Large-scale Assessment of Marine Debris and Benthic Coral Reef Organisms in the Florida Keys National Marine Sanctuary

2008 Quick Look Report and Data Summary




December 2008

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Cover photo. Examples of marine debris from fishing-related activities impacting benthic coral reef organisms in the Florida Keys. The density, distribution, and biological impacts of marine debris were quantified at 145 sites from northern Key Largo to Key West during June-September 2008.

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2008 Sampling Summary

During 25 days of fieldwork from June 21st through September 21st, 2008, research scientists from the Center for Marine Science at the University of North Carolina-Wilmington surveyed the density and size of benthic coral reef organisms and the density, amount, and biological impacts of marine debris throughout the Florida Keys National Marine Sanctuary from northern Key Largo to SW of Key West. This effort is part of a larger program dating back to 1999 that documents the status and condition of benthic coral reef resources in the Florida Keys.

Methods include a two-stage stratified random sampling design to partition the Florida Keys sampling domain by benthic habitat type, regional sector, and management zone. Five benthic habitat types were sampled from the inshore edge of Hawk Channel to the deeper fore-reef from 1.0 to 16.5 m depth, including: inshore and mid-channel patch reefs, offshore patch reefs, inner line spur and groove, platform margin spur and groove (< 6 m), and the deeper fore-reef (6-17 m) encompassing hard-bottom, patch hard-bottom, and low-relief spur and groove sites. Sites were also partitioned by regional sector (upper, middle, and lower Keys) and management zone within the FKNMS and included 22 of the 23 no-take zones from northern Key Largo to SW of Key West, designated as Sanctuary Preservation Areas, Ecological Reserves, and Special-use Areas/Research Only Areas. For the 145 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: depth and topographic complexity; *Acropora* coral presence-absence; gorgonian density and size, as well as gorgonian host occupation patterns by flamingo-tongue (*Cyphoma*) snails; density and size (test diameter) of urchins; density of anemones and corallimorpharians; and density, length, wet weight, and biological impacts of marine debris. These variables have been assessed periodically by our program over several years and add to a growing spatial and temporal data set to help ascertain the status and trends of various benthic organisms.

This report summarizes the major findings and provides descriptive data for the variables measured during 2008. The report is divided by chapter for each of the major categories of variables measured, and includes 25 tables and 193 figures of underwater photographs, maps, and data graphs. The data were collected by a two-member survey team that conducted 290 SCUBA dives comprising 263 hours of underwater bottom time.

For *Acropora* corals, data on presence-absence and habitat distribution indicated relatively consistent findings with results from similar surveys in 2006 and 2007. Staghorn coral (*A. cervicornis*) was more

frequently encountered on offshore patch reefs throughout the Florida Keys, followed by mid-channel patch reefs, particularly in the lower Keys. Colonies were much less frequent on the shallow platform margin and the deeper fore-reef. For elkhorn coral (*A. palmata*), colonies were only encountered on high-relief spur and groove habitats, especially within no-take zones in the upper and middle Keys compared to the lower Keys.

A total of 32,801 gorgonians were identified, counted, and measured for maximum colony height, along with assessments of the density, shell length, and host occupation patterns of flamingo-tongue snails (*Cyphoma* spp.). Results indicated that, with the exception of some shallow spur and groove sites, gorgonians are a dominant component of the sessile invertebrate assemblage, with densities as high as 46 colonies per m^2. Only 41 *C. gibbosum* snails and two *C. signatum* snails were encountered, and compared to a similar survey in 2001, snail densities were much lower overall in the study area, but still tended to be higher in reference areas compared to no-take zones.

Six urchin species were encountered within belt transect surveys and 1,752 individuals were counted and measured for test diameter. Of these, 83% were either *Echinometra viridis*, which was especially abundant on mid-channel and offshore patch reefs, or *Eucidaris tribuloides*, which was abundant on high-relief spur and groove and deeper fore-reef sites. Densities of the long-spined sea urchin (*Diadema antillarum*) are still relatively low (< 0.3 individuals per m^2) by historical (pre-1983) standards; however, two temporal trends are noteworthy. First, densities of *D. antillarum* have slowly increased since 1999, and the highest densities now occur on mid-channel and offshore patch reefs. Second, there has been a shift in the average and maximum sizes of individuals encountered over the past 10 years to larger individuals. In 2008, individuals as large as 10.7 cm TD were recorded, which was unheard of from 1999-2005. Where aggregations of urchins were found, there were clear and obvious impacts to the substratum, and it is expected that a recovering population, albeit slow, will make available more space for recruitment of invertebrates, perhaps including corals.

Six anemone species and three corallimorpharian species were sampled to compute densities among habitat types, regions, and between no-take zones and reference areas. A total of 530 anemones were counted, of which ~87% were *Bartholomea annulata* and *Lebrunia danae*. Both anemones and corallimorpharians exhibited similar spatial patterns in abundance in 2008 with previous surveys in 2000 and 2005. A total of 2,063 corallimorpharians were counted, of which ~77% were *Ricordea florida*, followed by two *Discosoma* species. *R. florida* was most abundant on mid-channel and offshore patch

reefs, especially in the lower Keys from Bahia Honda to Key West, and was particularly abundant in no-take zones compared to reference areas.

A significant amount of underwater time in 2008 was devoted to inventorying and collecting marine debris, including derelict fishing gear such as hook-and-line and trap gear. These surveys were a follow-up to similar work conducted by our group in 2000 and 2001. A total of 34,800 m^2 of benthic habitat was surveyed for marine debris and 686 incidences representing 59 different types of items or combinations of items were encountered. Throughout the study area and for the habitats surveyed, we found an average of ~2 pieces of marine debris per 100 m^2, a result somewhat higher than recorded in earlier surveys. Of the total debris encountered, 53% was lost hook-and-line angling gear (monofilament, hooks, leaders, wire, fishing poles, etc.) and 35% was trap debris (rope, wooden slats, pot openings or throats, cement). A total of 477.6 m of hook-and-line gear and 944.3 m of trap rope were measured. The marine debris encountered caused damage to 448 benthic invertebrates represented by *Millepora* corals, scleractinian corals, gorgonians, sponges, and the colonial zoanthid *Palythoa*. All debris encountered was retrieved from the bottom and a total of ~443 kg (~975 lbs.) wet weight was recovered. Similar to results from 2000 and 2001, lost hook-and-line fishing gear was generally more prevalent offshore in high-relief spur and groove and deeper fore-reef habitats, while derelict trap gear was more frequently encountered on mid-channel and offshore patch reefs. Similar to historical observations, marine debris is ubiquitous and abundant in the Florida Keys and is not benign in terms of the impacts to organisms. It is particularly noteworthy that there is a high density and amount of derelict fishing gear present in the Sanctuary no-take zones, due to continued non-compliance, gear that is set close to the no-take zones and that is moved, or a combination of the two. The extensive presence of marine debris throughout the Sanctuary, and especially within the no-take zones, has obvious management implications.

I. Introduction

Like many coral reef ecosystems, the Florida Keys have experienced signs of degradation in recent decades, including declines in urchins and corals, particular acroporid corals that have also occurred in the wider Caribbean (Jaap 1984; Dustan and Halas 1987; Aronson and Precht 2001; Chiappone et al. 2002).

In the case of *Acropora* corals, both species were under consideration for addition to the U.S. Endangered Species List since the early 1990s and were formally added to the list as threatened in 2006 based upon Caribbean-wide population declines and poor recovery. The reader is referred to the *Acropora* Biological Review Team summary at http://sero.nmfs.noaa.gov/pr/pdf/050303%20status%20review.pdf for further

information. Symptoms of degradation include declines in the abundances of corals, concurrent increases in algae, increased prevalence of disease and bleaching events, and overfishing. In addition to impacts from over-use and coastal development, there are a considerable array of natural phenomena affecting Florida Keys reefs such as atmospheric cold fronts because of high latitude, continental influence (Florida Bay-Atlantic Ocean 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).

Part of the uncertainty in understanding the factors drive decreases in populations stems from the quality of the data used to document spatial patterns and temporal changes. Many historical studies lacked the statistical rigor necessary to adequately evaluate changes at the population-scale; in other words, the ecosystem area inhabited by a closed, interbreeding unit (Gardner et al. 2003). Generally, sampling has been at a habitat-level of stratification; that is, limited to a few reef sites within particular habitat types in restricted portions of the spatial domain (Dustan and Halas 1987; Porter and Meier 1992; Chiappone and Sullivan 1997). Frequently, selection of sampling sites within a given habitat did not follow standard randomization protocols, and consequently, the derived abundance metrics may not have been representative of the sampled habitats (Murdoch and Aronson 1999). Additionally, the locations sampled may not have been representative of the full range of habitats. Also, sampling is rarely conducted at the appropriate temporal scale to specifically identify the causes of decline: for example, annual sampling programs are not sufficient to document the affects of bleaching or disease. We contend that, at least for the Florida Keys, the documented temporal changes and current views of spatial distribution and abundance patterns of coral reef benthos are partly biased by the selection of specific, non-random, reef habitats along the Florida Reef Tract that are not be representative of the larger ecosystem. For example, there is no doubt that areas historically dominated by *Acropora* corals, particularly the shallow (< 6 m) and deeper (8-15 m) fore-reef, have changed substantially, largely due to Caribbean-wide disease events (Dustan and Halas 1987; Aronson and Precht 2001) and bleaching (Somerfield et al. 2008). However, debate continues regarding the causes of coral reef decline (Porter and Meier 1992; Precht and Miller 2007; Somerfield et al. 2008), thus making it important for resource managers to distinguish between the significance of localized threats in lieu of larger-scale factors such as climate change.

During just over three weeks of underwater fieldwork in the Florida Keys, we had the opportunity to sample 145 different locations stratified by habitat, regional sector, and management zone from northern Key Largo to Key West within the Florida Keys National Marine Sanctuary. Several metrics, such as urchin density and size by species, add to a growing temporal base of observations made by our program

since 1999 (Chiappone et al. 2002a, b; Miller et al. 2002). Previous surveys conducted by this program aided in optimizing a sampling plan for obtaining estimates for abundance and size or amount of benthic coral reef invertebrates and marine debris. Quick Look reports from previous years are available at http://people.uncw.edu/millers. These observations are designed to help resource managers evaluate the performance of smaller protected areas (no-take zones) relative to other factors that influence the larger ecosystem. In this communication, we report on a large-scale sampling effort that encompassed 145 sites across the south Florida shelf to determine patterns of benthic invertebrate density and size, as well as density, amount, and impacts of marine debris.

A significant part of the field effort in 2008 was devoted to documenting and retrieving marine debris, most of which is derelict fishing gear, from all of the sites visited. This represents a follow-up to similar surveys conducted in the FKNMS during 2000 and 2001 (Chiappone et al. 2002c, 2004). Fishing constitutes one of the most significant threats to marine biodiversity and ecosystem function, documented by a growing 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 species population structure, 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 can be expected in any area 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 in landings, dockside value, and numbers of commercial fishing vessels, especially for highly valued invertebrate fisheries (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). The marine debris data collected in 2008 are particularly timely because this coastal ecosystem continues to experience a growing number of recreational fishers, and both commercial and recreational fishers exploit hundreds of invertebrates and fish species (Bohnsack et al. 1994; Ault et al. 1998). The 2008 study addressed several issues on marine debris occurrence in shallow-water coral reef and hard-bottom habitats. First, what is the spatial extent and frequency of marine debris at multiple spatial scales in the Florida Keys? Secondly, what factors, such as habitat type (depth) or management regime (closed or open to fishing) affect the spatial variability of marine debris occurrence? Thirdly, what

are the biological impacts of marine debris, especially from derelict angling and trap fishing gear, on benthic coral reef organisms such as stony corals and sponges?

II. Study area and methods

Study area and sampling objectives

The Florida Keys are an archipelago of limestone islands stretching more than 360 km from near Miami to the Dry Tortugas and represent the only region of extensive reef development in the continental United States, with the exception of isolated banks in the Flower Gardens region of the Gulf of Mexico (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). From inshore to offshore of the Pleistocene islands, a nearshore rock ledge extends ~2.5 km seaward from the shoreline, and consists of hard-bottom, seagrass, and some inshore patch reefs (FMRI 1998). Further seaward is Hawk Channel, a broad trough-like depression dominated by non-coralline, non-oolitic grainstone, but also harboring 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). 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 Florida Straits. The main, semi-continuous 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). Coral reef distribution 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, the locations of major tidal passes, and the proximity of the Florida Current to the platform margin (Pitts 1994; Smith 1994).

