South of S. Carysfort	0 ± 0	0	0 ± 0	
700A – South Carysfort Reef**	0 ± 0	0	0 ± 0	
700 – South Carysfort Reef**	0 ± 0	0	0 ± 0	
B67 – Carysfort Reef C2**	0 ± 0	0	0 ± 0	
701 – Carysfort Reef C5**	0 ± 0	0	0 ± 0	
659 – Turtle Reef	25 ± 25	1	0.017 ± 0.017	7.0
Upper Florida Keys Total (24)	13 ± 4	14	0.010 ± 0.004	4.3 ± 0.5
High-relief Spur & Groove Total (42)	**13 ± 4**	**14**	**0.010 ± 0.004**	**4.3 ± 0.5**
Deeper Fore-reef (6-15 m)				
Middle Florida Keys				
552 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
551 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
568 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
569 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
612 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A941 – North of Davis Reef	0 ± 0	0	0 ± 0	
A942 – Little Conch Reef	0 ± 0	0	0 ± 0	
A94 – Little Conch Reef	0 ± 0	0	0 ± 0	
B24 – Conch Reef RO**	0 ± 0	0	0 ± 0	
625 – Conch Reef RO**	0 ± 0	0	0 ± 0	
611 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
626 – Conch Reef RO**	0 ± 0	0	0 ± 0	
610 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
B16 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (16)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
708 – NE of Conch Reef	0 ± 0	0	0 ± 0	
709 – Pickles Reef	0 ± 0	0	0 ± 0	
710 – SW of Molasses Reef SPA	0 ± 0	0	0 ± 0	
712 – SW of French Reef	0 ± 0	0	0 ± 0	
B71 – Dixie Shoal	25 ± 25	1	0.017 ± 0.017	1.5
671 – South of Grecian Rocks	0 ± 0	0	0 ± 0	
B51 – East of Dry Rocks	0 ± 0	0	0 ± 0	
713 – North of Elbow Reef	0 ± 0	0	0 ± 0	
682 – North of Elbow Reef	0 ± 0	0	0 ± 0	
B57 – SE of Watson's Reef	25 ± 25	1	0.017 ± 0.017	6.5
716 – South Carysfort Reef**	0 ± 0	0	0 ± 0	
678 – North Carysfort Reef**	25 ± 25	1	0.017 ± 0.017	0.4
717 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
679 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
675 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
676 – North of Carysfort Reef	25 ± 25	1	0.017 ± 0.017	2.7
677 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
715 – North of Carysfort Reef	25 ± 25	1	0.017 ± 0.017	5.3
Upper Florida Keys Total (18)	7 ± 3	5	0.005 ± 0.002	3.3 ± 1.2
Deeper Fore-reef Total (34)	**4 ± 2**	**5**	**0.002 ± 0.001**	3.3 ± 1.2

Table 5-2. Mean ± 1 SE transect frequencies (%), densities (no. individuals per m^2), numbers of individuals (N), and test diameters of *Echinometra lucunter* in the upper Florida Keys, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-August 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
Inshore and mid-channel patch reefs				
Middle Florida Keys				
A741 – Tavernier Rocks	0 ± 0	0	0 ± 0	
534 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
535 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
A74 – West of Conch Reef	0 ± 0	0	0 ± 0	
533 – West of Conch Reef	0 ± 0	0	0 ± 0	
A73 – West of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (6)	**0 ± 0**	**0**	**0 ± 0**	
Upper Florida Keys				
638 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	
B25B – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
B25 – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
B25A – Inshore of Molasses Reef	50 ± 29	2	0.033 ± 0.019	1.8 ± 0.0
627 – Mosquito Bank	25 ± 25	1	0.017 ± 0.017	1.9
629A – Mosquito Bank	0 ± 0	0	0 ± 0	
628 – Mosquito Bank	0 ± 0	0	0 ± 0	
629 – Mosquito Bank	0 ± 0	0	0 ± 0	
629B – Mosquito Bank	0 ± 0	0	0 ± 0	
630 – SE of Cannon Patch Reef	0 ± 0	0	0 ± 0	
631 – Marker 33	0 ± 0	0	0 ± 0	
633 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
634 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
637 – West of Turtle Rocks	0 ± 0	0	0 ± 0	
636 – West of Turtle Rocks	25 ± 25	1	0.017 ± 0.017	2.6
Upper Florida Keys Total (15)	7 ± 4	4	0.004 ± 0.003	2.0 ± 0.2
Mid-channel Patch Reef Total (21)	**5 ± 3**	**4**	**0.003 ± 0.002**	**2.0 ± 0.2**
Offshore patch reefs				
Middle Florida Keys				
A802 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
A801 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579A – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579B – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
639 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	
640 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	
641 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	
642 – SE of White Bank Dry Rocks	0 ± 0	0	0 ± 0	
B33 – East of White Bank Dry Rocks	0 ± 0	0	0 ± 0	
643 – White Bank (NW of French)	0 ± 0	0	0 ± 0	
B35 – West of Elbow Reef	0 ± 0	0	0 ± 0	
644 – Watson's Reef	0 ± 0	0	0 ± 0	
645 – Watson's Reef	0 ± 0	0	0 ± 0	
648 – East of Basin Hill Shoals	0 ± 0	0	0 ± 0	
649 – West of Carysfort Reef	75 ± 25	5	0.083 ± 0.042	2.0 ± 0.3
B39 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	
653 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (13)	6 ± 6	5	0.006 ± 0.006	2.0 ± 0.3

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
Offshore Patch Reef Total (17)	**4 ± 4**	**5**	**0.005 ± 0.005**	**2.0 ± 0.3**
Back reef rubble				
Middle Florida Keys				
578 – Crocker Reef	0 ± 0	0	0 ± 0	
583 – Crocker Reef	0 ± 0	0	0 ± 0	
555A – Conch Reef	100 ± 0	22	0.367 ± 0.088	1.1 ± 0.1
555B – Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (4)	25 ± 25	22	0.092 ± 0.092	1.1 ± 0.1
Upper Florida Keys				
688A – Pickles Reef	0 ± 0	0	0 ± 0	
688B – Pickles Reef	0 ± 0	0	0 ± 0	
B62 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
691 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
688 – Sand Island	50 ± 29	2	0.033 ± 0.019	1.0 ± 0.1
689 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
702B – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
702A – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (8)	6 ± 6	2	0.004 ± 0.004	1.0 ± 0.1
Back Reef Rubble Total (12)	**13 ± 9**	**24**	**0.033 ± 0.030**	**1.1 ± 0.1**
Low-relief hard-bottom (< 6 m)				
Middle Florida Keys				
A932 – Crocker Reef	0 ± 0	0	0 ± 0	
556 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A87 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A84 – Little Conch Reef	0 ± 0	0	0 ± 0	
A85 – Little Conch Reef	0 ± 0	0	0 ± 0	
554 – Conch Reef C1**	0 ± 0	0	0 ± 0	
555 – Conch Reef C2**	0 ± 0	0	0 ± 0	
A86 – Conch Reef C3**	0 ± 0	0	0 ± 0	
579C – NE of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (9)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
693 – Little Pickles Reef	0 ± 0	0	0 ± 0	
664 – North of French Reef	0 ± 0	0	0 ± 0	
665 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (3)	0 ± 0	0	0 ± 0	
Shallow Hard-bottom Total (17)	**0 ± 0**	**0**	**0 ± 0**	
High-relief spur & groove				
Upper Florida Keys				
697 – Pickles Reef P1	0 ± 0	0	0 ± 0	
695 – Pickles Reef P3	0 ± 0	0	0 ± 0	
696 – NE Pickles Reef	0 ± 0	0	0 ± 0	
706 – Molasses Reef SPA**	25 ± 25	1	0.017 ± 0.017	1.6
707 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
711 – Sand Island	0 ± 0	0	0 ± 0	
704 – French Reef SPA**	0 ± 0	0	0 ± 0	
705 – French Reef SPA**	0 ± 0	0	0 ± 0	
699 – North of French Reef	0 ± 0	0	0 ± 0	
662 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	
663 – Grecian Rocks SPA**	25 ± 25	1	0.017 ± 0.017	1.8
B42 – Little Grecian Rocks	0 ± 0	0	0 ± 0	
660 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	
661 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
656 – North Dry Rocks	0 ± 0	0	0 ± 0	
657 – North-North Dry Rocks	0 ± 0	0	0 ± 0	
702 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
703 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
B66 – South of S. Carysfort	0 ± 0	0	0 ± 0	
700A – South Carysfort Reef**	0 ± 0	0	0 ± 0	
700 – South Carysfort Reef**	0 ± 0	0	0 ± 0	
B67 – Carysfort Reef C2**	0 ± 0	0	0 ± 0	
701 – Carysfort Reef C5**	0 ± 0	0	0 ± 0	
659 – Turtle Reef	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (24)	2 ± 1	2	0.001 ± 0.001	1.7 ± 0.1
High-relief Spur & Groove Total (42)	**2 ± 1**	**2**	**0.001 ± 0.001**	**1.7 ± 0.1**
Deeper Fore-reef (6-15 m)				
Middle Florida Keys				
552 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
551 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
568 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
569 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
612 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A941 – North of Davis Reef	0 ± 0	0	0 ± 0	
A942 – Little Conch Reef	0 ± 0	0	0 ± 0	
A94 – Little Conch Reef	0 ± 0	0	0 ± 0	
B24 – Conch Reef RO**	0 ± 0	0	0 ± 0	
625 – Conch Reef RO**	0 ± 0	0	0 ± 0	
611 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
626 – Conch Reef RO**	0 ± 0	0	0 ± 0	
610 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
B16 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (16)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
708 – NE of Conch Reef	0 ± 0	0	0 ± 0	
709 – Pickles Reef	0 ± 0	0	0 ± 0	
710 – SW of Molasses Reef SPA	0 ± 0	0	0 ± 0	
712 – SW of French Reef	0 ± 0	0	0 ± 0	
B71 – Dixie Shoal	0 ± 0	0	0 ± 0	
671 – South of Grecian Rocks	0 ± 0	0	0 ± 0	
B51 – East of Dry Rocks	0 ± 0	0	0 ± 0	
713 – North of Elbow Reef	0 ± 0	0	0 ± 0	
682 – North of Elbow Reef	0 ± 0	0	0 ± 0	
B57 – SE of Watson's Reef	0 ± 0	0	0 ± 0	
716 – South Carysfort Reef**	0 ± 0	0	0 ± 0	
678 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
717 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
679 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
675 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
676 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
677 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
715 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (18)	0 ± 0	0	0 ± 0	
Deeper Fore-reef Total (34)	**0 ± 0**	**0**	**0 ± 0**	

Table 5-3. Mean ± 1 SE transect frequencies (%), densities (no. individuals per m^2), numbers of individuals (N), and test diameters of *Echinometra viridis* in the upper Florida Keys, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-August 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
Inshore and mid-channel patch reefs				
Middle Florida Keys				
A741 – Tavernier Rocks	0 ± 0	0	0 ± 0	
534 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
535 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
A74 – West of Conch Reef	0 ± 0	0	0 ± 0	
533 – West of Conch Reef	0 ± 0	0	0 ± 0	
A73 – West of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (6)	**0 ± 0**	**0**	**0 ± 0**	
Upper Florida Keys				
638 – Inshore of Pickles Reef	50 ± 29	7	0.117 ± 0.096	2.4 ± 0.2
B25B – Inshore of Molasses Reef	25 ± 25	2	0.033 ± 0.033	2.6 ± 0.1
B25 – Inshore of Molasses Reef	75 ± 25	6	0.100 ± 0.043	2.6 ± 0.3
B25A – Inshore of Molasses Reef	50 ± 29	4	0.067 ± 0.038	2.1 ± 0.3
627 – Mosquito Bank	0 ± 0	0	0 ± 0	
629A – Mosquito Bank	25 ± 25	1	0.017 ± 0.017	2.0
628 – Mosquito Bank	50 ± 29	2	0.033 ± 0.019	2.0 ± 1.6
629 – Mosquito Bank	25 ± 25	1	0.017 ± 0.017	2.5
629B – Mosquito Bank	25 ± 25	1	0.017 ± 0.017	3.2
630 – SE of Cannon Patch Reef	75 ± 25	3	0.050 ± 0.017	2.3 ± 1.0
631 – Marker 33	0 ± 0	0	0 ± 0	
633 – Basin Hill Shoals	100 ± 0	71	1.183 ± 0.199	3.0 ± 0.1
634 – Basin Hill Shoals	100 ± 0	80	1.333 ± 0.446	3.0 ± 0.1
637 – West of Turtle Rocks	0 ± 0	0	0 ± 0	
636 – West of Turtle Rocks	50 ± 29	13	0.217 ± 0.132	2.2 ± 0.2
Upper Florida Keys Total (15)	43 ± 9	191	0.212 ± 0.111	2.9 ± 0.1
Mid-channel Patch Reef Total (21)	**31 ± 8**	**191**	**0.152 ± 0.081**	**2.9 ± 0.1**
Offshore patch reefs				
Middle Florida Keys				
A802 – Inshore of Conch Reef	50 ± 29	3	0.050 ± 0.032	2.5 ± 0.5
A801 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579A – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579B – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (4)	13 ± 13	3	0.013 ± 0.013	2.5 ± 0.5
Upper Florida Keys				
639 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	
640 – White Bank (West of Molasses)	100 ± 0	27	0.450 ± 0.113	2.1 ± 0.1
641 – White Bank (West of Molasses)	25 ± 25	1	0.017 ± 0.017	2.0
642 – SE of White Bank Dry Rocks	25 ± 25	1	0.017 ± 0.017	2.1
B33 – East of White Bank Dry Rocks	25 ± 25	1	0.017 ± 0.017	1.3
643 – White Bank (NW of French)	0 ± 0	0	0 ± 0	
B35 – West of Elbow Reef	0 ± 0	0	0 ± 0	
644 – Watson's Reef	25 ± 25	2	0.033 ± 0.033	1.2 ± 0.2
645 – Watson's Reef	25 ± 25	1	0.017 ± 0.017	2.2
648 – East of Basin Hill Shoals	25 ± 25	1	0.017 ± 0.017	3.2
649 – West of Carysfort Reef	25 ± 25	1	0.017 ± 0.017	1.9
B39 – Carysfort Reef SPA**	25 ± 25	2	0.033 ± 0.033	1.5 ± 0.8
653 – Carysfort Reef SPA**	25 ± 25	1	0.017 ± 0.017	2.2
Upper Florida Keys Total (13)	25 ± 7	38	0.049 ± 0.034	2.0 ± 0.1

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
Offshore Patch Reef Total (17)	**22 ± 6**	**41**	**0.040 ± 0.026**	**2.1 ± 0.1**
Back reef rubble				
Middle Florida Keys				
578 – Crocker Reef	25 ± 25	1	0.017 ± 0.017	1.1
583 – Crocker Reef	0 ± 0	0	0 ± 0	
555A – Conch Reef	75 ± 25	6	0.100 ± 0.043	1.2 ± 0.1
555B – Conch Reef	50 ± 29	3	0.050 ± 0.032	1.3 ± 0.0
Middle Florida Keys Total (4)	38 ± 16	10	0.042 ± 0.022	1.1 ± 0.1
Upper Florida Keys				
688A – Pickles Reef	0 ± 0	0	0 ± 0	
688B – Pickles Reef	50 ± 29	6	0.100 ± 0.079	1.4 ± 0.3
B62 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
691 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
688 – Sand Island	75 ± 25	4	0.067 ± 0.027	1.4 ± 0.2
689 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
702B – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
702A – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (8)	16 ± 10	10	0.021 ± 0.014	1.4 ± 0.2
Back Reef Rubble Total (12)	**23 ± 9**	**20**	**0.028 ± 0.012**	**1.2 ± 0.1**
Low-relief hard-bottom (< 6 m)				
Middle Florida Keys				
A932 – Crocker Reef	0 ± 0	0	0 ± 0	
556 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A87 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A84 – Little Conch Reef	0 ± 0	0	0 ± 0	
A85 – Little Conch Reef	25 ± 25	1	0.017 ± 0.017	0.9
554 – Conch Reef C1**	0 ± 0	0	0 ± 0	
555 – Conch Reef C2**	0 ± 0	0	0 ± 0	
A86 – Conch Reef C3**	0 ± 0	0	0 ± 0	
579C – NE of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (9)	3 ± 3	1	0.002 ± 0.002	0.9
Upper Florida Keys				
693 – Little Pickles Reef	0 ± 0	0	0 ± 0	
664 – North of French Reef	0 ± 0	0	0 ± 0	
665 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (3)	0 ± 0	0	0 ± 0	
Shallow Hard-bottom Total (17)	**2 ± 2**	**1**	**0.001 ± 0.001**	0.9
High-relief spur & groove				
Upper Florida Keys				
697 – Pickles Reef P1	50 ± 29	2	0.033 ± 0.019	1.5 ± 0.3
695 – Pickles Reef P3	0 ± 0	0	0 ± 0	
696 – NE Pickles Reef	0 ± 0	0	0 ± 0	
706 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
707 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
711 – Sand Island	0 ± 0	0	0 ± 0	
704 – French Reef SPA**	0 ± 0	0	0 ± 0	
705 – French Reef SPA**	0 ± 0	0	0 ± 0	
699 – North of French Reef	0 ± 0	0	0 ± 0	
662 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	
663 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	
B42 – Little Grecian Rocks	0 ± 0	0	0 ± 0	
660 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	
661 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
656 – North Dry Rocks	0 ± 0	0	0 ± 0	
657 – North-North Dry Rocks	0 ± 0	0	0 ± 0	
702 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
703 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
B66 – South of S. Carysfort	0 ± 0	0	0 ± 0	
700A – South Carysfort Reef**	0 ± 0	0	0 ± 0	
700 – South Carysfort Reef**	0 ± 0	0	0 ± 0	
B67 – Carysfort Reef C2**	0 ± 0	0	0 ± 0	
701 – Carysfort Reef C5**	0 ± 0	0	0 ± 0	
659 – Turtle Reef	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (24)	2 ± 2	2	0.001 ± 0.001	1.5 ± 0.3
High-relief Spur & Groove Total (42)	**2 ± 2**	**2**	**0.001 ± 0.001**	**1.5 ± 0.3**
Deeper Fore-reef (6-15 m)				
Middle Florida Keys				
552 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
551 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
568 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
569 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
612 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A941 – North of Davis Reef	0 ± 0	0	0 ± 0	
A942 – Little Conch Reef	25 ± 25	1	0.017 ± 0.017	2.0
A94 – Little Conch Reef	0 ± 0	0	0 ± 0	
B24 – Conch Reef RO**	0 ± 0	0	0 ± 0	
625 – Conch Reef RO**	0 ± 0	0	0 ± 0	
611 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
626 – Conch Reef RO**	25 ± 25	1	0.017 ± 0.017	1.2
610 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
B16 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (16)	3 ± 2	2	0.002 ± 0.001	1.6 ± 0.4
Upper Florida Keys				
708 – NE of Conch Reef	0 ± 0	0	0 ± 0	
709 – Pickles Reef	0 ± 0	0	0 ± 0	
710 – SW of Molasses Reef SPA	0 ± 0	0	0 ± 0	
712 – SW of French Reef	50 ± 29	3	0.050 ± 0.032	1.9 ± 0.2
B71 – Dixie Shoal	0 ± 0	0	0 ± 0	
671 – South of Grecian Rocks	0 ± 0	0	0 ± 0	
B51 – East of Dry Rocks	0 ± 0	0	0 ± 0	
713 – North of Elbow Reef	0 ± 0	0	0 ± 0	
682 – North of Elbow Reef	0 ± 0	0	0 ± 0	
B57 – SE of Watson's Reef	0 ± 0	0	0 ± 0	
716 – South Carysfort Reef**	0 ± 0	0	0 ± 0	
678 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
717 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
679 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
675 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
676 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
677 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
715 – North of Carysfort Reef	25 ± 25	1	0.017 ± 0.017	1.1
Upper Florida Keys Total (18)	4 ± 3	4	0.004 ± 0.003	1.7 ± 0.2
Deeper Fore-reef Total (34)	**4 ± 2**	**6**	**0.003 ± 0.002**	1.7 ± 0.2

Table 5-4. Mean ± 1 SE transect frequencies (%), densities (no. individuals per m^2), numbers of individuals (N), and test diameters of *Eucidaris tribuloides* in the upper Florida Keys, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-August 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
Inshore and mid-channel patch reefs				
Middle Florida Keys				
A741 – Tavernier Rocks	0 ± 0	0	0 ± 0	
534 – Hen and Chickens SPA**	25 ± 25	1	0.017 ± 0.017	2.0
535 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
A74 – West of Conch Reef	25 ± 25	3	0.050 ± 0.050	2.6 ± 0.2
533 – West of Conch Reef	25 ± 25	1	0.017 ± 0.017	2.3
A73 – West of Conch Reef	75 ± 25	7	0.117 ± 0.042	2.6 ± 0.1
Middle Florida Keys Total (6)	25 ± 11	12	0.033 ± 0.018	2.5 ± 0.1
Upper Florida Keys				
638 – Inshore of Pickles Reef	25 ± 25	2	0.033 ± 0.033	2.3 ± 0.2
B25B – Inshore of Molasses Reef	25 ± 25	1	0.017 ± 0.017	2.5
B25 – Inshore of Molasses Reef	25 ± 25	1	0.017 ± 0.017	2.4
B25A – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
627 – Mosquito Bank	25 ± 25	2	0.033 ± 0.033	3.3 ± 0.1
629A – Mosquito Bank	25 ± 25	1	0.017 ± 0.017	3.5
628 – Mosquito Bank	50 ± 29	2	0.033 ± 0.019	3.2 ± 0.7
629 – Mosquito Bank	25 ± 25	1	0.017 ± 0.017	3.0
629B – Mosquito Bank	50 ± 29	2	0.033 ± 0.019	3.3 ± 0.4
630 – SE of Cannon Patch Reef	25 ± 25	1	0.017 ± 0.017	3.1
631 – Marker 33	0 ± 0	0	0 ± 0	
633 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
634 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
637 – West of Turtle Rocks	100 ± 0	10	0.167 ± 0.043	2.7 ± 0.2
636 – West of Turtle Rocks	25 ± 25	2	0.033 ± 0.033	2.4 ± 0.1
Upper Florida Keys Total (15)	27 ± 7	25	0.028 ± 0.010	2.8 ± 0.1
Mid-channel Patch Reef Total (21)	**26 ± 6**	**37**	**0.029 ± 0.009**	**2.7 ± 0.1**
Offshore patch reefs				
Middle Florida Keys				
A802 – Inshore of Conch Reef	75 ± 25	8	0.133 ± 0.061	2.5 ± 0.2
A801 – Inshore of Conch Reef	100 ± 0	9	0.150 ± 0.042	2.7 ± 0.2
579A – Inshore of Conch Reef	100 ± 0	5	0.083 ± 0.017	2.8 ± 0.3
579B – Inshore of Conch Reef	50 ± 29	3	0.050 ± 0.032	2.6 ± 0.2
Middle Florida Keys Total (4)	81 ± 12	25	0.104 ± 0.023	2.7 ± 0.1
Upper Florida Keys				
639 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	
640 – White Bank (West of Molasses)	50 ± 29	2	0.033 ± 0.019	2.8 ± 0.3
641 – White Bank (West of Molasses)	100 ± 0	14	0.233 ± 0.043	2.7 ± 0.1
642 – SE of White Bank Dry Rocks	25 ± 25	1	0.017 ± 0.017	2.0
B33 – East of White Bank Dry Rocks	50 ± 29	2	0.033 ± 0.019	2.4 ± 0.1
643 – White Bank (NW of French)	50 ± 29	3	0.050 ± 0.032	2.8 ± 0.4
B35 – West of Elbow Reef	25 ± 25	1	0.017 ± 0.017	2.6
644 – Watson's Reef	0 ± 0	0	0 ± 0	
645 – Watson's Reef	50 ± 29	3	0.050 ± 0.032	2.6 ± 0.3
648 – East of Basin Hill Shoals	0 ± 0	0	0 ± 0	
649 – West of Carysfort Reef	50 ± 29	4	0.067 ± 0.047	3.0 ± 0.4
B39 – Carysfort Reef SPA**	25 ± 25	1	0.017 ± 0.017	2.5
653 – Carysfort Reef SPA**	50 ± 29	2	0.033 ± 0.019	1.6 ± 0.3
Upper Florida Keys Total (13)	37 ± 8	33	0.042 ± 0.017	2.6 ± 0.1

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
Offshore Patch Reef Total (17)	**47 ± 8**	**58**	**0.057 ± 0.015**	**2.6 ± 0.1**
Back reef rubble				
Middle Florida Keys				
578 – Crocker Reef	50 ± 29	2	0.033 ± 0.033	1.2 ± 0.2
583 – Crocker Reef	0 ± 0	0	0 ± 0	
555A – Conch Reef	100 ± 0	19	0.317 ± 0.057	1.3 ± 0.1
555B – Conch Reef	100 ± 0	47	0.783 ± 0.175	2.6 ± 0.1
Middle Florida Keys Total (4)	63 ± 24	68	0.283 ± 0.181	1.5 ± 0.1
Upper Florida Keys				
688A – Pickles Reef	100 ± 0	32	0.533 ± 0.156	2.1 ± 0.1
688B – Pickles Reef	100 ± 0	70	1.167 ± 0.362	1.8 ± 0.1
B62 – Molasses Reef SPA**	25 ± 25	2	0.033 ± 0.033	1.0 ± 0.1
691 – Molasses Reef SPA**	75 ± 25	8	0.133 ± 0.047	1.1 ± 0.1
688 – Sand Island	75 ± 25	4	0.067 ± 0.027	1.4 ± 0.1
689 – Inshore of Dixie Shoal	25 ± 25	1	0.017 ± 0.017	1.0
702B – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
702A – Elbow Reef SPA**	25 ± 25	1	0.017 ± 0.017	1.0
Upper Florida Keys Total (8)	53 ± 14	118	0.246 ± 0.146	1.8 ± 0.1
Back Reef Rubble Total (12)	**56 ± 12**	**186**	**0.258 ± 0.110**	**1.7 ± 0.1**
Low-relief hard-bottom (< 6 m)				
Middle Florida Keys				
A932 – Crocker Reef	50 ± 29	2	0.033 ± 0.019	1.7 ± 0.0
556 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A87 – Davis Reef SPA**	50 ± 29	2	0.033 ± 0.019	1.8 ± 0.2
A84 – Little Conch Reef	100 ± 0	23	0.383 ± 0.100	2.2 ± 0.1
A85 – Little Conch Reef	100 ± 0	11	0.183 ± 0.057	1.9 ± 0.3
554 – Conch Reef C1**	100 ± 0	14	0.233 ± 0.079	2.1 ± 0.1
555 – Conch Reef C2**	25 ± 25	1	0.017 ± 0.017	2.6
A86 – Conch Reef C3**	75 ± 25	6	0.100 ± 0.043	2.1 ± 0.2
579C – NE of Conch Reef	50 ± 29	3	0.050 ± 0.032	2.1 ± 0.1
Middle Florida Keys Total (9)	61 ± 12	62	0.115 ± 0.043	2.1 ± 0.1
Upper Florida Keys				
693 – Little Pickles Reef	100 ± 0	8	0.133 ± 0.067	1.7 ± 0.2
664 – North of French Reef	100 ± 0	7	0.117 ± 0.032	2.4 ± 0.1
665 – Inshore of Dixie Shoal	100 ± 0	6	0.100 ± 0.019	2.5 ± 0.1
Upper Florida Keys Total (3)	100 ± 100	21	0.117 ± 0.010	2.1 ± 0.1
Shallow Hard-bottom Total (17)	**71 ± 10**	**83**	**0.115 ± 0.032**	**2.1 ± 0.1**
High-relief spur & groove				
Upper Florida Keys				
697 – Pickles Reef P1	75 ± 25	8	0.133 ± 0.072	2.2 ± 0.1
695 – Pickles Reef P3	100 ± 0	9	0.150 ± 0.050	1.9 ± 0.1
696 – NE Pickles Reef	75 ± 25	5	0.083 ± 0.032	2.0 ± 0.2
706 – Molasses Reef SPA**	50 ± 29	3	0.050 ± 0.032	2.0 ± 0.4
707 – Molasses Reef SPA**	50 ± 29	2	0.033 ± 0.019	2.5 ± 0.5
711 – Sand Island	0 ± 0	0	0 ± 0	
704 – French Reef SPA**	0 ± 0	0	0 ± 0	
705 – French Reef SPA**	50 ± 29	2	0.033 ± 0.019	2.0 ± 0.2
699 – North of French Reef	50 ± 29	13	0.217 ± 0.195	2.0 ± 0.1
662 – Grecian Rocks SPA**	75 ± 25	5	0.083 ± 0.042	2.4 ± 0.2
663 – Grecian Rocks SPA**	100 ± 0	6	0.100 ± 0.019	2.2 ± 0.1
B42 – Little Grecian Rocks	0 ± 0	0	0 ± 0	
660 – Key Largo Dry Rocks**	25 ± 25	1	0.017 ± 0.017	2.0
661 – Key Largo Dry Rocks**	50 ± 29	4	0.067 ± 0.047	1.9 ± 0.1

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
656 – North Dry Rocks	75 ± 25	5	0.083 ± 0.032	1.7 ± 0.1
657 – North-North Dry Rocks	0 ± 0	0	0 ± 0	
702 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
703 – Elbow Reef SPA**	25 ± 25	1	0.017 ± 0.017	2.2
B66 – South of S. Carysfort	50 ± 29	4	0.067 ± 0.047	2.1 ± 0.3
700A – South Carysfort Reef**	0 ± 0	0	0 ± 0	
700 – South Carysfort Reef**	50 ± 29	2	0.033 ± 0.019	2.3 ± 0.3
B67 – Carysfort Reef C2**	75 ± 25	6	0.100 ± 0.058	1.7 ± 0.2
701 – Carysfort Reef C5**	25 ± 25	2	0.033 ± 0.033	2.0 ± 0.1
659 – Turtle Reef	25 ± 25	1	0.017 ± 0.017	2.0
Upper Florida Keys Total (24)	43 ± 7	79	0.055 ± 0.011	2.1 ± 0.0
High-relief Spur & Groove Total (42)	**43 ± 7**	**79**	**0.055 ± 0.011**	**2.1 ± 0.0**
Deeper Fore-reef (6-15 m)				
Middle Florida Keys				
552 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
551 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
568 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
569 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
612 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A941 – North of Davis Reef	25 ± 25	1	0.017 ± 0.017	1.6
A942 – Little Conch Reef	25 ± 25	1	0.017 ± 0.017	2.1
A94 – Little Conch Reef	0 ± 0	0	0 ± 0	
B24 – Conch Reef RO**	0 ± 0	0	0 ± 0	
625 – Conch Reef RO**	0 ± 0	0	0 ± 0	
611 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
626 – Conch Reef RO**	0 ± 0	0	0 ± 0	
610 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
B16 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (16)	3 ± 2	2	0.002 ± 0.001	1.9 ± 0.3
Upper Florida Keys				
708 – NE of Conch Reef	0	0	0 ± 0	
709 – Pickles Reef	25 ± 25	1	0.017 ± 0.017	1.9
710 – SW of Molasses Reef SPA	0	0	0 ± 0	
712 – SW of French Reef	50 ± 29	2	0.033 ± 0.019	2.1 ± 0.1
B71 – Dixie Shoal	0	0	0 ± 0	
671 – South of Grecian Rocks	75 ± 25	4	0.067 ± 0.027	2.4 ± 0.1
B51 – East of Dry Rocks	0	0	0 ± 0	
713 – North of Elbow Reef	25 ± 25	1	0.017 ± 0.017	2.5
682 – North of Elbow Reef	25 ± 25	1	0.017 ± 0.017	2.6
B57 – SE of Watson's Reef	0	0	0 ± 0	
716 – South Carysfort Reef**	0	0	0 ± 0	
678 – North Carysfort Reef**	0	0	0 ± 0	
717 – North Carysfort Reef**	0	0	0 ± 0	
679 – North Carysfort Reef**	0	0	0 ± 0	
675 – North of Carysfort Reef	25 ± 25	1	0.017 ± 0.017	1.3
676 – North of Carysfort Reef	0	0	0 ± 0	
677 – North of Carysfort Reef	0	0	0 ± 0	
715 – North of Carysfort Reef	0	0	0 ± 0	
Upper Florida Keys Total (18)	13 ± 5	10	0.009 ± 0.004	2.2 ± 0.1
Deeper Fore-reef Total (34)	**8 ± 3**	**12**	**0.006 ± 0.002**	**2.1 ± 0.1**

Table 5-5. Mean ± 1 SE transect frequencies (%), densities (no. individuals per m^2), numbers of individuals (N), and test diameters of *Tripneustes ventricosus* in the upper Florida Keys, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-August 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
Inshore and mid-channel patch reefs				
Middle Florida Keys				
A741 – Tavernier Rocks	0 ± 0	0	0 ± 0	
534 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
535 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
A74 – West of Conch Reef	25 ± 25	1	0.067 ± 0.067	8.5 ± 0.7
533 – West of Conch Reef	0 ± 0	0	0 ± 0	
A73 – West of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (6)	**4 ± 4**	**4**	**0.003 ± 0.003**	**8.5 ± 0.7**
Upper Florida Keys				
638 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	
B25B – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
B25 – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
B25A – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
627 – Mosquito Bank	0 ± 0	0	0 ± 0	
629A – Mosquito Bank	0 ± 0	0	0 ± 0	
628 – Mosquito Bank	0 ± 0	0	0 ± 0	
629 – Mosquito Bank	0 ± 0	0	0 ± 0	
629B – Mosquito Bank	0 ± 0	0	0 ± 0	
630 – SE of Cannon Patch Reef	0 ± 0	0	0 ± 0	
631 – Marker 33	0 ± 0	0	0 ± 0	
633 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
634 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
637 – West of Turtle Rocks	0 ± 0	0	0 ± 0	
636 – West of Turtle Rocks	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (15)	0 ± 0	0	0 ± 0	
Mid-channel Patch Reef Total (21)	**1 ± 1**	**4**	**0.003 ± 0.003**	**8.5 ± 0.7**
Offshore patch reefs				
Middle Florida Keys				
A802 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
A801 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579A – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579B – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
639 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	
640 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	
641 – White Bank (West of Molasses)	25 ± 25	1	0.017 ± 0.017	8.0
642 – SE of White Bank Dry Rocks	0 ± 0	0	0 ± 0	
B33 – East of White Bank Dry Rocks	0 ± 0	0	0 ± 0	
643 – White Bank (NW of French)	0 ± 0	0	0 ± 0	
B35 – West of Elbow Reef	0 ± 0	0	0 ± 0	
644 – Watson's Reef	0 ± 0	0	0 ± 0	
645 – Watson's Reef	0 ± 0	0	0 ± 0	
648 – East of Basin Hill Shoals	0 ± 0	0	0 ± 0	
649 – West of Carysfort Reef	25 ± 25	2	0.033 ± 0.019	9.1 ± 0.9
B39 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	
653 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (13)	6 ± 4	3	0.004 ± 0.003	8.7 ± 0.7

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
Offshore Patch Reef Total (17)	**4 ± 3**	**3**	**0.003 ± 0.002**	**8.7 ± 0.7**
Back reef rubble				
Middle Florida Keys				
578 – Crocker Reef	0 ± 0	0	0 ± 0	
583 – Crocker Reef	0 ± 0	0	0 ± 0	
555A – Conch Reef	0 ± 0	0	0 ± 0	
555B – Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
688A – Pickles Reef	25 ± 25	1	0.017 ± 0.017	2.0
688B – Pickles Reef	0 ± 0	0	0 ± 0	
B62 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
691 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
688 – Sand Island	0 ± 0	0	0 ± 0	
689 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
702B – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
702A – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (8)	3 ± 3	1	0.002 ± 0.002	2.0
Back Reef Rubble Total (12)	**2 ± 2**	**1**	**0.001 ± 0.001**	**2.0**
Low-relief hard-bottom (< 6 m)				
Middle Florida Keys				
A932 – Crocker Reef	0 ± 0	0	0 ± 0	
556 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A87 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A84 – Little Conch Reef	0 ± 0	0	0 ± 0	
A85 – Little Conch Reef	0 ± 0	0	0 ± 0	
554 – Conch Reef C1**	0 ± 0	0	0 ± 0	
555 – Conch Reef C2**	0 ± 0	0	0 ± 0	
A86 – Conch Reef C3**	0 ± 0	0	0 ± 0	
579C – NE of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (9)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
693 – Little Pickles Reef	0 ± 0	0	0 ± 0	
664 – North of French Reef	0 ± 0	0	0 ± 0	
665 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (3)	0 ± 0	0	0 ± 0	
Shallow Hard-bottom Total (17)	**0 ± 0**	**0**	**0 ± 0**	
High-relief spur & groove				
Upper Florida Keys				
697 – Pickles Reef P1	0 ± 0	0	0 ± 0	
695 – Pickles Reef P3	0 ± 0	0	0 ± 0	
696 – NE Pickles Reef	25 ± 25	1	0.017 ± 0.017	6.7
706 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
707 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
711 – Sand Island	0 ± 0	0	0 ± 0	
704 – French Reef SPA**	0 ± 0	0	0 ± 0	
705 – French Reef SPA**	0 ± 0	0	0 ± 0	
699 – North of French Reef	0 ± 0	0	0 ± 0	
662 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	
663 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	
B42 – Little Grecian Rocks	0 ± 0	0	0 ± 0	
660 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	
661 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	

Site number/site location	Transect frequency	N	Mean no. per m^2	Mean size (cm)
656 – North Dry Rocks	0 ± 0	0	0 ± 0	
657 – North-North Dry Rocks	0 ± 0	0	0 ± 0	
702 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
703 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
B66 – South of S. Carysfort	0 ± 0	0	0 ± 0	
700A – South Carysfort Reef**	0 ± 0	0	0 ± 0	
700 – South Carysfort Reef**	0 ± 0	0	0 ± 0	
B67 – Carysfort Reef C2**	0 ± 0	0	0 ± 0	
701 – Carysfort Reef C5**	0 ± 0	0	0 ± 0	
659 – Turtle Reef	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (24)	1 ± 1	1	0.001 ± 0.001	6.7
High-relief Spur & Groove Total (42)	**1 ± 1**	**1**	**0.001 ± 0.001**	**6.7**
Deeper Fore-reef (6-15 m)				
Middle Florida Keys				
552 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
551 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
568 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
569 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
612 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A941 – North of Davis Reef	0 ± 0	0	0 ± 0	
A942 – Little Conch Reef	0 ± 0	0	0 ± 0	
A94 – Little Conch Reef	0 ± 0	0	0 ± 0	
B24 – Conch Reef RO**	0 ± 0	0	0 ± 0	
625 – Conch Reef RO**	0 ± 0	0	0 ± 0	
611 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
626 – Conch Reef RO**	0 ± 0	0	0 ± 0	
610 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
B16 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (16)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
708 – NE of Conch Reef	0 ± 0	0	0 ± 0	
709 – Pickles Reef	0 ± 0	0	0 ± 0	
710 – SW of Molasses Reef SPA	0 ± 0	0	0 ± 0	
712 – SW of French Reef	25 ± 25	1	0.017 ± 0.017	5.0
B71 – Dixie Shoal	0 ± 0	0	0 ± 0	
671 – South of Grecian Rocks	0 ± 0	0	0 ± 0	
B51 – East of Dry Rocks	0 ± 0	0	0 ± 0	
713 – North of Elbow Reef	0 ± 0	0	0 ± 0	
682 – North of Elbow Reef	0 ± 0	0	0 ± 0	
B57 – SE of Watson's Reef	0 ± 0	0	0 ± 0	
716 – South Carysfort Reef**	0 ± 0	0	0 ± 0	
678 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
717 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
679 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
675 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
676 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
677 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
715 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (18)	1 ± 1	1	0.001 ± 0.001	5.0
Deeper Fore-reef Total (34)	**1 ± 1**	**1**	**< 0.001 ± < 0.001**	**5.0**

Table 5-6. Number of individuals (N), mean, standard error (SE), and range in sea urchin test diameters by species and habitat type in the upper Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-August 2010.