The 2008 sampling of coral reef benthic invertebrates and marine debris in the Florida Keys National Marine Sanctuary (FKNMS) was undertaken as a spatially intensive effort to quantify the abundance and size of selected invertebrates, as well as the abundance and impacts of marine debris. The 2008 surveys conducted during June 21 to September 21 were an outgrowth of previous efforts conducted by the authors dating back to 1999 to quantify the abundance and condition of coral reef benthos throughout the FKNMS, including the Tortugas region, and represent a subset of the total number of variables measured by the program (Miller et al. 2002). Previous surveys in the FKNMS, excluding the Tortugas region, included 80 sites sampled in 1999, 45 sites in 2000, 108 sites in 2001, 195 sites in 2005, 107 sites in the upper Keys region in 2006, and 235 sites Keyswide in 2007. 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 2008. The objectives of the 2008 sampling effort were to provide information on:

- Depth and physical structure (maximum vertical relief) of survey sites;
- Habitat-based presence-absence distribution patterns of *Acropora* corals within diverse hard-bottom and coral reef habitat types from 1 m to 16 m depth, including a photographic archival record of where both *Acropora* coral species were found;
- Density and size (maximum colony heights) of gorgonians, as well as gorgonian host occupation patterns of flamingo-tongue snails;
- Density and size (test diameter) of all sea urchins encountered, representing a continuing effort to monitor recovery of the historically abundant long-spined sea urchin *Diadema antillarum*;
- Density of sea anemones and corallimorpharians; and
- Density, amount (length and wet weight), and biological impacts of marine debris.

Sampling design and field methodology

The sampling design for assessing benthic coral reef invertebrates and marine debris encompassed 145 sites visited during June-September 2008. Sites were distributed from northern Key Largo near the boundary between the FKNMS and Biscayne National Park to southwest of Key West at Satan Shoal (Figure 1). The sampling design included five habitat types in three regions, as well as 22 of the 23 no-take marine reserves designated as Sanctuary Preservation Areas (SPA), Ecological Reserves (ER), and Research Only Areas (RO) in the FKNMS, not including the Tortugas region (Table 1). Table 2 chronologically lists the sampling locations during June-September 2008. The original sampling plan was delayed somewhat due to Hurricanes Faye and Gustav in August and September. In contrast to the previous two years, generally windy conditions prevailed during the 2008 summer sampling.

The habitat strata selected for the 2008 sampling incorporated most of the hard-bottom and coral reef habitat types from the shoreward edge of Hawk Channel to 16 m depth along the reef tract, but did not include back reef rubble, nearshore hard-bottom, or hard-bottom/seagrass matrix habitats. Habitats sampled during 2008 were inshore and mid-channel patch reefs, offshore patch reefs along the platform margin, 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 6 m to 16.5 m depth. Deeper fore-reef habitats encompassed continuous, low-relief hard-bottom, patchy hard-bottom and sand, and low-relief spur and groove. The list of sites organized by benthic habitat type is provided in Table 3, together with site-level data on depth and maximum vertical relief. Besides habitat type, sites

were further stratified according to regional sector and management zone. Figures 2-3 show the spatial distribution of sampling locations by habitat type for the upper, middle, and lower Florida Keys regional sectors, along with the boundaries of existing no-take marine reserves in the FKNMS. Figures 4-6 illustrate examples of each of the hard-bottom and coral reef habitats sampled during 2008.

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. Map resolution was such that the survey domain was divided into a grid with individual cells of size 200 m by 200 m (40,000 m^2) that defined unique habitat classes (Table 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 population abundance metrics, we divided the Florida Keys survey domain into strata based upon: 1) habitat class; 2) geographic region; 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 influence the distribution, community dynamics, and biotic composition of reefs (Marszalek et al. 1977; Shinn et al. 1989). Regional sectors were 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). Regional sectors potentially reflect differences in oceanographic influences, geological history, and habitat distribution. FKNMS management zones (i.e. no-take marine reserves) were incorporated as a third stratification variable that delineated areas open and closed to consumptive activities. This stratification included sites inside and outside of FKNMS no-take marine reserves (SPA, ER, and RO). Within each no-take zone, two replicate sites were sampled in a given habitat type.

The power of this stratified random sampling approach is essentially two-fold. First, the habitats comprising the most area are allocated more sites than those with less area (i.e., a proportional design). Second, habitats with more variability in a particular metric are allocated more sites than those with less variability. The ultimate power of this approach is derived 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 included 150 sampling locations, with an additional 150 alternate sites for the upper, middle, and lower Florida Keys regions. 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 in length, marked in 1-m increments, along the bottom. A 60 m^2 area (a 1-m wide belt centered on each 15-m long transect tape) was surveyed at each site for most variables, except marine debris, where a 240 m^2 area (a 4-m wide belt centered on each 15-m transect tape) was surveyed. Each of divers surveyed two of the four transects for: depth and maximum vertical relief; *Acropora* coral presence-absence; gorgonian numbers and sizes (maximum colony heights) by genera, as well as *Cyphoma* snail numbers, sizes, and gorgonian hosts; urchin numbers and sizes (test diameter); anemone and corallimorpharian numbers; and the type, frequency, amount, and biological impacts of marine debris. Transects were placed in a haphazard fashion, but in a way that best represented the habitat at the randomly selected site coordinates. 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. Digital photographs of each site were taken to record general site features and organisms encountered.

For *Acropora* coral presence-absence, any colonies observed within the 15-m x 1-m belt transects were noted (sample size of 60 m^2 per site). For gorgonian densities and colony heights, all branching gorgonians identified along two 8-m x 1-m belt transects were counted and measured for maximum colony height (sample size of 16 m^2 per site). Gorgonians were identified to genus to minimize inconsistencies in field identification of species. In the same sampling area, any flamingo-tongue snails (*Cyphoma gibbosum* and *C. signatum*) encountered were counted, measured for shell length, and the gorgonian hosts they occupied were noted. The numbers of anemones and corallimorpharians, as well as

the numbers and sizes (test diameter) of urchins were recorded along each 15-m x 1-m belt transect, for a sample size of 60 m^2 per site.

Marine debris was surveyed along all four 15-m x 4-m belt transects per site, yielding a total sample area of 240 m^2 per site. Along each belt transect, any marine debris encountered was identified, counted, and collected. The number of organisms impacted by marine debris was also noted, considered as debris causing abrasion stress of *Millepora* and scleractinian corals, gorgonians, sponges, and the colonial zoanthid *Palythoa*. For derelict hook-and-line angling gear, measurements of total length of monofilament, wire leaders, wire, and hooks (not lead weights) were made either underwater or on-board the research vessel. For derelict trap gear, total length of trap rope was measured, not including plastic pot openings, wooden slats, and cement used to weight the traps. For each transect, all marine debris encountered was recovered from the bottom and placed into labeled mesh gear bags to determine total wet weight per transect once on-board the research vessel. A digital 50-pound scale was used (Rapala® model RSDS-50) to obtain the wet weight of marine debris collected along each transect. Debris was also categorized according to whether it was biologically fouled or not.

The 2008 sampling effort (145 sites) required 25 field days from June 21 to September 21 (Table 2). Several days were lost due to inclement weather in August and September. The June-September sampling was generally marked by windy conditions, but rather outstanding underwater visibility, especially in the middle and lower Keys. A private research vessel (R/V *Expedition II*, New World Expeditions, Key Largo, captained by Bernie Altmeir) provided on-the-water diving support. The survey team consisted of personnel from the Center for Marine Science/UNCW (Mark Chiappone and Leanne Rutten) (Table 4). SCUBA tank fills and lodging were provided by the National Undersea Research Center-UNCW facility on Key Largo and local area dive shops and hotels/marinas in Marathon and Key West. The sampling effort depended upon 6 to 7 hours in the water daily by a two-person benthic team to complete an average of 6-8 sites per day. Typically 35-60 minutes per site were needed to sample all of the variables. Table 4 summarizes the diving statistics for 2008. The benthic surveys for targeted marine invertebrates and marine debris at the 145 sites required 145 two-person dives (290 dives total) comprising nearly 263 hours of underwater bottom time.

Figure 1. Sampling locations for marine debris and benthic coral reef organisms from southwest of Key West to northern Key Largo during June-September 2008.

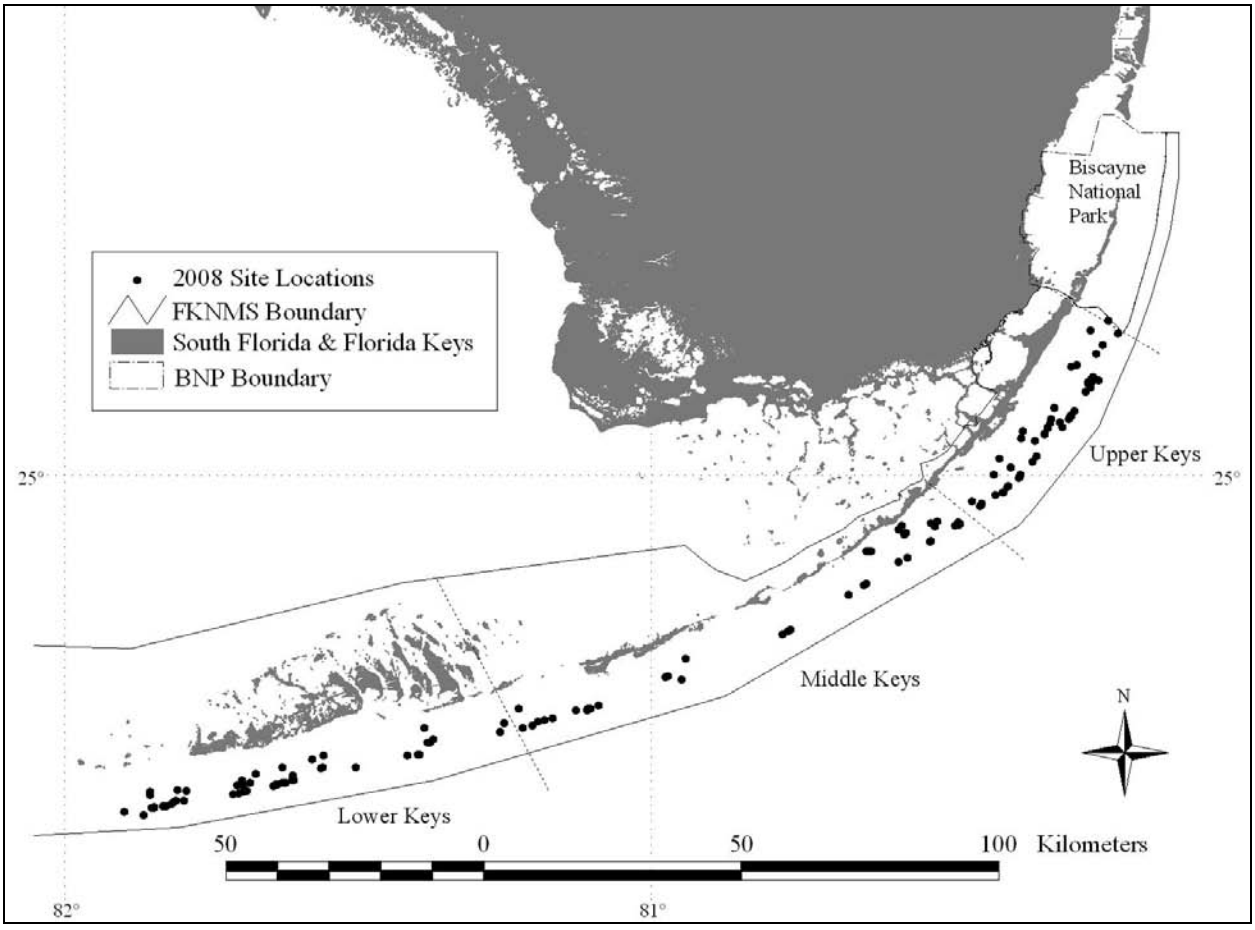


Figure 2. Sampling locations by benthic habitat type from the southern Biscayne National Park boundary to Tavernier (top) and Tavernier to Bahia Honda (bottom) in the Florida Keys during 2008.