Habitat type (no. sites)	Transect depth (m)	N	Mean test size (cm)	SE	Min. test size (cm)	Max. test size (cm)
Diadema antillarum						
Inshore and mid-channel patch reef (21)	1.2-6.7	9	4.7	0.9	1.5	8.2
Offshore patch reef (17)	1.8-8.2	20	6.3	0.6	0.7	10.0
Back reef rubble (12)	1.5-6.1	21	1.5	0.1	0.6	2.5
Shallow (< 6 m) hard-bottom (12)	3.0-7.3	6	5.3	0.6	4.5	8.0
High-relief spur and groove (24)	1.5-8.2	14	4.3	0.5	1.2	8.0
Deeper (6-15 m) fore-reef (34)	5.8-14.9	5	3.3	1.2	0.4	6.5
All habitats combined (120 sites)	1.2-14.9	75	4.1	0.3	0.4	10.0
Echinometra lucunter						
Inshore and mid-channel patch reef (21)	1.2-6.7	4	2.0	0.2	1.7	2.6
Offshore patch reef (17)	1.8-8.2	5	2.0	0.3	0.9	3.0
Back reef rubble (12)	1.5-6.1	24	1.1	0.1	0.7	2.5
Shallow (< 6 m) hard-bottom (12)	3.0-7.3	0				
High-relief spur and groove (24)	1.5-8.2	2	1.7	0.1	1.6	1.8
Deeper (6-15 m) fore-reef (34)	5.8-14.9	0				
All habitats combined (120 sites)	1.2-14.9	35	1.4	0.1	0.7	3.0
Echinometra viridis						
Inshore and mid-channel patch reef (21)	1.2-6.7	191	2.9	0.1	0.3	5.0
Offshore patch reef (17)	1.8-8.2	41	2.1	0.1	0.7	3.5
Back reef rubble (12)	1.5-6.1	20	1.2	0.1	0.6	2.2
Shallow (< 6 m) hard-bottom (12)	3.0-7.3	1	0.9		0.9	0.9
High-relief spur and groove (24)	1.5-8.2	2	1.5	0.3	1.2	1.7
Deeper (6-15 m) fore-reef (34)	5.8-14.9	6	1.7	0.2	1.1	2.2
All habitats combined (120 sites)	1.2-14.9	261	2.6	0.1	0.3	5.0
Eucidaris tribuloides						
Inshore and mid-channel patch reef (21)	1.2-6.7	37	2.7	0.1	1.9	3.9
Offshore patch reef (17)	1.8-8.2	58	2.6	0.1	1.3	4.0
Back reef rubble (12)	1.5-6.1	186	1.7	0.1	0.5	3.4
Shallow (< 6 m) hard-bottom (12)	3.0-7.3	83	2.1	0.4	1.0	4.5
High-relief spur and groove (24)	1.5-8.2	79	2.0	0.0	1.2	3.0
Deeper (6-15 m) fore-reef (34)	5.8-14.9	12	2.1	0.1	1.3	2.6
All habitats combined (120 sites)	1.2-14.9	455	2.1	0.0	0.5	4.5
Tripneustes ventricosus						
Inshore and mid-channel patch reef (21)	1.2-6.7	4	8.5	0.7	7.0	10.0
Offshore patch reef (17)	1.8-8.2	3	8.7	0.7	8.0	10.0
Back reef rubble (12)	1.5-6.1	1	2.0		2.0	2.0
Shallow (< 6 m) hard-bottom (12)	3.0-7.3	0				
High-relief spur and groove (24)	1.5-8.2	1	6.7		6.7	6.7
Deeper (6-15 m) fore-reef (34)	5.8-14.9	1	5.0		5.0	5.0
All habitats combined (120 sites)	1.2-14.9	10	7.4	0.8	2.0	10.0

VI. Anemone and Corallimorpharian Density

Background

Commercial marine-life fisheries and aquarium hobbyists remove an incredible diversity and number of invertebrates and fishes in the Florida Keys (Bohnsack et al. 1994). Otherwise known as the marine ornamental fishery, aquarium fisheries from West Palm Beach to Key West target a diversity of fish, invertebrate, and algal species, in addition to sand and live rock (FWCC 2001). State and Federal waters near Key West and Marathon in the Florida Keys constitute 94% of the total fishes and invertebrates removed in southeast Florida for the marine aquarium trade. Commercial data do not include an undocumented effort from recreational fishers, nor are data available concerning species abundance patterns and population trends relative to fishing effort (NOAA 1996). Key Largo has been protected from marine aquarium trade species collection since 1960 in John Pennekamp Coral Reef State Park, followed by the protection in federal waters in 1975 with the establishment of Key Largo National Marine Sanctuary. The Looe Key area has been protected since 1981, as well as Everglades National Park (Florida Bay), portions of the Dry Tortugas area, Biscayne National Park, and Fish and Wildlife Service management areas.

There is a paucity of basic ecological information for most Florida Keys anemone and corallimorpharian (Cnidaria, Anthozoa) species, and even fewer studies have explored the population effects of exploitation. During 2010, we continued a time series dating back to 1999 that quantifies the habitat distribution and abundance patterns of selected actinians (O. Actiniaria) and corallimorpharians (O. Corallimorpharia) in the Florida Keys in relation to cross-shelf habitat type, along-shelf regional variation, and management zones, including no-take areas. With the exception of general Caribbean field guides (e.g. Sefton and Webster 1986; Kaplan 1988; Humann 1992) and isolated distribution studies (Voss and Voss 1955; Wheaton and Jaap 1988; reviewed in Levy et al. 1996), there are few density estimates we are aware of that consider multiple sites and benthic habitat types in the Florida Keys. The ecological importance of these organisms is best exemplified by many anemones that form associations with several invertebrates such as cleaner shrimps (Limbaugh et al. 1961; Shick 1991) and provide refuge for smaller reef fishes (Hanlon and Kaufman 1976; Colin and Heiser 1973). Some of these associations, such as cleaning stations, provide a valuable function to reef fishes (Herrnkind et al. 1976; Sluka et al. 1999) and the large-scale removal of certain species may have important, but as of yet, undocumented effects on other biota. The establishment of the Florida Keys National Marine Sanctuary (FKNMS) in 1990 and the subsequent designation of 23 no-fishing zones in 1997 afford the opportunity to evaluate the effects of exploitation for a variety of species, including those targeted by the marine aquarium fishery (Bohnsack 1997). These data provide a means from which to measure the responses of organisms to protection from exploitation.

Quantitative surveys in the upper Florida Keys during June-August 2010 targeted anemones (O. Actiniaria) and corallimorpharians (O. Corallimorpharia) known or suspected to occur in the Florida Keys, and focused on the larger and conspicuous or field-identifiable members of both orders. Similar surveys were conducted in the study area during 1999-2001 (211 sites), 2005 (195 sites), 2008 (145 sites), and 2009 (160 sites), as well as in the Dry Tortugas region during 2000, 2006, and 2008. Five anemone species were recorded during 2010 (classification according to Cairns et al. 1991), all of which tend to have solitary and larger polyps compared to other cnidarians: the giant Caribbean or pink-tipped anemone *Condylactis gigantea* in the Family Actiniidae, the ringed or corkscrew anemone *Bartholomea annulata* in the Family Aiptasiidae, the speckled anemone *Epicystes* (=*Phymanthus*) *crucifera* in the Family Phymanthidae, *Bunodosoma granulifera* (first record since study inception), and *Lebrunia danae*. Although we searched for specimens, no individuals of the knobby anemone (*Heteractis lucida*) or the sun anemone *Stichodactyla* (=*Stoichactis*) *helianthus* were found. Two corallimorpharians were encountered: *Discosoma* (=*Paradiscosoma*) *carlgreni* in the Family Actinodiscidae and *Ricordea florida* in the Family Corallimorpharidae. No *D. sanctithomae* were encountered during 2010, a reflection of the fact that this species is more abundant in the lower Keys region (see 2009 Quick Look Report at http://people.uncw.edu/millers). Corallimorpharians, sometimes called false corals, differ from anemones in the arrangement of the tentacles, and may be solitary, but are typically found in clusters.

2010 Survey Results

Five anemone species representing 297 individuals were recorded from 7,200 m^2 of benthic habitat across the 120 upper Florida Keys survey sites in 2010 (Figure 6-1). Tables 6-1 and 6-2 provide transect frequency of occurrence and site-level densities for four of the five anemone species. The five anemone species were represented by: *Bartholomea annulata* (259 individuals, 87% of all anemones), *Bunodosoma granulifera* (2 individuals, 0.7%), *Condylactis gigantea* (24 individuals, 8%), *Epicystes crucifera* (1 individual, 0.3%), and *Lebrunia danae* (11 individuals, 4%). Only two individuals of *B. granulifera* were found from one mid-channel patch reef inshore of Molasses Reef (site B25); this is the first time we have encountered this anemone. One individual of *E. crucifera* was found on an offshore patch reef in the White Bank area (site 643) (Table 6-2). As in previous years, *B. annulata* was the most abundant and wide-ranging anemone, with individuals documented within belt transects at 91 out of 120 sites (76%). *B. annulata* was distributed among all of the cross-shelf habitats sampled in the upper Florida Keys during 2010 (Table 6-1). Site-level densities were as high as 0.183 ± 0.032 individuals per m^2, with the greatest density recorded from a mid-channel patch reef in Basin Hill Shoals (site 634). Figures 6-2 to 6-4 show the spatial distribution of *B. annulata* densities across the upper Florida Keys. Deeper fore-reef (6-15 m)

habitats yielded the greatest transect mean frequency of occurrence (51% ± 5%) and density (0.050 ± 0.060 per m^2), followed by mid-channel patch reefs (42% ± 7% of transects, 0.048 ± 0.010 per m^2) (Figures 6-5 and 6-6).

Similar to previous surveys dating back to 1999, frequency of occurrence and densities of *Condylactis gigantea* were relatively low in 2010 for the habitats surveyed (Table 6-1). A total of 24 individuals were found among the 120 upper Keys sites, with individuals present at 18 of the 120 sites (15%). Most *C. gigantea* (71%) were observed on mid-channel (46%) and offshore patch reefs (25%). A maximum density of 0.050 ± 0.032 individuals per m^2 was recorded from an offshore patch reef east of Basin Hill Shoals (site 648). Mean transect frequency of occurrence (13% ± 4%) and density (0.009 ± 0.002 per m^2) were greatest on mid-channel patch reefs, followed by offshore patch reefs (7% ± 4% transect occurrence, 0.006 ± 0.003 per m^2) (Table 6-1). *Lebrunia danae*, the third most common anemone (11 individuals) encountered in the upper Keys, was only observed on mid-channel patch reefs, offshore patch reefs, and the deeper (6-15 m) fore reef (Table 6-2). This anemone was most abundant on mid-channel patch reefs (6% ± 3% transect occurrence, 0.006 ± 0.003 per m^2) (Table 6-2).

A total of 311 corallimorpharians representing two species were recorded during 2010: *Discosoma carlgreni* (20 individuals, 6%) and *Ricordea florida* (291 individuals, 94%) (Figure 6-7). Table 6-3 provides site-level transect frequency of occurrence and density values for the two corallimorpharians. *D. carlgreni* occurred within three habitat types, with 50% of all individuals found on high-relief spur and groove reefs, followed by offshore patch reefs (40%) and deeper (6-15) fore-reef habitats (10%) (Table 6-3). A maximum site-level density of 0.150 ± 0.150 individuals per m^2 was recorded from the high-relief spur and groove reef at Little Grecian Rocks (site B42) (Table 6-3). Similar to previous years, the most abundant corallimorpharian encountered during 2010 in the upper Keys was *Ricordea florida* (Table 6-3). The greatest site-level mean density (1.550 ± 0.615 per m^2) occurred at an offshore patch reef at Watson's Reef (site 645). Just over 87% of *R. florida* were found on mid-channel (39%) and offshore patch reefs (48%). Figures 6-8 to 6-10 show the spatial distribution of *R. florida* throughout the upper Florida Keys study area. Mean transect frequency of occurrence (18% ± 7%) and density (0.137 ± 0.091 per m^2) were greatest on offshore patch reefs, followed by mid-channel patch reefs (8% ± 4%, 0.090 ± 0.056 per m^2) (Figures 6-11 and 6-12).

Discussion

While numerous studies address the life history characteristics of anemones and corallimorpharians, including feeding behavior (Bursey and Guanciale 1977; Bursey and Harmer 1979; Elliot and Cook

1989), reproduction (Jennison 1981), and associations with other fauna (Limbaugh et al. 1961; Colin and Heiser 1973; Hanlon and Kaufman 1976), studies that describe or quantify habitat distribution and abundance in the Florida Keys are limited. Nine actinian species are common in the Caribbean; of these, seven are planktivores, while the two larger species (*Condylactis gigantea* and *Stichodactyla helianthus*) can eat macroscopic prey such as gastropods and echinoids (Van-Praët 1985). Several field guidebooks provide qualitative descriptions of habitat occurrence, biogeographic distribution, and taxonomic characters (Voss 1976; Kaplan 1988; Humann 1992), but with the exception of one quantitative study of benthic cnidarians at Looe Key, in which *Ricordea florida* was included (Wheaton and Jaap 1988), the data collected by our program represent the only large-scale assessments of habitat distribution and abundance of actinians and corallimorpharians on Florida Keys ocean-side habitats. Levy et al. (1996) reviewed Florida Keys invertebrate inventories as of 1995 and found only three publications (e.g. Voss and Voss 1955; Voss et al. 1969) that discussed abundance and habitat distribution as of the mid-1990s.

The 2010 upper Florida Keys survey results indicate that, with the exception of the corallimorpharian *Ricordea florida* on some mid-channel and offshore patch reefs, mean densities of the anemones and corallimorpharians sampled were usually below one individual per 100 m^2 for the habitats sampled. All but one of the five actinians and one of the two corallimorpharians species were rare and/or exhibited limited habitat distribution. The more commonly encountered species exhibited different density and distribution patterns. *B. annulata* was the most frequently encountered anemone and generally had similar densities among most habitats, while *Condylactis gigantea* and *Lebrunia danae* were more common on patch reefs. The most abundant corallimorpharian, *R. florida*, was most abundant on mid-channel and offshore patch reefs.

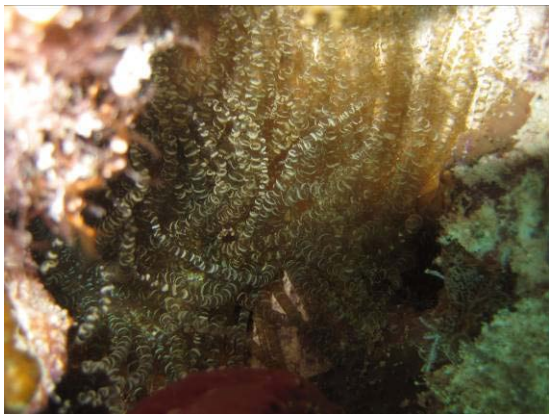
Conclusions from the 2010 surveys are confined because of poor life history knowledge and the paucity of historical abundance data for anemones and corallimorpharians. Interpretation of density patterns is further complicated because of the possibility that large numbers of these organisms are removed from the Florida Keys by commercial and private collectors. However, surveys dating back to 1999 confirm, at least for a 10-year period, consistent patterns in habitat-based patterns of abundance. It is also possible that locations not sampled by our program, including nearshore hard-bottom and seagrass beds (ocean-side and bay-side), mangrove channels, and tidal channels into Florida Bay, comprise important habitat types for various anemones and corallimorpharians. We did not sample any soft-sediment communities such as seagrass beds, and it is well known that some of the actinians (e.g. *Bartholomea annulata* and *Condylactis gigantea*) form relatively large aggregations in these habitats.

Certain aspects of cnidarian life history have implications for fisheries management. For example, recruitment of sexually produced planula into natural populations of sea anemones seems rare, and it appears that most anemones studied (see review in Shick 1991) have great longevity of adults, low and sporadic larval recruitment, and high juvenile mortality. Asexual reproduction, especially for corallimorpharians, appears to be very important for maintenance of local aggregations if recruitment is successful (Elliot and Cook 1989), and probably explains the very high, but localized densities or clusters of *Discosoma sanctithomae* and *Ricordea florida*. Without basic information on life history, it will remain difficult to ascertain the ability of these organisms to maintain populations, especially considering the apparent level of exploitation in the Florida Keys (Bohnsack et al. 1994).

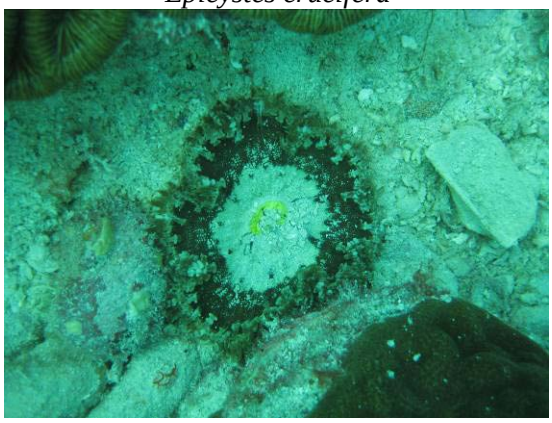
Although spatially explicit (e.g. at the scale of individual reefs) landings and fishing effort data are not available for Florida Keys anemones and corallimorpharians, the possibility that the observed density patterns are influenced by fishing should not be dismissed. For example, anecdotal observations, acquired from interviews with Florida Keys residents in 1993, indicated that *Condylactis gigantea* declined by the early 1990s, possibly due to collection, disease, or other causes (DeMaria 1996). Commercial marine life collectors and aquarium hobbyists potentially collect all of the cnidarians surveyed in this study (Bohnsack et al. 1994). Only a saltwater license is needed for recreational fishing, and a saltwater products license and commercial vessel registration is required to fish commercial quantities of unregulated species (NOAA 1996; FWCC 2000). In addition to a prohibition on collection in 23 of the no-take zones within the FKNMS (not including Tortugas North and South), fishing for these "unregulated" species is also prohibited in Biscayne National Park, John Pennekamp Coral Reef State Park/Key Largo National Marine Sanctuary (since 1960), the Florida Bay area within Everglades National Park, and Dry Tortugas National Park. Management of exploited species obviously requires information on fishing effort, population trends, and life history parameters. Density estimates for anemones and corallimorpharians provide a baseline from which to measure the effects of protection within no-fishing zones. Usage and modification of a stratified random sampling design, in which future optimization is achieved based upon both stratum-specific covariates (e.g. habitat type) and variance estimates (Ault et al. 1999), can provide fishery-independent density and total abundance estimates for cnidarians and other taxa. When coupled with important and much needed information on the marine life fishery, the outputs of this sampling approach can furnish state and federal resource managers with improved guidelines on population estimates and trends relative to fishing intensity. Moreover, the implementation of no-fishing zones in the Florida Keys National Marine Sanctuary presents a unique opportunity to evaluate the effects of fishing (Bohnsack 1997), not only on the most economically important species (Bohnsack et al. 1994), but also on a diversity of targeted, but relatively understudied taxa.

Figure 6-1. Anemones (Cnidaria, Anthozoa) surveyed for presence-absence, density, and habitat distribution in the Florida Keys during June-August 2010. Not pictured is *Stichodactyla helianthus*, which was not observed in the upper Florida Keys during 2010.

Bartholomea annulata

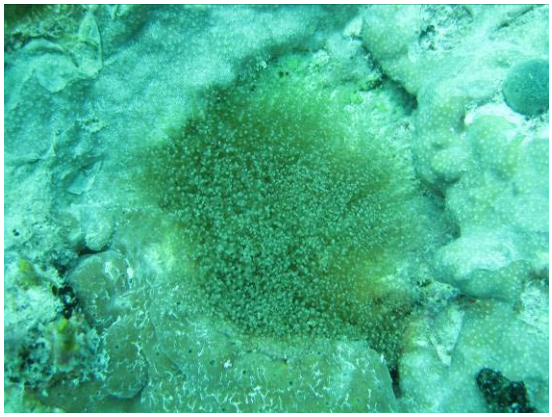


Epicystes crucifera



Bunodosoma granulifera

Heteractis lucida



Condylactis gigantea

Lebrunia danae

Figure 6-2. Densities (no. per m^2) of corkscrew anemones (*Bartholomea annulata*) in the upper Florida Keys National Marine Sanctuary from the southern BNP boundary to Carysfort/S. Carysfort SPA surveyed during June-August 2010.

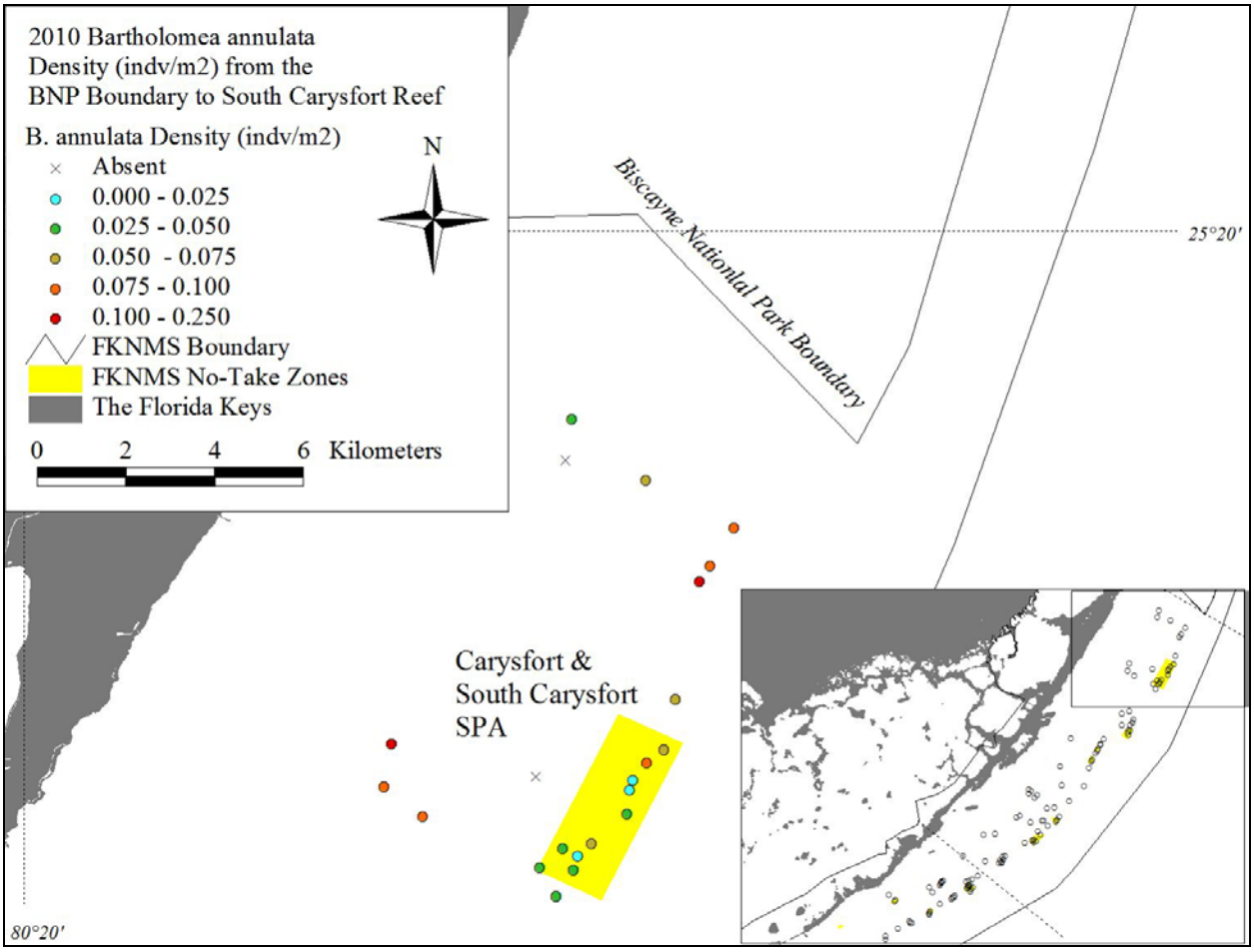


Figure 6-3. Densities (no. per m^2) of corkscrew anemones (*Bartholomea annulata*) in the upper Florida Keys National Marine Sanctuary from Elbow Reef to Pickles Reef surveyed during June-August 2010.

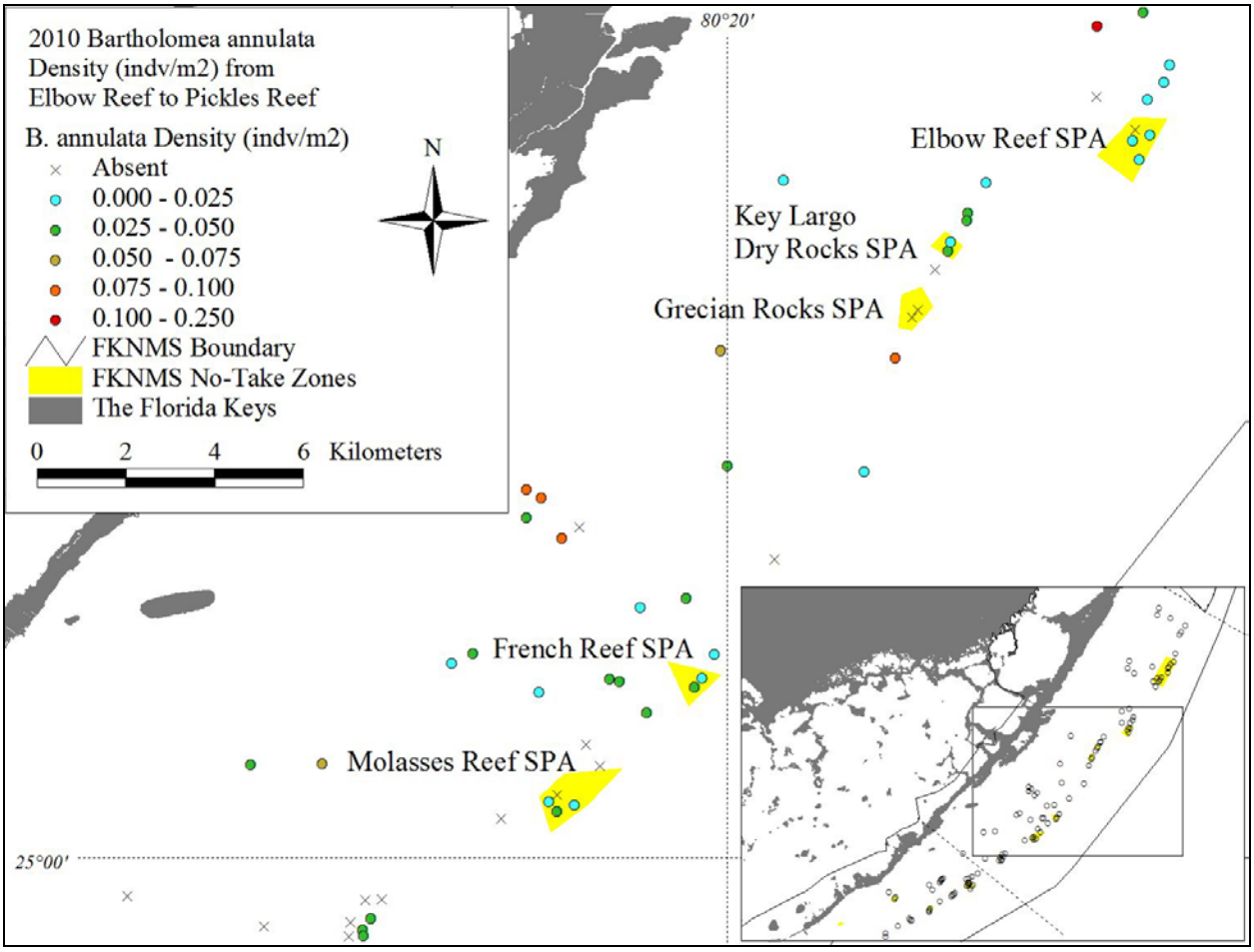


Figure 6-4. Densities (no. per m^2) of corkscrew anemones (*Bartholomea annulata*) in the upper Florida Keys National Marine Sanctuary from Conch Reef SPA to Crocker Reef surveyed during June-August 2010.

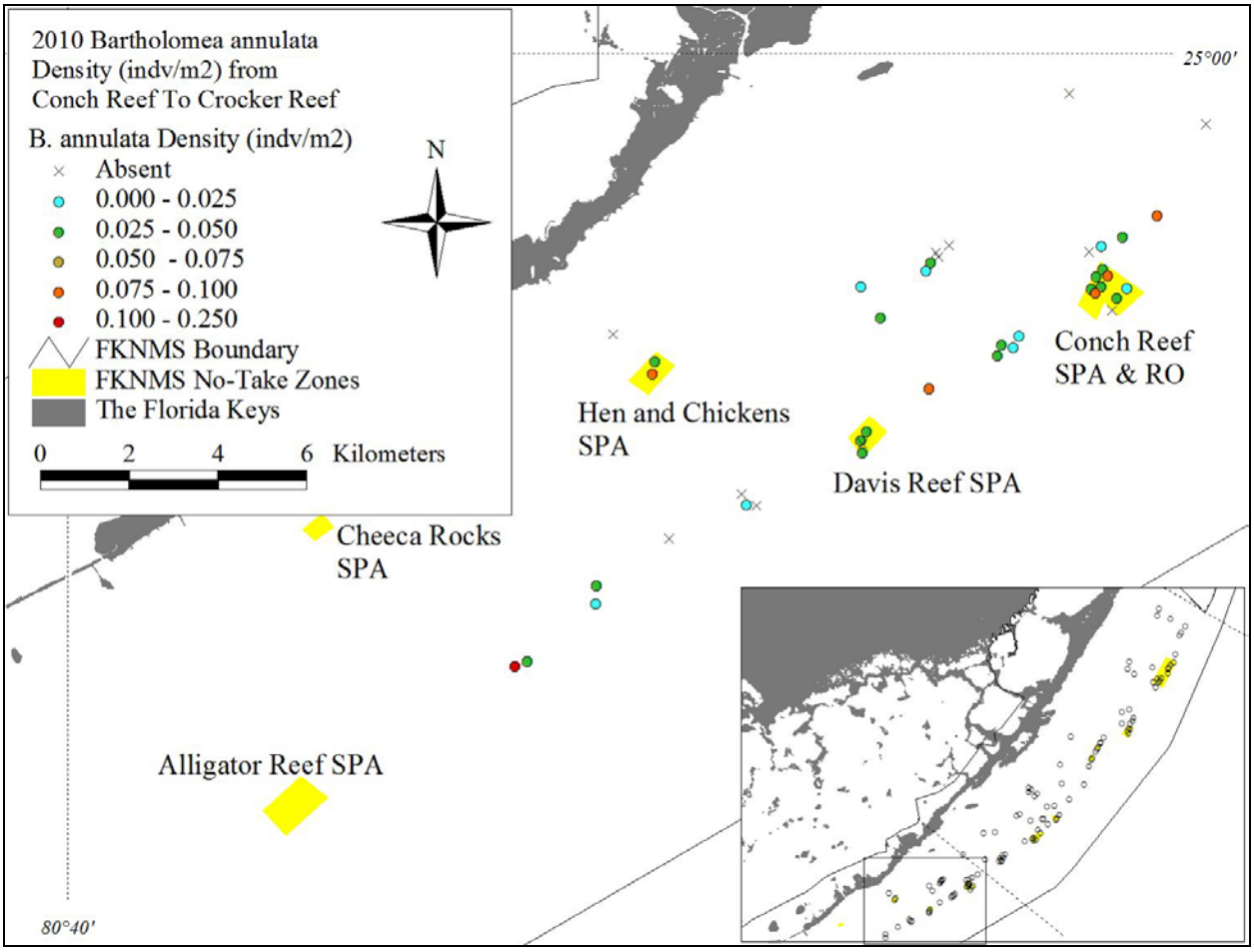
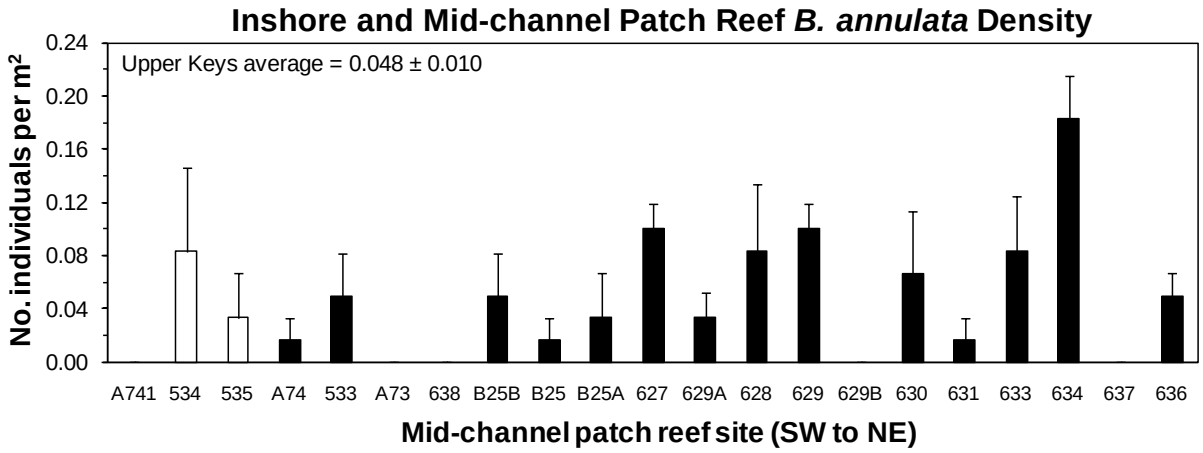
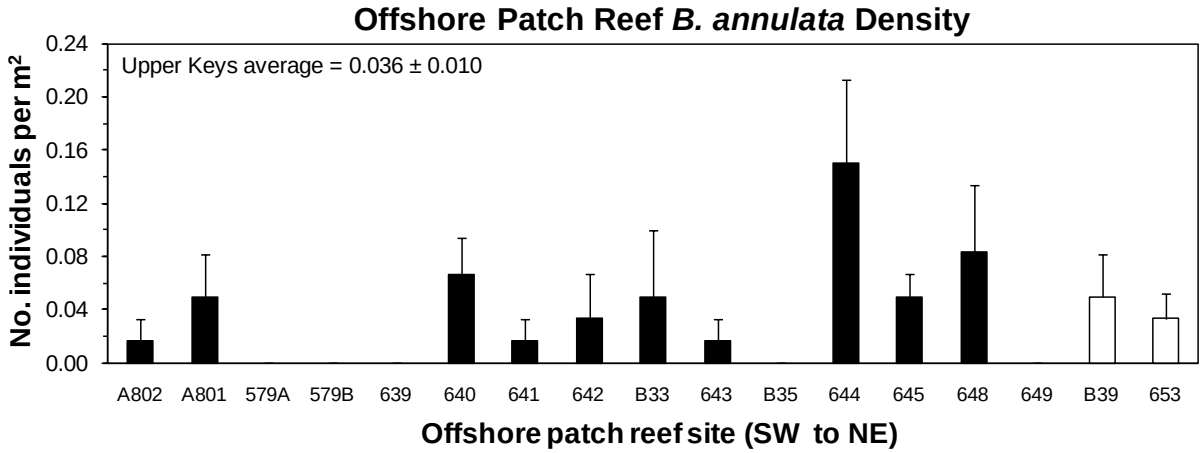


Figure 6-5. Mean (+ 1 SE) densities (no. per m^2) of corkscrew anemones (*Bartholomea annulata*) on inshore and mid-channel patch reefs (top), offshore patch reefs (middle, and back reef rubble habitats in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.





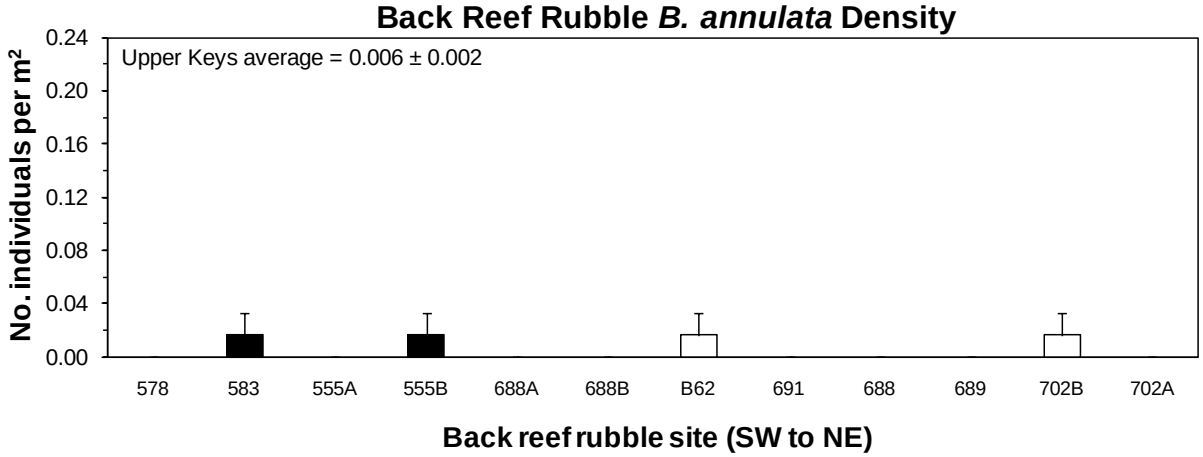


Figure 6-6. Mean (+ 1 SE) densities (no. per m^2) of corkscrew anemones (*Bartholomea annulata*) on shallow (< 6 m) hard-bottom (top), high-relief spur and groove reefs (middle) and deeper (6-15 m) fore reef habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.