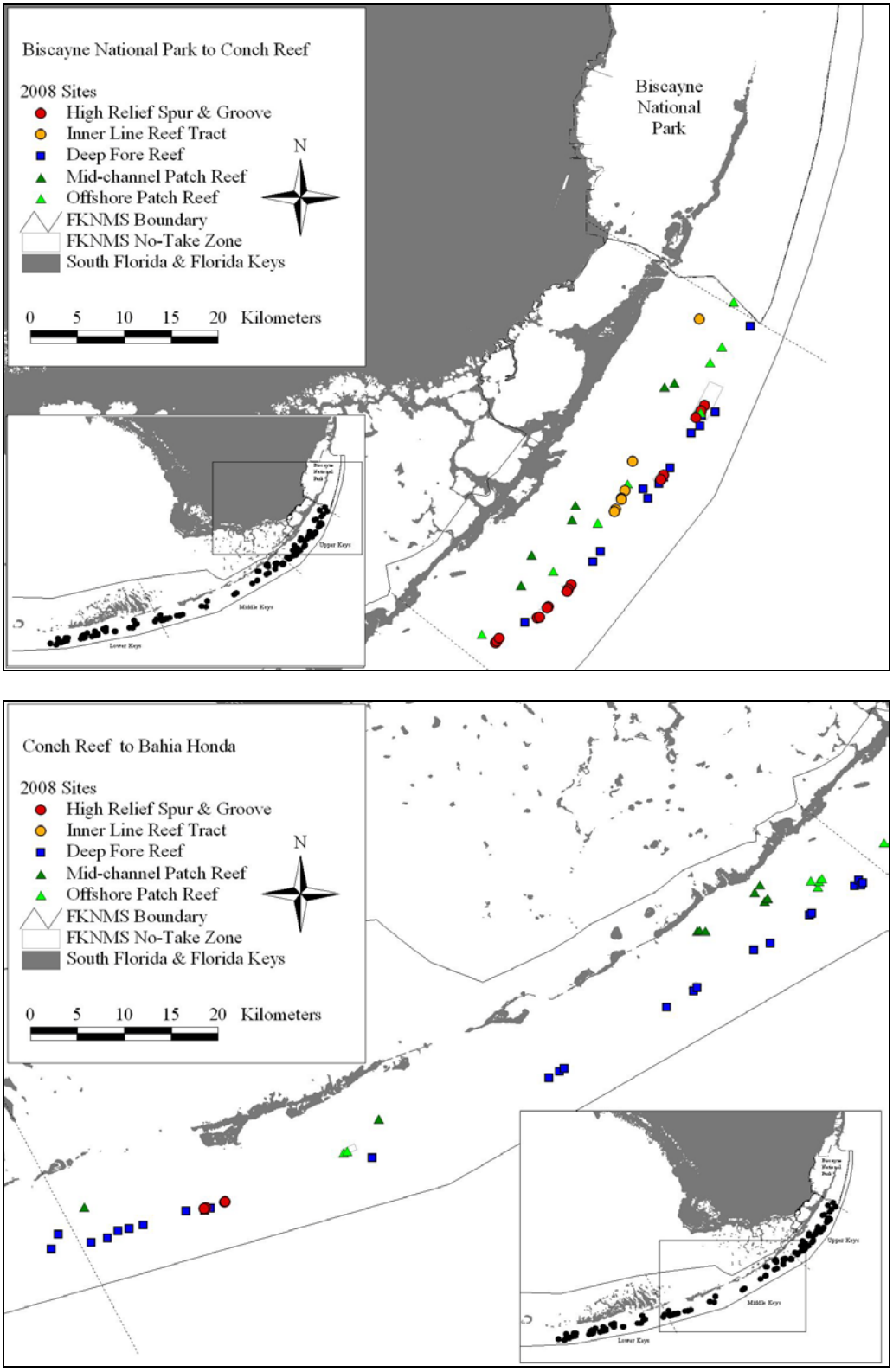


Figure 3. Sampling locations by benthic habitat type from Bahia Honda to Satan Shoal in the Florida Keys during 2008.

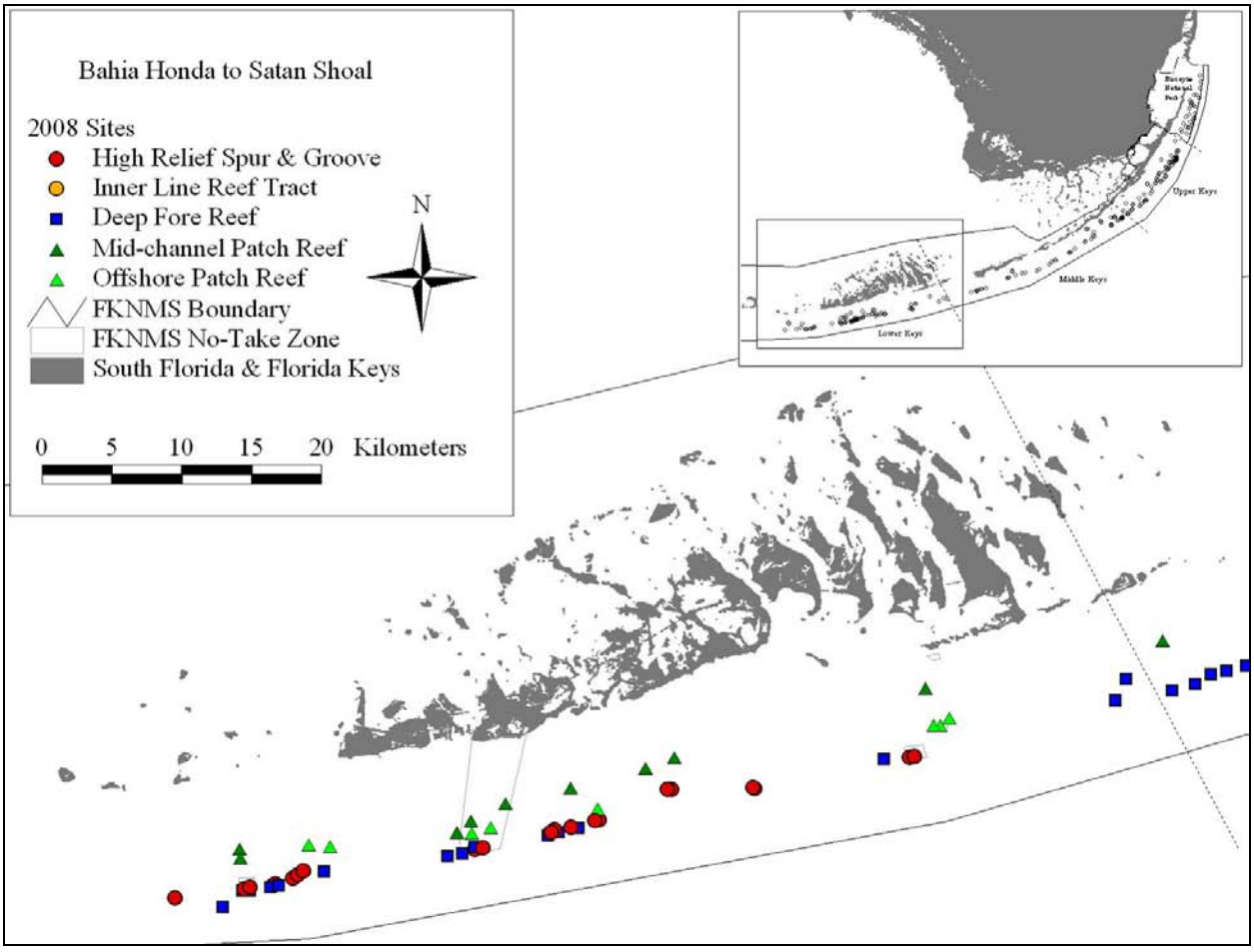
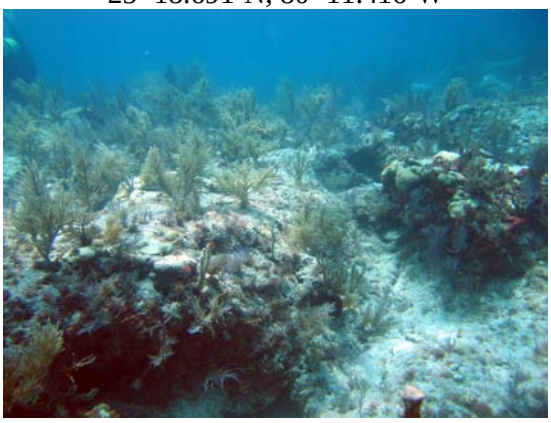


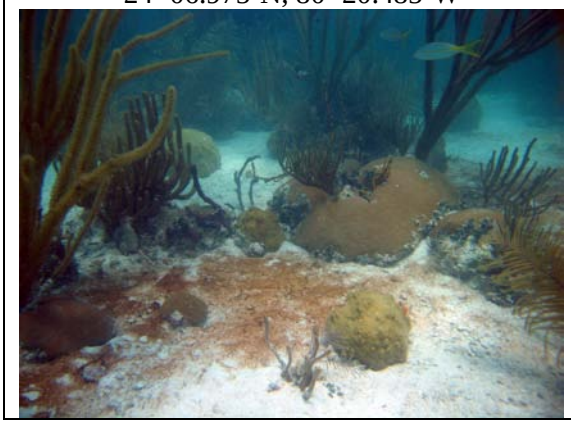
Figure 4. Examples of mid-channel and offshore patch reefs sampled in the Florida Keys during 2008.

Mid-channel patch reef
Site #6, Basin Hill Shoals, 2.4-3.0 m
25° 14.019'N, 80° 14.788'W

Offshore patch reef
Site #12, South of BNP, 4.6-7.0 m
25° 18.691'N, 80° 11.416'W



Mid-channel patch reef
Site #4, Inshore of Grecian Rocks, 3.0-4.9 m
24° 06.975'N, 80° 20.485'W



Offshore patch reef
Site #11, North of Carysfort SPA, 4.0-5.8 m
25° 15.190'N, 80° 12.756'W

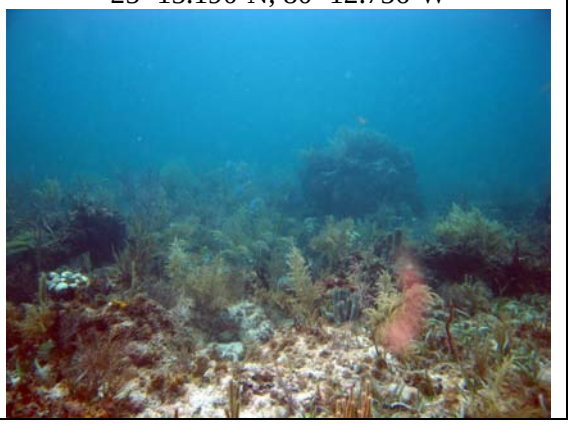
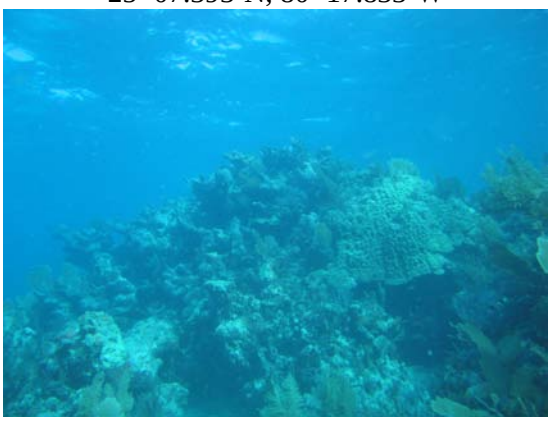
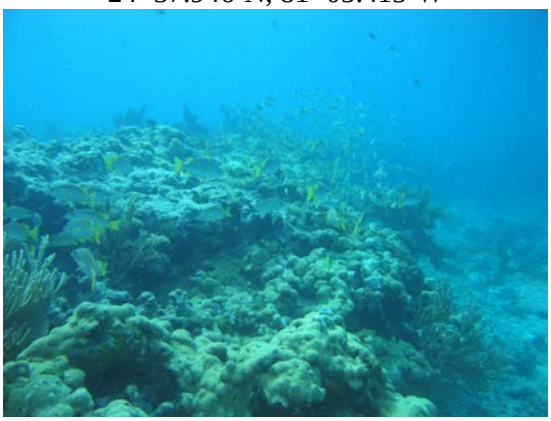


Figure 5. Examples of inner line reef tract and high-relief spur and groove reefs sampled in the Florida Keys during 2008.