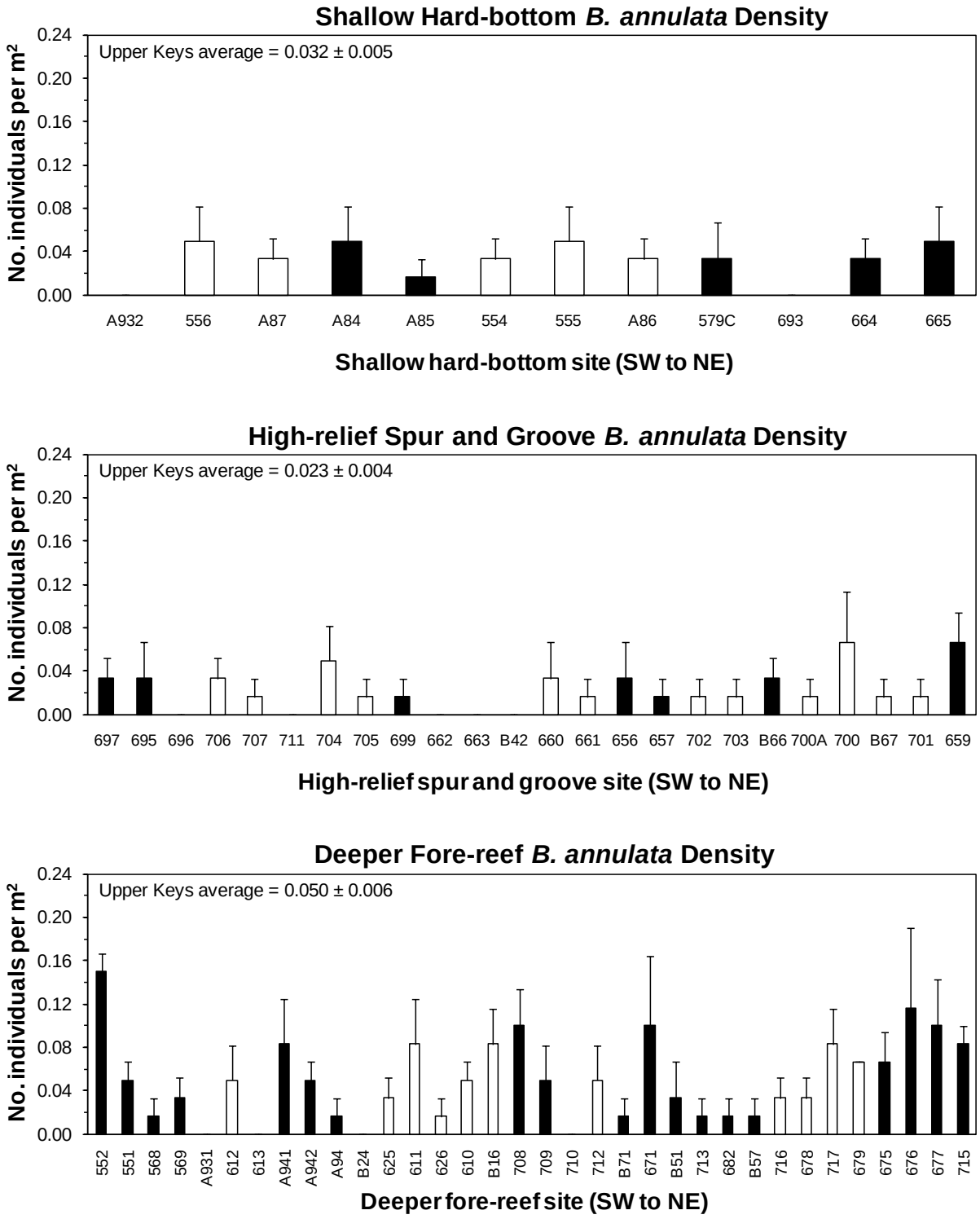
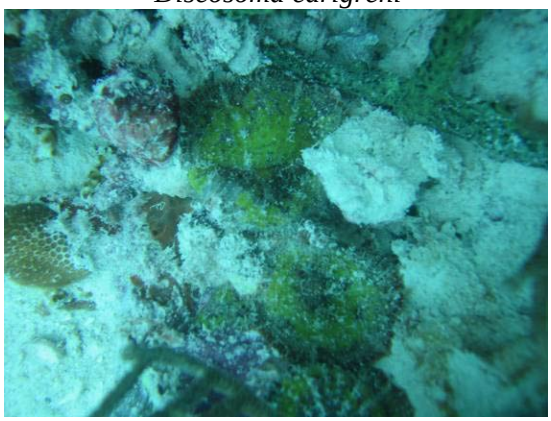


Figure 6-7. Corallimorpharians (Cnidaria, Anthozoa, Corallimorpharia) surveyed for presence-absence, density and habitat distribution in the upper Florida Keys National Marine Sanctuary during June-August 2010. Note that *Discosoma sanctithomae* was not encountered in the upper Keys during 2010.

Discosoma carlgreni

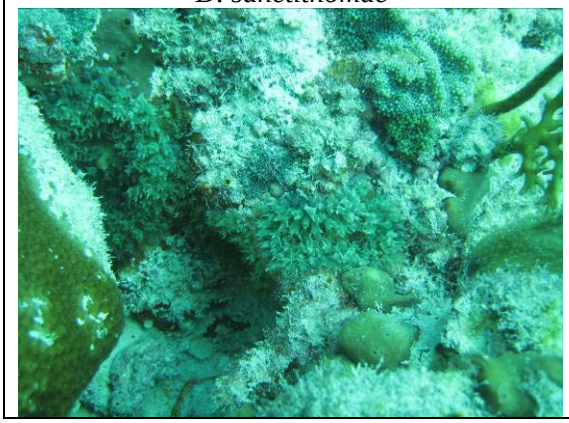


Ricordea florida

D. sanctithomae

R. florida

D. sanctithomae



R. florida

Figure 6-8. Densities (no. per m^2) of the Florida corallimorph (*Ricordea florida*) in the upper Florida Keys National Marine Sanctuary from the southern BNP boundary to Carysfort/S. Carysfort SPA surveyed during June-August 2010.

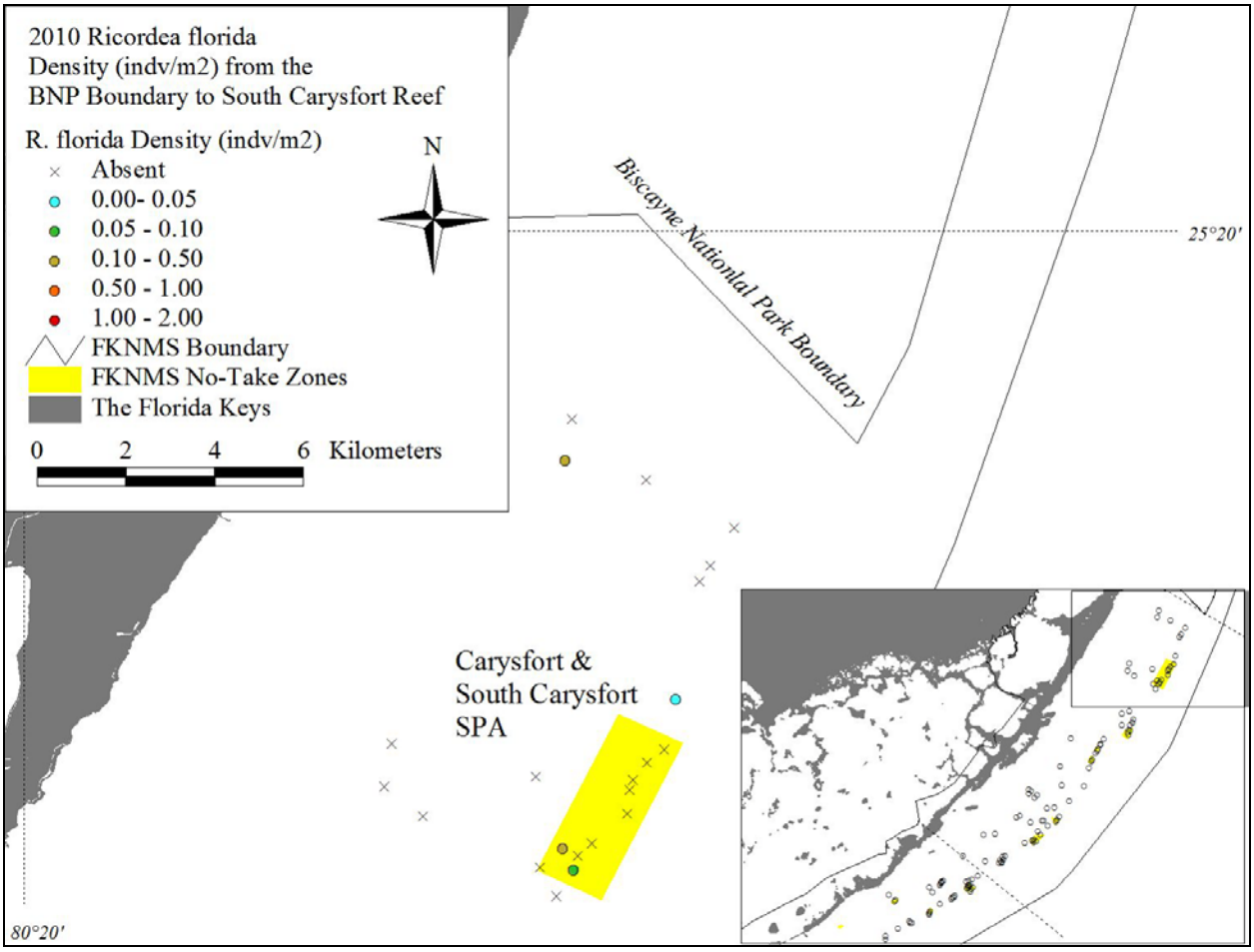


Figure 6-9. Densities (no. per m^2) of the Florida corallimorph (*Ricordea florida*) in the upper Florida Keys National Marine Sanctuary from Elbow Reef to Pickles Reef surveyed during June-August 2010.

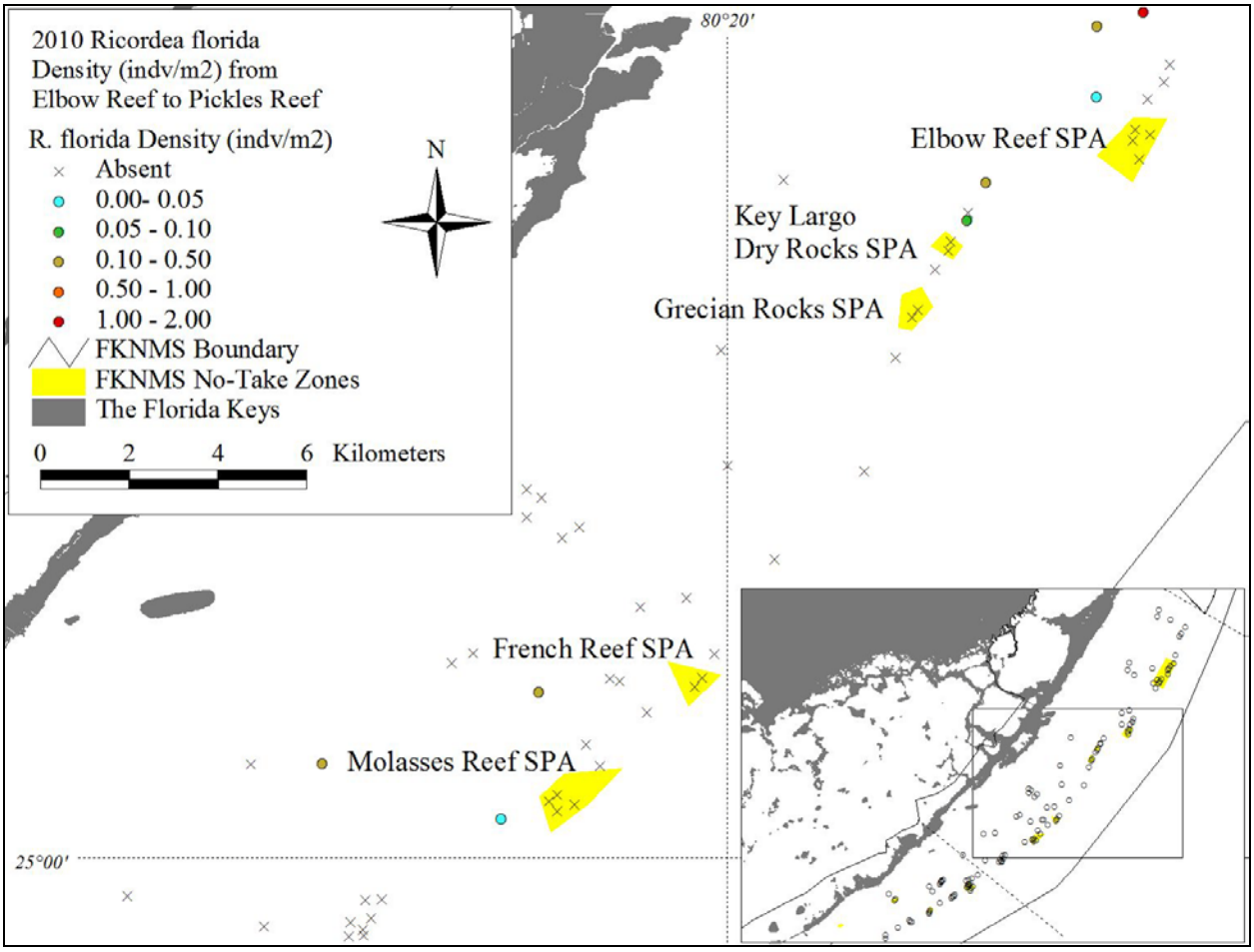


Figure 6-10. Densities (no. per m^2) of the Florida corallimorph (*Ricordea florida*) in the upper Florida Keys National Marine Sanctuary from Conch Reef SPA to Crocker Reef surveyed during June-August 2010.

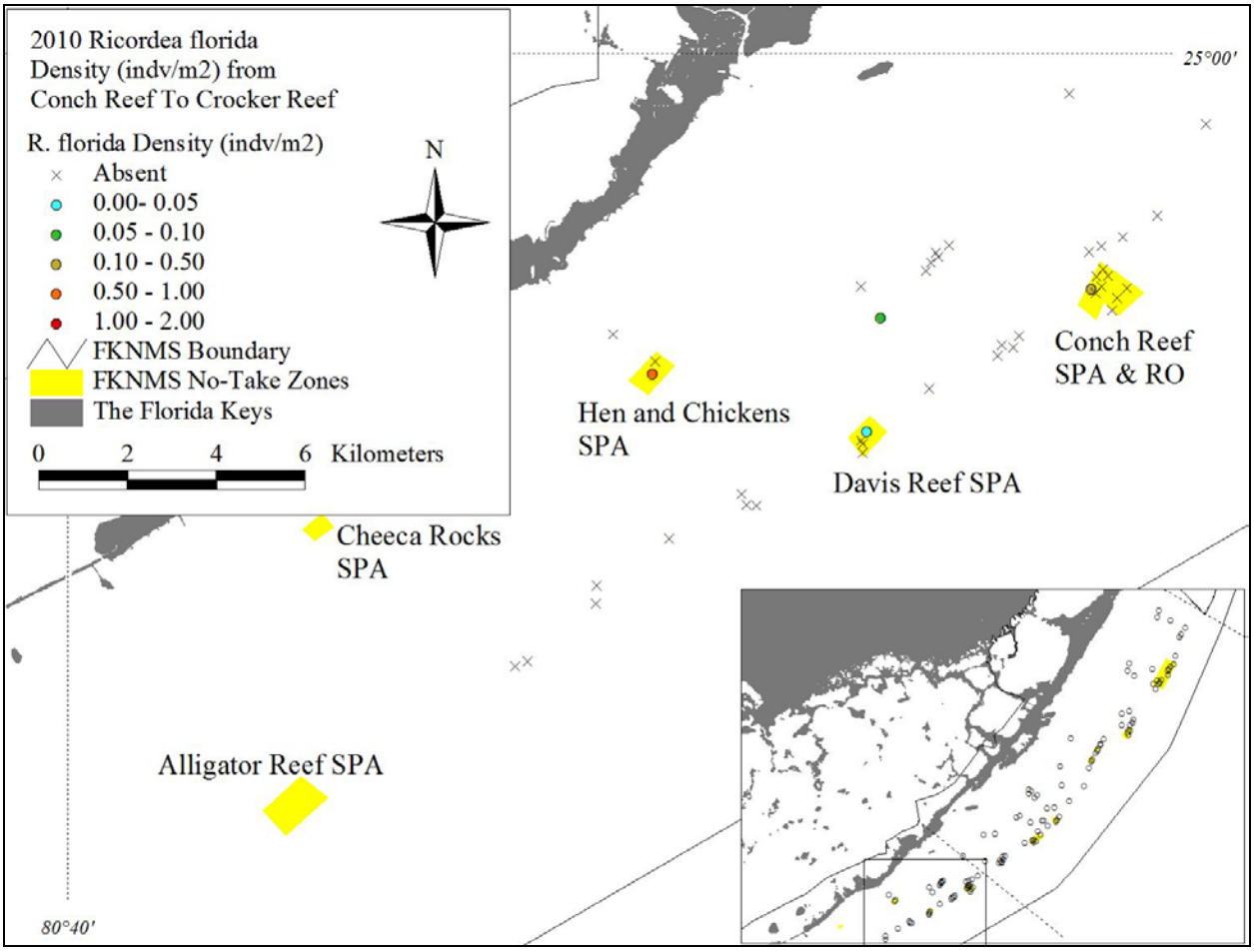
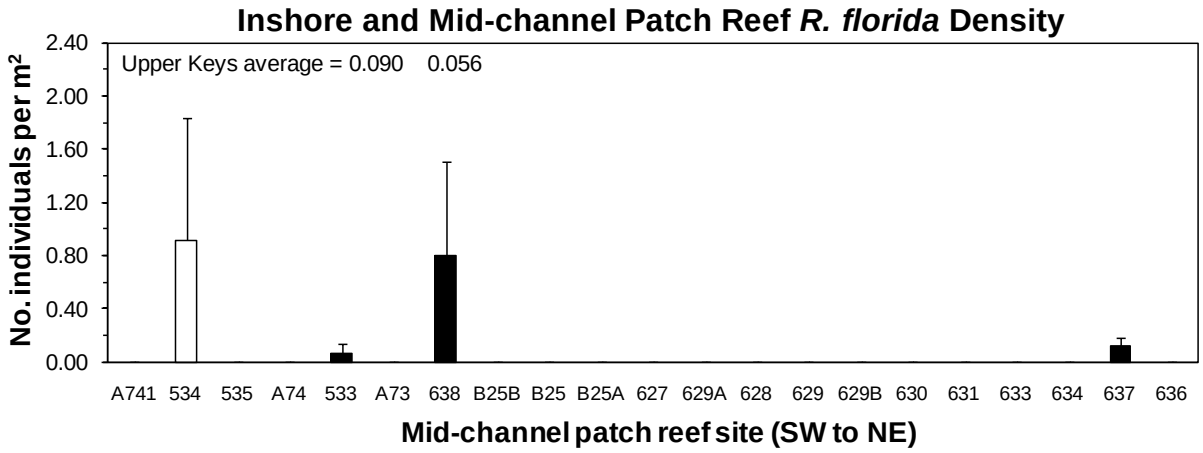
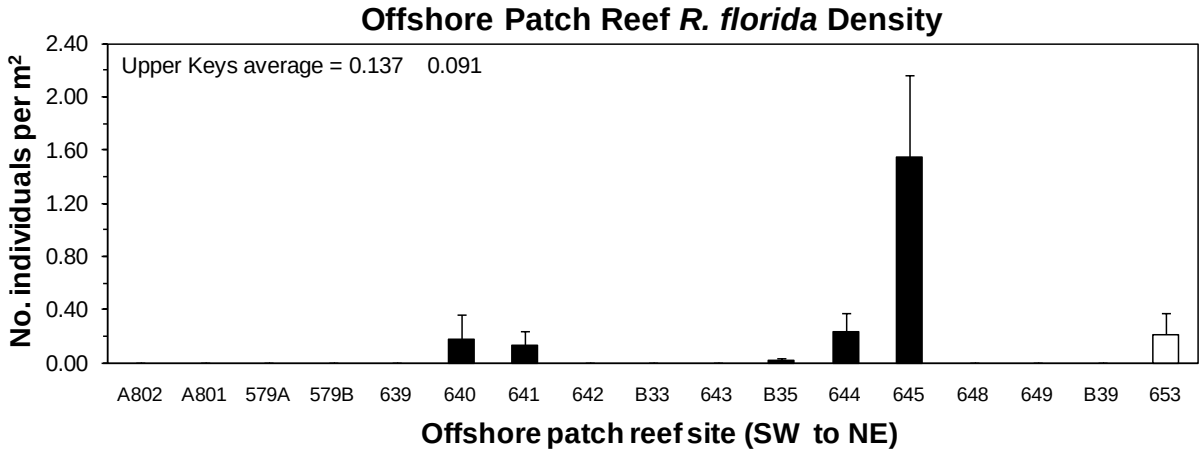


Figure 6-11. Mean (+ 1 SE) densities (no. per m^2) of the Florida corallimorph (*Ricordea florida*) on inshore and mid-channel patch reefs (top), offshore patch reefs (middle, and back reef rubble habitats in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.





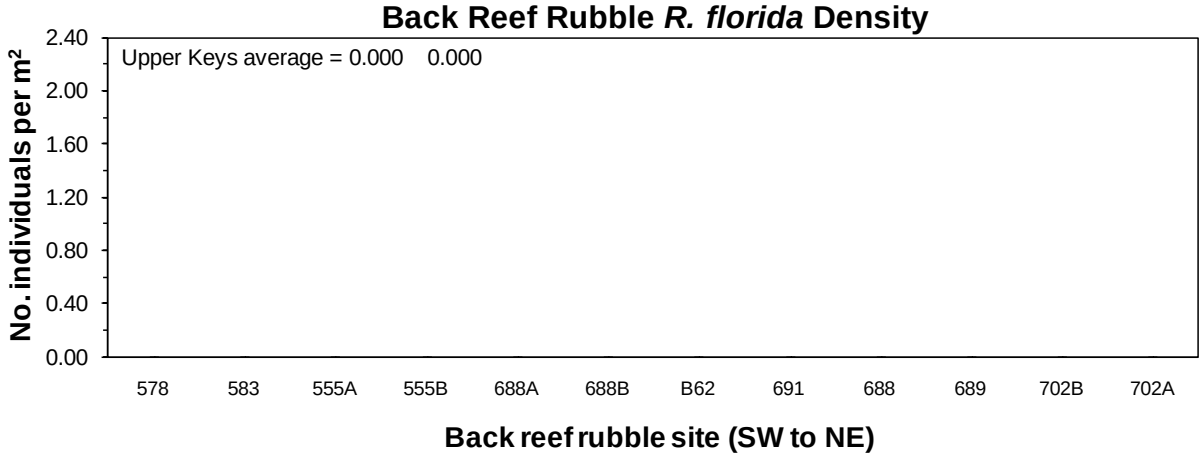


Figure 6-12. Mean (+ 1 SE) densities (no. per m^2) of the Florida corallimorph (*Ricordea florida*) on shallow (< 6 m) hard-bottom (top), high-relief spur and groove reefs (middle) and deeper (6-15 m) fore reef habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.

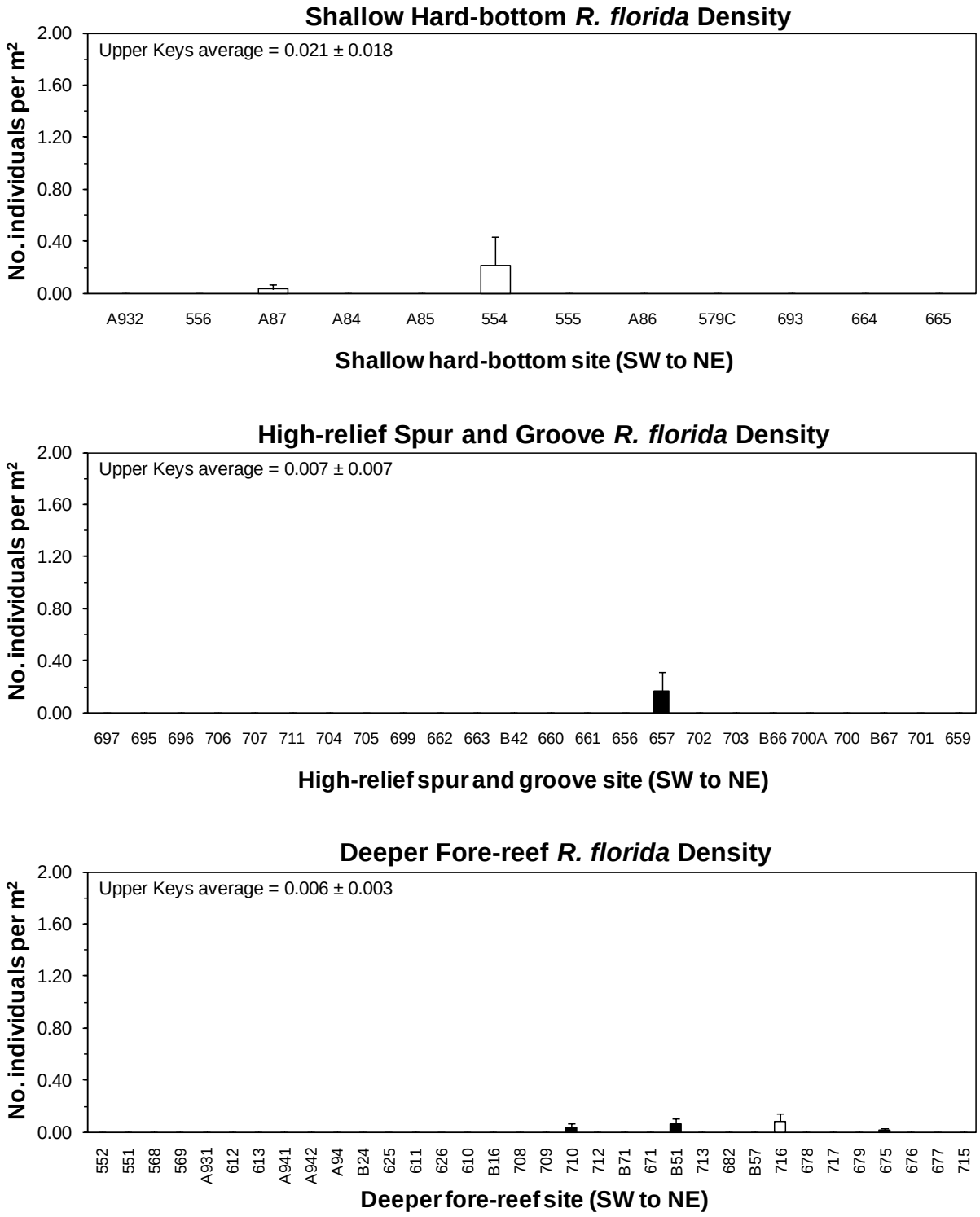


Table 6-1. Mean ± 1 SE proportional station frequencies, densities (no. individuals per m^2) and numbers of individuals recorded (N) for the anemones *Bartholomea annulata* and *Condylactis gigantea* in the upper Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-August 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	***Bartholomea annulata***			***Condylactis gigantea***		
	Frequency	**N**	**No./m^2**	**Frequency**	**N**	**No./m^2**
Inshore and mid-channel patch reefs						
Middle Florida Keys						
A741 – Tavernier Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
534 – Hen and Chickens SPA**	50 ± 29	5	0.083 ± 0.063	0 ± 0	0	0 ± 0
535 – Hen and Chickens SPA**	25 ± 25	2	0.033 ± 0.033	0 ± 0	0	0 ± 0
A74 – West of Conch Reef	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
533 – West of Conch Reef	50 ± 29	3	0.050 ± 0.032	25 ± 25	1	0.017 ± 0.017
A73 – West of Conch Reef	0 ± 0	0	0 ± 0	25 ± 25	1	0.017 ± 0.017
Middle Florida Keys Total (6)	25 ± 9	11	0.031 ± 0.013	8 ± 5	2	0.006 ± 0.004
Upper Florida Keys						
638 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B25B – Inshore of Molasses Reef	50 ± 29	3	0.050 ± 0.032	0 ± 0	0	0 ± 0
B25 – Inshore of Molasses Reef	25 ± 25	1	0.017 ± 0.017	25 ± 25	1	0.017 ± 0.017
B25A – Inshore of Molasses Reef	25 ± 25	2	0.033 ± 0.033	25 ± 25	1	0.017 ± 0.017
627 – Mosquito Bank	100 ± 0	6	0.100 ± 0.019	25 ± 25	1	0.017 ± 0.017
629A – Mosquito Bank	50 ± 29	2	0.033 ± 0.019	0 ± 0	0	0 ± 0
628 – Mosquito Bank	50 ± 29	5	0.083 ± 0.050	25 ± 25	1	0.017 ± 0.017
629 – Mosquito Bank	100 ± 0	6	0.100 ± 0.019	0 ± 0	0	0 ± 0
629B – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
630 – SE of Cannon Patch Reef	50 ± 29	4	0.067 ± 0.047	0 ± 0	0	0 ± 0
631 – Marker 33	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
633 – Basin Hill Shoals	75 ± 25	5	0.083 ± 0.042	50 ± 29	2	0.033 ± 0.019
634 – Basin Hill Shoals	100 ± 0	11	0.183 ± 0.032	50 ± 29	2	0.033 ± 0.019
637 – West of Turtle Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
636 – West of Turtle Rocks	75 ± 25	3	0.050 ± 0.017	25 ± 25	1	0.017 ± 0.017
Upper Florida Keys Total (15)	48 ± 9	49	0.054 ± 0.013	0 ± 0	9	0.010 ± 0.003
Mid-channel Patch Reef Total (21)	**42 ± 7**	**60**	**0.048 ± 0.010**	**0 ± 0**	**11**	**0.009 ± 0.002**
Offshore patch reefs						
Middle Florida Keys						
A802 – Inshore of Conch Reef	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
A801 – Inshore of Conch Reef	50 ± 29	3	0.050 ± 0.032	25 ± 25	1	0.017 ± 0.017
579A – Inshore of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
579B – Inshore of Conch Reef	0 ± 0	0	0 ± 0	25 ± 25	1	0.017 ± 0.017
Middle Florida Keys Total (4)	19 ± 12	4	0.017 ± 0.012	13 ± 7	2	0.008 ± 0.005
Upper Florida Keys						
639 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
640 – White Bank (West of Molasses)	75 ± 25	4	0.067 ± 0.027	0 ± 0	0	0 ± 0
641 – White Bank (West of Molasses)	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
642 – SE of White Bank Dry Rocks	25 ± 25	2	0.033 ± 0.033	0 ± 0	0	0 ± 0
B33 – East of White Bank Dry Rocks	25 ± 25	3	0.050 ± 0.050	0 ± 0	0	0 ± 0
643 – White Bank (NW of French)	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
B35 – West of Elbow Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
644 – Watson's Reef	100 ± 0	9	0.150 ± 0.063	0 ± 0	0	0 ± 0
645 – Watson's Reef	75 ± 25	3	0.050 ± 0.017	0 ± 0	0	0 ± 0
648 – East of Basin Hill Shoals	50 ± 29	5	0.083 ± 0.050	50 ± 29	3	0.050 ± 0.032
649 – West of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B39 – Carysfort Reef SPA**	50 ± 29	3	0.050 ± 0.032	25 ± 25	1	0.017 ± 0.017

Site number/site location	*Bartholomea annulata*			*Condylactis gigantea*		
	Frequency	**N**	**No./m^2**	**Frequency**	**N**	**No./m^2**
653 – Carysfort Reef SPA**	50 ± 29	2	0.033 ± 0.019	0 ± 0	0	0 ± 0
Upper Florida Keys Total (13)	38 ± 9	33	0.042 ± 0.012	6 ± 4	4	0.005 ± 0.004
Offshore Patch Reef Total (17)	**34 ± 7**	**37**	**0.036 ± 0.010**	**7 ± 4**	**6**	**0.006 ± 0.003**
Back reef rubble						
Middle Florida Keys						
578 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
583 – Crocker Reef	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
555A – Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
555B – Conch Reef	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
Middle Florida Keys Total (4)	13 ± 7	2	0.008 ± 0.005	0 ± 0	0	0 ± 0
Upper Florida Keys						
688A – Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
688B – Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B62 – Molasses Reef SPA**	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
691 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
688 – Sand Island	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
689 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	25 ± 25	1	0.017 ± 0.017
702B – Elbow Reef SPA**	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
702A – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (8)	6 ± 4	2	0.004 ± 0.003	3 ± 3	1	0.002 ± 0.002
Back Reef Rubble Total (12)	**8 ± 4**	**4**	**0.006 ± 0.002**	**2 ± 2**	**1**	**0.001 ± 0.001**
Low-relief hard-bottom (< 6 m)						
Middle Florida Keys						
A932 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
556 – Davis Reef SPA**	50 ± 29	3	0.050 ± 0.032	0 ± 0	0	0 ± 0
A87 – Davis Reef SPA**	50 ± 29	2	0.033 ± 0.019	0 ± 0	0	0 ± 0
A84 – Little Conch Reef	50 ± 29	3	0.050 ± 0.032	0 ± 0	0	0 ± 0
A85 – Little Conch Reef	25 ± 25	1	0.017 ± 0.017	25 ± 25	1	0.017 ± 0.017
554 – Conch Reef C1**	50 ± 29	2	0.033 ± 0.019	0 ± 0	0	0 ± 0
555 – Conch Reef C2**	50 ± 29	3	0.050 ± 0.032	0 ± 0	0	0 ± 0
A86 – Conch Reef C3**	50 ± 29	2	0.033 ± 0.019	0 ± 0	0	0 ± 0
579C – NE of Conch Reef	25 ± 25	2	0.033 ± 0.033	0 ± 0	0	0 ± 0
Middle Florida Keys Total (9)	39 ± 6	18	0.033 ± 0.006	3 ± 3	1	0.002 ± 0.002
Upper Florida Keys						
693 – Little Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
664 – North of French Reef	50 ± 29	2	0.033 ± 0.019	0 ± 0	0	0 ± 0
665 – Inshore of Dixie Shoal	50 ± 29	3	0.050 ± 0.032	50 ± 29	2	0.033 ± 0.019
Upper Florida Keys Total (3)	0 ± 0	5	0.028 ± 0.015	17 ± 17	2	0.011 ± 0.011
Shallow Hard-bottom Total (17)	**0 ± 0**	**23**	**0.032 ± 0.005**	**6 ± 4**	**3**	**0.004 ± 0.003**
High-relief spur and groove						
Upper Florida Keys						
697 – Pickles Reef P1	50 ± 29	2	0.033 ± 0.019	0 ± 0	0	0 ± 0
695 – Pickles Reef P3	25 ± 25	2	0.033 ± 0.033	0 ± 0	0	0 ± 0
696 – NE Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
706 – Molasses Reef SPA**	50 ± 29	2	0.033 ± 0.019	0 ± 0	0	0 ± 0
707 – Molasses Reef SPA**	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
711 – Sand Island	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
704 – French Reef SPA**	50 ± 29	3	0.050 ± 0.032	0 ± 0	0	0 ± 0
705 – French Reef SPA**	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
699 – North of French Reef	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
662 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0