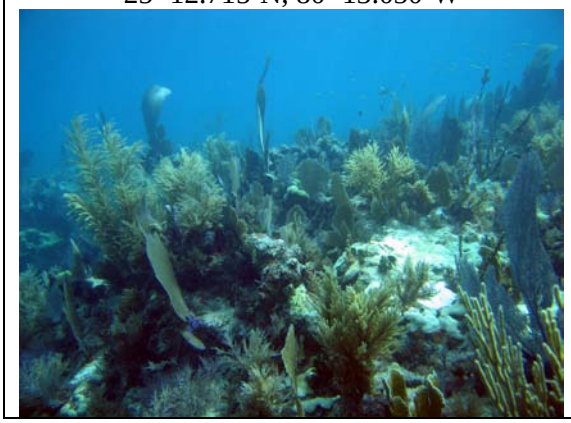
Inner line reef tract
Site #34, Dry Rocks SPA, 2.7-4.6 m
25° 07.393'N, 80° 17.833'W



High-relief spur and groove
Site #67, Delta Shoal, 3.7-5.2 m
24° 37.946'N, 81° 05.415'W



High-relief spur and groove
Site #23, Carysfort Reef SPA, 2.7-5.2 m
25° 12.715'N, 80° 13.050'W



High-relief spur and groove
Site #114, Western Dry Rocks, 3.7-5.8 m
24° 26.707'N, 80° 55.662'W

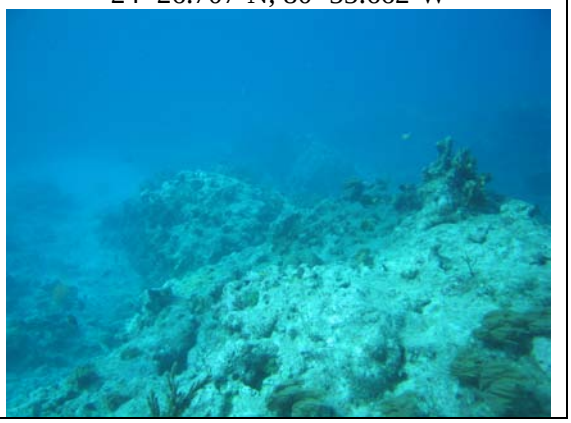
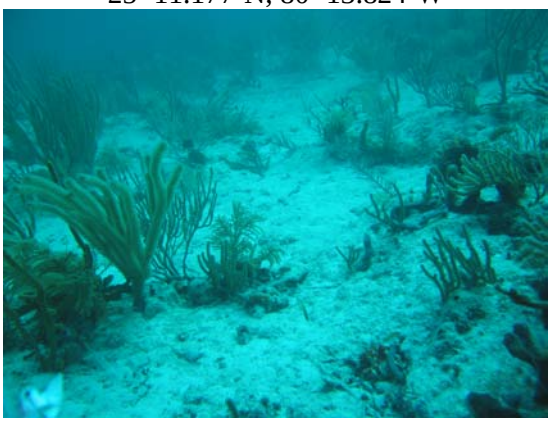
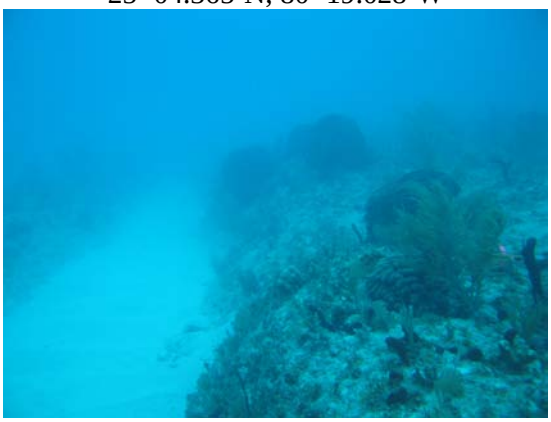


Figure 6. Examples of deeper (6-15 m) fore-reef habitats sampled in the Florida Keys during 2008.

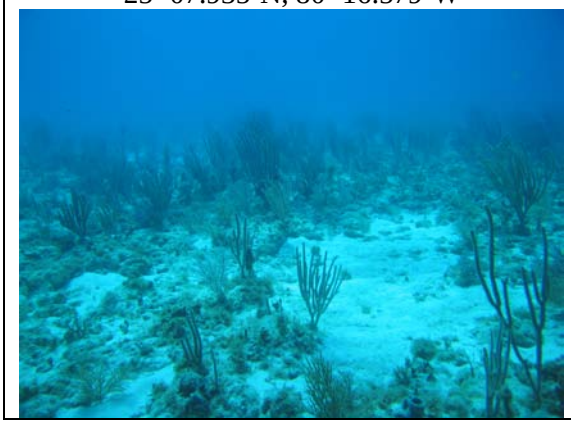
Low-relief hard-bottom
Site #40, SW of Carysfort Reef, 12.2-13.1 m
25° 11.177'N, 80° 13.824'W



Low-relief spur and groove
Site #37, Dixie Shoal, 11.0-12.2 m
25° 04.365'N, 80° 19.028'W



Patchy hard-bottom
Site #38, SW of Elbow Reef, 8.8-9.4 m
25° 07.935'N, 80° 16.579'W



Low-relief spur and groove
Site #135, West of Looe Key, 11.9-12.8 m
24° 32.638'N, 81° 25.655'W

Table 1. Survey effort for marine debris and benthic coral reef organisms in the Florida Keys National Marine Sanctuary during June-September 2008. 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 (1998) habitat mapping data. Asterisked sites (**) are 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	6	4.14	787	10.45	0.76
Middle Florida Keys					
Reference sites	5	3.45	326	4.33	1.53
Hen and Chickens SPA**	2	1.38	10	0.13	20.00
Cheeca Rocks SPA**	2	1.38	11	0.15	18.18
Lower Florida Keys					
Reference sites	7	4.83	1,025	13.61	0.68
Western Sambo ER**	2	1.38	35	0.46	5.71
MPR Habitat Total	**24**	**16.55**	**2,194**	**29.14**	**1.09**
Offshore patch reef (OPR)					
Upper Florida Keys					
Reference sites	7	4.83	719	9.55	0.97
Carysfort/S. Carysfort SPA**	2	1.38	7	0.09	28.57
Middle Florida Keys					
Reference sites	4	2.76	55	0.73	7.27
Coffins Patch SPA**	2	1.38	5	0.07	40.00
Lower Florida Keys					
Reference sites	4	2.76	125	1.66	3.20
Looe Key RO**	2	1.38	13	0.17	15.38
Western Sambo ER**	2	1.38	55	0.73	3.64
OPR Habitat Total	**23**	**15.86**	**979**	**13.00**	**2.35**
Inner line spur and groove (IRT)					
Upper Florida Keys					
Reference sites	3	2.07	68	0.90	4.41
Dry Rocks SPA**	2	1.38	5	0.07	40.00
Grecian Rocks SPA**	2	1.38	14	0.19	14.29
IRT Habitat Total	**7**	**4.83**	**87**	**1.12**	**8.05**
High-relief spur and groove (HSG)					
Upper Florida Keys					
Reference sites	7	4.83	32	0.42	21.88
Carysfort/S. Carysfort SPA**	2	1.38	34	0.45	5.88
Elbow Reef SPA**	2	1.38	15	0.20	13.33
French Reef SPA**	2	1.38	12	0.16	16.67
Molasses Reef SPA**	2	1.38	18	0.24	11.11
Middle Florida Keys					
Reference sites	2	1.38	2	0.03	100.00
Sombrero Reef SPA**	2	1.38	7	0.09	28.57
Lower Florida Keys					
Reference	9	6.21	42	0.56	21.43
Looe Key SPA**	2	1.38	15	0.20	13.33
Eastern Sambo RO**	2	1.38	6	0.08	33.33
Western Sambo ER**	2	1.38	14	0.19	14.29
Eastern Dry Rocks SPA**	2	1.38	4	0.05	50.00
Rock Key SPA**	2	1.38	6	0.08	33.33
Sand Key SPA**	2	1.38	3	0.04	66.67
HSG Habitat Total	**40**	**27.59**	**210**	**2.79**	**19.05**

Habitat type/region/protection	Sites sampled (n)	% of Effort	Sites available (n_{tot})	n_{tot} (%)	n/n_{tot} (%)
Fore-reef (6-15 m)					
Upper Florida Keys					
Reference sites	9	6.21	1,036	13.76	0.87
Carysfort/S. Carysfort SPA**	2	1.38	93	1.24	2.15
Elbow Reef SPA**	2	1.38	13	0.17	15.38
Middle Florida Keys					
Reference sites	10	6.90	1,669	22.16	0.60
Conch Reef SPA**	2	1.38	14	0.19	14.29
Conch Reef RO**	2	1.38	6	0.08	33.33
Davis Reef SPA**	2	1.38	10	0.13	20.00
Alligator Reef SPA**	2	1.38	6	0.08	33.33
Tennessee Reef RO**	2	1.38	16	0.21	12.50
Sombrero Reef SPA**	2	1.38	8	0.11	25.00
Lower Florida Keys					
Reference sites	8	5.52	1,150	15.27	0.70
Eastern Sambo RO**	2	1.38	7	0.09	28.57
Western Sambo ER**	2	1.38	28	0.37	7.14
Rock Key SPA**	2	1.38	2	0.03	100.00
Sand Key SPA**	2	1.38	2	0.03	100.00
Fore-reef (6-15 m) Total	**51**	**35.17**	**4,060**	**53.92**	**1.26**
Sampling Design Total	**145**	**100.00**	**7,530**	**100.00**	**100.00**