Site number/site location	*Bartholomea annulata*			*Condylactis gigantea*		
	Frequency	**N**	**No./m^2**	**Frequency**	**N**	**No./m^2**
663 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B42 – Little Grecian Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
660 – Key Largo Dry Rocks**	25 ± 25	2	0.033 ± 0.033	0 ± 0	0	0 ± 0
661 – Key Largo Dry Rocks**	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
656 – North Dry Rocks	25 ± 25	2	0.033 ± 0.033	0 ± 0	0	0 ± 0
657 – North-North Dry Rocks	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
702 – Elbow Reef SPA**	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
703 – Elbow Reef SPA**	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
B66 – South of S. Carysfort	50 ± 29	2	0.033 ± 0.019	0 ± 0	0	0 ± 0
700A – South Carysfort Reef**	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
700 – South Carysfort Reef**	50 ± 29	4	0.067 ± 0.047	0 ± 0	0	0 ± 0
B67 – Carysfort Reef C2**	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
701 – Carysfort Reef C5**	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
659 – Turtle Reef	75 ± 25	4	0.067 ± 0.027	0 ± 0	0	0 ± 0
Upper Florida Keys Total (24)	27 ± 4	33	0.023 ± 0.004	0 ± 0	0	0 ± 0
High-relief Spur & Groove Total (42)	**27 ± 4**	**33**	**0.023 ± 0.004**	**0 ± 0**	**0**	**0 ± 0**
Deeper Fore-reef (6-15 m)						
Middle Florida Keys						
552 – SW of Crocker Reef	75 ± 25	9	0.150 ± 0.017	0 ± 0	0	0 ± 0
551 – SW of Crocker Reef	75 ± 25	3	0.050 ± 0.017	0 ± 0	0	0 ± 0
568 – SW of Crocker Reef	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
569 – SW of Crocker Reef	50 ± 29	2	0.033 ± 0.019	0 ± 0	0	0 ± 0
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
612 – Davis Reef SPA**	50 ± 29	3	0.050 ± 0.032	0 ± 0	0	0 ± 0
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A941 – North of Davis Reef	75 ± 25	5	0.083 ± 0.042	0 ± 0	0	0 ± 0
A942 – Little Conch Reef	75 ± 25	3	0.050 ± 0.017	0 ± 0	0	0 ± 0
A94 – Little Conch Reef	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
B24 – Conch Reef RO**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
625 – Conch Reef RO**	50 ± 29	2	0.033 ± 0.019	0 ± 0	0	0 ± 0
611 – Conch Reef SPA**	75 ± 25	5	0.083 ± 0.042	0 ± 0	0	0 ± 0
626 – Conch Reef RO**	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
610 – Conch Reef SPA**	75 ± 25	3	0.050 ± 0.017	0 ± 0	0	0 ± 0
B16 – Conch Reef SPA**	75 ± 25	5	0.083 ± 0.032	0 ± 0	0	0 ± 0
Middle Florida Keys Total (16)	47 ± 8	43	0.045 ± 0.010	0 ± 0	0	0 ± 0
Upper Florida Keys						
708 – NE of Conch Reef	100 ± 0	6	0.100 ± 0.033	0 ± 0	0	0 ± 0
709 – Pickles Reef	50 ± 29	3	0.050 ± 0.032	0 ± 0	0	0 ± 0
710 – SW of Molasses Reef SPA	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
712 – SW of French Reef	50 ± 29	3	0.050 ± 0.032	0 ± 0	0	0 ± 0
B71 – Dixie Shoal	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
671 – South of Grecian Rocks	50 ± 29	6	0.100 ± 0.064	0 ± 0	0	0 ± 0
B51 – East of Dry Rocks	25 ± 25	2	0.033 ± 0.033	0 ± 0	0	0 ± 0
713 – North of Elbow Reef	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
682 – North of Elbow Reef	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
B57 – SE of Watson's Reef	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
716 – South Carysfort Reef**	50 ± 29	2	0.033 ± 0.019	0 ± 0	0	0 ± 0
678 – North Carysfort Reef**	50 ± 29	2	0.033 ± 0.019	0 ± 0	0	0 ± 0
717 – North Carysfort Reef**	75 ± 25	5	0.083 ± 0.032	0 ± 0	0	0 ± 0
679 – North Carysfort Reef**	100 ± 0	4	0.067 ± 0.000	0 ± 0	0	0 ± 0
675 – North of Carysfort Reef	75 ± 25	4	0.067 ± 0.027	0 ± 0	0	0 ± 0
676 – North of Carysfort Reef	75 ± 25	7	0.117 ± 0.074	0 ± 0	0	0 ± 0
677 – North of Carysfort Reef	75 ± 25	6	0.100 ± 0.043	25 ± 25	1	0.017 ± 0.017
715 – North of Carysfort Reef	100 ± 0	5	0.083 ± 0.017	50 ± 29	2	0.033 ± 0.019
Upper Florida Keys Total (18)	54 ± 7	59	0.055 ± 0.009	4 ± 3	3	0.003 ± 0.002
Deeper Fore-reef Total (34)	**51 ± 5**	**102**	**0.050 ± 0.006**	**2 ± 2**	**3**	**0.001 ± 0.001**

Table 6-2. Mean ± 1 SE proportional station frequencies, densities (no. individuals per m^2) and numbers of individuals recorded (N) for the anemones *Epicystes crucifera* and *Lebrunia danae* in the upper Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-August 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	***Epicystes crucifera***			***Lebrunia danae***		
	Frequency	**N**	**No./m^2**	**Frequency**	**N**	**No./m^2**
Inshore and mid-channel patch reefs						
Middle Florida Keys						
A741 – Tavernier Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
534 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
535 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A74 – West of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
533 – West of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A73 – West of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (6)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys						
638 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B25B – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B25 – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B25A – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
627 – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
629A – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
628 – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
629 – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
629B – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
630 – SE of Cannon Patch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
631 – Marker 33	0 ± 0	0	0 ± 0	50 ± 29	4	0.067 ± 0.047
633 – Basin Hill Shoals	0 ± 0	0	0 ± 0	25 ± 25	1	0.017 ± 0.017
634 – Basin Hill Shoals	0 ± 0	0	0 ± 0	25 ± 25	1	0.017 ± 0.017
637 – West of Turtle Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
636 – West of Turtle Rocks	0 ± 0	0	0 ± 0	25 ± 25	1	0.017 ± 0.017
Upper Florida Keys Total (15)	0 ± 0	0	0 ± 0	8 ± 4	7	0.008 ± 0.005
Mid-channel Patch Reef Total (21)	**0 ± 0**	**0**	**0 ± 0**	**6 ± 3**	**7**	**0.006 ± 0.003**
Offshore patch reefs						
Middle Florida Keys						
A802 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	25 ± 25	1	0.017 ± 0.017
A801 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
579A – Inshore of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
579B – Inshore of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	6 ± 6	1	0.004 ± 0.004
Upper Florida Keys						
639 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
640 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
641 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
642 – SE of White Bank Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B33 – East of White Bank Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
643 – White Bank (NW of French)	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
B35 – West of Elbow Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
644 – Watson's Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
645 – Watson's Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
648 – East of Basin Hill Shoals	0 ± 0	0	0 ± 0	25 ± 25	1	0.017 ± 0.017
649 – West of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B39 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	25 ± 25	1	0.017 ± 0.017

Site number/site location	*Epicystes crucifera*			*Lebrunia danae*		
	Frequency	**N**	**No./m^2**	**Frequency**	**N**	**No./m^2**
653 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (13)	2 ± 2	1	0.001 ± 0.001	4 ± 3	2	0.003 ± 0.002
Offshore Patch Reef Total (17)	**1 ± 1**	**1**	**0.001 ± 0.001**	**4 ± 2**	**3**	**0.003 ± 0.002**
Back reef rubble						
Middle Florida Keys						
578 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
583 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
555A – Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
555B – Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys						
688A – Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
688B – Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B62 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
691 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
688 – Sand Island	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
689 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
702B – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
702A – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (8)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Back Reef Rubble Total (12)	**0 ± 0**	**0**	**0 ± 0**	**0 ± 0**	**0**	**0 ± 0**
Low-relief hard-bottom (< 6 m)						
Middle Florida Keys						
A932 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
556 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A87 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A84 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A85 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
554 – Conch Reef C1**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
555 – Conch Reef C2**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A86 – Conch Reef C3**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
579C – NE of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (9)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys						
693 – Little Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
664 – North of French Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
665 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (3)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Shallow Hard-bottom Total (17)	**0 ± 0**	**0**	**0 ± 0**	**0 ± 0**	**0**	**0 ± 0**
High-relief spur and groove						
Upper Florida Keys						
697 – Pickles Reef P1	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
695 – Pickles Reef P3	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
696 – NE Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
706 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
707 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
711 – Sand Island	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
704 – French Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
705 – French Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
699 – North of French Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
662 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0

Site number/site location	*Epicystes crucifera*			*Lebrunia danae*		
	Frequency	**N**	**No./m^2**	**Frequency**	**N**	**No./m^2**
663 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B42 – Little Grecian Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
660 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
661 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
656 – North Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
657 – North-North Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
702 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
703 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B66 – South of S. Carysfort	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
700A – South Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
700 – South Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B67 – Carysfort Reef C2**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
701 – Carysfort Reef C5**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
659 – Turtle Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (24)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
High-relief Spur & Groove Total (42)	**0 ± 0**	**0**	**0 ± 0**	**0 ± 0**	**0**	**0 ± 0**
Deeper Fore-reef (6-15 m)						
Middle Florida Keys						
552 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
551 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
568 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
569 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
612 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A941 – North of Davis Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A942 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A94 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B24 – Conch Reef RO**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
625 – Conch Reef RO**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
611 – Conch Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
626 – Conch Reef RO**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
610 – Conch Reef SPA**	0 ± 0	0	0 ± 0	25 ± 25	1	0.017 ± 0.017
B16 – Conch Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (16)	0 ± 0	0	0 ± 0	2 ± 2	1	0.001 ± 0.001
Upper Florida Keys						
708 – NE of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
709 – Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
710 – SW of Molasses Reef SPA	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
712 – SW of French Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B71 – Dixie Shoal	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
671 – South of Grecian Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B51 – East of Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
713 – North of Elbow Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
682 – North of Elbow Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B57 – SE of Watson's Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
716 – South Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
678 – North Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
717 – North Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
679 – North Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
675 – North of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
676 – North of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
677 – North of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
715 – North of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (18)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Deeper Fore-reef Total (34)	**0 ± 0**	**0**	**0 ± 0**	**0 ± 0**	**0**	**0 ± 0**

Table 6-3. Mean ± 1 SE proportional station frequencies, densities (no. individuals per m^2) and numbers of individuals recorded (N) for the corallimorpharians *Discosoma carlgreni* and *Ricordea florida* in the upper Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-August 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	*Discosoma carlgreni*			*Ricordea florida*		
	Frequency	**N**	**No./m^2**	**Frequency**	**N**	**No./m^2**
Inshore and mid-channel patch reefs						
Middle Florida Keys						
A741 – Tavernier Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
534 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	25 ± 25	55	0.917 ± 0.917
535 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A74 – West of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
533 – West of Conch Reef	0 ± 0	0	0 ± 0	25 ± 25	4	0.067 ± 0.067
A73 – West of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (6)	0 ± 0	0	0 ± 0	8 ± 5	59	0.164 ± 0.151
Upper Florida Keys						
638 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	75 ± 25	48	0.800 ± 0.712
B25B – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B25 – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B25A – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
627 – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
629A – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
628 – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
629 – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
629B – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
630 – SE of Cannon Patch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
631 – Marker 33	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
633 – Basin Hill Shoals	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
634 – Basin Hill Shoals	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
637 – West of Turtle Rocks	0 ± 0	0	0 ± 0	50 ± 29	7	0.117 ± 0.069
636 – West of Turtle Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (15)	0 ± 0	0	0 ± 0	8 ± 6	55	0.061 ± 0.053
Mid-channel Patch Reef Total (21)	**0 ± 0**	**0**	**0 ± 0**	**8 ± 4**	**114**	**0.090 ± 0.056**
Offshore patch reefs						
Middle Florida Keys						
A802 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A801 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
579A – Inshore of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
579B – Inshore of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys						
639 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
640 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	50 ± 29	7	0.117 ± 0.069
641 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	50 ± 29	7	0.117 ± 0.069
642 – SE of White Bank Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B33 – East of White Bank Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
643 – White Bank (NW of French)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B35 – West of Elbow Reef	0 ± 0	0	0 ± 0	50 ± 29	7	0.117 ± 0.069
644 – Watson's Reef	25 ± 25	8	0.133 ± 0.133	50 ± 29	7	0.117 ± 0.069
645 – Watson's Reef	0 ± 0	0	0 ± 0	50 ± 29	7	0.117 ± 0.069
648 – East of Basin Hill Shoals	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
649 – West of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B39 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0

Site number/site location	*Discosoma carlgreni*			*Ricordea florida*		
	Frequency	**N**	**No./m^2**	**Frequency**	**N**	**No./m^2**
653 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	50 ± 29	7	0.117 ± 0.069
Upper Florida Keys Total (13)	2 ± 2	8	0.010 ± 0.010	23 ± 9	140	0.179 ± 0.117
Offshore Patch Reef Total (17)	**1 ± 1**	**8**	**0.008 ± 0.008**	**18 ± 7**	**140**	**0.137 ± 0.091**
Back reef rubble						
Middle Florida Keys						
578 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
583 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
555A – Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
555B – Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys						
688A – Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
688B – Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B62 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
691 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
688 – Sand Island	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
689 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
702B – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
702A – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (8)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Back Reef Rubble Total (12)						
Low-relief hard-bottom (< 6 m)						
Middle Florida Keys						
A932 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
556 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A87 – Davis Reef SPA**	0 ± 0	0	0 ± 0	25 ± 25	2	0.033 ± 0.033
A84 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A85 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
554 – Conch Reef C1**	0 ± 0	0	0 ± 0	25 ± 25	13	0.217 ± 0.217
555 – Conch Reef C2**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A86 – Conch Reef C3**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
579C – NE of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (9)	0 ± 0	0	0 ± 0	6 ± 4	15	0.028 ± 0.024
Upper Florida Keys						
693 – Little Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
664 – North of French Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
665 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (3)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Shallow Hard-bottom Total (17)	**0 ± 0**	**0**	**0 ± 0**	**4 ± 3**	**15**	**0.021 ± 0.018**
High-relief spur and groove						
Upper Florida Keys						
697 – Pickles Reef P1	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
695 – Pickles Reef P3	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
696 – NE Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
706 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
707 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
711 – Sand Island	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
704 – French Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
705 – French Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
699 – North of French Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
662 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0

Site number/site location	*Discosoma carlgreni*			*Ricordea florida*		
	Frequency	**N**	**No./m^2**	**Frequency**	**N**	**No./m^2**
663 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B42 – Little Grecian Rocks	25 ± 25	9	0.150 ± 0.150	0 ± 0	0	0 ± 0
660 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
661 – Key Largo Dry Rocks**	25 ± 25	1	0.017 ± 0.017	0 ± 0	0	0 ± 0
656 – North Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
657 – North-North Dry Rocks	0 ± 0	0	0 ± 0	50 ± 29	10	0.167 ± 0.145
702 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
703 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B66 – South of S. Carysfort	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
700A – South Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
700 – South Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B67 – Carysfort Reef C2**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
701 – Carysfort Reef C5**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
659 – Turtle Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (24)	2 ± 1	10	0.007 ± 0.006	2 ± 2	10	0.007 ± 0.007
High-relief Spur & Groove Total (42)	**2 ± 1**	**10**	**0.007 ± 0.006**	**2 ± 2**	**10**	**0.007 ± 0.007**
Deeper Fore-reef (6-15 m)						
Middle Florida Keys						
552 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
551 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
568 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
569 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
612 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A941 – North of Davis Reef	25 ± 25	2	0.033 ± 0.033	0 ± 0	0	0 ± 0
A942 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A94 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B24 – Conch Reef RO**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
625 – Conch Reef RO**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
611 – Conch Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
626 – Conch Reef RO**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
610 – Conch Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B16 – Conch Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (16)	2 ± 2	2	0.002 ± 0.002	0 ± 0	0	0 ± 0
Upper Florida Keys						
708 – NE of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
709 – Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
710 – SW of Molasses Reef SPA	0 ± 0	0	0 ± 0	25 ± 25	2	0.033 ± 0.033
712 – SW of French Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B71 – Dixie Shoal	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
671 – South of Grecian Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B51 – East of Dry Rocks	0 ± 0	0	0 ± 0	75 ± 25	4	0.067 ± 0.038
713 – North of Elbow Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
682 – North of Elbow Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B57 – SE of Watson's Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
716 – South Carysfort Reef**	0 ± 0	0	0 ± 0	50 ± 29	5	0.083 ± 0.063
678 – North Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
717 – North Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
679 – North Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
675 – North of Carysfort Reef	0 ± 0	0	0 ± 0	25 ± 25	1	0.017 ± 0.017
676 – North of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
677 – North of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
715 – North of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (18)	0 ± 0	0	0 ± 0	10 ± 5	12	0.011 ± 0.006
Deeper Fore-reef Total (34)	**1 ± 1**	**2**	**0.001 ± 0.001**	**5 ± 3**	**12**	**0.006 ± 0.003**

VII. Abundance and Size of Selected Mollusks

Background

The Florida Keys marine ecosystem supports a diverse fauna of mollusks belonging to several orders. Opisthobranch mollusks, for example, are represented by at least 30 species of sea slugs (Sacoglossa) and 23 species of nudibranchs (Nudibranchia) (Clark and DeFreese 1987; Levy et al. 1996), including at least three endemic species (Clark 1994). Data on the status and trends of mollusk populations and habitat utilization patterns in the Florida Keys, with the exception of queen conch (*Strombus gigas*), are generally limited (Marcus 1960; Jensen and Clark 1983; Clark and DeFreese 1987), as most previous studies have been qualitative in nature (Clark 1994; Trowbridge 2002). Clark (1994) noted a declining population trend for the lettuce sea slug, *Elysia* (*Tridachia*) *crispata* Mörch (see cladistic analyses in Gosliner 1995; Jensen 1996) in southern Florida, based upon qualitative comparisons of occurrence and population densities between 1969-80 and 1987-93. About 50% of the nearshore populations assessed by Clark (1994) nearly 17 years ago were declining due to habitat destruction, siltation, eutrophication, and over-collection, particularly evident in nearshore habitats.

Since 2001, we have conducted intermittent surveys of various gastropod mollusk species in conjunction with assessments of other benthic variables. For example, we encountered unusually high densities of lettuce sea slugs among 63 shallow fore reef sites during June-September 2001. While sacoglossans are not particularly rare in many shallow-water marine habitats where densities correlate with algal biomass (Clarke and DeFreese 1987), our observations offshore were considered unusual because fleshy algal cover tends to be relatively low (Chiappone et al. 1997; Miller et al. 2002). In 2007 we surveyed *Coralliophila* snail predation on *Acropora* corals and also quantified the density two other Neogastropoda species that were especially abundant on high-relief spur and groove reefs. During 2001 and 2008-2009, we surveyed *Cyphoma* abundance, size, and gorgonian host occupation patterns (Chiappone et al. 2003).

During June-August 2010, four 15-m x 1-m belt transects per site at all 120 sites (7,200 m^2) were surveyed for the following sacoglossan, nudibranch, and neogastropoda mollusks:

- The lettuce sea slug, *Elysia* (*Tradachia*) *crispata* (Mörch), Class Gastropoda, Subclass Opisthobranchia, Order Sacoglossa, Family Elysiidae;
- The nudibranchs *Hypselodoris edenticulata* (Florida regal sea goddess), *H. bayeri* (black-spotted sea goddess), *Chromodoris kempfi* (purple-crowned sea goddess), *C. nyalya* (red-line blue sea goddess), and *Glossodoris sedna* (red-tipped sea goddess) of the Class Gastropoda, Subclass Opisthobranchia, Order Nudibranchia; and

- The Neogastropoda mollusks *Thais deltoidea* (Lamarck) of the Family Thaididae, *Coralliophila* sp. of the Family Coralliophilidae, and *Leucozonia nassa* (Gmelin) of the Family Fasciolariidae.

Of these targeted species, *C. kempfi* and *Hypselodoris* spp. were not encountered in the upper Keys during 2010 (Figure 7-1). The remaining species that were encountered quantified to determine transect frequency of occurrence, density, shell or total length, and substratum occupancy patterns.

2010 Survey Results

A total of 7,200 m^2 of benthic habitat was surveyed during 2010 for the aforementioned gastropod mollusks. The 2010 surveys yielded two nudibranch species, *Chromodoris nyalya* and *Glossodoris sedna*, one sacoglossan sea slug (*Elysia crispata*), and three Neogastropoda snails (*Coralliophila* sp., *Leucozonia nassa*, and *Thais deltoidea*) (Figure 7-1). Table 7-1 provides site-level transect frequency of occurrence and mean density data for the two nudibranch species, while Tables 7-2 to 7-5 provide frequency of occurrence, mean density, and mean total or shell length data for the lettuce sea slug and the three gastropods. Figures 7-2 to 7-4 provide spatial distribution maps for the most common gastropod mollusk sampled (*T. deltoidea*), while Figure 7-5 illustrates mean density patterns for the three gastropods among upper Keys high-relief spur and groove reefs. Nudibranch species observed in previous years, but not recorded during 2010, included *Hypselodoris edenticulata* (Florida regal sea goddess), *H. bayeri* (black-spotted sea goddess), and *Chromodoris kempfi* (purple-crowned sea goddess). Two individuals of *C. nyalya* were recorded from one site (710) in a low-relief spur and groove habitat southwest of Molasses Reef SPA (Table 7-1). Only one individual of *G. sedna* (red-tipped sea goddess) was found at a high-relief spur and groove site (705) within French Reef SPA (Table 7-1).

A total of 37 individuals of the lettuce sea slug (*Elysia crispata*) were recorded, with all individuals found among high-relief spur and groove reefs in the upper Keys (Table 7-2). This distribution pattern is similar to historical surveys conducted in 2001, 2005, 2007, and 2009. A maximum site-level density of 0.100 ± 0.064 individuals per m^2 was recorded from a high-relief spur and groove site at Elbow Reef SPA (Table 7-2). On all high-relief spur and groove reefs sampled, *E. crispata* occurred on 29% ± 6% of all transects, with an overall mean habitat density of 0.026 ± 0.006 individuals per m^2. Total lengths of the 37 individuals ranged from 1.5 to 3.9 cm, with a mean (± 1 SE) size of 2.6 ± 0.1 cm (Table 7-6). All *E. crispata* were found on algal turf substrate when encountered. As in previous years, *E. crispata* was more frequently encountered and generally occurred in greater densities in no-take zones compared to reference areas. Transect frequency of occurrence was more than four times greater and mean density nearly five times greater in no-take zones compared to reference sites (Table 7-2). For the ten reference sites

sampled, mean (± 1 SE) transect frequency of occurrence was 10% ± 6%, while mean density was 0.008 ± 0.005 individuals per m^2, with a maximum site-level density of 0.050 ± 0.032 individuals per m^2. At the 14 sites distributed among six SPAs in the upper Keys region, mean transect frequency of occurrence (43% ± 8%), mean density (0.038 ± 0.008 per m^2), and the maximum site-level density (0.100 ± 0.064 per m^2) were greater than in reference areas (Table 7-2).

The three Neogastropoda mollusks surveyed in 2010 exhibited similar habitat and abundance patterns as in 2007 and 2009 (Tables 7-3 to 7-5). A total of 91 *Coralliophila* sp. individuals were found on offshore patch reefs (9 individuals, 9.9%), shallow (< 6 m) hard-bottom (8 individuals, 8.8%), high-relief spur and groove (45 individuals, 49.5%), and deeper fore-reef sites (29 individuals, 31.9%) (Table 7-3). The maximum site-level density of 0.233 ± 0.145 individuals per m^2 was recorded from a high-relief spur and groove reef (site 711) at Sand Island (Table 7-3). Figure 7-5 shows mean densities among high-relief spur and groove sites in the upper Keys, illustrating the highly aggregate nature of this snail. The 91 *Coralliophila* sp. enumerated ranged in size (shell length) from 0.6 cm to 4.2 cm, with a mean (± 1 SE) size of 1.9 ± 0.1 cm (Table 7-6). Of the 91 *Coralliophila* sp., 87 individuals (~95.6%) were found on live coral colonies, while the remaining four individuals (4.4%) were found on algal turf (Table 7-7). *Coralliophila* sp. exhibited a highly aggregated distribution and was almost always found as clusters of individuals on the edges of live coral colonies. In contrast to previous survey years, we have noted an increase in the frequency of *Coralliophila* snails and the diversity of coral species affected by snail predation. Eight coral species were found with active snail predation, including both *Acropora* species (Table 7-7). On high-relief spur and groove reefs, mean snail densities were more than three times greater in reference areas (0.053 per m^2) compared to no-take zones (0.015 per m^2); this habitat also yielded greater mean size and maximum size of *Coralliophila*. A similar pattern was evident for shallow (< 6 m) hard-bottom, where *Coralliophila* densities were four times greater in Davis Reef SPA and Conch Reef SPA compared to reference areas. In contrast, mean densities were highly similar between reference areas (0.013 per m^2) and no-take zones (0.017 per m^2) on deeper fore-reef habitats.

Also sampled in 2010, the common lesser tulip shell (*Leucozonia nassa*) (Figure 7-1) exhibited a relatively restricted habitat distribution, similar to observations from previous survey years (Table 7-4). Of the 53 individuals recorded, nearly 70% were found on high-relief spur and groove reefs, with the remaining recorded from shallow (< 6 m) hard-bottom (12 individuals, 23%), back-reef rubble (3 individuals, 6%) and the deeper (6-15m) fore reef (1 individual, 2%).). The maximum site-level density of 0.217 ± 0.134 per m^2 was recorded from a high-relief spur and groove site (711) at Sand Island (Figure 7-5). Transect frequency of occurrence (26% ± 6%) and mean density (0.026 ± 0.009) on high-relief spur

and groove reefs and shallow (< 6 m) hard-bottom (21% ± 6% transect occurrence, 0.017 ± 0.006 per m^2) were substantially greater than in other habitats (Table 7-4). Shell lengths of the 53 individuals recorded ranged from 1.4 to 6.1 cm, with a mean ± 1 SE size of 3.1 ± 0.1 cm (Table 7-6). Most *L. nassa* snails were found on either crustose coralline algae (~70%) or algal turf (25%), with the balance found on *Dictyota* algae or sand (Table 7-7).

Similar to 2007 and 2009, the most abundant neogastropoda mollusk surveyed in 2010 was the deltoid rock shell (*Thais deltoidea*) (Figure 7-1). A total of 385 individuals were found, with 321 individuals (~83%) recorded from high-relief spur and groove reefs, followed by shallow (< 6 m) hard-bottom (53 individuals, 14%) (Table 7-5). Transect frequency of occurrence (83% ± 5%) and mean density (0.223 ± 0.036) were much greater on high-relief spur and groove reefs compared to other habitats (Figure 7-2 to 7-4). This is similar to 2007 and 2009, where nearly 90% of all individuals were recorded on high-relief spur and groove reefs. The maximum site-level density of 0.750 ± 0.185 individuals per m^2 was found on a high-relief spur and groove site (B66) south of South Carysfort Reef near the Maitland Grounding area (Figure 7-5). For the 385 *T. deltoidea* individuals measured, total shell lengths ranged from 1.3 to 4.7 cm, with a mean ± 1 SE size of 2.67 ± 0.03 cm (Table 7-6). Nearly 90% of the snails were found on algal turf, with the balance found on crustose coralline algae, *Dictyota* algae, sand, or on other *T. deltoidea* individuals (Table 7-7). On high-relief spur and groove reefs, mean transect frequency of occurrence (89% vs. 75%) and mean density (0.226 vs. 0.218 per m^2) were slightly greater in no-take zones compared to reference areas (Table 7-5). A similar pattern was observed for shallow hard-bottom sites.

Figure 7-1. Selected mollusks (sacoglossans, nudibranchs, gastropods) surveyed for habitat distribution and density in the upper Florida Keys National Marine Sanctuary during June-August 2010.

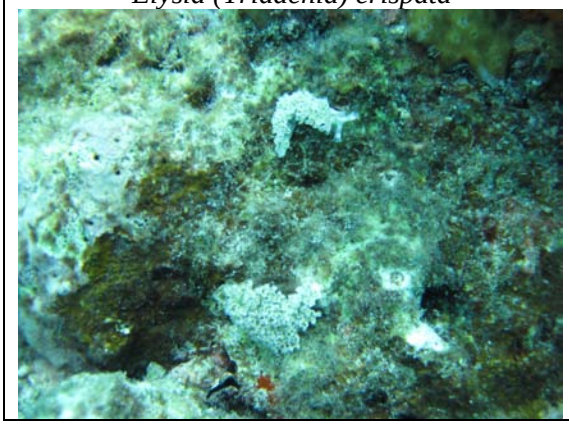
Coralliophila sp.

Thais deltoidea

Leucozonia nassa

Chromodoris nyalya

Elysia (Tridachia) crispata



Glossodoris sedna

Figure 7-2. Densities (no. per m^2) of deltoid rock snails (*Thais deltoidea*) in the upper Florida Keys National Marine Sanctuary from the southern BNP boundary to Carysfort/S. Carysfort SPA surveyed during June-August 2010.

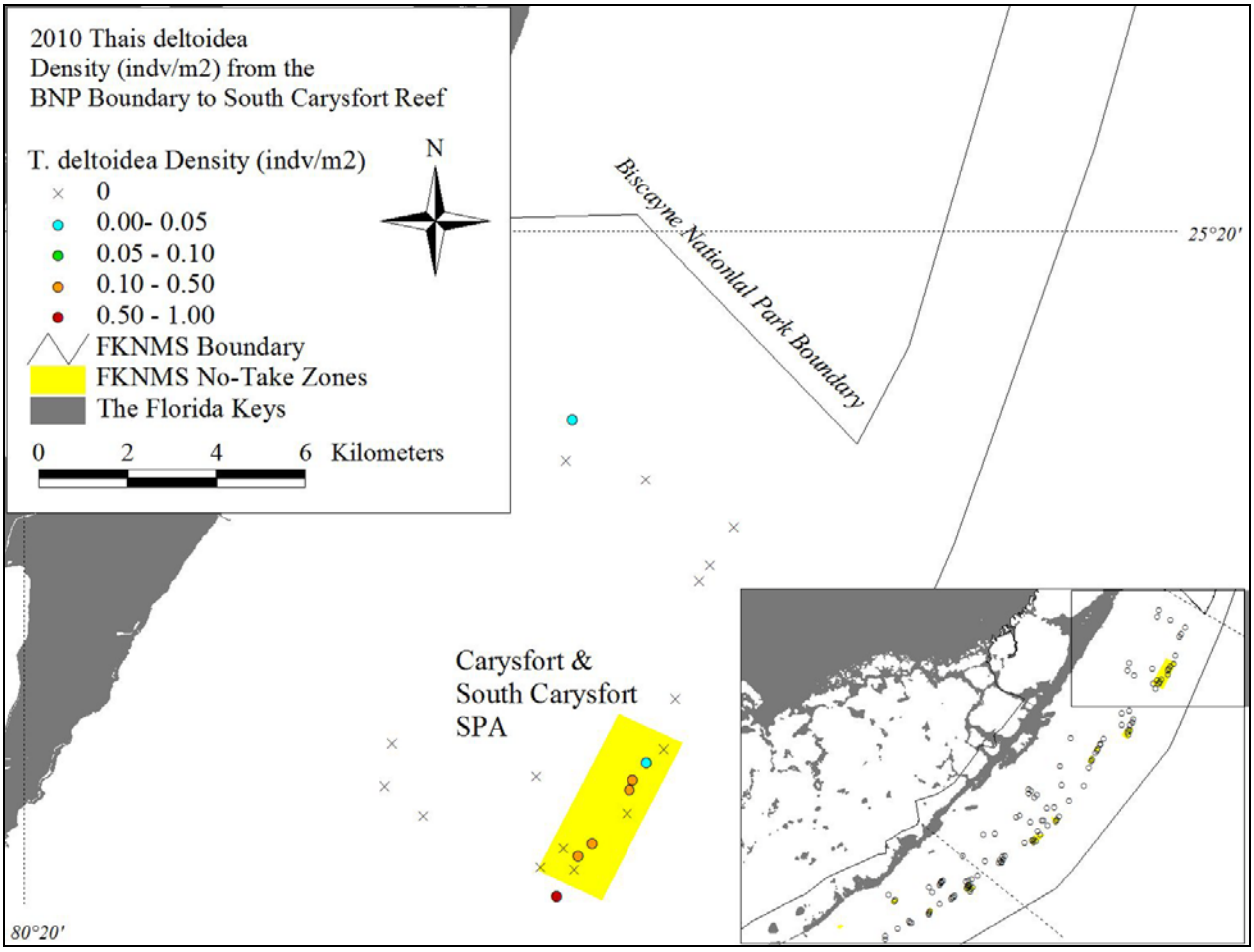


Figure 7-3. Densities (no. per m^2) of deltoid rock snails (*Thais deltoidea*) in the upper Florida Keys National Marine Sanctuary from Elbow Reef to Pickles Reef (bottom) surveyed during June-August 2010.

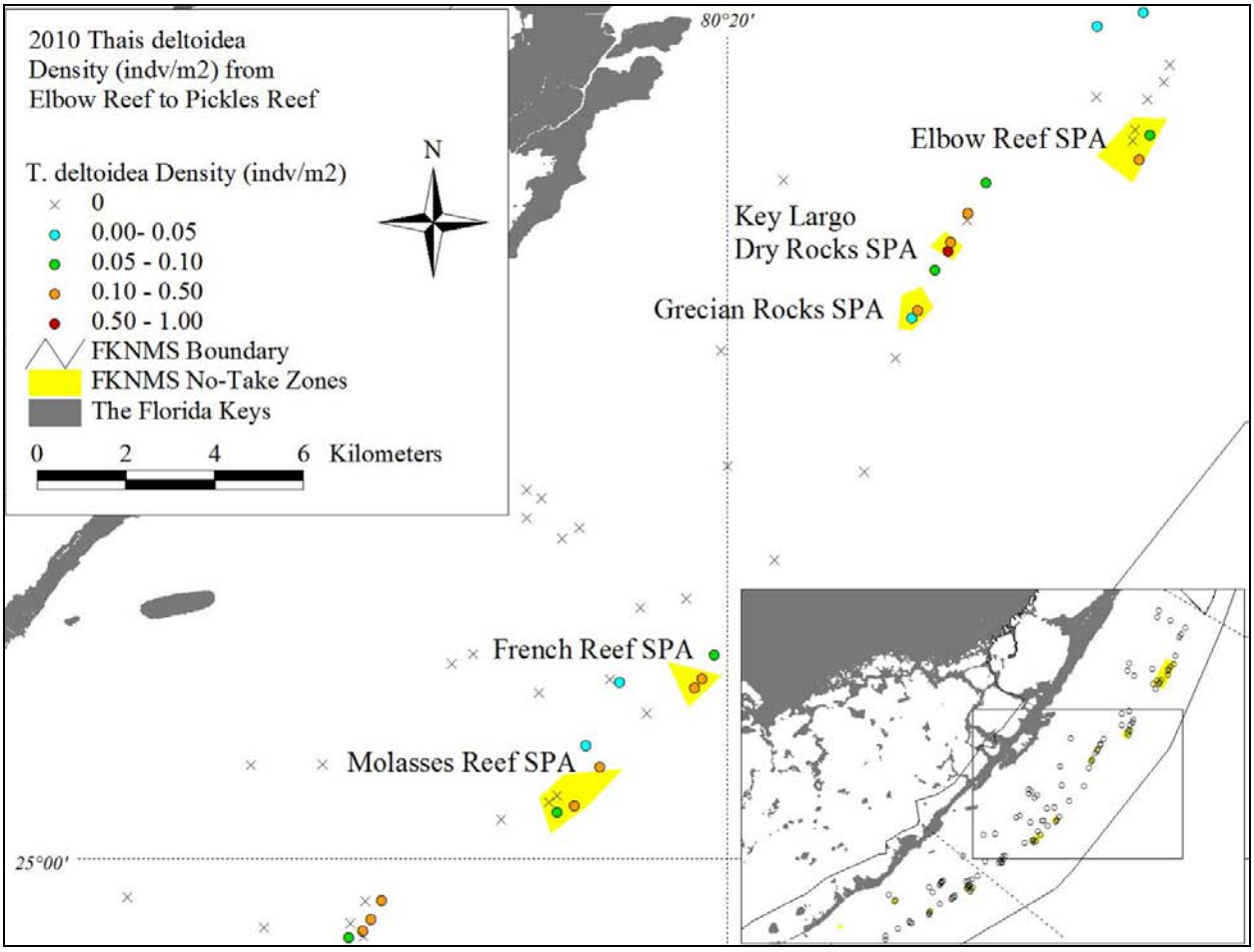


Figure 7-4. Densities (no. per m^2) of deltoid rock snails (*Thais deltoidea*) in the upper Florida Keys National Marine Sanctuary from Conch Reef SPA to Crocker Reef surveyed during June-August 2010.

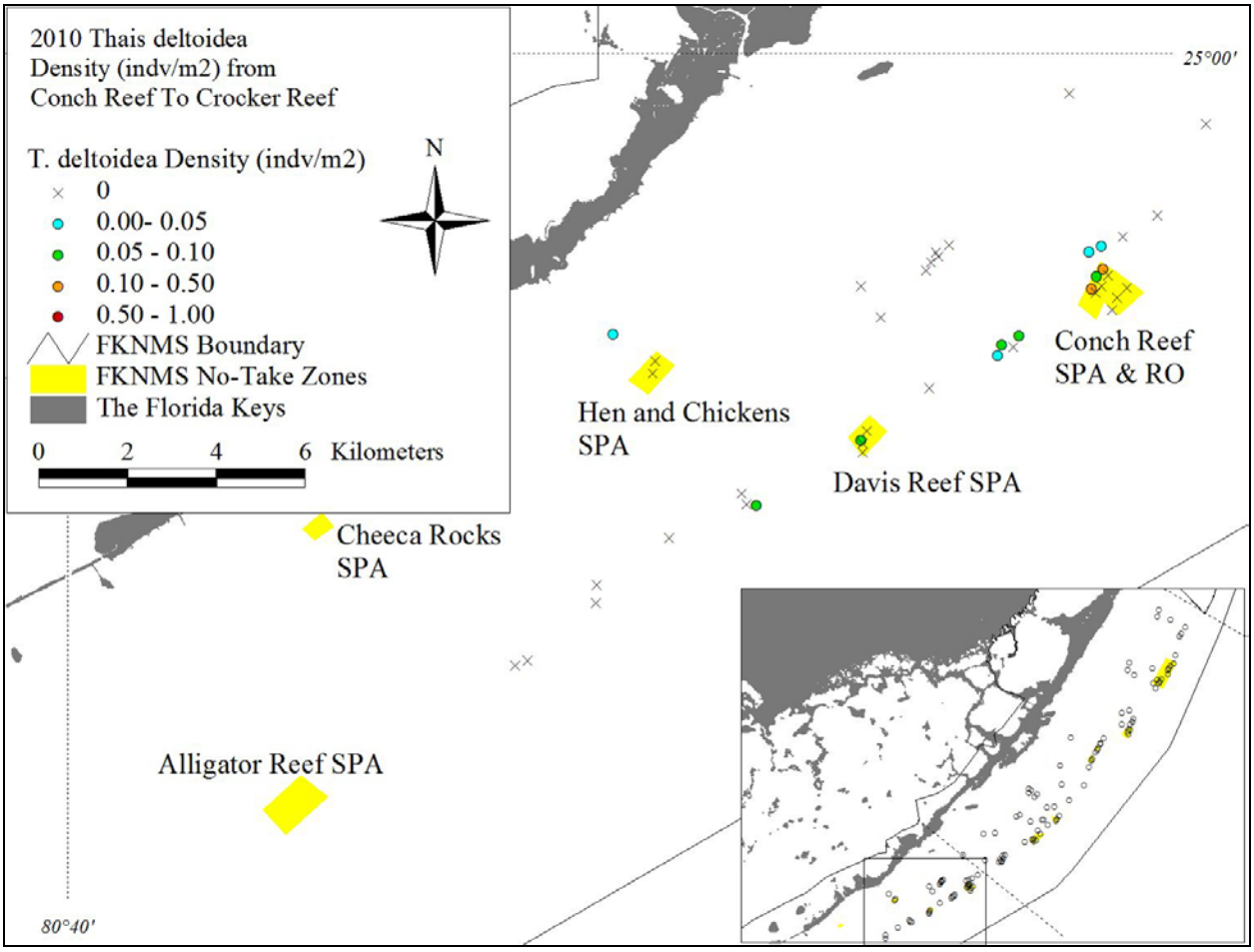


Figure 7-5. Mean (+ 1 SE) densities (no. per m^2) of *Coralliophila* sp., *Leucozonia nassa*, and *Thais deltoidea* gastropods on high-relief spur and groove reefs in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.

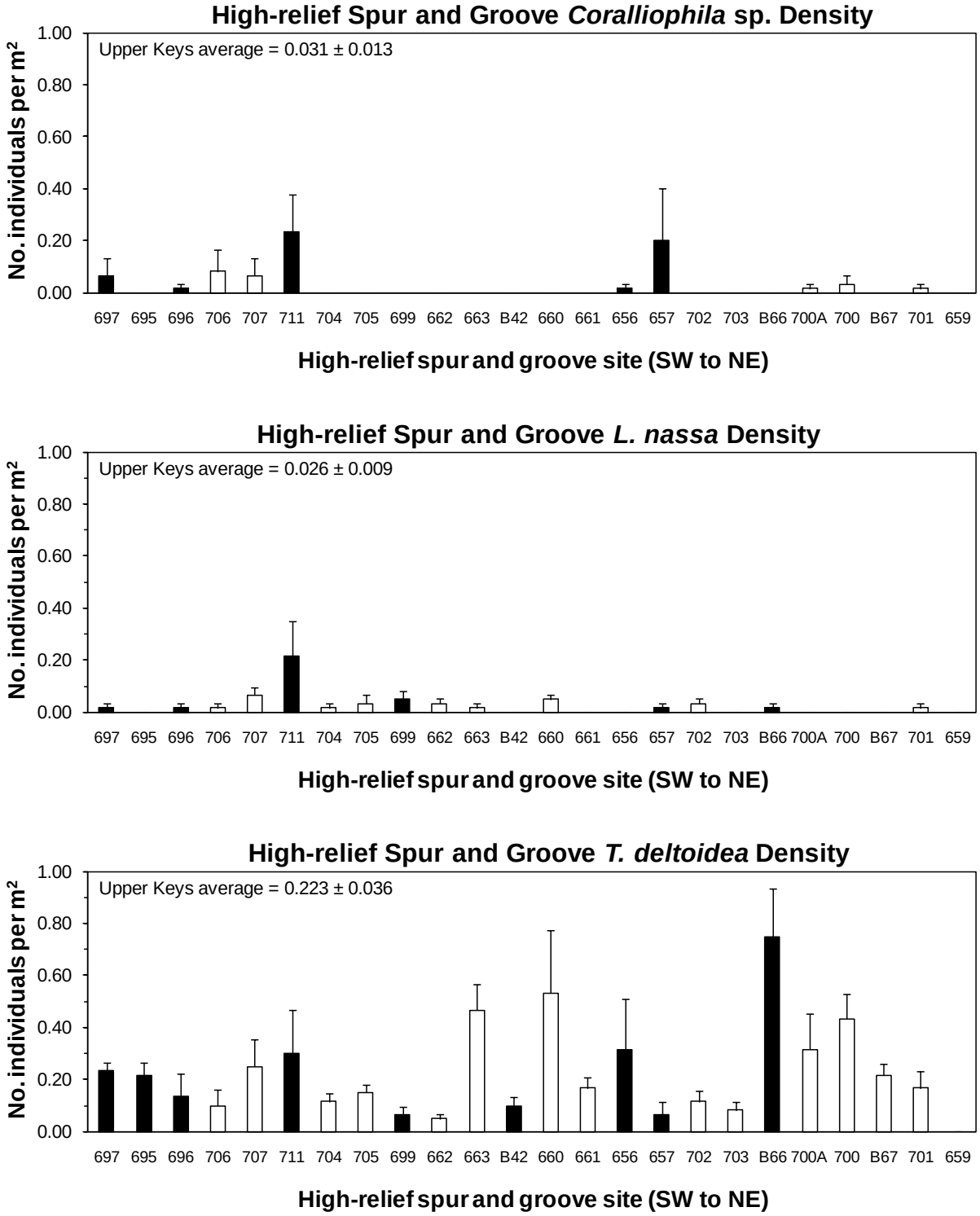


Table 7-1. Mean ± 1 SE transect frequencies (%), densities (no. individuals per m^2), and number of individuals (N) sampled for the nudibranchs *Chromodoris nyalya* and *Glossodoris sedna* in the upper Florida Keys, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-September 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	***Chromodoris nyalya***			***Glossodoris sedna***		
	Frequency	**N**	**No./m^2**	**Frequency**	**N**	**No./m^2**
Inshore and mid-channel patch reefs						
Middle Florida Keys						
A741 – Tavernier Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
534 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
535 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A74 – West of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
533 – West of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A73 – West of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (6)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys						
638 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B25B – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B25 – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B25A – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
627 – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
629A – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
628 – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
629 – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
629B – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
630 – SE of Cannon Patch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
631 – Marker 33	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
633 – Basin Hill Shoals	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
634 – Basin Hill Shoals	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
637 – West of Turtle Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
636 – West of Turtle Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (15)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Mid-channel Patch Reef Total (21)	**0 ± 0**	**0**	**0 ± 0**	**0 ± 0**	**0**	**0 ± 0**
Offshore patch reefs						
Middle Florida Keys						
A802 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A801 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
579A – Inshore of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
579B – Inshore of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys						
639 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
640 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
641 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
642 – SE of White Bank Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B33 – East of White Bank Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
643 – White Bank (NW of French)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B35 – West of Elbow Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
644 – Watson's Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
645 – Watson's Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
648 – East of Basin Hill Shoals	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
649 – West of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B39 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0

Site number/site location	*Chromodoris nyalya*			*Glossodoris sedna*		
	Frequency	**N**	**No./m^2**	**Frequency**	**N**	**No./m^2**
653 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (13)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Offshore Patch Reef Total (17)	**0 ± 0**	**0**	**0 ± 0**	**0 ± 0**	**0**	**0 ± 0**
Back reef rubble						
Middle Florida Keys						
578 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
583 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
555A – Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
555B – Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys						
688A – Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
688B – Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B62 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
691 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
688 – Sand Island	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
689 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
702B – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
702A – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (8)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Back Reef Rubble Total (12)	**0 ± 0**	**0**	**0 ± 0**	**0 ± 0**	**0**	**0 ± 0**
Low-relief hard-bottom (< 6 m)						
Middle Florida Keys						
A932 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
556 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A87 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A84 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A85 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
554 – Conch Reef C1**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
555 – Conch Reef C2**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A86 – Conch Reef C3**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
579C – NE of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (9)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys						
693 – Little Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
664 – North of French Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
665 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (3)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Shallow Hard-bottom Total (17)	**0 ± 0**	**0**	**0 ± 0**	**0 ± 0**	**0**	**0 ± 0**
High-relief spur and groove						
Upper Florida Keys						
697 – Pickles Reef P1	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
695 – Pickles Reef P3	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
696 – NE Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
706 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
707 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
711 – Sand Island	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
704 – French Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
705 – French Reef SPA**	0 ± 0	0	0 ± 0	25 ± 25	1	0.017 ± 0.017
699 – North of French Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
662 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0

Site number/site location	*Chromodoris nyalya*			*Glossodoris sedna*		
	Frequency	**N**	**No./m^2**	**Frequency**	**N**	**No./m^2**
663 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B42 – Little Grecian Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
660 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
661 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
656 – North Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
657 – North-North Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
702 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
703 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B66 – South of S. Carysfort	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
700A – South Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
700 – South Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B67 – Carysfort Reef C2**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
701 – Carysfort Reef C5**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
659 – Turtle Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (24)	0 ± 0	0	0 ± 0	1 ± 1	1	0.001 ± 0.001
High-relief Spur & Groove Total (42)	**0 ± 0**	**0**	**0 ± 0**	**1 ± 1**	**1**	**0.001 ± 0.001**
Deeper Fore-reef (6-15 m)						
Middle Florida Keys						
552 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
551 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
568 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
569 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
612 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A941 – North of Davis Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A942 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A94 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B24 – Conch Reef RO**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
625 – Conch Reef RO**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
611 – Conch Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
626 – Conch Reef RO**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
610 – Conch Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B16 – Conch Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (16)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys						
708 – NE of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
709 – Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
710 – SW of Molasses Reef SPA	25 ± 25	2	0.033 ± 0.033	0 ± 0	0	0 ± 0
712 – SW of French Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B71 – Dixie Shoal	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
671 – South of Grecian Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B51 – East of Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
713 – North of Elbow Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
682 – North of Elbow Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B57 – SE of Watson's Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
716 – South Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
678 – North Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
717 – North Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
679 – North Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
675 – North of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
676 – North of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
677 – North of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
715 – North of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (18)	1 ± 1	2	0.002 ± 0.002	0 ± 0	0	0 ± 0
Deeper Fore-reef Total (34)	**1 ± 1**	**2**	**0.001 ± 0.001**	**0 ± 0**	**0**	**0 ± 0**

Table 7-2. Mean ± 1 SE transect frequencies (%), densities (no. individuals per m^2), total length, and number of individuals (N) sampled for the sacoglossan *Elysia crispata* (lettuce sea slug) in the upper Florida Keys, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-September 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	Station frequency	N	Mean no. per m^2	Mean total length (cm)
Inshore and mid-channel patch reefs				
Middle Florida Keys				
A741 – Tavernier Rocks	0 ± 0	0	0 ± 0	
534 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
535 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
A74 – West of Conch Reef	0 ± 0	0	0 ± 0	
533 – West of Conch Reef	0 ± 0	0	0 ± 0	
A73 – West of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (6)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
638 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	
B25B – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
B25 – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
B25A – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
627 – Mosquito Bank	0 ± 0	0	0 ± 0	
629A – Mosquito Bank	0 ± 0	0	0 ± 0	
628 – Mosquito Bank	0 ± 0	0	0 ± 0	
629 – Mosquito Bank	0 ± 0	0	0 ± 0	
629B – Mosquito Bank	0 ± 0	0	0 ± 0	
630 – SE of Cannon Patch Reef	0 ± 0	0	0 ± 0	
631 – Marker 33	0 ± 0	0	0 ± 0	
633 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
634 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
637 – West of Turtle Rocks	0 ± 0	0	0 ± 0	
636 – West of Turtle Rocks	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (15)	0 ± 0	0	0 ± 0	
Mid-channel Patch Reef Total (21)	**0 ± 0**	**0**	**0 ± 0**	
Offshore patch reefs				
Middle Florida Keys				
A802 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
A801 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579A – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579B – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
639 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	
640 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	
641 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	
642 – SE of White Bank Dry Rocks	0 ± 0	0	0 ± 0	
B33 – East of White Bank Dry Rocks	0 ± 0	0	0 ± 0	
643 – White Bank (NW of French)	0 ± 0	0	0 ± 0	
B35 – West of Elbow Reef	0 ± 0	0	0 ± 0	
644 – Watson's Reef	0 ± 0	0	0 ± 0	
645 – Watson's Reef	0 ± 0	0	0 ± 0	
648 – East of Basin Hill Shoals	0 ± 0	0	0 ± 0	
649 – West of Carysfort Reef	0 ± 0	0	0 ± 0	
B39 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	
653 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	

Site number/site location	Station frequency	N	Mean no. per m^2	Mean total length (cm)
Upper Florida Keys Total (13)	0 ± 0	0	0 ± 0	
Offshore Patch Reef Total (17)	**0 ± 0**	**0**	**0 ± 0**	
Back reef rubble				
Middle Florida Keys				
578 – Crocker Reef	0 ± 0	0	0 ± 0	
583 – Crocker Reef	0 ± 0	0	0 ± 0	
555A – Conch Reef	0 ± 0	0	0 ± 0	
555B – Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
688A – Pickles Reef	0 ± 0	0	0 ± 0	
688B – Pickles Reef	0 ± 0	0	0 ± 0	
B62 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
691 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
688 – Sand Island	0 ± 0	0	0 ± 0	
689 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
702B – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
702A – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (8)	0 ± 0	0	0 ± 0	
Back Reef Rubble Total (12)	**0 ± 0**	**0**	**0 ± 0**	
Low-relief hard-bottom (< 6 m)				
Middle Florida Keys				
A932 – Crocker Reef	0 ± 0	0	0 ± 0	
556 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A87 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A84 – Little Conch Reef	0 ± 0	0	0 ± 0	
A85 – Little Conch Reef	0 ± 0	0	0 ± 0	
554 – Conch Reef C1**	0 ± 0	0	0 ± 0	
555 – Conch Reef C2**	0 ± 0	0	0 ± 0	
A86 – Conch Reef C3**	0 ± 0	0	0 ± 0	
579C – NE of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (9)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
693 – Little Pickles Reef	0 ± 0	0	0 ± 0	
664 – North of French Reef	0 ± 0	0	0 ± 0	
665 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (3)	0 ± 0	0	0 ± 0	
Shallow Hard-bottom Total (17)	**0 ± 0**	**0**	**0 ± 0**	
High-relief spur & groove				
Upper Florida Keys				
697 – Pickles Reef P1	0 ± 0	0	0 ± 0	
695 – Pickles Reef P3	0.25 ± 25	1	0.017 ± 0.017	3.5
696 – NE Pickles Reef	0 ± 0	0	0 ± 0	
706 – Molasses Reef SPA**	0.25 ± 25	1	0.017 ± 0.017	2.4
707 – Molasses Reef SPA**	0.50 ± 29	2	0.033 ± 0.019	2.7 ± 0.3
711 – Sand Island	0.50 ± 29	3	0.050 ± 0.032	3.0 ± 0.0
704 – French Reef SPA**	0 ± 0	0	0 ± 0	
705 – French Reef SPA**	0 ± 0	0	0 ± 0	
699 – North of French Reef	0 ± 0	0	0 ± 0	
662 – Grecian Rocks SPA**	0.50 ± 29	4	0.067 ± 0.047	2.6 ± 0.2
663 – Grecian Rocks SPA**	0.75 ± 25	3	0.050 ± 0.017	2.7 ± 0.5
B42 – Little Grecian Rocks	0.25 ± 25	1	0.017 ± 0.017	2.6
660 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	

Site number/site location	Station frequency	N	Mean no. per m^2	Mean total length (cm)
661 – Key Largo Dry Rocks**	0.25 ± 25	1	0.017 ± 0.017	2.2
656 – North Dry Rocks	0 ± 0	0	0 ± 0	
657 – North-North Dry Rocks	0 ± 0	0	0 ± 0	
702 – Elbow Reef SPA**	0.50 ± 29	6	0.100 ± 0.064	2.0 ± 0.2
703 – Elbow Reef SPA**	0.75 ± 25	3	0.050 ± 0.017	2.4 ± 0.4
B66 – South of S. Carysfort	0 ± 0	0	0 ± 0	
700A – South Carysfort Reef**	0.75 ± 25	3	0.050 ± 0.017	2.4 ± 0.5
700 – South Carysfort Reef**	0.50 ± 29	2	0.033 ± 0.019	2.8 ± 0.5
B67 – Carysfort Reef C2**	0.50 ± 29	2	0.033 ± 0.019	2.5 ± 0.5
701 – Carysfort Reef C5**	0.75 ± 25	5	0.083 ± 0.032	2.8 ± 0.3
659 – Turtle Reef	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (24)	29 ± 6	37	0.026 ± 0.006	2.6 ± 0.1
High-relief Spur & Groove Total (42)	**29 ± 6**	**37**	**0.026 ± 0.006**	**2.6 ± 0.1**
Deeper Fore-reef (6-15 m)				
Middle Florida Keys				
552 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
551 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
568 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
569 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
612 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A941 – North of Davis Reef	0 ± 0	0	0 ± 0	
A942 – Little Conch Reef	0 ± 0	0	0 ± 0	
A94 – Little Conch Reef	0 ± 0	0	0 ± 0	
B24 – Conch Reef RO**	0 ± 0	0	0 ± 0	
625 – Conch Reef RO**	0 ± 0	0	0 ± 0	
611 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
626 – Conch Reef RO**	0 ± 0	0	0 ± 0	
610 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
B16 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (16)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
708 – NE of Conch Reef	0 ± 0	0	0 ± 0	
709 – Pickles Reef	0 ± 0	0	0 ± 0	
710 – SW of Molasses Reef SPA	0 ± 0	0	0 ± 0	
712 – SW of French Reef	0 ± 0	0	0 ± 0	
B71 – Dixie Shoal	0 ± 0	0	0 ± 0	
671 – South of Grecian Rocks	0 ± 0	0	0 ± 0	
B51 – East of Dry Rocks	0 ± 0	0	0 ± 0	
713 – North of Elbow Reef	0 ± 0	0	0 ± 0	
682 – North of Elbow Reef	0 ± 0	0	0 ± 0	
B57 – SE of Watson's Reef	0 ± 0	0	0 ± 0	
716 – South Carysfort Reef**	0 ± 0	0	0 ± 0	
678 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
717 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
679 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
675 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
676 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
677 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
715 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (18)	0 ± 0	0	0 ± 0	
Deeper Fore-reef Total (34)	**0 ± 0**	**0**	**0 ± 0**	

Table 7-3. Mean ± 1 SE transect frequencies (%), densities (no. individuals per m^2), total shell length, and number of individuals (N) sampled for the gastropod *Coralliophila* sp. in the upper Florida Keys, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-September 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	Station frequency	N	Mean no. per m^2	Shell length (cm)
Inshore and mid-channel patch reefs				
Middle Florida Keys				
A741 – Tavernier Rocks	0 ± 0	0	0 ± 0	
534 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
535 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
A74 – West of Conch Reef	0 ± 0	0	0 ± 0	
533 – West of Conch Reef	0 ± 0	0	0 ± 0	
A73 – West of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (6)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
638 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	
B25B – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
B25 – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
B25A – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
627 – Mosquito Bank	0 ± 0	0	0 ± 0	
629A – Mosquito Bank	0 ± 0	0	0 ± 0	
628 – Mosquito Bank	0 ± 0	0	0 ± 0	
629 – Mosquito Bank	0 ± 0	0	0 ± 0	
629B – Mosquito Bank	0 ± 0	0	0 ± 0	
630 – SE of Cannon Patch Reef	0 ± 0	0	0 ± 0	
631 – Marker 33	0 ± 0	0	0 ± 0	
633 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
634 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
637 – West of Turtle Rocks	0 ± 0	0	0 ± 0	
636 – West of Turtle Rocks	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (15)	0 ± 0	0	0 ± 0	
Mid-channel Patch Reef Total (21)	**0 ± 0**	**0**	**0 ± 0**	
Offshore patch reefs				
Middle Florida Keys				
A802 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
A801 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579A – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579B – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
639 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	
640 – White Bank (West of Molasses)	25 ± 25	1	0.017 ± 0.017	0.6
641 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	
642 – SE of White Bank Dry Rocks	25 ± 25	1	0.017 ± 0.017	1.0
B33 – East of White Bank Dry Rocks	0 ± 0	0	0 ± 0	
643 – White Bank (NW of French)	0 ± 0	0	0 ± 0	
B35 – West of Elbow Reef	0 ± 0	0	0 ± 0	
644 – Watson's Reef	50 ± 29	7	0.117 ± 0.079	1.9 ± 0.2
645 – Watson's Reef	0 ± 0	0	0 ± 0	
648 – East of Basin Hill Shoals	0 ± 0	0	0 ± 0	
649 – West of Carysfort Reef	0 ± 0	0	0 ± 0	
B39 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	
653 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	

Site number/site location	Station frequency	N	Mean no. per m^2	Shell length (cm)
Upper Florida Keys Total (13)	8 ± 4	9	0.012 ± 0.009	1.7 ± 0.2
Offshore Patch Reef Total (17)	**6 ± 3**	**9**	**0.009 ± 0.007**	**1.7 ± 0.2**
Back reef rubble				
Middle Florida Keys				
578 – Crocker Reef	0 ± 0	0	0 ± 0	
583 – Crocker Reef	0 ± 0	0	0 ± 0	
555A – Conch Reef	0 ± 0	0	0 ± 0	
555B – Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
688A – Pickles Reef	0 ± 0	0	0 ± 0	
688B – Pickles Reef	0 ± 0	0	0 ± 0	
B62 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
691 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
688 – Sand Island	0 ± 0	0	0 ± 0	
689 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
702B – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
702A – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (8)	0 ± 0	0	0 ± 0	
Back Reef Rubble Total (12)	**0 ± 0**	**0**	**0 ± 0**	
Low-relief hard-bottom (< 6 m)				
Middle Florida Keys				
A932 – Crocker Reef	25 ± 25	1	0.017 ± 0.017	2.5
556 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A87 – Davis Reef SPA**	25 ± 25	1	0.017 ± 0.017	2.5
A84 – Little Conch Reef	0 ± 0	0	0 ± 0	
A85 – Little Conch Reef	0 ± 0	0	0 ± 0	
554 – Conch Reef C1**	50 ± 29	5	0.083 ± 0.050	1.8 ± 0.3
555 – Conch Reef C2**	0 ± 0	0	0 ± 0	
A86 – Conch Reef C3**	0 ± 0	0	0 ± 0	
579C – NE of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (9)	11 ± 6	7	0.013 ± 0.009	2.0 ± 0.3
Upper Florida Keys				
693 – Little Pickles Reef	25 ± 25	1	0.017 ± 0.017	1.1
664 – North of French Reef	0 ± 0	0	0 ± 0	
665 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (3)	8 ± 8	1	0.006 ± 0.006	1.1
Shallow Hard-bottom Total (17)	**10 ± 5**	**8**	**0.011 ± 0.007**	**1.9 ± 0.2**
High-relief spur & groove				
Upper Florida Keys				
697 – Pickles Reef P1	25 ± 25	4	0.067 ± 0.067	1.4 ± 0.2
695 – Pickles Reef P3	0 ± 0	0	0 ± 0	
696 – NE Pickles Reef	25 ± 25	1	0.017 ± 0.017	4.0
706 – Molasses Reef SPA**	25 ± 25	5	0.083 ± 0.083	1.5 ± 0.2
707 – Molasses Reef SPA**	25 ± 25	4	0.067 ± 0.067	1.2 ± 0.0
711 – Sand Island	50 ± 29	14	0.233 ± 0.145	2.6 ± 0.2
704 – French Reef SPA**	0 ± 0	0	0 ± 0	
705 – French Reef SPA**	0 ± 0	0	0 ± 0	
699 – North of French Reef	0 ± 0	0	0 ± 0	
662 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	
663 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	
B42 – Little Grecian Rocks	0 ± 0	0	0 ± 0	
660 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	

Site number/site location	Station frequency	N	Mean no. per m^2	Shell length (cm)
661 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	
656 – North Dry Rocks	25 ± 25	1	0.017 ± 0.017	2.0
657 – North-North Dry Rocks	25 ± 25	12	0.200 ± 0.200	1.8 ± 0.1
702 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
703 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
B66 – South of S. Carysfort	0 ± 0	0	0 ± 0	
700A – South Carysfort Reef**	25 ± 25	1	0.017 ± 0.017	1.8
700 – South Carysfort Reef**	25 ± 25	2	0.033 ± 0.033	2.6 ± 0.8
B67 – Carysfort Reef C2**	0 ± 0	0	0 ± 0	
701 – Carysfort Reef C5**	25 ± 25	1	0.017 ± 0.017	2.1
659 – Turtle Reef	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (24)	11 ± 3	45	0.031 ± 0.013	2.1 ± 0.1
High-relief Spur & Groove Total (42)	**11 ± 3**	**45**	**0.031 ± 0.013**	**2.1 ± 0.1**
Deeper Fore-reef (6-15 m)				
Middle Florida Keys				
552 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
551 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
568 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
569 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
612 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A941 – North of Davis Reef	0 ± 0	0	0 ± 0	
A942 – Little Conch Reef	25 ± 25	2	0.033 ± 0.033	1.8 ± 0.6
A94 – Little Conch Reef	50 ± 29	7	0.117 ± 0.069	1.8 ± 0.2
B24 – Conch Reef RO**	0 ± 0	0	0 ± 0	
625 – Conch Reef RO**	50 ± 29	6	0.100 ± 0.064	1.8 ± 0.1
611 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
626 – Conch Reef RO**	25 ± 25	5	0.083 ± 0.083	1.7 ± 0.2
610 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
B16 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (16)	9 ± 4	20	0.021 ± 0.010	1.8 ± 0.1
Upper Florida Keys				
708 – NE of Conch Reef	0 ± 0	0	0 ± 0	
709 – Pickles Reef	0 ± 0	0	0 ± 0	
710 – SW of Molasses Reef SPA	0 ± 0	0	0 ± 0	
712 – SW of French Reef	0 ± 0	0	0 ± 0	
B71 – Dixie Shoal	50 ± 29	2	0.033 ± 0.019	0.8 ± 0.2
671 – South of Grecian Rocks	0 ± 0	0	0 ± 0	
B51 – East of Dry Rocks	25 ± 25	1	0.017 ± 0.017	1.0
713 – North of Elbow Reef	25 ± 25	1	0.017 ± 0.017	1.8
682 – North of Elbow Reef	25 ± 25	1	0.017 ± 0.017	2.1
B57 – SE of Watson's Reef	25 ± 25	2	0.017 ± 0.017	2.0 ± 0.0
716 – South Carysfort Reef**	0 ± 0	0	0 ± 0	
678 – North Carysfort Reef**	25 ± 25	1	0.017 ± 0.017	2.4
717 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
679 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
675 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
676 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
677 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
715 – North of Carysfort Reef	25 ± 25	6	0.100 ± 0.064	1.6
Upper Florida Keys Total (18)	11 ± 4	9	0.008 ± 0.003	1.6 ± 0.2
Deeper Fore-reef Total (34)	**10 ± 3**	**29**	**0.014 ± 0.005**	**1.7 ± 0.1**

Table 7-4. Mean ± 1 SE transect frequencies (%), densities (no. individuals per m^2), total shell length, and number of individuals (N) sampled for the gastropod *Leucozonia nassa* in the upper Florida Keys, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-September 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	Station frequency	N	Mean no. per m^2	Shell length (cm)
Inshore and mid-channel patch reefs				
Middle Florida Keys				
A741 – Tavernier Rocks	0 ± 0	0	0 ± 0	
534 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
535 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
A74 – West of Conch Reef	0 ± 0	0	0 ± 0	
533 – West of Conch Reef	0 ± 0	0	0 ± 0	
A73 – West of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (6)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
638 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	
B25B – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
B25 – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
B25A – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
627 – Mosquito Bank	0 ± 0	0	0 ± 0	
629A – Mosquito Bank	0 ± 0	0	0 ± 0	
628 – Mosquito Bank	0 ± 0	0	0 ± 0	
629 – Mosquito Bank	0 ± 0	0	0 ± 0	
629B – Mosquito Bank	0 ± 0	0	0 ± 0	
630 – SE of Cannon Patch Reef	0 ± 0	0	0 ± 0	
631 – Marker 33	0 ± 0	0	0 ± 0	
633 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
634 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
637 – West of Turtle Rocks	0 ± 0	0	0 ± 0	
636 – West of Turtle Rocks	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (15)	0 ± 0	0	0 ± 0	
Mid-channel Patch Reef Total (21)	**0 ± 0**	**0**	**0 ± 0**	
Offshore patch reefs				
Middle Florida Keys				
A802 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
A801 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579A – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579B – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
639 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	
640 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	
641 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	
642 – SE of White Bank Dry Rocks	0 ± 0	0	0 ± 0	
B33 – East of White Bank Dry Rocks	0 ± 0	0	0 ± 0	
643 – White Bank (NW of French)	0 ± 0	0	0 ± 0	
B35 – West of Elbow Reef	0 ± 0	0	0 ± 0	
644 – Watson's Reef	0 ± 0	0	0 ± 0	
645 – Watson's Reef	0 ± 0	0	0 ± 0	
648 – East of Basin Hill Shoals	0 ± 0	0	0 ± 0	
649 – West of Carysfort Reef	0 ± 0	0	0 ± 0	
B39 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	
653 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	

Site number/site location	Station frequency	N	Mean no. per m^2	Shell length (cm)
Upper Florida Keys Total (13)	0 ± 0	0	0 ± 0	
Offshore Patch Reef Total (17)	**0 ± 0**	**0**	**0 ± 0**	
Back reef rubble				
Middle Florida Keys				
578 – Crocker Reef	0 ± 0	0	0 ± 0	
583 – Crocker Reef	25 ± 25	1	0.017 ± 0.017	3.7
555A – Conch Reef	0 ± 0	0	0 ± 0	
555B – Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (4)	6 ± 6	1	0.004 ± 0.004	3.7
Upper Florida Keys				
688A – Pickles Reef	0 ± 0	0	0 ± 0	
688B – Pickles Reef	25 ± 25	1	0.017 ± 0.017	2.3
B62 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
691 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
688 – Sand Island	25 ± 25	1	0.017 ± 0.017	1.8
689 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
702B – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
702A – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (8)	6 ± 4	2	0.004 ± 0.003	2.1 ± 0.3
Back Reef Rubble Total (12)	**6 ± 3**	**3**	**0.004 ± 0.002**	2.6 ± 0.6
Low-relief hard-bottom (< 6 m)				
Middle Florida Keys				
A932 – Crocker Reef	25 ± 25	1	0.017 ± 0.017	3.1
556 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A87 – Davis Reef SPA**	25 ± 25	1	0.017 ± 0.017	3.8
A84 – Little Conch Reef	25 ± 25	1	0.017 ± 0.017	2.8
A85 – Little Conch Reef	0 ± 0	0	0 ± 0	
554 – Conch Reef C1**	75 ± 25	5	0.083 ± 0.032	3.2 ± 0.5
555 – Conch Reef C2**	25 ± 25	1	0.017 ± 0.017	2.4
A86 – Conch Reef C3**	0 ± 0	0	0 ± 0	
579C – NE of Conch Reef	25 ± 25	1	0.017 ± 0.017	2.4
Middle Florida Keys Total (9)	22 ± 8	10	0.019 ± 0.009	3.1 ± 0.3
Upper Florida Keys				
693 – Little Pickles Reef	25 ± 25	1	0.017 ± 0.017	4.4
664 – North of French Reef	25 ± 25	1	0.017 ± 0.017	4.3
665 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (3)	17 ± 8	2	0.011 ± 0.006	4.4 ± 0.1
Shallow Hard-bottom Total (17)	**21 ± 6**	**12**	**0.017 ± 0.006**	**3.3 ± 0.3**
High-relief spur & groove				
Upper Florida Keys				
697 – Pickles Reef P1	25 ± 25	1	0.017 ± 0.017	3.2
695 – Pickles Reef P3	0 ± 0	0	0 ± 0	
696 – NE Pickles Reef	25 ± 25	1	0.017 ± 0.017	3.4
706 – Molasses Reef SPA**	25 ± 25	1	0.017 ± 0.017	3.5
707 – Molasses Reef SPA**	100 ± 0	4	0.067 ± 0.027	2.9 ± 0.6
711 – Sand Island	75 ± 25	13	0.217 ± 0.134	2.9 ± 0.2
704 – French Reef SPA**	25 ± 25	1	0.017 ± 0.017	3.0
705 – French Reef SPA**	25 ± 25	2	0.033 ± 0.033	2.8 ± 0.5
699 – North of French Reef	50 ± 29	3	0.050 ± 0.032	2.5 ± 0.2
662 – Grecian Rocks SPA**	50 ± 29	2	0.033 ± 0.019	3.6 ± 0.2
663 – Grecian Rocks SPA**	25 ± 25	1	0.017 ± 0.017	3.8
B42 – Little Grecian Rocks	0 ± 0	0	0 ± 0	
660 – Key Largo Dry Rocks**	75 ± 25	3	0.050 ± 0.017	3.1 ± 0.1

Site number/site location	Station frequency	N	Mean no. per m^2	Shell length (cm)
661 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	
656 – North Dry Rocks	0 ± 0	0	0 ± 0	
657 – North-North Dry Rocks	25 ± 25	1	0.017 ± 0.017	6.0
702 – Elbow Reef SPA**	50 ± 29	2	0.033 ± 0.019	2.6 ± 0.1
703 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
B66 – South of S. Carysfort	25 ± 25	1	0.017 ± 0.017	3.6
700A – South Carysfort Reef**	0 ± 0	0	0 ± 0	
700 – South Carysfort Reef**	0 ± 0	0	0 ± 0	
B67 – Carysfort Reef C2**	0 ± 0	0	0 ± 0	
701 – Carysfort Reef C5**	25 ± 25	1	0.017 ± 0.017	1.4
659 – Turtle Reef	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (24)	26 ± 6	37	0.026 ± 0.009	3.0 ± 0.1
High-relief Spur & Groove Total (42)	**26 ± 6**	**37**	**0.026 ± 0.009**	**3.0 ± 0.1**
Deeper Fore-reef (6-15 m)				
Middle Florida Keys				
552 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
551 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
568 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
569 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
612 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A941 – North of Davis Reef	0 ± 0	0	0 ± 0	
A942 – Little Conch Reef	0 ± 0	0	0 ± 0	
A94 – Little Conch Reef	0 ± 0	0	0 ± 0	
B24 – Conch Reef RO**	0 ± 0	0	0 ± 0	
625 – Conch Reef RO**	0 ± 0	0	0 ± 0	
611 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
626 – Conch Reef RO**	0 ± 0	0	0 ± 0	
610 – Conch Reef SPA**	25 ± 25	1	0.017 ± 0.017	6.1
B16 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (16)	2 ± 2	1	0.001 ± 0.001	6.1
Upper Florida Keys				
708 – NE of Conch Reef	0 ± 0	0	0 ± 0	
709 – Pickles Reef	0 ± 0	0	0 ± 0	
710 – SW of Molasses Reef SPA	0 ± 0	0	0 ± 0	
712 – SW of French Reef	0 ± 0	0	0 ± 0	
B71 – Dixie Shoal	0 ± 0	0	0 ± 0	
671 – South of Grecian Rocks	0 ± 0	0	0 ± 0	
B51 – East of Dry Rocks	0 ± 0	0	0 ± 0	
713 – North of Elbow Reef	0 ± 0	0	0 ± 0	
682 – North of Elbow Reef	0 ± 0	0	0 ± 0	
B57 – SE of Watson's Reef	0 ± 0	0	0 ± 0	
716 – South Carysfort Reef**	0 ± 0	0	0 ± 0	
678 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
717 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
679 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
675 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
676 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
677 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
715 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (18)	0 ± 0	0	0 ± 0	
Deeper Fore-reef Total (34)	**1 ± 1**	**1**	**<0.001 ± <0.001**	**6.1**

Table 7-5. Mean ± 1 SE transect frequencies (%), densities (no. individuals per m^2), total shell length, and number of individuals (N) sampled for the gastropod *Thais deltoidea* in the upper Florida Keys, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-September 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	Station frequency	N	Mean no. per m^2	Shell length (cm)
Inshore and mid-channel patch reefs				
Middle Florida Keys				
A741 – Tavernier Rocks	25 ± 25	1	0.017 ± 0.017	4.2
534 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
535 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	
A74 – West of Conch Reef	0 ± 0	0	0 ± 0	
533 – West of Conch Reef	0 ± 0	0	0 ± 0	
A73 – West of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (6)	4 ± 4	1	0.003 ± 0.003	4.2
Upper Florida Keys				
638 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	
B25B – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
B25 – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
B25A – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	
627 – Mosquito Bank	0 ± 0	0	0 ± 0	
629A – Mosquito Bank	0 ± 0	0	0 ± 0	
628 – Mosquito Bank	0 ± 0	0	0 ± 0	
629 – Mosquito Bank	0 ± 0	0	0 ± 0	
629B – Mosquito Bank	0 ± 0	0	0 ± 0	
630 – SE of Cannon Patch Reef	0 ± 0	0	0 ± 0	
631 – Marker 33	0 ± 0	0	0 ± 0	
633 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
634 – Basin Hill Shoals	0 ± 0	0	0 ± 0	
637 – West of Turtle Rocks	0 ± 0	0	0 ± 0	
636 – West of Turtle Rocks	25 ± 25	1	0.017 ± 0.017	3.1
Upper Florida Keys Total (15)	2 ± 2	1	0.001 ± 0.001	3.1
Mid-channel Patch Reef Total (21)	**2 ± 2**	**2**	**0.002 ± 0.001**	**3.7 ± 0.6**
Offshore patch reefs				
Middle Florida Keys				
A802 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
A801 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579A – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
579B – Inshore of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	
Upper Florida Keys				
639 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	
640 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	
641 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	
642 – SE of White Bank Dry Rocks	0 ± 0	0	0 ± 0	
B33 – East of White Bank Dry Rocks	25 ± 25	1	0.017 ± 0.017	4.7
643 – White Bank (NW of French)	0 ± 0	0	0 ± 0	
B35 – West of Elbow Reef	0 ± 0	0	0 ± 0	
644 – Watson's Reef	25 ± 25	1	0.017 ± 0.017	3.9
645 – Watson's Reef	25 ± 25	1	0.017 ± 0.017	4.1
648 – East of Basin Hill Shoals	0 ± 0	0	0 ± 0	
649 – West of Carysfort Reef	0 ± 0	0	0 ± 0	
B39 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	
653 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	