Table 2. Chronological list of site locations for marine debris and benthic coral reef organism surveys in the Florida Keys National Marine Sanctuary during June-September 2008. 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
42	6/21/2008	South of BNP Boundary	25°17.304’	80°10.439’	Patchy hard-bottom (6-15 m)
12	6/21/2008	South of BNP Boundary	25°18.691’	80°11.416’	Offshore patch reef
32	6/21/2008	Turtle Rocks	25°17.686’	80°13.342’	Inner line reef tract
41	6/21/2008	North of Carysfort Reef SPA	25°16.119’	80°12.083’	Offshore patch reef
11	6/21/2008	North of Carysfort Reef SPA	25°15.190’	80°12.756’	Offshore patch reef
5	6/22/2008	Basin Hill Shoals	25°13.795’	80°15.376’	Mid-channel patch reef
6	6/22/2008	Basin Hill Shoals	25°14.019’	80°14.788’	Mid-channel patch reef
52	6/22/2008	Carysfort Reef SPA**	25°12.384’	80°12.488’	Low-relief spur and groove (6-15 m)
51	6/22/2008	Carysfort Reef SPA**	25°12.174’	80°13.222’	Low-relief spur and groove (6-15 m)
23	6/22/2008	Carysfort Reef SPA**	25°12.715’	80°13.050’	High-relief spur and groove (< 6 m)
22	6/22/2008	Carysfort Reef SPA**	25°12.415’	80°13.242’	High-relief spur and groove (< 6 m)
50	6/23/2008	SW of Carysfort Reef SPA	25°11.579’	80°13.323’	Low-relief spur and groove (6-15 m)
14	6/23/2008	Carysfort Reef SPA**	25°12.326’	80°13.302’	Offshore patch reef
13	6/23/2008	Carysfort Reef SPA**	25°12.189’	80°13.624’	Offshore patch reef
21	6/23/2008	Maitland Grounding Site	25°12.024’	80°13.569’	High-relief spur and groove (< 6 m)
40	6/23/2008	SW of Carysfort Reef SPA	25°11.177’	80°13.824’	Low-relief hard-bottom (6-15 m)
31	6/23/2008	Inshore of Elbow Reef SPA	25°09.483’	80°17.184’	Inner line reef tract
39	6/24/2008	North of Elbow Reef SPA	25°09.158’	80°15.051’	Patchy hard-bottom (6-15 m)
46	6/24/2008	Elbow Reef SPA**	25°08.252’	80°15.672’	Reef-sand-rubble matrix (6-15 m)
245	6/24/2008	Elbow Reef SPA**	25°08.630’	80°15.418’	Reef-sand-rubble matrix (6-15 m)
24	6/24/2008	Elbow Reef SPA**	25°08.729’	80°15.391’	High-relief spur and groove (< 6 m)
223	6/24/2008	Elbow Reef SPA**	25°08.450’	80°15.560’	High-relief spur and groove (< 6 m)
38	6/24/2008	SW of Elbow Reef SPA	25°07.935’	80°16.579’	Patchy hard-bottom (6-15 m)
49	6/25/2008	South of Elbow Reef SPA	25°07.419’	80°16.298’	Low-relief spur and groove (6-15 m)
10	6/25/2008	North of Dry Rocks SPA	25°08.227’	80°17.488’	Offshore patch reef
30	6/25/2008	North Dry Rocks	25°07.825’	80°17.625’	Inner line reef tract
9	6/25/2008	SW of Grecian Rocks SPA	25°05.962’	80°19.208’	Offshore patch reef
4	6/25/2008	Inshore of Grecian Rocks	25°06.975’	80°20.485’	Mid-channel patch reef
114	7/19/2008	Western Dry Rocks	24°26.707’	81°55.662’	High-relief spur and groove (< 6 m)
142	7/19/2008	SW of Sand Key SPA	24°26.364’	81°53.633’	Low-relief hard-bottom (6-15 m)
150	7/19/2008	Sand Key SPA**	24°27.052’	81°52.799’	Low-relief spur and groove (6-15 m)
347	7/19/2008	Sand Key SPA**	24°27.053’	81°52.491’	Low-relief spur and groove (6-15 m)
328	7/19/2008	Sand Key SPA**	24°27.117’	81°52.729’	High-relief spur and groove (< 6 m)
131	7/19/2008	Sand Key SPA**	24°27.173’	81°52.501’	High-relief spur and groove (< 6 m)
98	7/20/2008	Middle Ground	24°28.801’	81°52.949’	Mid-channel patch reef
97	7/20/2008	Middle Ground	24°28.427’	81°52.897’	Mid-channel patch reef
130	7/20/2008	Rock Key SPA**	24°27.258’	81°51.505’	High-relief spur and groove (< 6 m)
327	7/20/2008	Rock Key SPA**	24°27.296’	81°51.400’	High-relief spur and groove (< 6 m)
149	7/21/2008	Rock Key SPA**	24°27.224’	81°51.604’	Low-relief spur and groove (6-15 m)
346	7/21/2008	Rock Key SPA**	24°27.295’	81°51.253’	Low-relief spur and groove (6-15 m)
128	7/21/2008	Eastern Dry Rocks SPA**	24°27.560’	81°50.657’	High-relief spur and groove (< 6 m)
129	7/21/2008	Eastern Dry Rocks SPA**	24°27.707’	81°50.461’	High-relief spur and groove (< 6 m)
115	7/21/2008	East of E. Dry Rocks SPA	24°27.879’	81°50.217’	High-relief spur and groove (< 6 m)
132	7/21/2008	East of E. Dry Rocks SPA	24°27.854’	81°49.334’	Low-relief spur and groove (6-15 m)
106	7/22/2008	NE of E. Dry Rocks SPA	24°28.975’	81°49.999’	Offshore patch reef
133	7/22/2008	NE of E. Dry Rocks SPA	24°28.915’	81°49.112’	Offshore patch reef
143	7/22/2008	West of Western Sambo ER	24°28.547’	81°44.116’	Low-relief spur and groove (6-15 m)
140	7/22/2008	Western Sambo ER**	24°28.649’	81°43.502’	Low-relief spur and groove (6-15 m)
126	7/22/2008	Western Sambo ER**	24°28.770’	81°42.985’	High-relief spur and groove (< 6 m)
141	7/23/2008	Western Sambo ER**	24°28.907’	81°42.985’	Low-relief spur and groove (6-15 m)
127	7/23/2008	Western Sambo ER**	24°28.852’	81°42.643’	High-relief spur and groove (< 6 m)
112	7/23/2008	Western Sambo ER**	24°29.701’	81°42.303’	Offshore patch reef
113	7/23/2008	Western Sambo ER**	24°29.466’	81°43.108’	Offshore patch reef
99	7/23/2008	West of Western Sambo ER	24°29.509’	81°43.729’	Mid-channel patch reef

Site #	Date	Site location	Latitude (N)	Longitude (W)	Habitat type
135	7/24/2008	West of Looe Key SPA	24°32.638’	81°25.655’	Low-relief spur and groove (6-15 m)
123	7/24/2008	Looe Key SPA**	24°32.691’	81°24.564’	High-relief spur and groove (< 6 m)
124	7/24/2008	Looe Key SPA**	24°32.726’	81°24.380’	High-relief spur and groove (< 6 m)
110	7/24/2008	Looe Key RO**	24°34.041’	81°23.307’	Offshore patch reef
111	7/24/2008	Looe Key RO**	24°34.029’	81°23.574’	Offshore patch reef
109	7/24/2008	East of Looe Key RO	24°34.367’	81°22.922’	Offshore patch reef
103	7/24/2008	North of Looe Key RO	24°35.590’	81°23.904’	Mid-channel patch reef
122	7/25/2008	American Shoal	24°31.345’	81°31.129’	High-relief spur and groove (< 6 m)
120	7/25/2008	American Shoal	24°31.383’	81°31.190’	High-relief spur and groove (< 6 m)
119	7/25/2008	Maryland Shoal	24°31.327’	81°34.649’	High-relief spur and groove (< 6 m)
121	7/25/2008	Maryland Shoal	24°31.318’	81°34.837’	High-relief spur and groove (< 6 m)
102	7/25/2008	North of Maryland Shoal	24°32.677’	81°34.545’	Mid-channel patch reef
118	7/25/2008	Pelican Shoal	24°30.036’	81°37.716’	High-relief spur and groove (< 6 m)
101	7/26/2008	North of Maryland Shoal	24°32.238’	81°35.752’	Mid-channel patch reef
107	7/26/2008	North of Pelican Shoal	24°30.520’	81°37.787’	Offshore patch reef
117	7/26/2008	Pelican Shoal	24°29.994’	81°37.895’	High-relief spur and groove (< 6 m)
134	7/26/2008	West of Pelican Shoal	24°29.723’	81°38.599’	Low-relief spur and groove (6-15 m)
116	7/26/2008	No Name Reef	24°29.730’	81°38.910’	High-relief spur and groove (< 6 m)
100	7/26/2008	North of Eastern Sambo RO	24°31.382’	81°38.940’	Mid-channel patch reef
336	7/27/2008	Eastern Sambo RO**	24°29.391’	81°39.891’	Low-relief spur and groove (6-15 m)
139	7/27/2008	Eastern Sambo RO**	24°29.534’	81°39.416’	Low-relief spur and groove (6-15 m)
322	7/27/2008	Eastern Sambo RO**	24°29.610’	81°39.579’	High-relief spur and groove (< 6 m)
125	7/27/2008	Eastern Sambo RO**	24°29.525’	81°39.719’	High-relief spur and groove (< 6 m)
105	7/27/2008	Western Sambo ER**	24°30.710’	81°41.699’	Mid-channel patch reef
104	7/27/2008	Western Sambo ER**	24°30.003’	81°43.149’	Mid-channel patch reef
136	8/15/2008	South of Bahia Honda	24°35.131’	81°15.869’	Patchy hard-bottom (6-15 m)
138	8/15/2008	South of Bahia Honda	24°36.028’	81°15.421’	Patchy hard-bottom (6-15 m)
137	8/15/2008	South of Bahia Honda	24°35.532’	81°13.471’	Low-relief spur and groove (6-15 m)
90	8/15/2008	South of Moser Channel	24°35.811’	81°12.482’	Low-relief spur and groove (6-15 m)
70	8/15/2008	South of Moser Channel	24°36.239’	81°11.836’	Patchy hard-bottom (6-15 m)
53	8/15/2008	South of Ohio Key	24°37.637’	81°13.872’	Mid-channel patch reef
72	8/16/2008	South of Moser Channel	24°36.369’	81°11.177’	Patchy hard-bottom (6-15 m)
71	8/16/2008	South of Moser Channel	24°36.568’	81°10.325’	Low-relief spur and groove (6-15 m)
73	8/16/2008	West of Sombrero Key SPA	24°37.404’	81°07.790’	Patchy hard-bottom (6-15 m)
96	8/16/2008	Sombrero Key SPA**	24°37.438’	81°06.636’	Low-relief spur and groove (6-15 m)
293	8/16/2008	Sombrero Key SPA**	24°37.586’	81°06.302’	Low-relief spur and groove (6-15 m)
69	8/16/2008	Sombrero Key SPA**	24°37.581’	81°06.579’	High-relief spur and groove (< 6 m)
266	8/16/2008	Sombrero Key SPA**	24°37.539’	81°06.666’	High-relief spur and groove (< 6 m)
66	8/17/2008	Delta Shoal	24°37.927’	81°05.467’	High-relief spur and groove (< 6 m)
67	8/17/2008	Delta Shoal	24°37.946’	81°05.451’	High-relief spur and groove (< 6 m)
88	8/17/2008	Coffins Patch SPA**	24°40.890’	80°58.321’	Offshore patch reef
89	8/17/2008	Coffins Patch SPA**	24°41.020’	80°58.107’	Offshore patch reef
75	8/17/2008	East of Coffins Patch SPA	24°40.633’	80°56.603’	Low-relief spur and groove (6-15 m)
54	8/21/2008	South of Duck Key	24°42.933’	80°56.224’	Mid-channel patch reef
78	8/22/2008	SW of Crocker Reef	24°53.125’	80°33.689’	Low-relief hard-bottom (6-15 m)
79	8/22/2008	SW of Crocker Reef	24°53.571’	80°32.701’	Low-relief spur and groove (6-15 m)
83	8/22/2008	Davis Reef SPA**	24°55.241’	80°30.338’	Low-relief spur and groove (6-15 m)
84	8/22/2008	Davis Reef SPA**	24°55.334’	80°30.204’	Low-relief spur and groove (6-15 m)
80	8/22/2008	Conch Reef SPA**	24°56.992’	80°27.640’	Low-relief hard-bottom (6-15 m)
81	8/22/2008	Conch Reef SPA**	24°57.347’	80°27.378’	Low-relief hard-bottom (6-15 m)
62	8/23/2008	North of Davis Reef SPA	24°56.895’	80°29.843’	Offshore patch reef
63	8/23/2008	North of Davis Reef SPA	24°57.241’	80°29.775’	Offshore patch reef
64	8/23/2008	North of Davis Reef SPA	24°57.266’	80°30.280’	Offshore patch reef
65	8/23/2008	North of Davis Reef SPA	24°57.410’	80°29.603’	Offshore patch reef
15	8/23/2008	Pickles Reef	24°59.406’	80°25.026’	High-relief spur and groove (< 6 m)
16	8/23/2008	Pickles Reef	24°59.141’	80°24.964’	High-relief spur and groove (< 6 m)
17	8/23/2008	Pickles Reef	24°59.329’	80°24.825’	High-relief spur and groove (< 6 m)
279	8/24/2008	Conch Reef RO**	24°57.037’	80°27.254’	Low-relief spur and groove (6-15 m)
82	8/24/2008	Conch Reef RO**	24°57.162’	80°27.152’	Low-relief spur and groove (6-15 m)
7	8/24/2008	Inshore of Pickles Reef	24°59.549’	80°25.860’	Offshore patch reef