Site number/site location	Station frequency	N	Mean no. per m^2	Shell length (cm)
Upper Florida Keys Total (13)	6 ± 3	3	0.004 ± 0.002	4.2 ± 0.2
Offshore Patch Reef Total (17)	**4 ± 2**	**3**	**0.003 ± 0.002**	**4.2 ± 0.2**
Back reef rubble				
Middle Florida Keys				
578 – Crocker Reef	0 ± 0	0	0 ± 0	
583 – Crocker Reef	0 ± 0	0	0 ± 0	
555A – Conch Reef	25 ± 25	1	0.017 ± 0.017	2.1
555B – Conch Reef	25 ± 25	1	0.017 ± 0.017	3.4
Middle Florida Keys Total (4)	13 ± 7	2	0.008 ± 0.005	2.8 ± 0.7
Upper Florida Keys				
688A – Pickles Reef	0 ± 0	0	0 ± 0	
688B – Pickles Reef	0 ± 0	0	0 ± 0	
B62 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
691 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	
688 – Sand Island	50 ± 29	2	0.033 ± 0.019	1.6 ± 0.2
689 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
702B – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
702A – Elbow Reef SPA**	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (8)	6 ± 6	2	0.004 ± 0.004	1.6 ± 0.2
Back Reef Rubble Total (12)	**8 ± 5**	**4**	**0.006 ± 0.003**	**2.2 ± 0.4**
Low-relief hard-bottom (< 6 m)				
Middle Florida Keys				
A932 – Crocker Reef	0 ± 0	0	0 ± 0	
556 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A87 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A84 – Little Conch Reef	0 ± 0	0	0 ± 0	
A85 – Little Conch Reef	0 ± 0	0	0 ± 0	
554 – Conch Reef C1**	0 ± 0	0	0 ± 0	
555 – Conch Reef C2**	0 ± 0	0	0 ± 0	
A86 – Conch Reef C3**	0 ± 0	0	0 ± 0	
579C – NE of Conch Reef	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (9)	0 ± 0	48	0 ± 0	2.7 ± 0.1
Upper Florida Keys				
693 – Little Pickles Reef	0 ± 0	0	0 ± 0	
664 – North of French Reef	0 ± 0	0	0 ± 0	
665 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (3)	0 ± 0	5	0 ± 0	3.1 ± 0.2
Shallow Hard-bottom Total (17)	**0 ± 0**	**53**	**0 ± 0**	**2.8 ± 0.1**
High-relief spur & groove				
Upper Florida Keys				
697 – Pickles Reef P1	100 ± 0	14	0.233 ± 0.033	2.5 ± 0.1
695 – Pickles Reef P3	100 ± 0	13	0.217 ± 0.050	2.4 ± 0.1
696 – NE Pickles Reef	75 ± 36	8	0.133 ± 0.090	2.9 ± 0.2
706 – Molasses Reef SPA**	50 ± 29	6	0.100 ± 0.064	3.0 ± 0.2
707 – Molasses Reef SPA**	100 ± 0	15	0.250 ± 0.107	3.1 ± 0.1
711 – Sand Island	100 ± 0	18	0.300 ± 0.169	2.5 ± 0.1
704 – French Reef SPA**	100 ± 0	7	0.117 ± 0.032	2.8 ± 0.4
705 – French Reef SPA**	100 ± 0	9	0.150 ± 0.032	2.6 ± 0.1
699 – North of French Reef	75 ± 25	4	0.067 ± 0.027	3.4 ± 0.3
662 – Grecian Rocks SPA**	75 ± 25	3	0.050 ± 0.017	2.6 ± 0.2
663 – Grecian Rocks SPA**	100 ± 0	28	0.467 ± 0.098	2.6 ± 0.1
B42 – Little Grecian Rocks	75 ± 25	6	0.100 ± 0.033	2.9 ± 0.2
660 – Key Largo Dry Rocks**	100 ± 0	32	0.533 ± 0.239	2.6 ± 0.1

Site number/site location	Station frequency	N	Mean no. per m^2	Shell length (cm)
661 – Key Largo Dry Rocks**	100 ± 0	10	0.167 ± 0.043	2.9 ± 0.1
656 – North Dry Rocks	75 ± 25	19	0.317 ± 0.191	2.6 ± 0.1
657 – North-North Dry Rocks	50 ± 29	4	0.067 ± 0.047	2.7 ± 0.2
702 – Elbow Reef SPA**	75 ± 25	7	0.117 ± 0.042	2.8 ± 0.3
703 – Elbow Reef SPA**	75 ± 25	5	0.083 ± 0.032	2.5 ± 0.2
B66 – South of S. Carysfort	100 ± 0	45	0.750 ± 0.185	2.6 ± 0.1
700A – South Carysfort Reef**	75 ± 25	19	0.317 ± 0.137	2.6 ± 0.1
700 – South Carysfort Reef**	100 ± 0	26	0.433 ± 0.096	2.4 ± 0.1
B67 – Carysfort Reef C2**	100 ± 0	13	0.217 ± 0.042	2.6 ± 0.1
701 – Carysfort Reef C5**	100 ± 0	10	0.167 ± 0.064	2.5 ± 0.2
659 – Turtle Reef	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (24)	83 ± 5	321	0.223 ± 0.036	2.6 ± 0.0
High-relief Spur & Groove Total (42)	**83 ± 5**	**321**	**0.223 ± 0.036**	**2.6 ± 0.0**
Deeper Fore-reef (6-15 m)				
Middle Florida Keys				
552 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
551 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
568 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
569 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	
612 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	
A941 – North of Davis Reef	0 ± 0	0	0 ± 0	
A942 – Little Conch Reef	25 ± 25	1	0.017 ± 0.017	3.8
A94 – Little Conch Reef	0 ± 0	0	0 ± 0	
B24 – Conch Reef RO**	0 ± 0	0	0 ± 0	
625 – Conch Reef RO**	0 ± 0	0	0 ± 0	
611 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
626 – Conch Reef RO**	0 ± 0	0	0 ± 0	
610 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
B16 – Conch Reef SPA**	0 ± 0	0	0 ± 0	
Middle Florida Keys Total (16)	2 ± 2	1	0.001 ± 0.001	3.8
Upper Florida Keys				
708 – NE of Conch Reef	0 ± 0	0	0 ± 0	
709 – Pickles Reef	0 ± 0	0	0 ± 0	
710 – SW of Molasses Reef SPA	0 ± 0	0	0 ± 0	
712 – SW of French Reef	0 ± 0	0	0 ± 0	
B71 – Dixie Shoal	0 ± 0	0	0 ± 0	
671 – South of Grecian Rocks	0 ± 0	0	0 ± 0	
B51 – East of Dry Rocks	0 ± 0	0	0 ± 0	
713 – North of Elbow Reef	0 ± 0	0	0 ± 0	
682 – North of Elbow Reef	0 ± 0	0	0 ± 0	
B57 – SE of Watson's Reef	0 ± 0	0	0 ± 0	
716 – South Carysfort Reef**	0 ± 0	0	0 ± 0	
678 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
717 – North Carysfort Reef**	25 ± 25	1	0.017 ± 0.017	3.8
679 – North Carysfort Reef**	0 ± 0	0	0 ± 0	
675 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
676 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
677 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
715 – North of Carysfort Reef	0 ± 0	0	0 ± 0	
Upper Florida Keys Total (18)	1 ± 1	1	0.001 ± 0.001	3.8
Deeper Fore-reef Total (34)	**1 ± 1**	**2**	**0.001 ± 0.001**	**3.8 ± 0.0**

Table 7-6. Number of individuals (N), mean, standard error (SE) and range in total length or total shell length for nudibranch, sacoglossan, and gastropod mollusks by species and habitat type in the upper Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-August 2010.

Habitat type (no. sites)	Depth (m)	N	Mean length (cm)	SE	Min. length (cm)	Max. length (cm)
Chromodoris nyalya						
Inshore and mid-channel patch reef (21)	1.2-6.7	0				
Offshore patch reef (17)	1.8-8.2	0				
Back reef rubble (12)	1.5-6.1	0				
Shallow (< 6 m) hard-bottom (12)	3.0-7.3	0				
High-relief spur and groove (24)	1.5-8.2	0				
Deeper (6-15 m) fore-reef (34)	5.8-14.9	2	1.1	0.1	1.0	1.2
All habitats combined (120 sites)	1.2-14.9	2	1.1	0.1	1.0	1.2
Glossodoris sedna						
Inshore and mid-channel patch reef (21)	1.2-6.7	0				
Offshore patch reef (17)	1.8-8.2	0				
Back reef rubble (12)	1.5-6.1	0				
Shallow (< 6 m) hard-bottom (12)	3.0-7.3	0				
High-relief spur and groove (24)	1.5-8.2	1	2.5		2.5	2.5
Deeper (6-15 m) fore-reef (34)	5.8-14.9	0				
All habitats combined (120 sites)	1.2-14.9	1	2.5		2.5	2.5
Elysia crispata						
Inshore and mid-channel patch reef (21)	1.2-6.7	0				
Offshore patch reef (17)	1.8-8.2	0				
Back reef rubble (12)	1.5-6.1	0				
Shallow (< 6 m) hard-bottom (12)	3.0-7.3	0				
High-relief spur and groove (24)	1.5-8.2	37	2.6	0.1	1.5	3.9
Deeper (6-15 m) fore-reef (34)	5.8-14.9	0				
All habitats combined (120 sites)	1.2-14.9	37	2.6	0.1	1.5	3.9
***Coralliophila* sp.**						
Inshore and mid-channel patch reef (21)	1.2-6.7	0				
Offshore patch reef (17)	1.8-8.2	9	1.7	0.2	0.6	2.4
Back reef rubble (12)	1.5-6.1	0				
Shallow (< 6 m) hard-bottom (12)	3.0-7.3	8	1.9	0.2	1.1	2.8
High-relief spur and groove (24)	1.5-8.2	45	2.0	0.1	1.0	4.2
Deeper (6-15 m) fore-reef (34)	5.8-14.9	29	1.7	0.1	0.6	2.5
All habitats combined (120 sites)	1.2-14.9	91	1.9	0.1	0.6	4.2
Leucozonia nassa						
Inshore and mid-channel patch reef (21)	1.2-6.7	0				
Offshore patch reef (17)	1.8-8.2	0				
Back reef rubble (12)	1.5-6.1	3	2.6	0.6	1.8	3.7
Shallow (< 6 m) hard-bottom (12)	3.0-7.3	12	3.3	0.3	2.4	5.3
High-relief spur and groove (24)	1.5-8.2	37	3.0	0.1	1.4	6.0
Deeper (6-15 m) fore-reef (34)	5.8-14.9	1	6.1		6.1	6.1
All habitats combined (120 sites)	1.2-14.9	53	3.1	0.1	1.4	6.1
Thais deltoidea						
Inshore and mid-channel patch reef (21)	1.2-6.7	2	3.7	0.5	3.1	4.2
Offshore patch reef (17)	1.8-8.2	3	4.2	0.2	3.9	4.7
Back reef rubble (12)	1.5-6.1	4	2.2	0.4	1.4	3.4
Shallow (< 6 m) hard-bottom (12)	3.0-7.3	53	2.8	0.1	1.8	3.7
High-relief spur and groove (24)	1.5-8.2	321	2.6	0.0	1.3	4.0
Deeper (6-15 m) fore-reef (34)	5.8-14.9	2	3.8	0.0	3.8	3.8
All habitats combined (120 sites)	1.2-14.9	385	2.7	0.0	1.3	4.7

Table 7-7. Substratum occupancy patterns for gastropod mollusks surveyed at 120 sites in the upper Florida Keys National Marine Sanctuary during June-August 2010. Data represent the number of individuals (N) and the proportion (%) of individuals found on particular substrata. Note that other mollusks surveyed (nudibranchs, sacoglossans) were only found on algal turf.

Substratum type	*Coralliophila* sp.		*Leucozonia nassa*		*Thais deltoidea*	
	N	%	N	%	N	%
Scleractinian corals						
Agaricia agaricites	39	42.9	0	0	0	0
Acropora cervicornis	1	1.1	0	0	0	0
A. palmata	21	23.1	0	0	0	0
Colpophyllia natans	2	2.2	0	0	0	0
Diploria labyrinthiformis	9	9.9	0	0	0	0
Montastraea faveolata	10	11.0	0	0	0	0
Porites astreoides	3	3.3	0	0	0	0
Siderastrea siderea	2	2.2	0	0	0	0
Total coral	87	95.6	0	0	0	0
Algae						
Algal turf	4	4.4	13	24.5	345	89.6
Crustose coralline algae	0	0	37	69.8	20	5.2
Dictyota spp.	0	0	1	1.9	11	2.9
Total algae	4	4.4	51	96.2	376	97.7
Other snail	0	0	0	0	6	1.6
Sand	0	0	2	3.8	3	0.8
Total	91	100	53	100	385	100

VIII. Marine Debris

Background

Fishing constitutes one of the most significant threats to marine biodiversity and ecosystem function, as evidenced by a significant body of information on the numerous impacts to populations, community structure, and habitats (Dayton et al. 1995; Roberts 1995; Jennings and Polunin 1996). Besides the more obvious effects on the population structure of targeted species, fishing activities may also reduce the structural complexity of habitats or cause corresponding changes in ecological processes such as competition and predation (Russ 1991; Jones and Syms 1998; Auster and Langton 1999). These patterns are most obvious in areas where explosives, poisons, or other destructive fishing methods are used (Hatcher et al. 1989). However, ecological effects may occur in areas where traps, mobile fishing gear such as trawls, and potentially, even large numbers of recreational fishers operate (Russ 1991; Jennings and Lock 1996).

The Florida Keys have a long history of commercial and recreational fisheries that target a great diversity of fish and invertebrate species using a multitude of gears (Tilmant 1989; Bohnsack et al. 1994). In terms of volume of seafood landed, the Florida Keys is the most important area in the State of Florida in landings, dockside value, and numbers of commercial fishing vessels, especially for highly valued invertebrate fisheries represented by pink shrimp, stone crab, and spiny lobster (Adams 1992). There are also significant, but largely undocumented effects of tens of thousands of recreational fishers, who target hundreds of species using mostly hook-and-line and spear guns (Davis 1977; Bohnsack et al. 1994).

Baseline data on marine debris and the biological impacts to coral reef benthic organisms were collected by our program during 2000, 2001, and 2008 (Chiappone et al. 2002c, 2004, 2005). Earlier surveys consisted of quantitative surveys of debris at 45 sites in the lower Keys from inshore to offshore during 2000, followed by surveys of 63 platform margin sites Keys-wide in 2001. These initial efforts addressed several questions pertaining to marine debris and its impacts to benthic organisms. First, what is the spatial extent and frequency of remnant fishing gear at multiple spatial scales in the Florida Keys? Second, what factors, such as habitat type (depth) or management regime (closed or open to fishing) affect the spatial variability of marine debris occurrence? Third, what are the biological impacts of marine debris, especially from remnant commercial and recreational fishing gear, on reef biota such as hard corals and sponges? As a follow-up to these initial surveys, a major effort was expended during 2008 to document the different debris types, length (where applicable), weight, and impacts to benthic coral reef organisms (e.g. abrasion damage) at 145 sites partitioned by habitat type, regional sector, and management zone from northern Key Largo to SW of Key West. To our knowledge, these data represent

the most comprehensive site-level assessment of marine debris and its corresponding impacts in the Florida Keys. These data demonstrate the ubiquitous and damaging characteristics of marine debris, particularly derelict fishing gear, even within "protected" no-fishing zones in the Sanctuary. In 2010, we were able to incorporate marine debris surveys in our upper Keys sampling design to document the frequency of occurrence and biological impacts of marine debris encountered in the course of belt transect surveys for other benthic variables. Although logistics prevented us from retrieving much of the debris encountered, we were able to continue to build a temporal record of occurrence and impacts to benthic coral reef organisms.

2010 Survey Results

At the 120 upper Florida Keys sites sampled during 2010, four belt transects 15-m x 1-m in dimension were used to quantify the type, transect frequency of occurrence, density, and impacts (debris causing tissue abrasion) of marine debris to benthic coral reef organisms. In contrast to previous years, logistics prevented us from measuring and weighing the debris recovered from the seabed. Figure 8-1 illustrates examples of marine debris encountered. From surveys of 480 belt transects comprising 7,200 m^2 of hard-bottom and coral reef habitat, a total of 218 marine debris items were encountered, representing 28 different items or combinations of items (Table 8-1). Of these 28 different debris types, ten categories (36%) were clearly hook-and-line angling gear, five (18%) were lost lobster/crab trap gear, and the remaining 13 categories (46%) were designated as "other". Other marine debris included a range of metal, cloth, ceramic, and plastic items. Of the 218 total debris items counted, 149 (68%) were hook-and-line gear (monofilament, wire leaders, hooks, lead sinkers, etc.), followed by 43 trap debris items (20%), and other debris (26 items, 12%) (Table 8-1).

The debris items encountered caused abrasion damage (tissue loss) to 118 different coral reef benthic organisms, represented by *Millepora* and scleractinian corals, gorgonians, sponges, and the colonial zoanthid *Palythoa* (Table 8-1). Lost hook-and-line gear caused impacts to 72 different organisms (61%), followed by trap debris (37 impacted organisms, 31%) and other debris (9 impacted organisms, 8%). Similar to previous years, the data indicate that while lost hook-and-line fishing gear was the most prevalent in the habitats surveyed, the impact of lost lobster/crab trap debris was proportionally larger than for hook-and-line and other debris types, especially entangled rope from lost traps. The most frequently impacted organisms from marine debris were gorgonians (44% of the total impacts) and milleporid hydrocorals (26%), followed by scleractinian corals (16%), sponges (12%), and the colonial zoanthid *Palythoa* (2%). The summary below highlight aspects of the two dominant debris types, lost

hook-and-line fishing gear and lobster/crab trap gear, found in the upper Florida Keys study area in terms of the transect frequency of occurrence and mean density of debris items.

Lost Hook-and-line Gear

Hook-and-line gear was the most frequent type of marine debris in the upper Florida Keys during 2010 in terms of the number of sites (58 sites, 48% of all sites) and number of items encountered (149 items, 68% of total) (Table 8-2). Figures 8-2 to 8-4 show the spatial distribution of lost hook-and-line fishing gear density (no. items per 60 m^2) throughout the upper Florida Keys study area. Figures 8-5 and 8-6 illustrate the mean densities of lost hook-and-line debris for each of the habitats sampled. The distribution of hook-and-line debris indicates that it is ubiquitous throughout the study area in the habitats sampled, similar to previous years. Site-level mean (± 1 SE) densities of hook-and-line debris were as high as 15 items per 60 m^2 (Table 8-2). Hook-and-line debris was recovered from 58 out of the 120 sites (48%) and, with the exception of back-reef rubble zones, in all other habitats as follows: mid-channel patch reefs (11 sites, 52%), offshore patch reefs, (8 sites, 47%), shallow (< 6 m) hard-bottom (9 sites, 75%), high-relief spur and groove (13 sites, 54%), and the deeper (6-15 m) fore reef (17 sites, 50%). Differences in the mean transect frequency of occurrence and mean density (no. items per 60 m^2) of lost hook-and-line gear were evident among the habitats sampled. Mid-channel patch reefs (26% ± 7% of transects, 2.19 ± 0.82 items per 60 m^2), shallow (< 6 m) hard-bottom (27% ± 8%, 1.92 ± 0.75 items per 60 m^2), and high-relief spur and groove (24% ± 6%, 1.25 ± 0.35 items per 60 m^2) yielded the greatest transect frequency of occurrence and density of lost hook-and-line fishing gear, followed by offshore patch reefs (19% ± 6%, 1.18 ± 0.54 items per 60 m^2) and deeper (6-15 m) fore-reef habitats (18% ± 4%, 0.88 ± 0.19 items per 60 m^2).

Figures 8-5 and 8-6 provide comparisons of lost hook-and-line gear densities between no-take zones and reference areas for each habitat type sampled. The frequency of occurrence and mean density of lost hook-and-line gear was either similar or greater in FKNMS no-take zones compared to reference areas for mid-channel patch reefs, shallow hard-bottom, and the deeper fore-reef. Particularly noteworthy was the relatively high densities of hook-and-line debris documented at Hen and Chickens SPA, Davis Reef SPA, Conch Reef SPA, and Conch Reef RO (Figures 8-5 and 8-6). In contrast, lost hook-and-line gear frequencies and densities were lower on offshore patch reefs and high-relief spur and groove reefs within no-take zones compared to reference areas; however, debris was still recorded from most of the no-take zones, especially on high-relief spur and groove reefs (Table 8-2). On mid-channel patch reefs, mean ± 1 SE transect frequency of occurrence (75% ± 0%) and density (9.00 ± 6.00 items per 60 m^2) were substantially greater at two sites sampled within Hen and Chickens SPA compared to 19 reference patch reefs (21% ± 6%, 1.47 ± 0.56 items per 60 m^2) sampled from Tavernier Rocks to west of Turtle Shoal

(Table 8-2). On shallow hard-bottom sites, mean transect frequency of occurrence (30% ± 5%) and density (2.00 ± 0.77 items per 60 m^2) among five sites within Davis Reef SPA and Conch Reef SPA were slightly greater than at seven reference sites (25% ± 13% frequency of occurrence, 1.86 ± 1.22 items per 60 m^2) from Crocker Reef to Dixie Shoal. A similar pattern was observed on deeper (6-15 m) fore-reef habitats, where the mean transect frequency of occurrence and density (19% ± 7%, 0.83 ± 0.34 items per 60 m^2) at 12 sites within no-take zones at Davis Reef SPA, Conch Reef SPA and RO, and Carysfort/S. Carysfort SPA was similar to the average from 22 reference sites (17% ± 4%, 0.91 ± 0.23 items per 60 m^2) distributed from Crocker Reef to north of Carysfort Light.

Lost Lobster/Crab Trap Debris

Debris from lost lobster/crab trap fishing gear was the second most abundant debris category encountered in terms of the number of sites (22 sites, 18% of all sites) and items encountered (43 items, 20% of total) (Table 8-2). Figures 8-7 to 8-9 show the spatial distribution of trap debris density (no. items per 60 m^2) throughout the upper Florida Keys study area, while figures 8-10 and 8-11 illustrate mean densities of trap debris for each of the habitats sampled. Trap debris was recorded from all of the habitats sampled: mid-channel patch reefs (5 sites, 33%), offshore patch reefs, (6 sites, 35%), back-reef rubble (1 site, 8%), shallow (< 6 m) hard-bottom (4 sites, 33%), high-relief spur and groove (1 site, 4%), and the deeper (6-15 m) fore reef (5 sites, 15%). Site-level mean (± 1 SE) densities were as high as 5 items per 60 m^2 (Table 8-2). Differences in the mean transect frequency of occurrence and mean density (no. items per 60 m^2) of trap debris were evident among the habitats sampled. Transect frequency of occurrence and mean density were greatest on mid-channel patch reefs (14% ± 6%, 0.76 ± 0.34 items per 60 m^2) and offshore patch reefs (16% ± 6%, 0.71 ± 0.27 items per 60 m^2) compared to other habitats (Table 8-2).

Figures 8-10 and 8-11 provide comparisons of trap debris densities between no-take zones and reference areas for each habitat sampled. The frequency of occurrence and mean density of lost trap gear was either similar or higher in FKNMS no-take zones compared to reference areas for mid-channel and offshore patch reefs compared to reference areas (Table 8-2). Particularly noteworthy is the relatively high density of trap debris at Hen and Chickens SPA (Table 8-2). On mid-channel patch reefs, mean ± 1 SE transect frequency of occurrence (25% ± 25%) and density (2.50 ± 2.50 items per 60 m^2) were substantially greater at two sites sampled within Hen and Chickens SPA compared to 19 reference patch reefs (13% ± 6%, 0.58 ± 0.29 items per 60 m^2) sampled from Tavernier Rocks to west of Turtle Shoal (Table 8-2). On offshore patch reefs, mean transect frequency of occurrence (13% ± 13%) and density (0.50 ± 0.50 items per 60 m^2) at two sites within Carysfort/S. Carysfort SPA were similar to 15 reference sites (17% ± 7% frequency of occurrence, 0.73 ± 0.30 items per 60 m^2) distributed from Conch Reef to Carysfort Light.

Other Marine Debris

Other debris items encountered in the upper Florida Keys during 2010 are listed in Table 8-1. A total of 26 items represented by 13 types of "other" debris were found, of which glass bottles, plastic bags, and ree-bar stakes combined (13 items) represented 50% of the items. Mean site-level densities of other debris were as high as 3 items per 60 m^2, with mid-channel patch reefs yielding greater densities compared to other habitats (Table 8-3).

Total Marine Debris

The 218 total occurrences of marine debris documented in 480 belt transects (15-m x 1-m in dimension) represents an overall mean density of 1.82 items per m^2. The maximum site-level density was 20 items per m^2 (Table 8-3). One or more debris items were recovered from belt transect surveys at 76 sites (63%), distributed among all of the habitats surveyed. Figures 8-12 to 8-14 show the spatial distribution of total debris density (no. items per 60 m^2) throughout the upper Florida Keys study area, while Figures 8-15 and 8-16 illustrate the mean densities of total debris for each of the habitats sampled. Mid-channel patch reefs (43% ± 8% of transects, 3.33 ± 1.03 items per 60 m^2), shallow (< 6 m) hard-bottom (40% ± 9%, 2.67 ± 0.86 items per 60 m^2), and offshore patch reefs (34% ± 8%, 2.06 ± 0.60 items per 60 m^2) yielded the greatest transect frequency of occurrence and density of marine debris. Figures 8-15 and 8-16 illustrate total marine debris densities between no-take zones and reference areas for each of the habitats sampled. The frequency of occurrence and mean density of total marine debris was either similar or greater in FKNMS no-take zones compared to reference areas for mid-channel patch reefs and the deeper fore-reef, while lower overall values in no-take zones were recorded for other habitats.

Discussion

Methods of fishing that cause habitat modification or damage to benthic organisms represent serious consequences of fishing (Russ 1991; Benaka 1999). Although there is increasing recognition of the consequences to benthic habitats from the use of mobile fishing gear (Watling and Norse 1998; Auster and Langton 1999) and other destructive fishing practices (Saila et al. 1993; Jennings and Polunin 1996), only a handful of studies in the Florida Keys have quantified the spatial extent of marine debris, as well as the biological impacts to organisms and habitats (Chiappone et al. 2002c, 2004, 2005). Recent investigations of lobster trap movement (e.g. T. Matthews et al. at FWRI) indicate the potential for extensive movement of deployed gear, especially during storms. Similar to debris surveys completed by our program in 2000, 2001, and 2008, the results from 2010 indicate the persistence of marine debris, especially lost fishing gear, even within Sanctuary no-fishing zones.

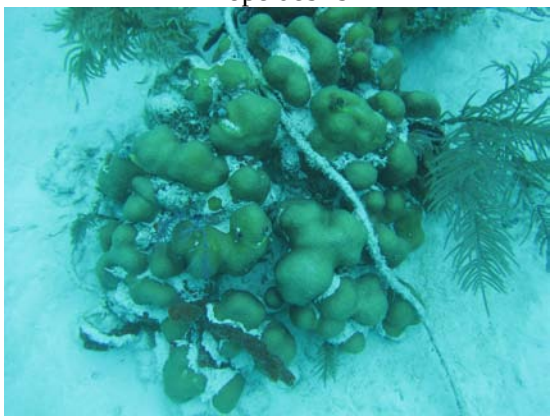
Interpretation of the biological impact data is complicated by several factors. Both the debris density and the distribution of sessile invertebrates sampled in this study are related to habitat type, and secondarily by management type. Future efforts need to consider the scaling of debris occurrence with impacts relative to these two factors. For example, it is probable that a coral-dominated reef with a given amount of hook-and-line gear will not be affected in the same way as a gorgonian-sponge dominated reef with the same density of gear. Estimates of the proportion of different taxa impacted by debris relative to total abundance estimates are also useful for placing the debris impact assessment into context. In addition, the long-term impacts to biota and the degree of recovery are unknown. For example, we continue to document instances where debris is overgrown by invertebrates, and it seems plausible that some debris will be incorporated into the habitat matrix. We also recognize that the future biological assessments would be more useful if data on the severity of each impact (e.g. amount of tissue damage) relative to the size of the organism were collected. We suggest that future debris surveys in the Florida Keys should compare debris densities between no-fishing zones and reference areas, as well as the impacts to sessile biota and whether fishing gear is relatively recent or biologically fouled. The site-level data presented in this report clearly indicate areas in the Florida Keys, including reefs heavily visited by divers and snorkelers, where public debris collection efforts such as "reef sweeps" should be focused.

Considering the intensive fishing effort and the significant increases in registered recreational boats and angler days in the Florida Keys (Bohnsack et al. 1994), patterns in the distribution and frequency of marine debris recorded during this study, especially derelict fishing gear, are not surprising. Marine debris documented in 2010, most of which was derelict fishing gear, was more or less proportional to the sampling effort, similar to previous surveys in 2000 (Chiappone et al. 2002c), 2001 (Chiappone et al. 2004), and 2008 (http://people.uncw.edu/millers). We generally found either similar or greater amounts of debris, especially lost fishing gear, in no-fishing zones compared to reference areas open to fishing for many of the habitats sampled. Non-compliance certainly occurs in Sanctuary no-fishing zones and it is common to find "fresh" (un-fouled) hook-and-line gear in the no-take zones. The no-take zones may attract fishers to fish illegally or to fish close to the zone boundaries, otherwise known as "fishing the line". Storms also re-distribute debris from areas where it is initially lost into adjacent areas, including coral reefs, suggesting the need for either less mobile gear types or for buffer areas to protect neighboring areas from physical damage.

Figure 8-1. Examples of marine debris encountered in the upper Florida Keys National Marine Sanctuary during June-August 2010.

Monofilament

Rope debris



Rope debris

Rope debris

Trap

Grating

Figure 8-2. Densities (no. items per 60 m^2) of lost hook-and-line fishing gear in the upper Florida Keys National Marine Sanctuary from the southern BNP boundary to Carysfort/S. Carysfort SPA surveyed during June-August 2010.

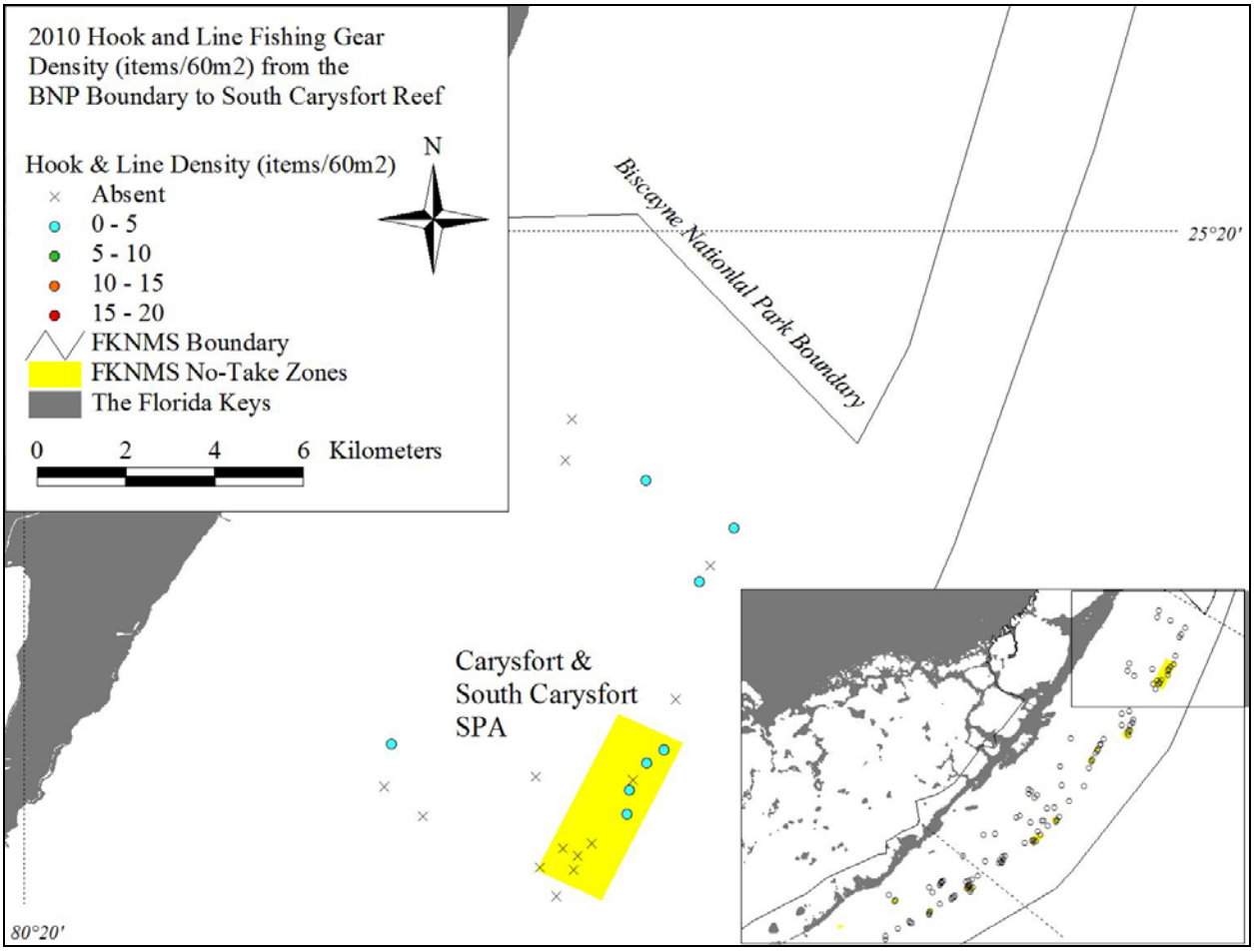


Figure 8-3. Densities (no. items per 60 m^2) of lost hook-and-line fishing gear in the upper Florida Keys National Marine Sanctuary from Elbow Reef to Pickles Reef (bottom) surveyed during June-August 2010.

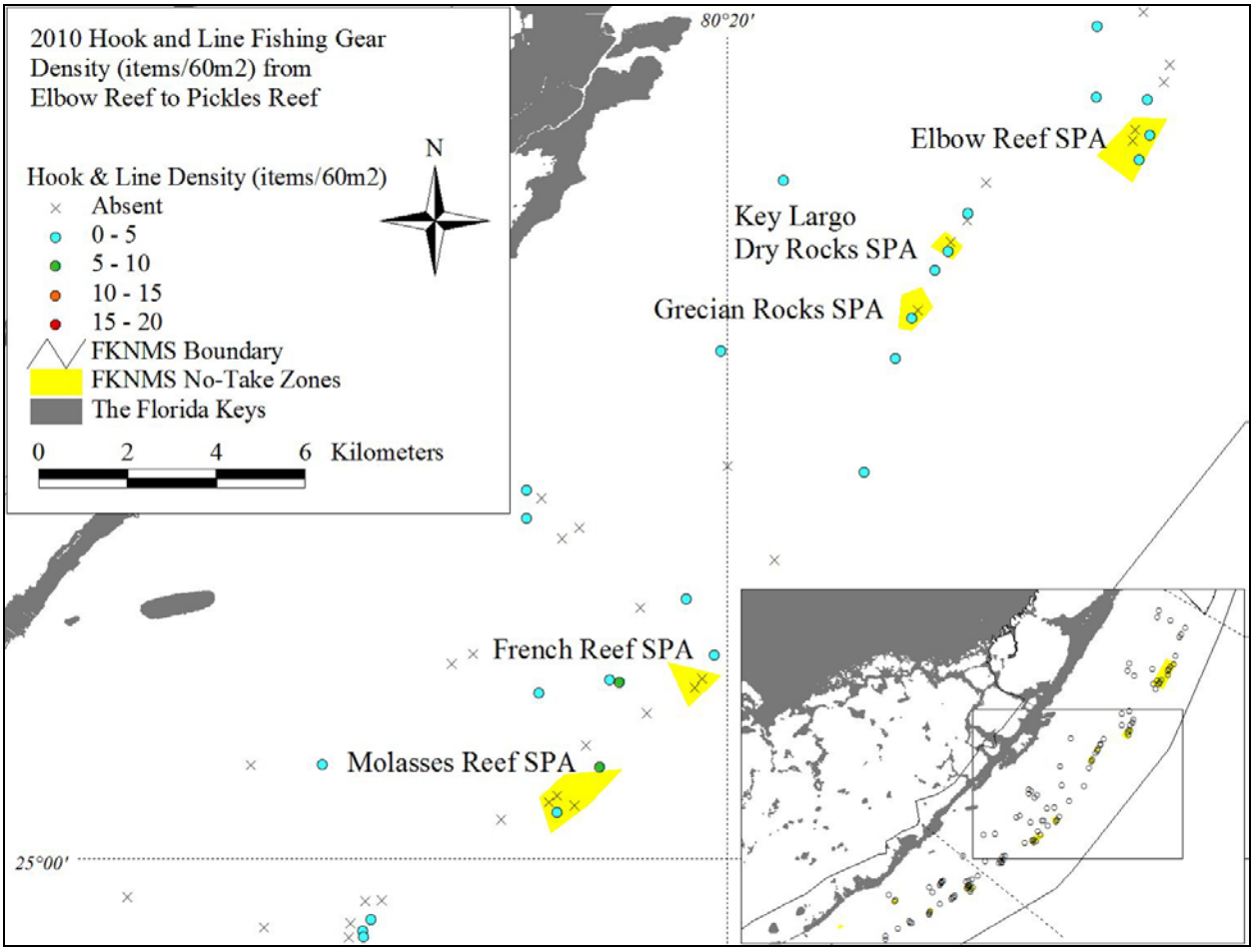


Figure 8-4. Densities (no. items per 60 m^2) of lost hook-and-line fishing gear in the upper Florida Keys National Marine Sanctuary from Conch Reef SPA to Crocker Reef surveyed during June-August 2010.

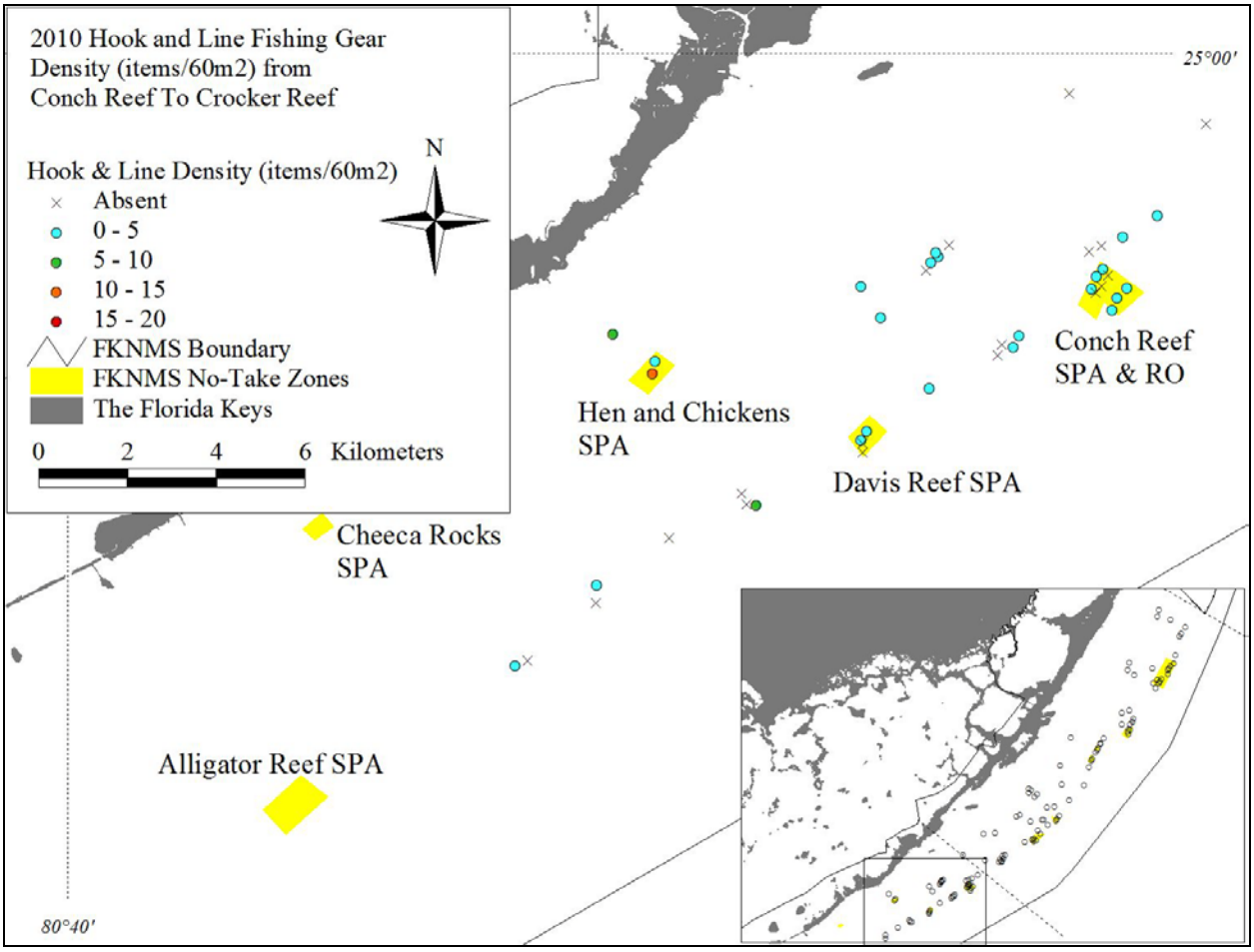


Figure 8-5. Mean (+ 1 SE) densities (no. items per 60 m^2) of lost hook-and-line fishing gear on inshore and mid-channel patch reefs (top), offshore patch reefs (middle), and back reef rubble habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.

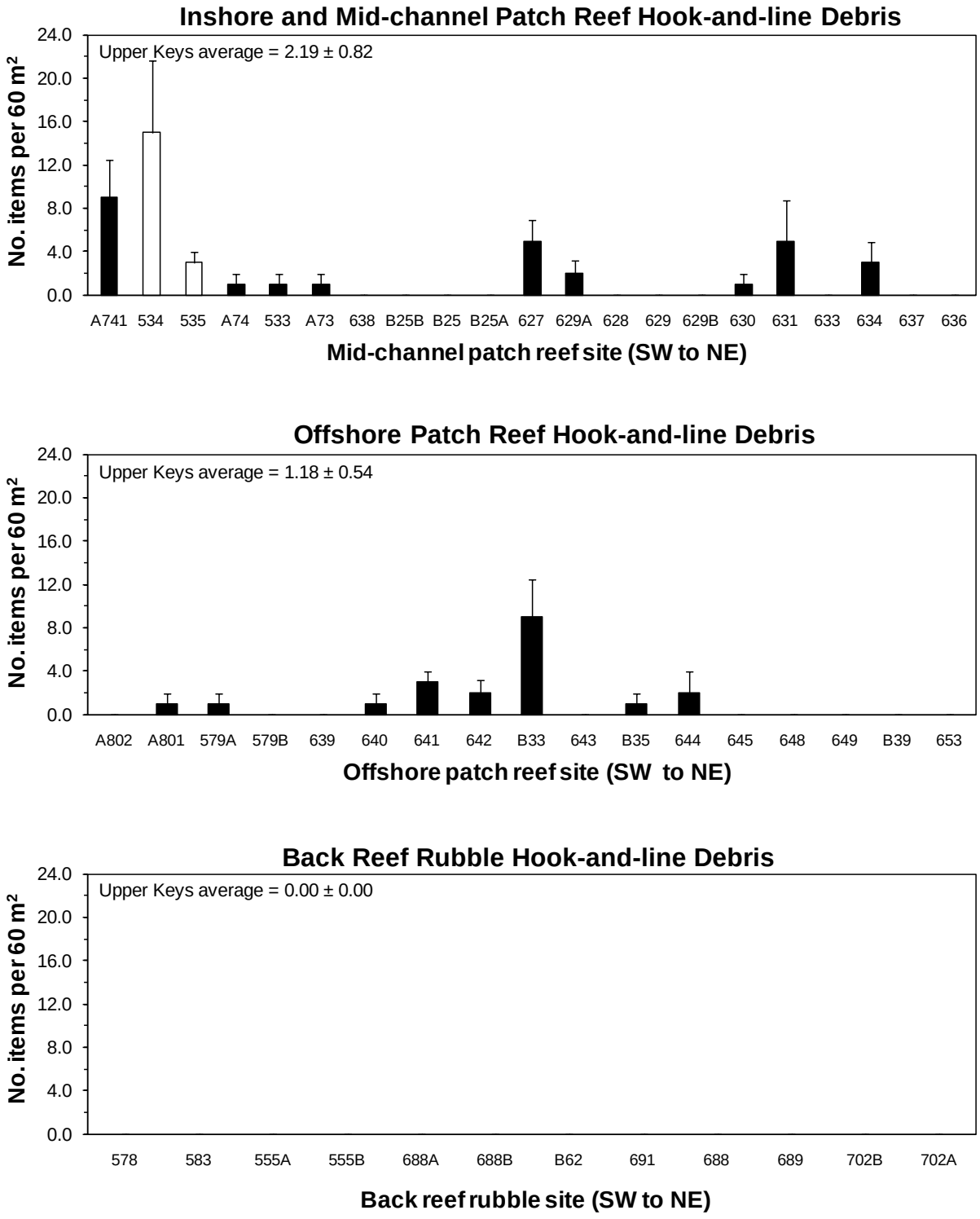


Figure 8-6. Mean (+ 1 SE) densities (no. items per 60 m^2) of lost hook-and-line fishing gear on shallow (< 6 m) hard-bottom (top), high-relief spur and groove reefs (middle) and deeper (6-15 m) fore reef habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.

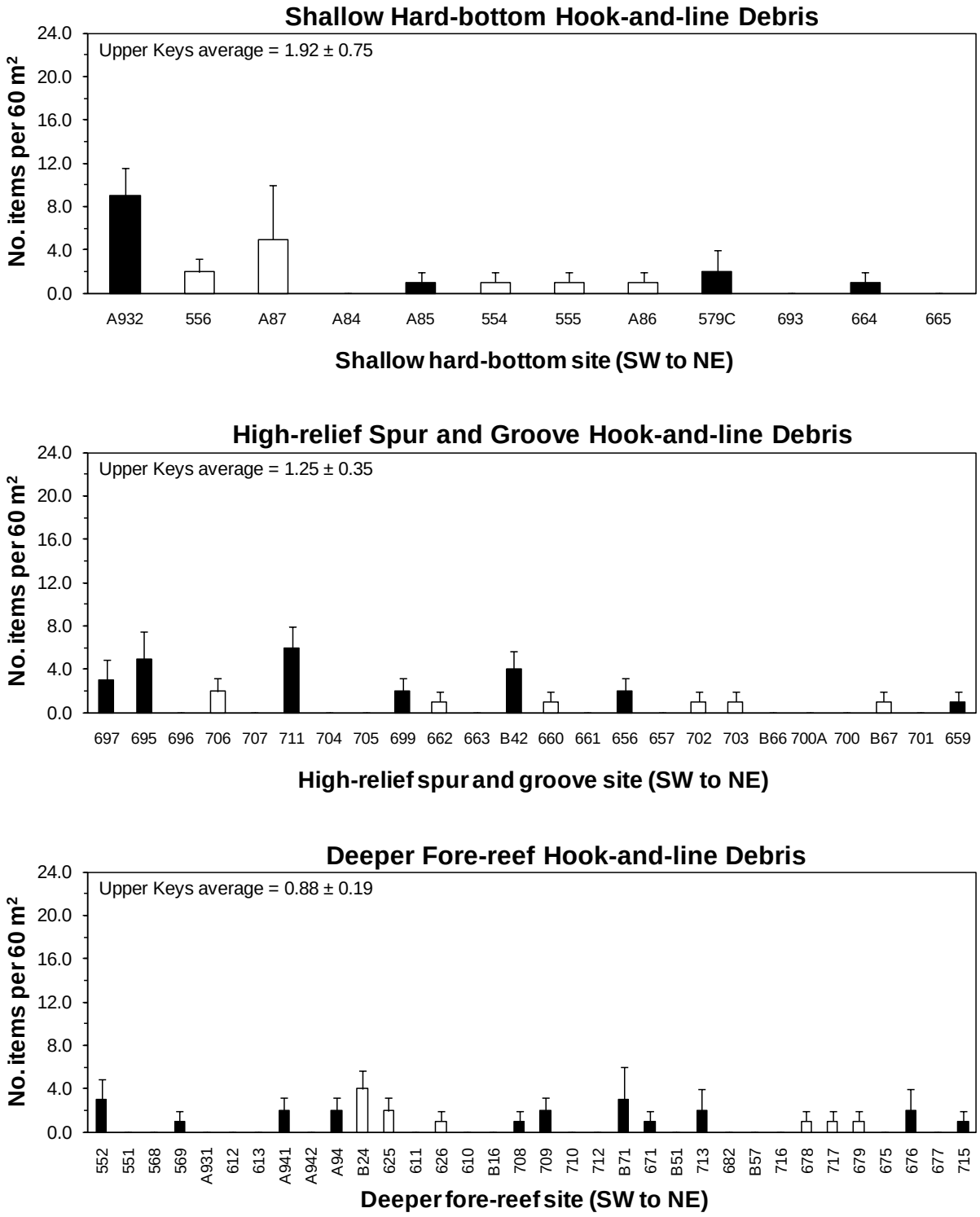


Figure 8-7. Densities (no. items per 60 m^2) of lost lobster trap fishing gear in the upper Florida Keys National Marine Sanctuary from the southern BNP boundary to Carysfort/S. Carysfort SPA surveyed during June-August 2010.

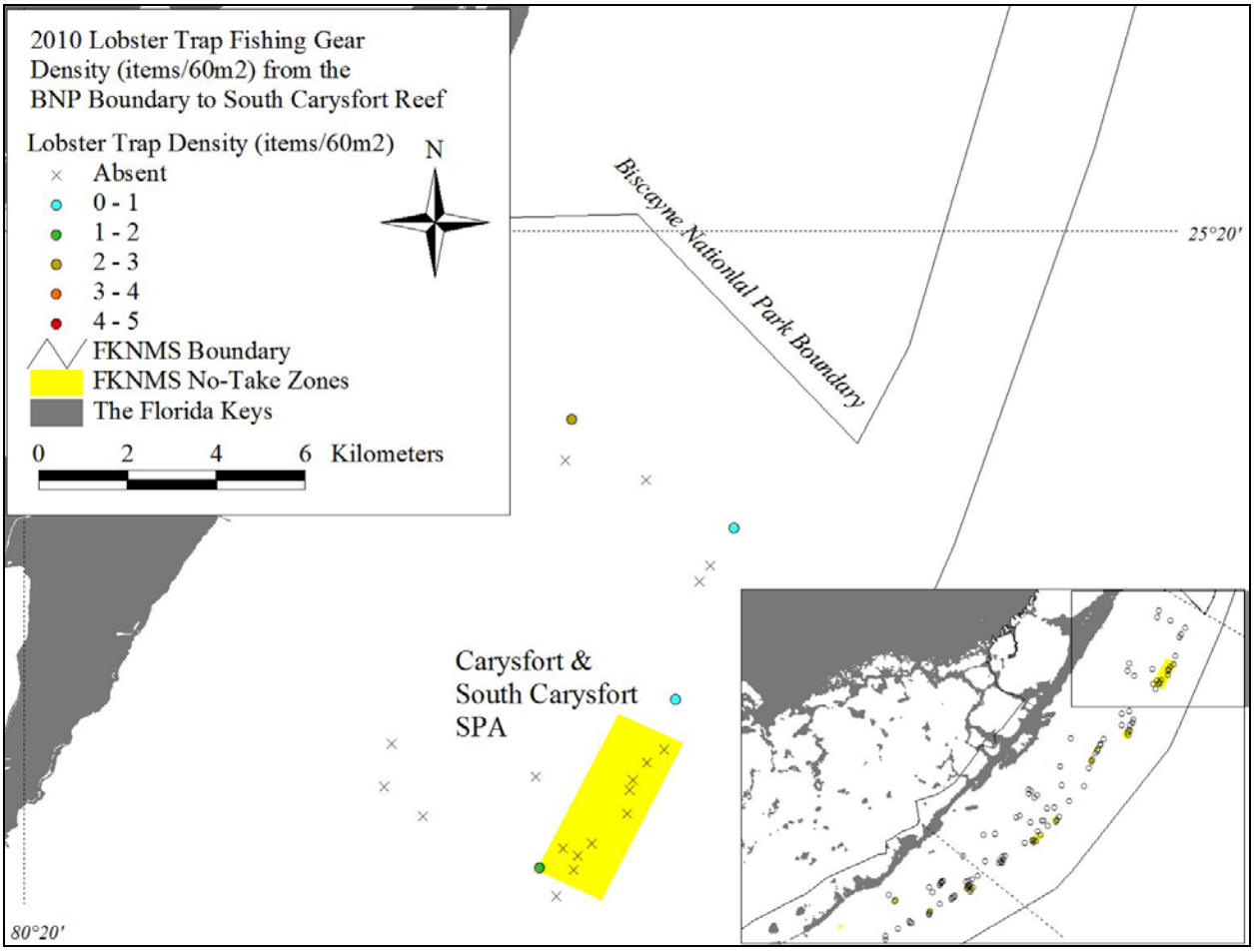


Figure 8-8. Densities (no. items per 60 m^2) of lost lobster trap fishing gear in the upper Florida Keys National Marine Sanctuary from Elbow Reef to Pickles Reef (bottom) surveyed during June-August 2010.

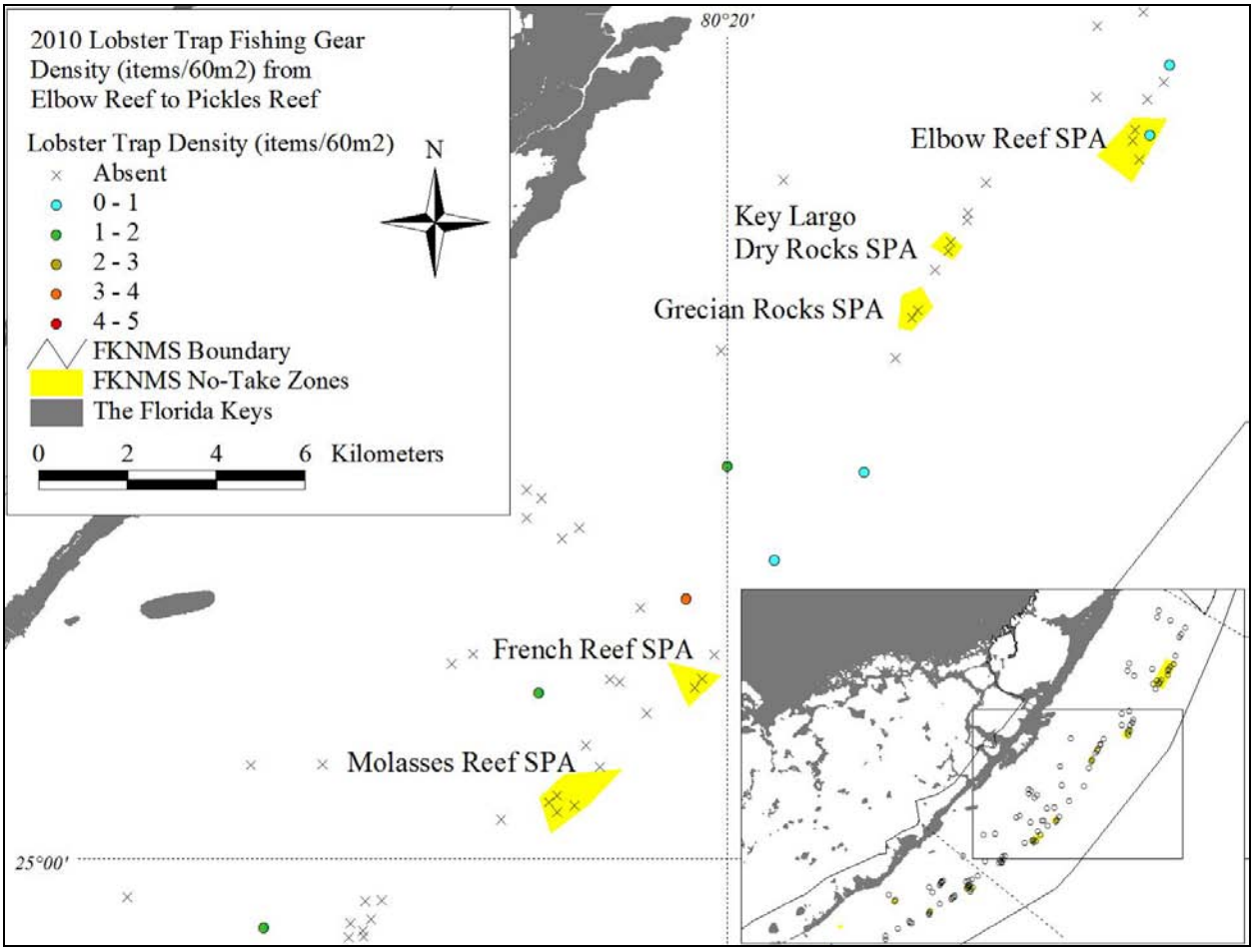


Figure 8-9. Densities (no. items per 60 m^2) of lost lobster trap fishing gear in the upper Florida Keys National Marine Sanctuary from Conch Reef SPA to Crocker Reef surveyed during June-August 2010.

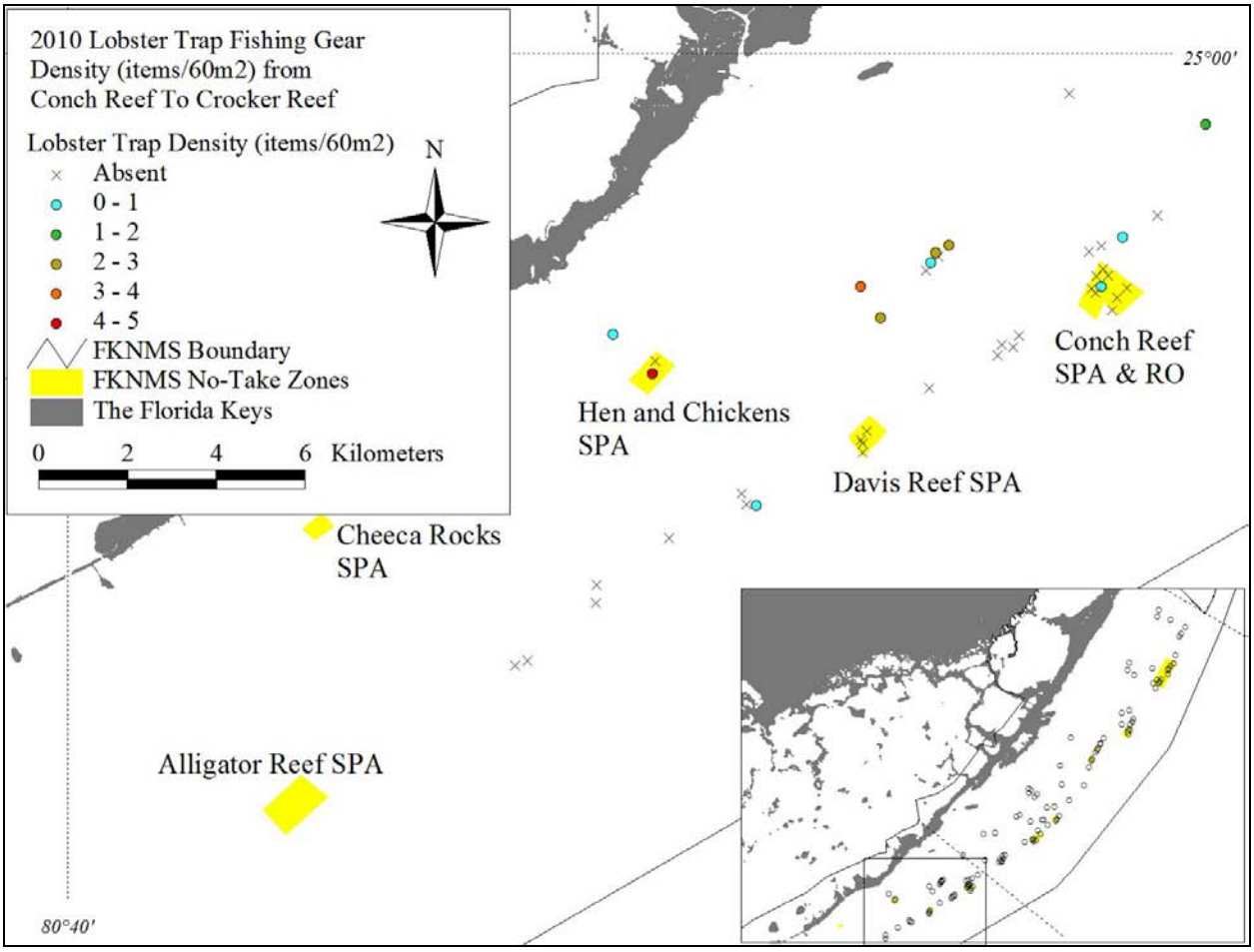


Figure 8-10. Mean (+ 1 SE) densities (no. items per 60 m^2) of lost lobster trap fishing gear on inshore and mid-channel patch reefs (top), offshore patch reefs (middle), and back reef rubble habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.

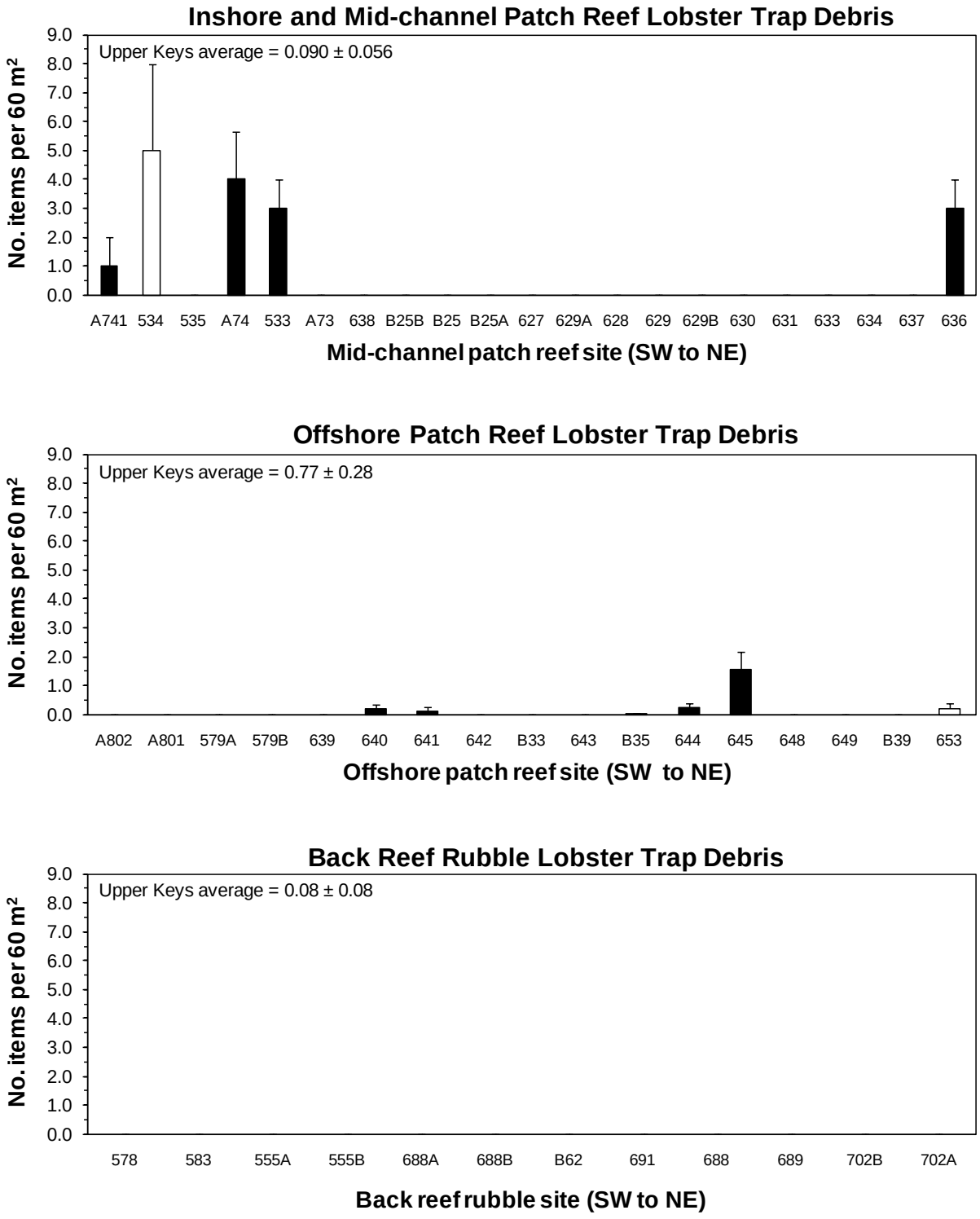


Figure 8-11. Mean (+ 1 SE) densities (no. items per 60 m^2) of lost lobster trap fishing gear on shallow (< 6 m) hard-bottom (top), high-relief spur and groove reefs (middle) and deeper (6-15 m) fore reef habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.

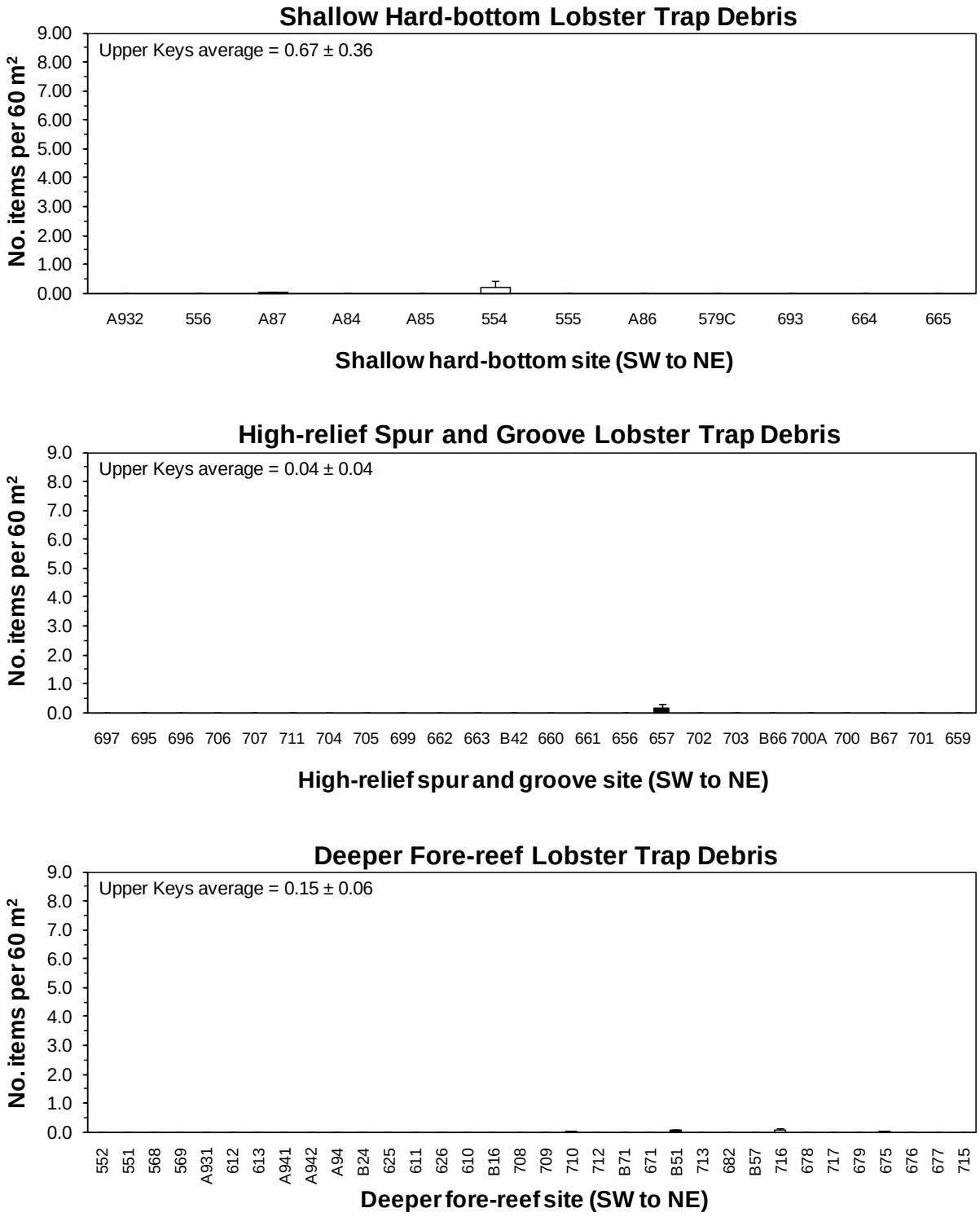


Figure 8-12. Densities (no. items per 60 m^2) of all marine debris categories in the upper Florida Keys National Marine Sanctuary from the southern BNP boundary to Carysfort/S. Carysfort SPA surveyed during June-August 2010.

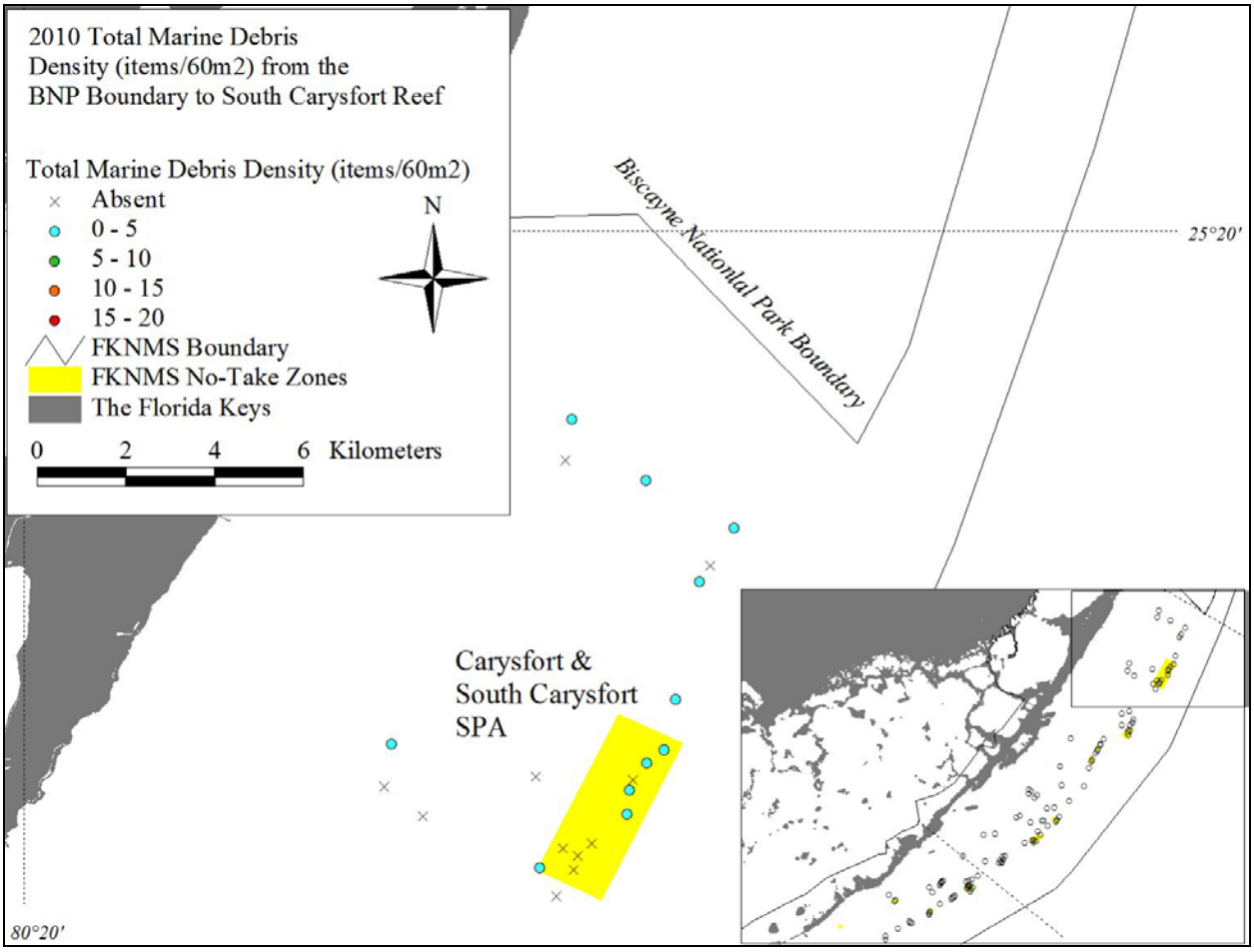


Figure 8-13. Densities (no. items per 60 m^2) of all marine debris categories in the upper Florida Keys National Marine Sanctuary from Elbow Reef to Pickles Reef (bottom) surveyed during June-August 2010.

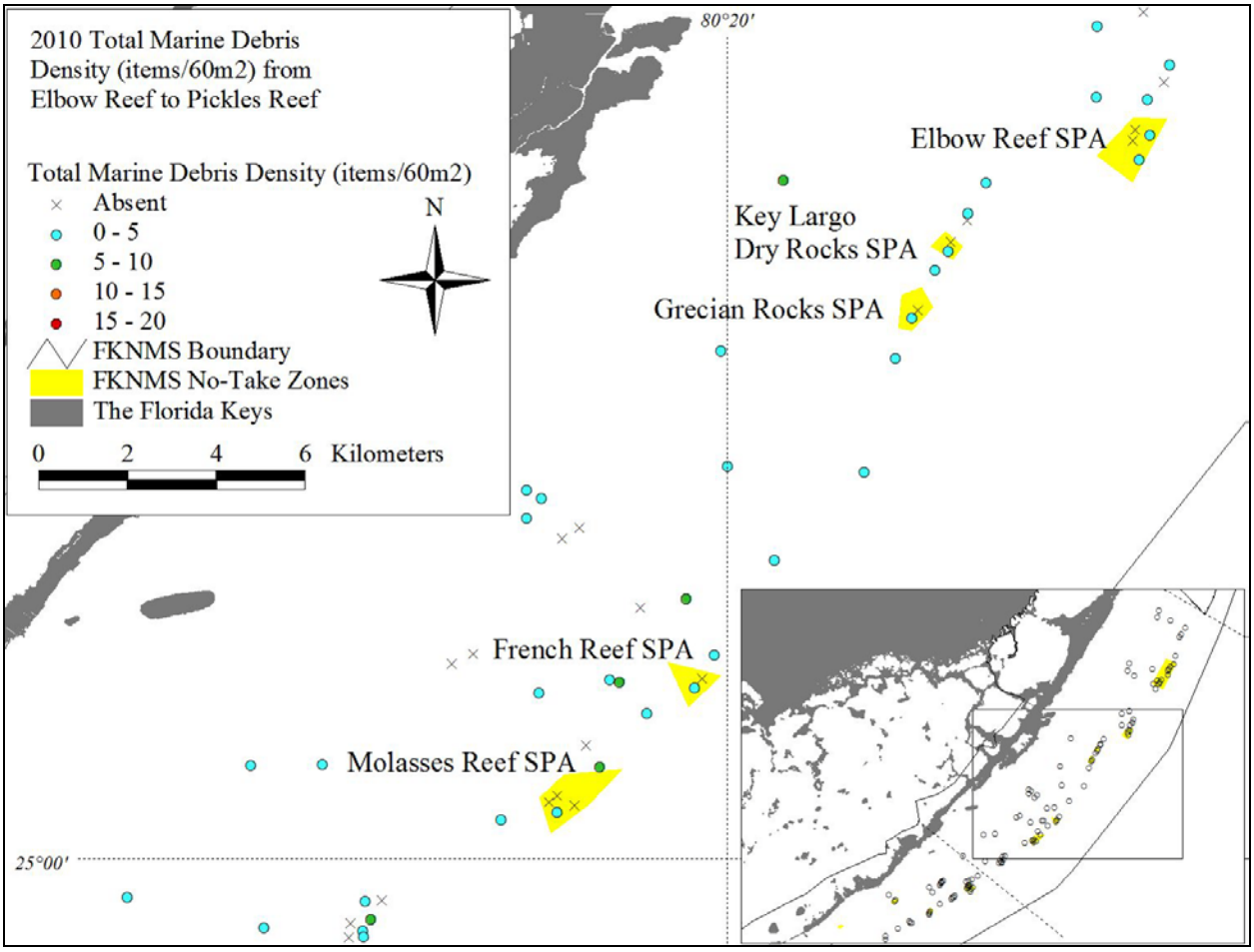


Figure 8-14. Densities (no. items per 60 m^2) of all marine debris categories in the upper Florida Keys National Marine Sanctuary from Conch Reef SPA to Crocker Reef surveyed during June-August 2010.