Site #	Date	Site location	Latitude (N)	Longitude (W)	Habitat type
47	8/24/2008	SW of Molasses Reef SPA	25°00.252’	80°23.376’	Low-relief spur and groove (6-15 m)
27	8/24/2008	Molasses Reef SPA**	25°00.503’	80°22.651’	High-relief spur and groove (< 6 m)
28	8/24/2008	Molasses Reef SPA**	25°00.519’	80°22.534’	High-relief spur and groove (< 6 m)
1	8/30/2008	Inshore of Molasses Reef	25°02.359’	80°23.605’	Mid-channel patch reef
2	8/30/2008	Mosquito Bank	25°04.113’	80°23.010’	Mid-channel patch reef
3	8/30/2008	South of Cannon Patch Reef	25°06.182’	80°20.683’	Mid-channel patch reef
8	8/30/2008	Inshore of French Reef	25°03.619’	80°21.766’	Offshore patch reef
37	9/01/2008	Dixie Shoal	25°04.365’	80°19.028’	Low-relief spur and groove (6-15 m)
48	9/01/2008	Dixie Shoal	25°03.741’	80°19.481’	Low-relief hard-bottom (6-15 m)
19	9/01/2008	North of French Reef SPA	25°02.400’	80°20.727’	High-relief spur and groove (< 6 m)
25	9/01/2008	French Reef SPA**	25°02.139’	80°20.869’	High-relief spur and groove (< 6 m)
26	9/01/2008	French Reef SPA**	25°02.015’	80°20.951’	High-relief spur and groove (< 6 m)
20	9/01/2008	Sand Island	25°01.140’	80°22.017’	High-relief spur and groove (< 6 m)
18	9/01/2008	Sand Island	25°01.072’	80°22.094’	High-relief spur and groove (< 6 m)
34	9/19/2008	Dry Rocks SPA**	25°07.393’	80°17.833’	Inner line reef tract
33	9/19/2008	Dry Rocks SPA**	25°07.317’	80°17.839’	Inner line reef tract
36	9/19/2008	Grecian Rocks SPA**	25°06.738’	80°18.166’	Inner line reef tract
35	9/19/2008	Grecian Rocks SPA**	25°06.606’	80°18.222’	Inner line reef tract
76	9/20/2008	NE of Tennessee Light	24°45.426’	80°45.975’	Low-relief spur and groove (6-15 m)
86	9/20/2008	Tennessee Reef RO**	24°45.806’	80°45.331’	Low-relief spur and groove (6-15 m)
87	9/20/2008	Tennessee Reef RO**	24°45.981’	80°45.072’	Low-relief spur and groove (6-15 m)
77	9/20/2008	SW of Alligator Light	24°49.680’	80°38.917’	Low-relief spur and groove (6-15 m)
68	9/20/2008	Alligator Reef SPA**	24°50.662’	80°37.313’	Low-relief spur and groove (6-15 m)
85	9/20/2008	Alligator Reef SPA**	24°50.879’	80°37.069’	Low-relief spur and groove (6-15 m)
60	9/21/2008	Cheeca Rocks SPA**	24°54.259’	80°37.078’	Mid-channel patch reef
61	9/21/2008	Cheeca Rocks SPA**	24°54.288’	80°36.942’	Mid-channel patch reef
57	9/21/2008	NE of Cheeca Rocks SPA	24°54.242’	80°36.583’	Mid-channel patch reef
58	9/21/2008	Hen and Chickens SPA**	24°56.039’	80°33.040’	Mid-channel patch reef
59	9/21/2008	Hen and Chickens SPA**	24°56.223’	80°32.880’	Mid-channel patch reef
55	9/21/2008	Tavernier Rocks	24°56.560’	80°33.647’	Mid-channel patch reef
56	9/21/2008	Tavernier Rocks	24°57.029’	80°33.307’	Mid-channel patch reef

Table 3. Site locations and physical data for marine debris and benthic coral reef organism surveys in the Florida Keys National Marine Sanctuary during June-September 2008. Sites are arranged from northeast to southwest by habitat type. Asterisked sites (**) are Sanctuary Preservation Areas (SPA), Ecological Reserves (ER), 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)
Mid-channel patch reefs				
Upper Florida Keys NMS				
6 - Basin Hill Shoals	25°14.019’	80°14.788’	2.7 ± 0.1	26 ± 5
5 - Basin Hill Shoals	25°13.795’	80°15.376’	3.6 ± 0.3	40 ± 6
4 - Inshore of Grecian Rocks SPA	25°06.975’	80°20.485’	4.1 ± 0.1	89 ± 2
3 - South of Cannon Patch Reef	25°06.182’	80°20.683’	2.5 ± 0.1	62 ± 13
2 - Mosquito Bank	25°04.113’	80°23.010’	2.0 ± 0.1	83 ± 3
1 - Inshore of Molasses Reef	25°02.359’	80°23.605’	4.1 ± 0.1	94 ± 22
Upper Florida Keys Total (6)			3.2 ± 0.4	66 ± 11
Middle Florida Keys NMS				
56 - Tavernier Rocks	24°57.029’	80°33.307’	3.1 ± 0.0	64 ± 20
55 - Tavernier Rocks	24°56.560’	80°33.647’	3.8 ± 0.1	44 ± 21
59 - Hen and Chickens SPA**	24°56.223’	80°32.880’	5.4 ± 0.3	249 ± 27
58 - Hen and Chickens SPA**	24°56.039’	80°33.040’	5.2 ± 0.2	201 ± 30
61 - Cheeca Rocks SPA**	24°54.288’	80°36.942’	3.4 ± 0.0	105 ± 8
60 - Cheeca Rocks SPA**	24°54.259’	80°37.078’	3.8 ± 0.2	97 ± 10
57 - NE of Cheeca Rocks SPA	24°54.242’	80°36.583’	3.7 ± 0.2	151 ± 16
54 - South of Duck Key	24°42.933’	80°56.224’	7.0 ± 0.2	67 ± 7
53 - South of Ohio Key	24°37.637’	81°13.872’	6.4 ± 0.2	91 ± 15
Middle Florida Keys Total (9)			4.6 ± 0.5	119 ± 23
Lower Florida Keys NMS				
103 - North of Looe Key RO	24°35.590’	81°23.904’	6.5 ± 0.1	81 ± 5
102 - North of Maryland Shoal	24°32.677’	81°34.545’	6.1 ± 0.1	60 ± 7
101 - North of Maryland Shoal	24°32.238’	81°35.752’	3.0 ± 0.0	50 ± 4
100 - North of Eastern Sambo RO	24°31.382’	81°38.940’	3.9 ± 0.0	51 ± 12
105 - Western Sambo ER**	24°30.710’	81°41.699’	6.2 ± 0.2	75 ± 6
104 - Western Sambo ER**	24°30.003’	81°43.149’	6.9 ± 0.2	66 ± 6
99 - West of Western Sambo ER	24°29.509’	81°43.729’	9.0 ± 0.4	76 ± 3
98 - Middle Ground	24°28.801’	81°52.949’	5.7 ± 0.1	39 ± 3
97 - Middle Ground	24°28.427’	81°52.897’	5.8 ± 0.2	32 ± 4
Lower Florida Keys Total (9)			5.9 ± 0.6	59 ± 6
Mid-channel Patch Reef Total (24)			**4.7 ± 0.4**	**83 ± 11**
Offshore patch reefs				
Upper Florida Keys NMS				
12 - South of BNP boundary	25°18.691’	80°11.416’	5.6 ± 0.3	80 ± 12
41 - North of Carysfort Reef SPA	25°16.119’	80°12.083’	10.7 ± 0.2	67 ± 4
11 - North of Carysfort Reef SPA	25°15.190’	80°12.756’	4.8 ± 0.2	74 ± 16
14 - Carysfort Reef SPA**	25°12.326’	80°13.302’	4.0 ± 0.2	40 ± 2
13 - Carysfort Reef SPA**	25°12.189’	80°13.624’	5.4 ± 0.2	80 ± 12
10 - North of Dry Rocks SPA	25°08.227’	80°17.488’	5.1 ± 0.1	35 ± 3
9 - SW of Grecian Rocks SPA	25°05.962’	80°19.208’	4.0 ± 0.1	61 ± 11
8 - Inshore of French Reef SPA	25°03.169’	80°21.766’	2.8 ± 0.3	48 ± 6
7 - Inshore of Pickles Reef	24°59.549’	80°25.860’	5.3 ± 0.1	58 ± 15
Upper Florida Keys Total (9)			5.3 ± 0.7	60 ± 6
Middle Florida Keys NMS				
65 - North of Davis Reef SPA	24°57.410’	80°29.603’	4.0 ± 0.1	36 ± 3
64 - North of Davis Reef SPA	24°57.266’	80°30.280’	4.0 ± 0.0	61 ± 12
63 - North of Davis Reef SPA	24°57.241’	80°29.775’	3.9 ± 0.1	39 ± 6
62 - North of Davis Reef SPA	24°56.895’	80°29.843’	4.0 ± 0.1	44 ± 4
89 - Coffins Patch SPA**	24°41.020’	80°58.107’	6.2 ± 0.0	45 ± 1
88 - Coffins Patch SPA**	24°40.890’	80°58.321’	6.9 ± 0.2	56 ± 8

Site number/site location	Latitude (N)	Longitude (W)	Mean depth (m)	Max. vertical relief (cm)
Middle Florida Keys Total (6)			4.8 ± 0.6	47 ± 4
Lower Florida Keys NMS				
109 - East of Looe Key RO	24°34.367’	81°22.922’	6.3 ± 0.0	63 ± 7
110 - Looe Key Research Only**	24°34.041’	81°23.307’	6.5 ± 0.1	76 ± 11
111 - Looe Key Research Only**	24°34.029’	81°23.574’	7.6 ± 0.1	75 ± 10
107 - North of Pelican Shoal	24°30.520’	81°37.787’	4.4 ± 0.2	39 ± 7
112 - Western Sambo ER**	24°29.701’	81°42.303’	8.6 ± 0.1	66 ± 9
113 - Western Sambo ER**	24°29.466’	81°43.108’	8.1 ± 0.1	49 ± 3
106 - NE of E. Dry Rocks SPA	24°28.975’	81°49.999’	6.5 ± 0.1	64 ± 10
133 - NE of E. Dry Rocks SPA	24°28.915’	81°49.112’	9.9 ± 0.3	106 ± 20
Lower Florida Keys Total (8)			7.2 ± 0.6	67 ± 7
Offshore Patch Reef Total (23)			**5.9 ± 0.4**	**59 ± 4**
Inner line reef tract spur & groove				
Upper Florida Keys NMS				
32 - Turtle Rocks	25°17.686’	80°13.342’	3.2 ± 0.1	60 ± 10
31 - Inshore of Elbow Reef SPA	25°09.483’	80°17.184’	4.3 ± 0.2	63 ± 14
30 - North Dry Rocks	25°07.825’	80°17.625’	4.9 ± 0.2	95 ± 25
34 - Dry Rocks SPA**	25°07.393’	80°17.833’	3.8 ± 0.2	106 ± 14
33 - Dry Rocks SPA**	25°07.317’	80°17.839’	4.2 ± 0.2	123 ± 13
36 - Grecian Rocks SPA**	25°06.738’	80°18.166’	4.8 ± 0.3	135 ± 13
35 - Grecian Rocks SPA**	25°06.606’	80°18.222’	4.0 ± 0.4	87 ± 18
Upper Florida Keys Total (7)			4.2 ± 0.2	95 ± 11
Inner Line Spur & Groove Total (7)			**4.2 ± 0.2**	**95 ± 11**
High-relief spur & groove				
Upper Florida Keys NMS				
23 - Carysfort Reef SPA**	25°12.715’	80°13.050’	3.7 ± 0.2	149 ± 16
22 - Carysfort Reef SPA**	25°12.415’	80°13.242’	3.5 ± 0.3	194 ± 11
21 - Maitland grounding site	25°12.024’	80°13.569’	3.7 ± 0.3	58 ± 13
24 - Elbow Reef SPA**	25°08.729’	80°15.391’	6.0 ± 0.2	160 ± 10
223 - Elbow Reef SPA**	25°08.450’	80°15.560’	5.4 ± 0.1	138 ± 34
19 - North of French Reef SPA	25°02.400’	80°20.727’	4.0 ± 0.1	43 ± 7
25 - French Reef SPA**	25°02.139’	80°20.869’	6.5 ± 0.2	113 ± 6
26 - French Reef SPA**	25°02.015’	80°20.951’	7.0 ± 0.3	82 ± 49
20 - Sand Island	25°01.140’	80°22.017’	5.3 ± 0.4	72 ± 10
18 - Sand Island	25°01.072’	80°22.094’	4.5 ± 0.2	105 ± 27
28 - Molasses Reef SPA**	25°00.519’	80°22.534’	4.5 ± 0.3	94 ± 22
27 - Molasses Reef SPA**	25°00.503’	80°22.651’	4.9 ± 0.2	112 ± 16
17 - Pickles Reef	24°59.329’	80°24.825’	3.5 ± 0.1	43 ± 9
16 - Pickles Reef	24°59.141’	80°24.964’	3.9 ± 0.2	69 ± 14
15 - Pickles Reef	24°59.046’	80°25.026’	4.9 ± 0.2	42 ± 4
Upper Florida Keys Total (15)			4.8 ± 0.3	98 ± 12
Middle Florida Keys NMS				
67 - Delta Shoal	24°37.946’	81°05.415’	4.4 ± 0.0	113 ± 22
66 - Delta Shoal	24°37.927’	81°05.467’	5.4 ± 0.2	83 ± 39
69 - Sombrero Key SPA**	24°37.581’	81°06.579’	3.2 ± 0.3	173 ± 39
266 - Sombrero Key SPA**	24°37.539’	81°06.666’	4.1 ± 0.4	186 ± 43
Middle Florida Keys Total (4)			4.3 ± 0.5	138 ± 24
Lower Florida Keys NMS				
124 - Looe Key SPA**	24°32.726’	81°24.380’	5.4 ± 0.1	124 ± 16
123 - Looe Key SPA**	24°32.691’	81°24.564’	4.3 ± 0.3	106 ± 26
120 - American Shoal	24°31.383’	81°31.190’	4.2 ± 0.1	118 ± 11
122 - American Shoal	24°31.345’	81°31.129’	6.4 ± 0.1	32 ± 4
119 - Maryland Shoal	24°31.327’	81°34.649’	3.4 ± 0.3	89 ± 15
121 - Maryland Shoal	24°31.318’	81°34.837’	1.8 ± 0.2	109 ± 18
118 - Pelican Shoal	24°30.036’	81°37.716’	4.5 ± 0.2	141 ± 26
117 - Pelican Shoal	24°29.994’	81°37.895’	4.3 ± 0.5	133 ± 12
116 - No Name Reef	24°29.730’	81°38.910’	3.7 ± 0.2	66 ± 7

Site number/site location	Latitude (N)	Longitude (W)	Mean depth (m)	Max. vertical relief (cm)
322 - Eastern Sambo RO**	24°29.610’	81°39.579’	4.3 ± 0.3	109 ± 11
125 - Eastern Sambo RO**	24°29.525’	81°39.719’	3.2 ± 0.3	89 ± 7
127 - Western Sambo ER**	24°28.852’	81°42.643’	3.4 ± 0.1	63 ± 6
126 - Western Sambo ER**	24°28.770’	81°42.985’	4.5 ± 0.2	94 ± 14
115 - East of E. Dry Rocks SPA	24°27.879’	81°50.217’	4.6 ± 0.2	120 ± 31
129 - Eastern Dry Rocks SPA**	24°27.707’	81°50.461’	3.7 ± 0.1	71 ± 12
128 - Eastern Dry Rocks**	24°27.560’	81°50.657’	4.0 ± 0.3	60 ± 21
327 - Rock Key SPA**	24°27.296’	81°51.400’	4.4 ± 0.4	104 ± 21
130 - Rock Key SPA**	24°27.258’	81°51.505’	3.2 ± 0.1	77 ± 23
131 - Sand Key SPA**	24°27.173’	81°52.501’	3.5 ± 0.1	50 ± 9
328 - Sand Key SPA**	24°27.117’	81°52.729’	3.6 ± 0.3	108 ± 11
114 - Western Dry Rocks	24°26.707’	81°55.662’	4.6 ± 0.3	110 ± 18
Lower Florida Keys Total (21)			4.1 ± 0.2	94 ± 6
High-relief Spur & Groove Total (40)			**4.3 ± 0.2**	**100 ± 6**
Fore-reef (6-15 m)				
Upper Florida Keys NMS				
42 - South of BNP boundary	25°17.304’	80°10.439’	9.6 ± 0.1	42 ± 4
52 - Carysfort Reef SPA**	25°12.384’	80°12.448’	12.6 ± 0.1	50 ± 3
51 - Carysfort Reef SPA**	25°12.174’	80°13.222’	14.2 ± 0.1	59 ± 9
50 - SW of Carysfort Reef SPA	25°11.579’	80°13.323’	15.7 ± 0.1	51 ± 2
40 - SW of Carysfort Reef SPA	25°11.177’	80°13.824’	12.6 ± 0.1	43 ± 9
39 - North of Elbow Reef SPA	25°09.158’	80°15.051’	10.9 ± 0.1	46 ± 5
245 - Elbow Reef SPA**	25°08.630’	80°15.418’	8.6 ± 0.2	60 ± 4
46 - Elbow Reef SPA**	25°08.252’	80°15.672’	7.4 ± 0.1	32 ± 6
38 - SW of Elbow Reef SPA	25°07.935’	80°16.579’	9.0 ± 0.1	33 ± 6
49 - South of Elbow Reef SPA	25°07.419’	80°16.298’	16.0 ± 0.1	54 ± 11
37 - Dixie Shoal	25°04.365’	80°19.028’	11.5 ± 0.1	40 ± 8
48 - Dixie Shoal	25°03.741’	80°19.481’	11.3 ± 0.1	45 ± 2
47 - SW of Molasses Reef SPA	2500.252’	80°23.376’	11.2 ± 0.1	47 ± 2
Upper Florida Keys Total (13)			11.6 ± 0.7	46 ± 2
Middle Florida Keys NMS				
81 - Conch Reef SPA**	24°57.347’	80°27.738’	10.0 ± 0.1	23 ± 6
80 - Conch Reef SPA**	24°56.992’	80°27.640’	9.3 ± 0.1	32 ± 6
82 - Conch Reef RO**	24°57.162’	80°27.152’	13.4 ± 0.1	70 ± 10
279 - Conch Reef RO**	24°57.037’	80°27.254’	12.8 ± 0.1	62 ± 19
84 - Davis Reef SPA**	24°55.334’	80°30.204’	11.1 ± 0.1	40 ± 5
83 - Davis Reef SPA**	24°55.241’	80°30.388’	10.9 ± 0.1	25 ± 5
79 - SW of Crocker Reef	24°53.571’	80°32.701’	11.0 ± 0.2	69 ± 8
78 - SW of Crocker Reef	24°53.125’	80°33.689’	8.0 ± 0.1	44 ± 3
85 - Alligator Reef SPA**	24°50.879’	80°37.069’	8.8 ± 0.1	39 ± 9
68 - Alligator Reef SPA**	24°50.662’	80°37.313’	12.0 ± 0.0	40 ± 7
77 - SW of Alligator Reef SPA	24°49.680’	80°38.917’	11.9 ± 0.2	107 ± 19
87 - Tennessee Reef RO**	24°45.981’	80°45.072’	10.1 ± 0.2	40 ± 6
86 - Tennessee Reef RO**	24°45.806’	80°45.331’	10.0 ± 0.0	73 ± 8
76 - NE of Tennessee Light	24°45.426’	80°45.975’	9.3 ± 0.0	37 ± 7
75 - East of Coffins Patch SPA	24°40.633’	80°56.603’	13.6 ± 0.1	47 ± 6
293 - Sombrero Key SPA**	24°37.586’	81°06.302’	10.7 ± 0.1	60 ± 9
96 - Sombrero Key SPA**	24°37.438’	81°06.636’	11.1 ± 0.1	47 ± 2
73 - West of Sombrero Key SPA	24°37.404’	81°07.790’	8.8 ± 0.1	34 ± 7
71 - South of Moser Channel	24°36.568’	81°10.325’	12.6 ± 0.1	73 ± 9
72 - South of Moser Channel	24°36.369’	81°11.177’	9.0 ± 0.1	39 ± 6
70 - South of Moser Channel	24°36.239’	81°11.836’	8.8 ± 0.1	48 ± 7
90 - South of Moser Channel	24°35.811’	81°12.482’	11.8 ± 0.1	29 ± 6
Middle Florida Keys Total (22)			10.7 ± 0.3	49 ± 4
Lower Florida Keys NMS				
136 - South of Bahia Honda Key	24°35.131’	81°15.869’	10.9 ± 0.1	20 ± 2
138 - South of Bahia Honda Key	24°36.028’	81°15.421’	8.6 ± 0.0	48 ± 6
137 - South of Bahia Honda Key	24°35.532’	81°13.471’	11.2 ± 0.2	47 ± 10

Site number/site location	Latitude (N)	Longitude (W)	Mean depth (m)	Max. vertical relief (cm)
135 - West of Looe Key SPA	24°32.638'	81°25.655'	12.4 ± 0.0	80 ± 6
134 - West of Pelican Shoal	24°29.723'	81°38.599'	9.8 ± 0.1	35 ± 4
139 - Eastern Sambo RO**	24°29.534'	81°39.416'	9.5 ± 0.2	21 ± 12
336 - Eastern Sambo RO**	24°29.391'	81°39.891'	10.4 ± 0.1	74 ± 11
141 - Western Sambo ER**	24°28.907'	81°42.985'	10.9 ± 0.1	72 ± 14
140 - Western Sambo ER**	24°28.649'	81°43.502'	12.2 ± 0.1	71 ± 11
143 - West of Western Sambo ER	24°28.547'	81°44.116'	11.4 ± 0.1	39 ± 6
132 - East of E. Dry Rocks SPA	24°27.854'	81°49.334'	10.7 ± 0.2	55 ± 8
346 - Rock Key SPA**	24°27.295'	81°51.253'	9.8 ± 0.1	60 ± 5
149 - Rock Key SPA**	24°27.224'	81°51.604'	9.9 ± 0.6	83 ± 5
347 - Sand Key SPA**	24°27.053'	81°52.491'	13.8 ± 0.1	58 ± 9
150 - Sand Key SPA**	24°27.052'	81°52.799'	12.1 ± 0.2	51 ± 3
142 - SW of Sand Key SPA	24°26.364'	81°53.633'	12.4 ± 0.2	54 ± 7
Lower Florida Keys Total (16)			11.0 ± 0.3	54 ± 5
Fore-reef Total (51)			**11.0 ± 0.3**	**50 ± 2**

Table 4. SCUBA diving effort for surveys of marine debris and benthic coral reef organisms in the Florida Keys National Marine Sanctuary during June-September 2008.

Diver	Affiliation	No. of dives	Depth range (m)	Bottom time
Benthic surveys				
Mark Chiappone	CMS/UNCW	145	0.5-16.8 m	134 hr 09 min
Leanne Rutten	CMS/UNCW	145	0.5-16.5 m	128 hr 24 min
Total all divers		290	0.5-16.8 m	262 hr 33 min

III. *Acropora* coral habitat distribution

Background

The declines in abundance of two of the principal Caribbean reef-building corals, staghorn coral (*Acropora cervicornis*) and elkhorn coral (*A. palmata*) (Figure 7), are often-cited examples of the changes in western Atlantic reefs that have occurred during the past several decades (Bruckner 2002; Gardner et al. 2003). The causes of these declines, which began in the late 1970s, include large-scale factors such as coral bleaching and disease, especially white band disease (Gladfelter 1982; Aronson and Precht 2001), as well as smaller-scale effects from storms and continued 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 since the early 1990s and were formally determined to be "threatened" based upon range-wide population declines and poor recovery (*Acropora* Biological Review Team 2005).