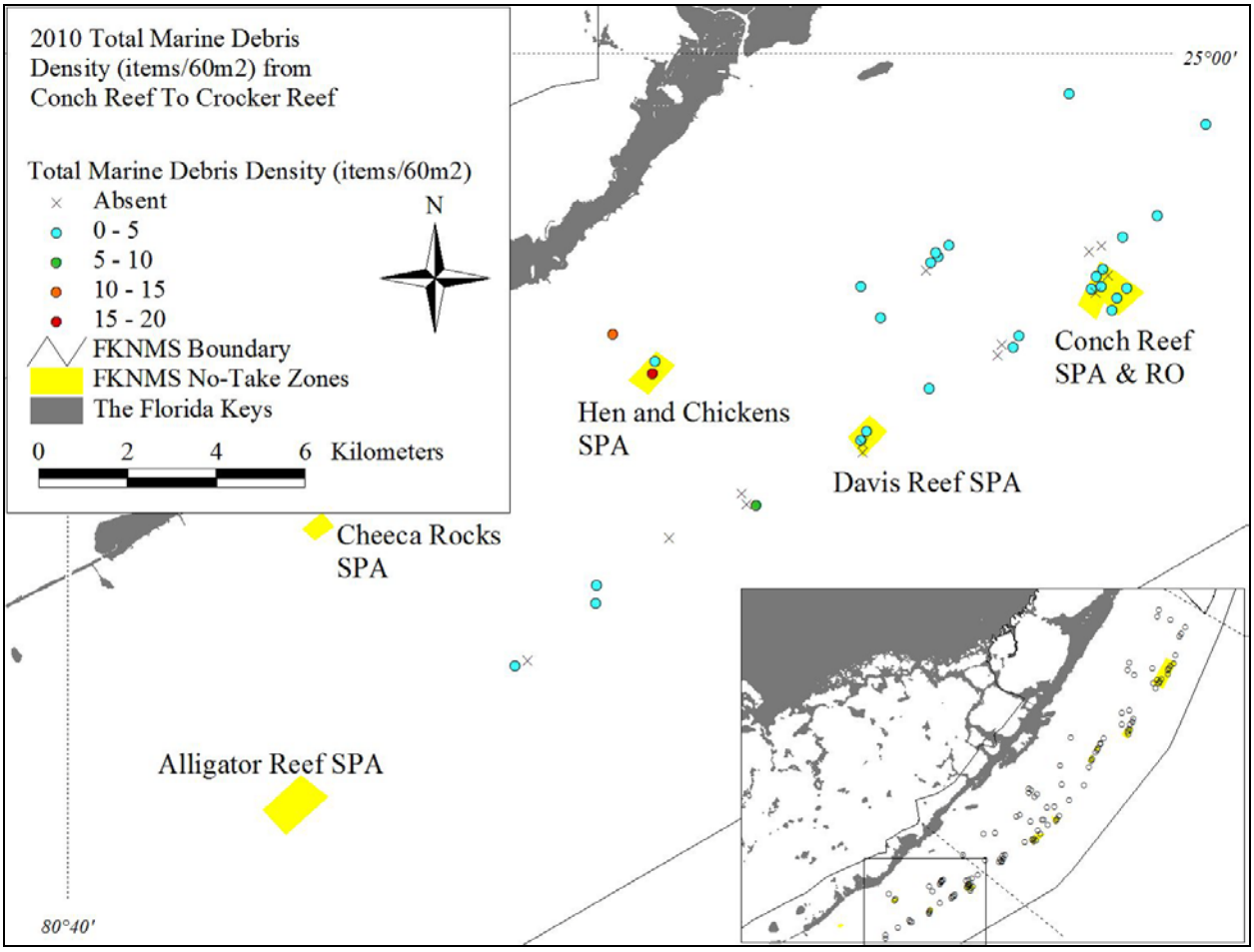


Figure 8-15. Mean (+ 1 SE) densities (no. items per 60 m^2) of all marine debris categories on inshore and mid-channel patch reefs (top), offshore patch reefs (middle), and back reef rubble habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.

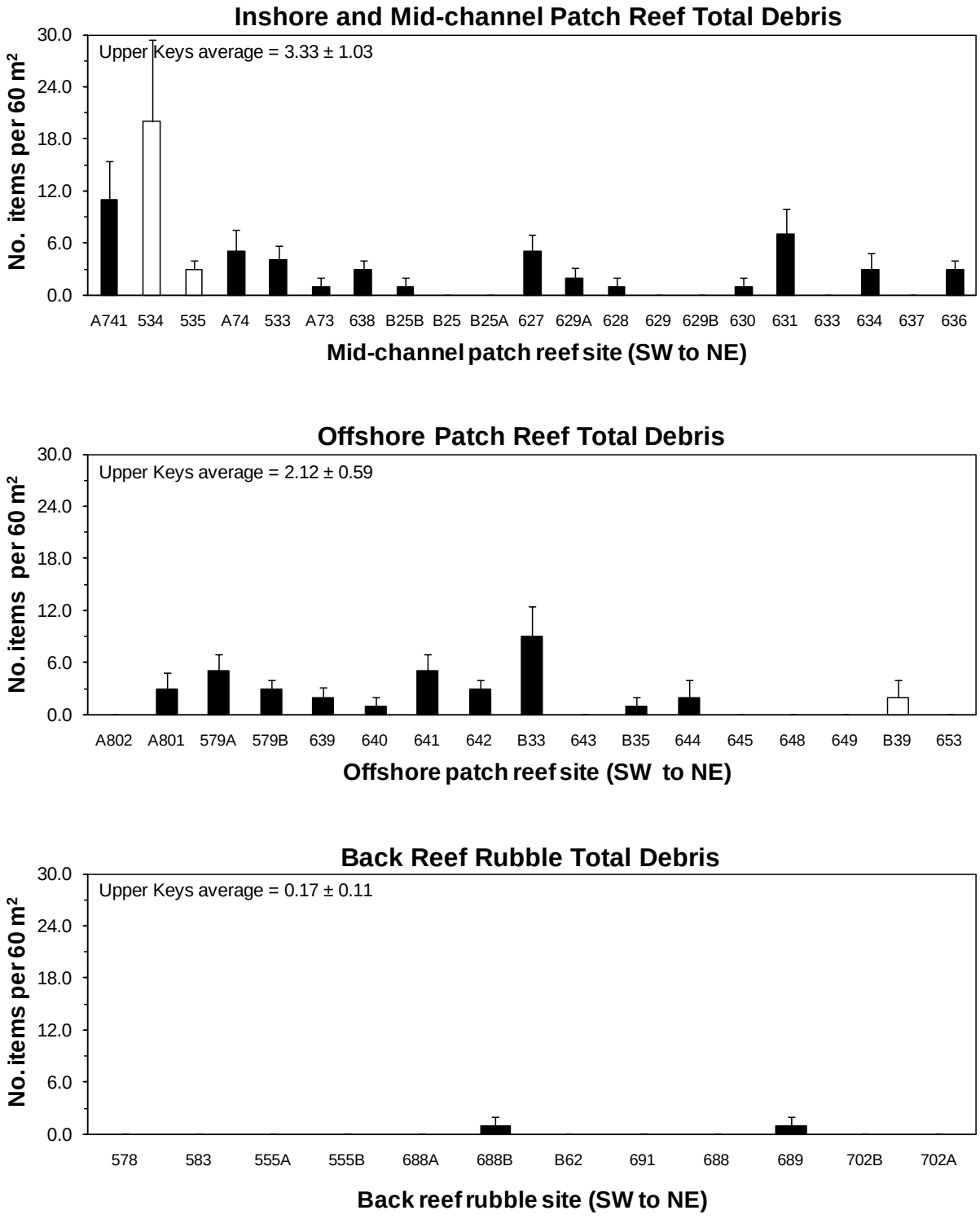


Figure 8-16. Mean (+ 1 SE) densities (no. items per 60 m^2) of all marine debris categories on shallow (< 6 m) hard-bottom (top), high-relief spur and groove reefs (middle) and deeper (6-15 m) fore reef habitats (bottom) in the upper Florida Keys during June-August 2010. Open bars = FKNMS no-take zones; filled bars = reference areas.

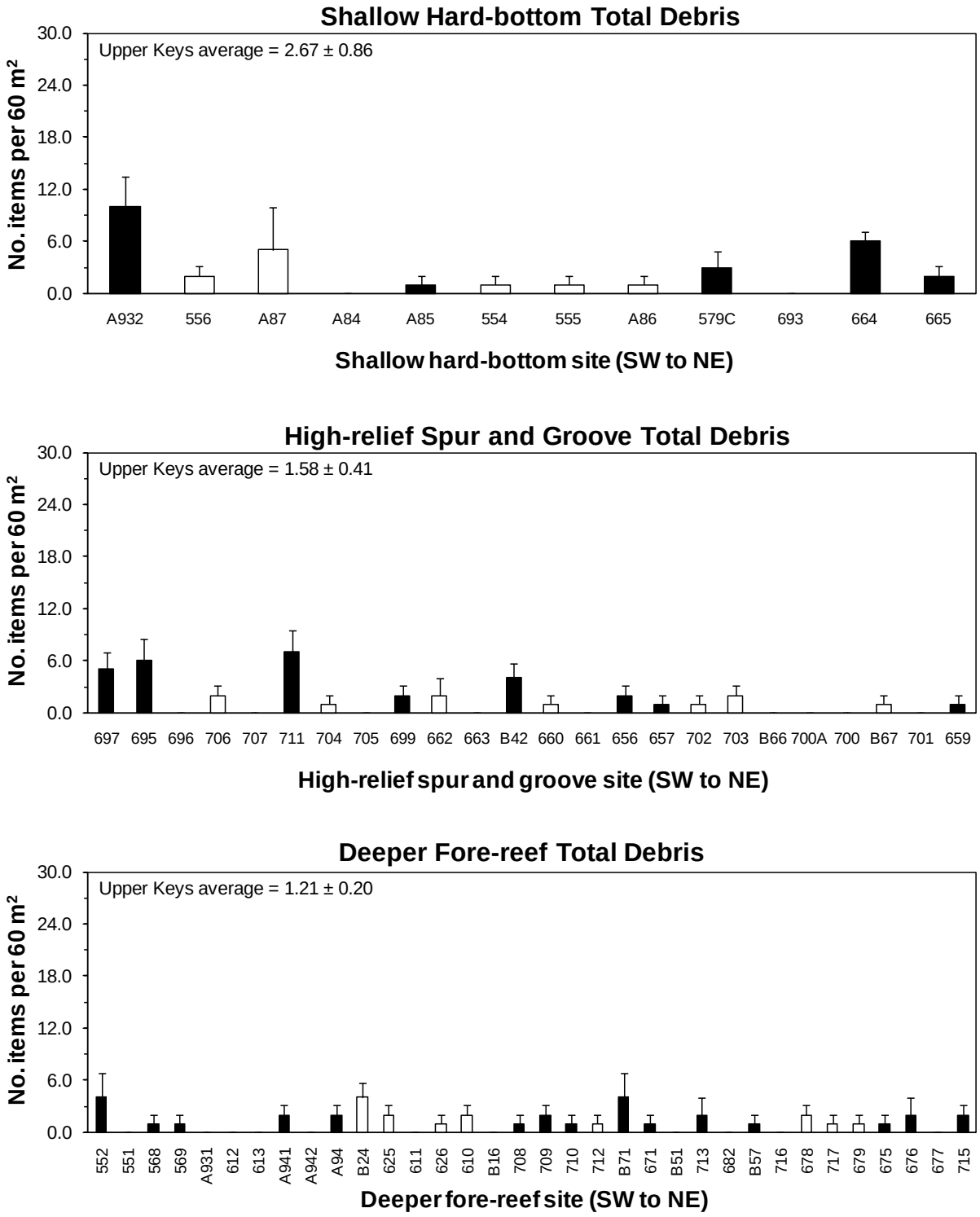


Table 8-1. Number and relative frequency (%) of marine debris items and number and relative frequency (%) of impacts to benthic coral reef organisms in the upper Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 4-m belt transects per site at 120 sites during June-August 2010. Impacted organisms were those exhibiting abrasion stress and tissue damage from debris.

Debris type	**N (%)**	***Millepora***	**Scleractinia**	**Gorgonians**	**Sponges**	***Palythoa***	**Total**
Hook-and-line gear							
Fishing rod	1 (0.5)						
Lead sinker	13 (6.0)						
Monofilament	77 (35.3)	15 (48.4)	2 (10.5)	25 (48.1)	11 (78.6)	1 (50.0)	54 (45.8)
Monofilament + hook	4 (1.8)		2 (10.5)	1 (1.9)			3 (2.5)
Monofilament + leader	3 (1.4)			2 (3.8)			2 (1.7)
Monofilament + sinker	2 (0.9)						
Wire leader	44 (20.2)	5 (16.1)		4 (7.7)	1 (7.1)		10 (8.5)
Wire leader + hook + sinker	1 (0.5)						
Wire leader + lure	1 (0.5)						
Wire leader + sinker	1 (0.5)	1 (3.2)		1 (1.9)		1 (50.0)	3 (2.5)
Total hook-and-line gear	**149 (68.3)**	**21 (67.7)**	**4 (21.1)**	**33 (63.5)**	**12 (85.7)**	**2 (100)**	**72 (61.0)**
Lobster/crab trap gear							
Cement block	4 (1.8)						
Plastic pot opening	4 (1.8)				1 (7.1)		1 (0.8)
Rope	18 (8.3)	3 (9.7)	14 (73.7)	17 (32.7)	1 (7.1)		35 (29.7)
Trap staple	1 (0.5)						
Wood	16 (7.3)		1 (5.3)				
Total trap gear	**43 (19.7)**	**3 (9.7)**	**15 (78.9)**	**17 (32.7)**	**2 (14.3)**	**0 (0)**	**37 (31.4)**
Other debris							
Anchor line + rope	1 (0.5)	2 (6.5)		1 (1.9)			3 (2.5)
Boat rub rail	1 (0.5)						
Cable tie	2 (0.9)						
Glass bottle	5 (2.3)						
Knife	2 (0.9)						
Mesh bag	1 (0.5)	1 (3.2)					1 (0.8)
Mesh rope	2 (0.9)	2 (6.5)					2 (1.7)
Plastic bag	4 (1.8)	2 (6.5)					2 (1.7)
Plastic cord	1 (0.5)						
Ree-bar stake	3 (1.4)						
Rope/string	1 (0.5)						
Skeg	1 (0.5)						
Speargun tubing	1 (0.5)			1			1 (0.8)
Total other debris	**26 (11.9)**	**7 (22.6)**	**0 (0)**	**2 (3.8)**	**0 (0)**	**0 (0)**	**9 (7.6)**
All marine debris	**218 (100)**	**31 (100)**	**19 (100)**	**52 (100)**	**14 (100)**	**2 (100)**	**118 (100)**

Table 8-2. Mean ± 1 SE transect frequencies (%), number of items encountered, and densities (no. items per 60 m^2) of combined lost hook-and-line fishing gear types and lost trap gear in the upper Florida Keys, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-September 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	Hook-and-line debris			Lobster trap debris		
	Frequency	N	No./60 m^2	Frequency	N	No./60 m^2
Inshore and mid-channel patch reefs						
Middle Florida Keys						
A741 – Tavernier Rocks	75 ± 25	9	9.00 ± 3.42	25 ± 25	1	1.00 ± 1.00
534 – Hen and Chickens SPA**	75 ± 25	15	15.00 ± 6.61	50 ± 29	5	5.00 ± 3.00
535 – Hen and Chickens SPA**	75 ± 25	3	3.00 ± 1.00	0 ± 0	0	0
A74 – West of Conch Reef	25 ± 25	1	1.00 ± 1.00	75 ± 25	4	4.00 ± 1.63
533 – West of Conch Reef	25 ± 25	1	1.00 ± 1.00	75 ± 25	3	3.00 ± 1.00
A73 – West of Conch Reef	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0
Middle Florida Keys Total (6)	50 ± 11	30	5.00 ± 2.37	38 ± 14	13	2.17 ± 0.87
Upper Florida Keys						
638 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B25B – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B25 – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B25A – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
627 – Mosquito Bank	75 ± 25	5	5.00 ± 1.91	0 ± 0	0	0 ± 0
629A – Mosquito Bank	50 ± 29	2	2.00 ± 1.15	0 ± 0	0	0 ± 0
628 – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
629 – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
629B – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
630 – SE of Cannon Patch Reef	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
631 – Marker 33	50 ± 29	5	5.00 ± 3.79	0 ± 0	0	0 ± 0
633 – Basin Hill Shoals	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
634 – Basin Hill Shoals	50 ± 29	3	3.00 ± 1.91	0 ± 0	0	0 ± 0
637 – West of Turtle Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
636 – West of Turtle Rocks	0 ± 0	0	0 ± 0	75 ± 25	3	3.00 ± 1.00
Upper Florida Keys Total (15)	17 ± 7	16	1.07 ± 0.47	5 ± 5	3	0.20 ± 0.20
Mid-channel Patch Reef Total (21)	**26 ± 7**	**46**	**2.19 ± 0.82**	**14 ± 6**	**16**	**0.76 ± 0.34**
Offshore patch reefs						
Middle Florida Keys						
A802 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A801 – Inshore of Conch Reef	25 ± 25	1	1.00 ± 1.00	25 ± 25	1	1.00 ± 1.00
579A – Inshore of Conch Reef	25 ± 25	1	1.00 ± 1.00	50 ± 29	3	3.00 ± 1.91
579B – Inshore of Conch Reef	0 ± 0	0	0 ± 0	75 ± 25	3	3.00 ± 1.00
Middle Florida Keys Total (4)	13 ± 7	2	0.50 ± 0.29	38 ± 16	7	1.75 ± 0.75
Upper Florida Keys						
639 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
640 – White Bank (West of Molasses)	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
641 – White Bank (West of Molasses)	75 ± 25	3	3.00 ± 1.00	50 ± 29	2	2.00 ± 1.15
642 – SE of White Bank Dry Rocks	50 ± 29	2	2.00 ± 1.15	0 ± 0	0	0 ± 0
B33 – East of White Bank Dry Rocks	25 ± 25	9	9.00 ± 3.42	0 ± 0	0	0 ± 0
643 – White Bank (NW of French)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B35 – West of Elbow Reef	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
644 – Watson's Reef	25 ± 25	2	2.00 ± 2.00	0 ± 0	0	0 ± 0
645 – Watson's Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
648 – East of Basin Hill Shoals	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
649 – West of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B39 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00

Site number/site location	Hook-and-line debris			Lobster trap debris		
	Frequency	**N**	**No./60 m^2**	**Frequency**	**N**	**No./60 m^2**
653 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (13)	21 ± 8	18	1.39 ± 0.69	10 ± 5	5	0.38 ± 0.21
Offshore Patch Reef Total (17)	**19 ± 6**	**20**	**1.18 ± 0.54**	**16 ± 6**	**12**	**0.71 ± 0.27**
Back reef rubble						
Middle Florida Keys						
578 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
583 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
555A – Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
555B – Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys						
688A – Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
688B – Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B62 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
691 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
688 – Sand Island	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
689 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
702B – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
702A – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (8)	0 ± 0	0	0 ± 0	3 ± 3	1	0.13 ± 0.13
Back Reef Rubble Total (12)	**0 ± 0**	**0**	**0 ± 0**	**2 ± 2**	**1**	**0.08 ± 0.08**
Low-relief hard-bottom (< 6 m)						
Middle Florida Keys						
A932 – Crocker Reef	100 ± 0	9	9.00 ± 2.52	25 ± 25	1	1.00 ± 1.00
556 – Davis Reef SPA**	50 ± 29	2	2.00 ± 1.15	0 ± 0	0	0 ± 0
A87 – Davis Reef SPA**	25 ± 25	5	5.00 ± 5.00	0 ± 0	0	0 ± 0
A84 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A85 – Little Conch Reef	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
554 – Conch Reef C1**	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
555 – Conch Reef C2**	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
A86 – Conch Reef C3**	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
579C – NE of Conch Reef	25 ± 25	2	2.00 ± 2.00	25 ± 25	1	1.00 ± 1.00
Middle Florida Keys Total (9)	33 ± 9	22	2.44 ± 0.94	6 ± 4	2	0.22 ± 0.15
Upper Florida Keys						
693 – Little Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
664 – North of French Reef	25 ± 25	1	1.00 ± 1.00	75 ± 25	4	4.00 ± 1.63
665 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
Upper Florida Keys Total (3)	8 ± 8	1	0.33 ± 0.33	42 ± 22	6	2.00 ± 1.16
Shallow Hard-bottom Total (17)	**27 ± 8**	**23**	**1.92 ± 0.75**	**15 ± 7**	**8**	**0.67 ± 0.36**
High-relief spur and groove						
Upper Florida Keys						
697 – Pickles Reef P1	50 ± 29	3	3.00 ± 1.91	0 ± 0	0	0 ± 0
695 – Pickles Reef P3	75 ± 25	5	5.00 ± 2.52	0 ± 0	0	0 ± 0
696 – NE Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
706 – Molasses Reef SPA**	50 ± 29	2	2.00 ± 1.15	0 ± 0	0	0 ± 0
707 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
711 – Sand Island	75 ± 25	6	6.00 ± 2.00	0 ± 0	0	0 ± 0
704 – French Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
705 – French Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
699 – North of French Reef	50 ± 29	2	2.00 ± 1.15	0 ± 0	0	0 ± 0
662 – Grecian Rocks SPA**	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0

Site number/site location	Hook-and-line debris			Lobster trap debris		
	Frequency	**N**	**No./60 m^2**	**Frequency**	**N**	**No./60 m^2**
663 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B42 – Little Grecian Rocks	75 ± 25	4	4.00 ± 1.63	0 ± 0	0	0 ± 0
660 – Key Largo Dry Rocks**	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
661 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
656 – North Dry Rocks	50 ± 29	2	2.00 ± 1.15	0 ± 0	0	0 ± 0
657 – North-North Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
702 – Elbow Reef SPA**	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
703 – Elbow Reef SPA**	25 ± 25	1	1.00 ± 1.00	25 ± 25	1	1.00 ± 1.00
B66 – South of S. Carysfort	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
700A – South Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
700 – South Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B67 – Carysfort Reef C2**	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
701 – Carysfort Reef C5**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
659 – Turtle Reef	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
Upper Florida Keys Total (24)	24 ± 6	30	1.25 ± 0.35	1 ± 1	1	0.04 ± 0.04
High-relief Spur & Groove Total (42)	**24 ± 6**	**30**	**1.25 ± 0.35**	**1 ± 1**	**1**	**0.04 ± 0.04**
Deeper Fore-reef (6-15 m)						
Middle Florida Keys						
552 – SW of Crocker Reef	50 ± 29	3	3.00 ± 1.91	0 ± 0	0	0 ± 0
551 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
568 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
569 – SW of Crocker Reef	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
612 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A941 – North of Davis Reef	50 ± 29	2	2.00 ± 1.15	0 ± 0	0	0 ± 0
A942 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A94 – Little Conch Reef	50 ± 29	2	2.00 ± 1.15	0 ± 0	0	0 ± 0
B24 – Conch Reef RO**	75 ± 25	4	4.00 ± 1.63	0 ± 0	0	0 ± 0
625 – Conch Reef RO**	50 ± 29	2	2.00 ± 1.15	0 ± 0	0	0 ± 0
611 – Conch Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
626 – Conch Reef RO**	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
610 – Conch Reef SPA**	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
B16 – Conch Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (16)	20 ± 7	15	0.94 ± 0.32	2 ± 2	1	0.06 ± 0.06
Upper Florida Keys						
708 – NE of Conch Reef	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
709 – Pickles Reef	50 ± 29	2	2.00 ± 1.15	0 ± 0	0	0 ± 0
710 – SW of Molasses Reef SPA	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
712 – SW of French Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B71 – Dixie Shoal	25 ± 25	3	3.00 ± 3.00	25 ± 25	1	1.00 ± 1.00
671 – South of Grecian Rocks	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
B51 – East of Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
713 – North of Elbow Reef	25 ± 25	2	2.00 ± 2.00	0 ± 0	0	0 ± 0
682 – North of Elbow Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B57 – SE of Watson's Reef	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
716 – South Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
678 – North Carysfort Reef**	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
717 – North Carysfort Reef**	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
679 – North Carysfort Reef**	25 ± 25	1	1.00 ± 1.00	0 ± 0	0	0 ± 0
675 – North of Carysfort Reef	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
676 – North of Carysfort Reef	25 ± 25	2	2.00 ± 2.00	0 ± 0	0	0 ± 0
677 – North of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
715 – North of Carysfort Reef	25 ± 25	1	1.00 ± 1.00	25 ± 25	1	1.00 ± 1.00
Upper Florida Keys Total (18)	15 ± 4	15	0.83 ± 0.22	6 ± 3	4	0.22 ± 0.10
Deeper Fore-reef Total (34)	**18 ± 4**	**30**	**0.88 ± 0.19**	**4 ± 2**	**5**	**0.15 ± 0.06**

Table 8-3. Mean ± 1 SE transect frequencies (%), number of items encountered, and densities (no. items per 60 m^2) of other marine debris and total marine debris in the upper Florida Keys, as determined from surveys of four 15-m x 1-m belt transects per site at 120 sites during June-September 2010. Sites are arranged by habitat from SW to NE and asterisked locations (**) are no-take zones.

Site number/site location	Other marine debris			Total marine debris		
	Frequency	N	No./60 m^2	Frequency	N	No./60 m^2
Inshore and mid-channel patch reefs						
Middle Florida Keys						
A741 – Tavernier Rocks	25 ± 25	1	1.00 ± 1.00	75 ± 25	11	11.00 ± 4.43
534 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	75 ± 25	20	20.00 ± 9.38
535 – Hen and Chickens SPA**	0 ± 0	0	0 ± 0	75 ± 25	3	3.00 ± 1.00
A74 – West of Conch Reef	0 ± 0	0	0 ± 0	75 ± 25	5	5.00 ± 2.52
533 – West of Conch Reef	0 ± 0	0	0 ± 0	75 ± 25	4	4.00 ± 1.63
A73 – West of Conch Reef	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
Middle Florida Keys Total (6)	4 ± 4	1	0.17 ± 0.17	67 ± 8	44	7.33 ± 2.88
Upper Florida Keys						
638 – Inshore of Pickles Reef	75 ± 25	3	3.00 ± 1.00	75 ± 25	3	3.00 ± 1.00
B25B – Inshore of Molasses Reef	25 ± 25	1	1.00 ± 1.00	25 ± 25	1	1.00 ± 1.00
B25 – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B25A – Inshore of Molasses Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
627 – Mosquito Bank	0 ± 0	0	0 ± 0	75 ± 25	5	5.00 ± 1.91
629A – Mosquito Bank	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
628 – Mosquito Bank	25 ± 25	1	1.00 ± 1.00	25 ± 25	1	1.00 ± 1.00
629 – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
629B – Mosquito Bank	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
630 – SE of Cannon Patch Reef	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
631 – Marker 33	50 ± 29	2	2.00 ± 1.15	100 ± 0	7	7.00 ± 3.00
633 – Basin Hill Shoals	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
634 – Basin Hill Shoals	0 ± 0	0	0 ± 0	50 ± 29	3	3.00 ± 1.91
637 – West of Turtle Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
636 – West of Turtle Rocks	0 ± 0	0	0 ± 0	75 ± 25	3	3.00 ± 1.00
Upper Florida Keys Total (15)	12 ± 6	7	0.47 ± 0.24	33 ± 9	26	1.73 ± 0.55
Mid-channel Patch Reef Total (21)	**10 ± 4**	**8**	**0.38 ± 0.18**	**43 ± 8**	**70**	**3.33 ± 1.03**
Offshore patch reefs						
Middle Florida Keys						
A802 – Inshore of Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A801 – Inshore of Conch Reef	25 ± 25	1	1.00 ± 1.00	50 ± 29	3	3.00 ± 1.91
579A – Inshore of Conch Reef	25 ± 25	1	1.00 ± 1.00	75 ± 25	5	5.00 ± 1.91
579B – Inshore of Conch Reef	0 ± 0	0	0 ± 0	75 ± 25	3	3.00 ± 1.00
Middle Florida Keys Total (4)	13 ± 7	2	0.50 ± 0.29	50 ± 18	11	2.75 ± 1.03
Upper Florida Keys						
639 – Inshore of Pickles Reef	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
640 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
641 – White Bank (West of Molasses)	0 ± 0	0	0 ± 0	75 ± 25	5	5.00 ± 1.91
642 – SE of White Bank Dry Rocks	25 ± 25	1	1.00 ± 1.00	75 ± 25	3	3.00 ± 1.00
B33 – East of White Bank Dry Rocks	0 ± 0	0	0 ± 0	75 ± 25	9	9.00 ± 3.42
643 – White Bank (NW of French)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B35 – West of Elbow Reef	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
644 – Watson's Reef	0 ± 0	0	0 ± 0	25 ± 25	2	2.00 ± 2.00
645 – Watson's Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
648 – East of Basin Hill Shoals	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
649 – West of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B39 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00

Site number/site location	Other marine debris			Total marine debris		
	Frequency	N	No./60 m^2	Frequency	N	No./60 m^2
653 – Carysfort Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (13)	2 ± 2	1	0.08 ± 0.08	33 ± 11	24	1.85 ± 0.72
Offshore Patch Reef Total (17)	**4 ± 2**	**3**	**0.18 ± 0.10**	**37 ± 9**	**35**	**2.06 ± 0.60**
Back reef rubble						
Middle Florida Keys						
578 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
583 – Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
555A – Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
555B – Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (4)	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys						
688A – Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
688B – Pickles Reef	25 ± 25	1	1.00 ± 1.00	25 ± 25	1	1.00 ± 1.00
B62 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
691 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
688 – Sand Island	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
689 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
702B – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
702A – Elbow Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (8)	3 ± 3	1	0.13 ± 0.13	6 ± 4	2	0.25 ± 0.16
Back Reef Rubble Total (12)	**2 ± 2**	**1**	**0.08 ± 0.08**	**4 ± 3**	**2**	**0.17 ± 0.11**
Low-relief hard-bottom (< 6 m)						
Middle Florida Keys						
A932 – Crocker Reef	0 ± 0	0	0 ± 0	100 ± 0	10	10.00 ± 3.46
556 – Davis Reef SPA**	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
A87 – Davis Reef SPA**	0 ± 0	0	0 ± 0	25 ± 25	5	5.00 ± 5.00
A84 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A85 – Little Conch Reef	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
554 – Conch Reef C1**	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
555 – Conch Reef C2**	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
A86 – Conch Reef C3**	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
579C – NE of Conch Reef	0 ± 0	0	0 ± 0	50 ± 29	3	3.00 ± 1.91
Middle Florida Keys Total (9)	0 ± 0	0	0 ± 0	36 ± 9	24	2.67 ± 1.04
Upper Florida Keys						
693 – Little Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
664 – North of French Reef	25 ± 25	1	1.00 ± 1.00	100 ± 0	6	6.00 ± 1.15
665 – Inshore of Dixie Shoal	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
Upper Florida Keys Total (3)	8 ± 8	1	0.33 ± 0.33	50 ± 29	8	2.76 ± 1.76
Shallow Hard-bottom Total (17)	**2 ± 2**	**1**	**0.08 ± 0.08**	**40 ± 9**	**32**	**2.67 ± 0.86**
High-relief spur and groove						
Upper Florida Keys						
697 – Pickles Reef P1	25 ± 25	2	2.00 ± 2.00	75 ± 25	5	5.00 ± 1.91
695 – Pickles Reef P3	25 ± 25	1	1.00 ± 1.00	75 ± 25	6	6.00 ± 2.58
696 – NE Pickles Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
706 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
707 – Molasses Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
711 – Sand Island	25 ± 25	1	1.00 ± 1.00	75 ± 25	7	7.00 ± 2.52
704 – French Reef SPA**	25 ± 25	1	1.00 ± 1.00	25 ± 25	1	1.00 ± 1.00
705 – French Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
699 – North of French Reef	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
662 – Grecian Rocks SPA**	25 ± 25	1	1.00 ± 1.00	25 ± 25	2	2.00 ± 2.00

Site number/site location	Other marine debris			Total marine debris		
	Frequency	**N**	**No./60 m^2**	**Frequency**	**N**	**No./60 m^2**
663 – Grecian Rocks SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B42 – Little Grecian Rocks	0 ± 0	0	0 ± 0	75 ± 25	4	4.00 ± 1.63
660 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
661 – Key Largo Dry Rocks**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
656 – North Dry Rocks	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
657 – North-North Dry Rocks	25 ± 25	1	1.00 ± 1.00	25 ± 25	1	1.00 ± 1.00
702 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
703 – Elbow Reef SPA**	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
B66 – South of S. Carysfort	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
700A – South Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
700 – South Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B67 – Carysfort Reef C2**	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
701 – Carysfort Reef C5**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
659 – Turtle Reef	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
Upper Florida Keys Total (24)	6 ± 2	7	0.29 ± 0.11	28 ± 6	38	1.58 ± 0.41
High-relief Spur & Groove Total (42)	**6 ± 2**	**7**	**0.29 ± 0.11**	**28 ± 6**	**38**	**1.58 ± 0.41**
Deeper Fore-reef (6-15 m)						
Middle Florida Keys						
552 – SW of Crocker Reef	25 ± 25	1	1.00 ± 1.00	50 ± 29	4	4.00 ± 2.83
551 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
568 – SW of Crocker Reef	25 ± 25	1	1.00 ± 1.00	25 ± 25	1	1.00 ± 1.00
569 – SW of Crocker Reef	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
A931 – SW of Crocker Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
612 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
613 – Davis Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A941 – North of Davis Reef	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
A942 – Little Conch Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
A94 – Little Conch Reef	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
B24 – Conch Reef RO**	0 ± 0	0	0 ± 0	75 ± 25	4	4.00 ± 1.63
625 – Conch Reef RO**	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
611 – Conch Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
626 – Conch Reef RO**	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
610 – Conch Reef SPA**	25 ± 25	1	1.00 ± 1.00	50 ± 29	2	2.00 ± 1.15
B16 – Conch Reef SPA**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (16)	5 ± 3	3	0.19 ± 0.10	25 ± 6	19	1.19 ± 0.34
Upper Florida Keys						
708 – NE of Conch Reef	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
709 – Pickles Reef	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
710 – SW of Molasses Reef SPA	25 ± 25	1	1.00 ± 1.00	25 ± 25	1	1.00 ± 1.00
712 – SW of French Reef	25 ± 25	1	1.00 ± 1.00	25 ± 25	1	1.00 ± 1.00
B71 – Dixie Shoal	0 ± 0	0	0 ± 0	50 ± 29	4	4.00 ± 2.83
671 – South of Grecian Rocks	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
B51 – East of Dry Rocks	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
713 – North of Elbow Reef	0 ± 0	0	0 ± 0	25 ± 25	2	2.00 ± 2.00
682 – North of Elbow Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
B57 – SE of Watson's Reef	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
716 – South Carysfort Reef**	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
678 – North Carysfort Reef**	25 ± 25	1	1.00 ± 1.00	50 ± 29	2	2.00 ± 1.15
717 – North Carysfort Reef**	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
679 – North Carysfort Reef**	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
675 – North of Carysfort Reef	0 ± 0	0	0 ± 0	25 ± 25	1	1.00 ± 1.00
676 – North of Carysfort Reef	0 ± 0	0	0 ± 0	25 ± 25	2	2.00 ± 2.00
677 – North of Carysfort Reef	0 ± 0	0	0 ± 0	0 ± 0	0	0 ± 0
715 – North of Carysfort Reef	0 ± 0	0	0 ± 0	50 ± 29	2	2.00 ± 1.15
Upper Florida Keys Total (18)	4 ± 2	3	0.17 ± 0.09	25 ± 4	22	1.22 ± 0.24
Deeper Fore-reef Total (34)	**4 ± 2**	**6**	**0.18 ± 0.07**	**25 ± 4**	**41**	**1.21 ± 0.20**

IX. Conclusions and Future Work

Survey results from 2010 add to a growing dataset on the distribution, abundance, size, and condition of benthic coral reef organisms in the Florida Keys National Marine Sanctuary. For many of the variables assessed, we have now developed an 11-year record dating back to 1999 to evaluate benthic community structure in no-take zones throughout the Sanctuary, within the context of larger-scale environmental variability of coral reef and hard-bottom habitats on the south Florida shelf. Benthic surveys completed in 2010 included a follow-up effort, albeit within the upper Keys region, for *Acropora* corals, urchins, anemones, corallimorpharians, selected mollusks, and marine debris. In addition, we were able to sample several nine sites in three depth intervals across Conch Reef to continue a time-series for that reef area. We are in the process of analyzing temporal trends in benthic organisms and community structure throughout the Sanctuary and evaluating the responses of the benthic community to protection from fishing the 23 no-take zones from Key Largo to Key West.

The cumulative results of our program define baseline conditions for coral reef community structure throughout the FKNMS and Dry Tortugas, including marine protected areas. However, sampling only began in 1999 and thus represents an effort established after major declines had already occurred throughout the system, especially related to the loss of *Acropora* corals from disease, the demise of the urchin *Diadema antillarum*, coral bleaching, and various other stressors that impact this ecosystem. To address the lack of a longer temporal framework of our program, we have an unprecedented opportunity to integrate our work with results from an unpublished NSF-funded project conducted in the 1970s. Specifically, we are partnering with the FKNMS, through B. Precht and his damage assessment team, to compare and extend work first started by Dr. Don Kissling in the early 1970s, when Dr. Kissling and his students completed over 190 days of underwater field studies from June 1970 to January 1974. Over 1,000 pages of field notes and data were compiled, reporting on the hydrological, sedimentological and ecological elements of nine reefs located from Looe Key to Sand Key. Kissling's data indicate diverse living coral assemblages. In addition, hundreds of black-and-white and color photographs were cataloged. In 1978, Dr. Kissling retired unexpectedly from academia, and this treasure trove of data has sat idle for over 30 years. Dr. Kissling has agreed to work with us to publish and resample the sites he visited over 30 years ago. The comparative work will be based on our on-going, long-term monitoring protocols, as well as additional work to resample the parameters he measured that are not presently included in our sampling program (e.g. brittle stars and sediments). In general, publications from this work will be based on comparisons of these reefs after three decades of decline, including what was lost and why. Other elements of this data rescue element include preparation of database files for publication on our website and digitizing photographs for archival purposes.

In 2011, we are coordinating a region-wide assessment of *Acropora* corals in U.S. territorial waters, including southeast Florida, the U.S. Virgin Islands, and Puerto Rico. We plan to survey *Acropora* corals for abundance, size, and condition throughout a large section of the Florida Keys, specifically from northern Biscayne National Park to near the Marquesas region. In addition, urchins, anemones/corallimorpharians, selected mollusks, and marine debris will be sampled Keyswide. We will also be coordinating similar efforts in the U.S. Caribbean to identify to develop abundance estimates structured by colony size and habitat type.

In 2011-2012, we plan to collaborate further with Nancy Sheridan of the Florida Fish & Wildlife Research Institute to sample ocean-side and nearshore-Florida Bay-Biscayne Bay hard-bottom and seagrass matrix habitats for benthic community structure, with a focus on several species targeted by the marine ornamental trade. Along with fishery-dependent data on landings and aggregation locations, these data will provide both fishery-dependent and independent population assessments of targeted species. This will also provide an unprecedented data set from nearshore to offshore habitats for evaluating population status of benthic organisms that provides a framework for monitoring trends over time.

In 2010-2011, we will also continue to analyze data and prepare publications. Of particular note is work related to our now 11-year record of surveys in the FKNMS and additional multivariate work related to the distribution and abundance of species and habitat types throughout the region. The data set provides unprecedented spatial coverage of organism habitat distribution, density, and size, as well as a means to evaluate temporal changes related to the FKNMS zoning action plan relative to larger-scale phenomena.

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