Although there is increased awareness of the fragility of Atlantic *Acropora* corals and the potential for further potential population decline, there is little information on habitat distribution, colony size, density, and population abundance estimates for wider Caribbean reefs. Notable exceptions to this pattern include recent population assessments of *A. palmata* in the U.S. Virgin Islands, southern Caribbean, and in the Florida Keys at one reef (Miller et al. 2002; Mayor et al. 2006; Zubillaga et al. 2008). While some recovery is apparent in localized areas, populations of both species remain well-below historical levels, including populations in the Florida Keys (Dustan and Halas 1987; Porter and Meier 1992), and threats continue that will potentially inhibit population recovery (*Acropora* Biological Review Team 2005). To help support efforts to ascertain the current population status of both staghorn and elkhorn corals, we undertook an intensive assessment of the spatial distribution, colony abundance, size, and condition of both species throughout the Florida Keys during 2007 (Miller et al. 2007, in press), followed by a continued temporal assessment of habitat distribution and frequency of occurrence in 2008. Using a stratified random sampling design, the goals of the survey were to determine patterns in habitat distribution and presence-absence for the habitats, regional sectors, and management zones surveyed in the Florida Keys National Marine Sanctuary (FKNMS).

2008 Survey Results

Staghorn coral (*Acropora cervicornis*) (Figure 7) was observed within transect boundaries at 28 of the 145 sampled sites (19%) (Table 5). Figures 8-13 show the spatial distribution of staghorn coral presence-absence and transect frequency (the proportion of the number of transects with that species present compared to the number of transects sampled) for the upper, middle, and lower Keys. The habitat distribution of staghorn coral was much broader than elkhorn coral, with colonies found within transects

in all five habitats surveyed, albeit at different site-level frequencies of occurrence: mid-channel patch reefs (41.7% of 24 sites), offshore patch reefs (47.8% of 23 sites), inner line reef tract spur and groove (14.3% of 7 sites), high-relief spur and groove (10.0% of 40 sites), and deeper fore-reef deeper (3.9% of 51 sites). In contrast to patch reefs, staghorn corals were relatively rare in shallow spur and groove habitats along the inner reef line and the platform margin, as well as the deeper fore-reef (Table 5). Besides variation among habitats, regional variation in staghorn coral presence-absence was evident as well. *A. cervicornis* was more commonly found within transects on mid-channel patch reefs in the lower Keys (78% of 9 sites) compared to all other regions (Table 5). Proportional transect frequency was four times or greater in the lower Keys compared to the upper and middle Keys. On offshore patch reefs, *A. cervicornis* was more commonly encountered in the middle Keys (50% of 6 sites) compared to the upper and lower Keys, a result similar to observations in 2007.

Elkhorn coral (*Acropora palmata*) (Figure 7) was observed within transect boundaries at only 9 of the 145 sampled sites (6.2%) (Table 5). Figures 14-19 show the spatial distribution of elkhorn coral presence-absence and proportional transect frequency for the upper, middle, and lower Keys. The habitat distribution of elkhorn coral was much narrower than staghorn coral, with colonies found in only two of the five habitats, both consisting of high-relief spur and groove structure: inner line reef tract spur and groove (42.9% of 7 sites) and platform margin high-relief spur and groove (15.0% of 40 sites). On inner line reefs in the upper Keys, elkhorn coral colonies were only encountered within Sanctuary Preservation Areas. On platform margin high-relief spur and groove, proportional transect frequency was 1.8 times greater or more in the upper Keys compared to other regions.

Results from the 2008 sampling effort provide a growing temporal and spatial data set on the distribution of *Acropora palmata* and *A. cervicornis* in the Florida Keys. Previous efforts in 2007 (Miller et al. 2007, in press) yielded domain-wide abundance estimates, structured by colony size that provided population abundance estimates by habitat, region, and for individual no-take marine reserves. What is apparent from the *Acropora* surveys is that the distribution patterns of these two species are clearly different, perhaps necessitating different management approaches. Although 27 different spur and groove reefs, including inner line reef tract sites, were sampled, significant *A. palmata* stands remain at only a handful of sites such as Elbow Reef, French Reef, Sand Island, and Looe Key. While most of these sites are within existing FKNMS no-take zones, tissue damage caused by snails and damselfishes, as well as physical impacts from lost fishing gear is still prevalent. In contrast, the distribution pattern of *A. cervicornis* reflects the importance of patch reefs. While there are over 5,000 patch reef sites on the south Florida shelf, staghorn coral is variably distributed, and the factors responsible for this pattern are not well

known. Lower Keys mid-channel patch reefs and middle Keys offshore patch reefs yield the greatest site and transect frequencies for this species. In contrast, areas on the deeper fore-reef historically noted for dense staghorn coral thickets only yielded a few colonies among 51 sites sampled.

The sheer number of sites visited will allow us to update existing habitat maps for the study area, as well as assist in further optimizing future Keys-wide sampling. We also hope that this information will highlight the importance of the Florida Keys patch reef environment, little of which is located within no-take marine reserves, with most sites visited impacted by derelict fishing gear. Patch reefs include many of the best remaining reefs in the region, particularly in terms of coral cover and diversity. The sheer number of patch reefs inshore of the reef tract, their coral species composition dominated by mounding corals, and a highly variable natural physical environment (i.e., temperature, turbidity, sedimentation), are factors that contrast with habitats found along the platform margin. Patch reefs support the most numerous stands of staghorn coral, but they are also subjected to physical damage caused by lost fishing gear. This reflects both the higher coral cover remaining on patch reefs, significant habitat heterogeneity compared to surrounding areas (resulting in accumulation or concentration of debris), their large number, proximity to trap placements, and generally favored status as fishing sites. Under current conditions of diminished population numbers, damage from lost fishing gear is one factor that potentially affects existing staghorn corals. While management options for the recovery of *Acropora* corals are being developed, there are obvious actions that can be taken at the local level to enhance survival of existing populations that include removing marine debris and minimizing the potential for debris to negatively impact these habitats.

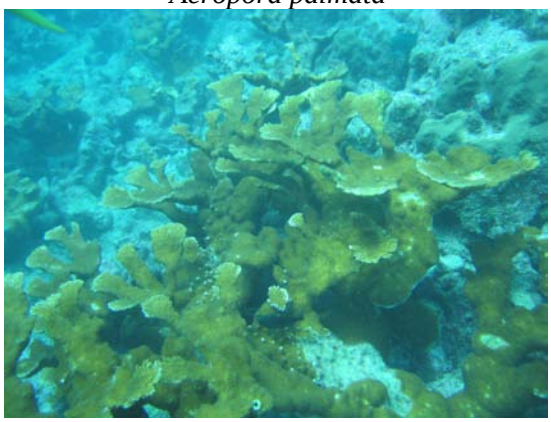
Figure 7. Staghorn coral (*Acropora cervicornis*) and elkhorn coral (*A. palmata*) sampled in the Florida Keys during 2008.

Acropora cervicornis

Acropora palmata

Acropora cervicornis

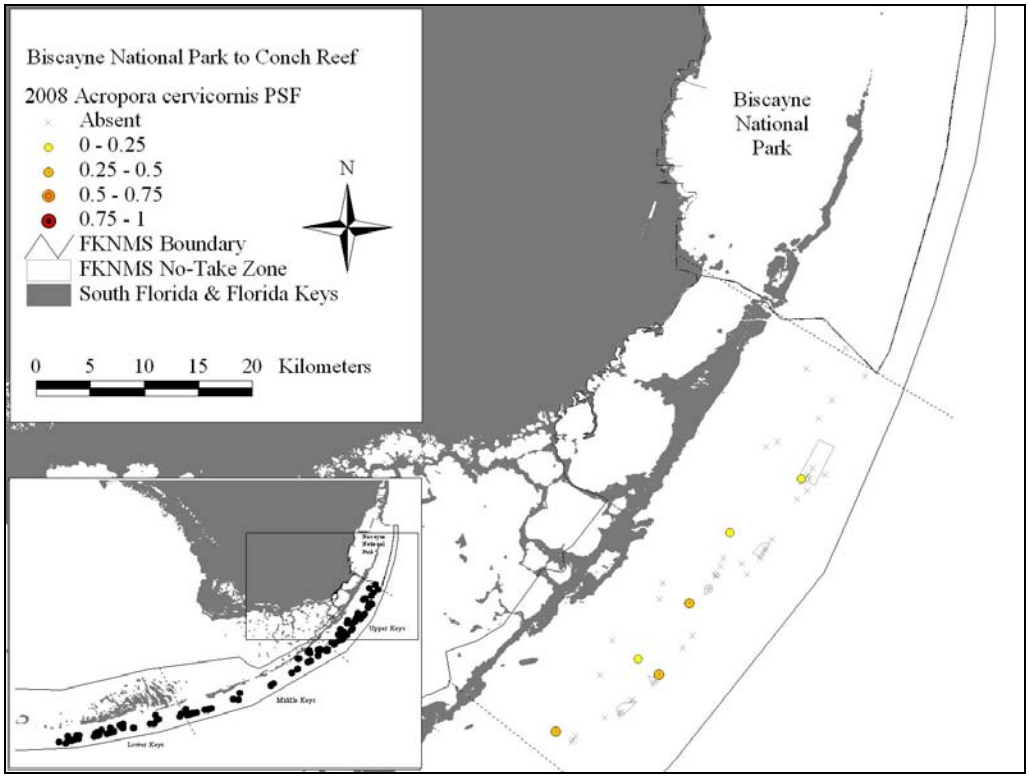
Acropora palmata



Acropora prolifera

Acropora palmata

Figure 8. Staghorn coral (*Acropora cervicornis*) presence-absence and proportional transect frequency (% of transects present) in the upper Florida Keys (top) and from the southern BNP boundary to Carysfort Reef (bottom) during June-September 2008.



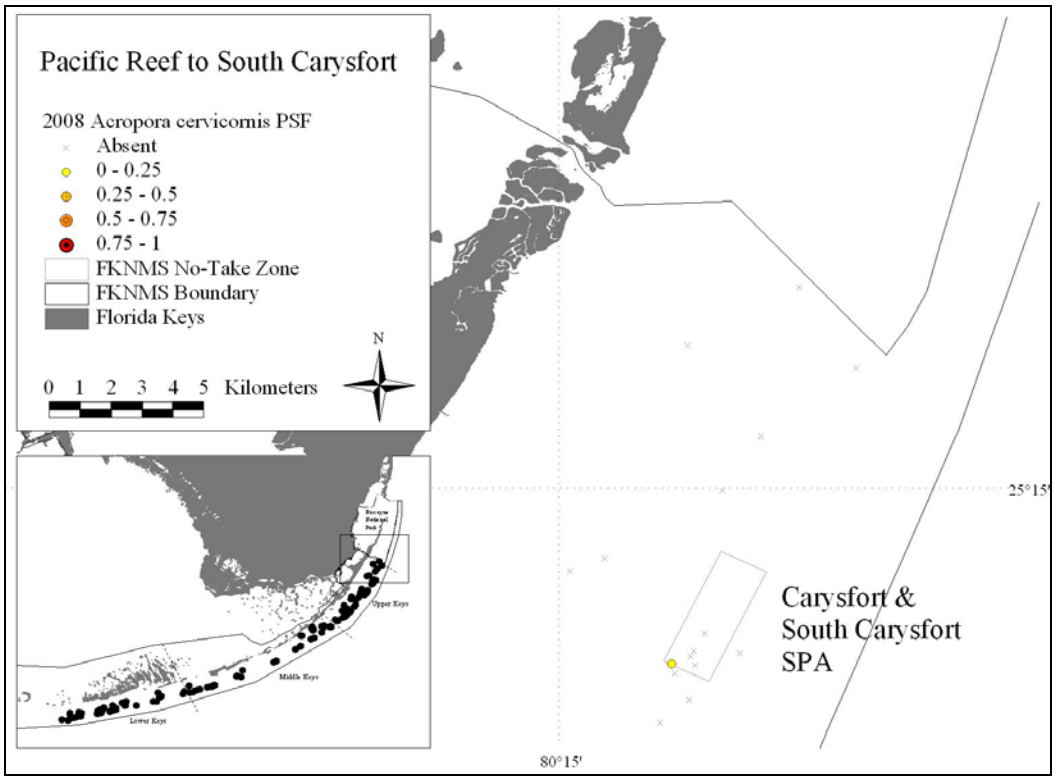
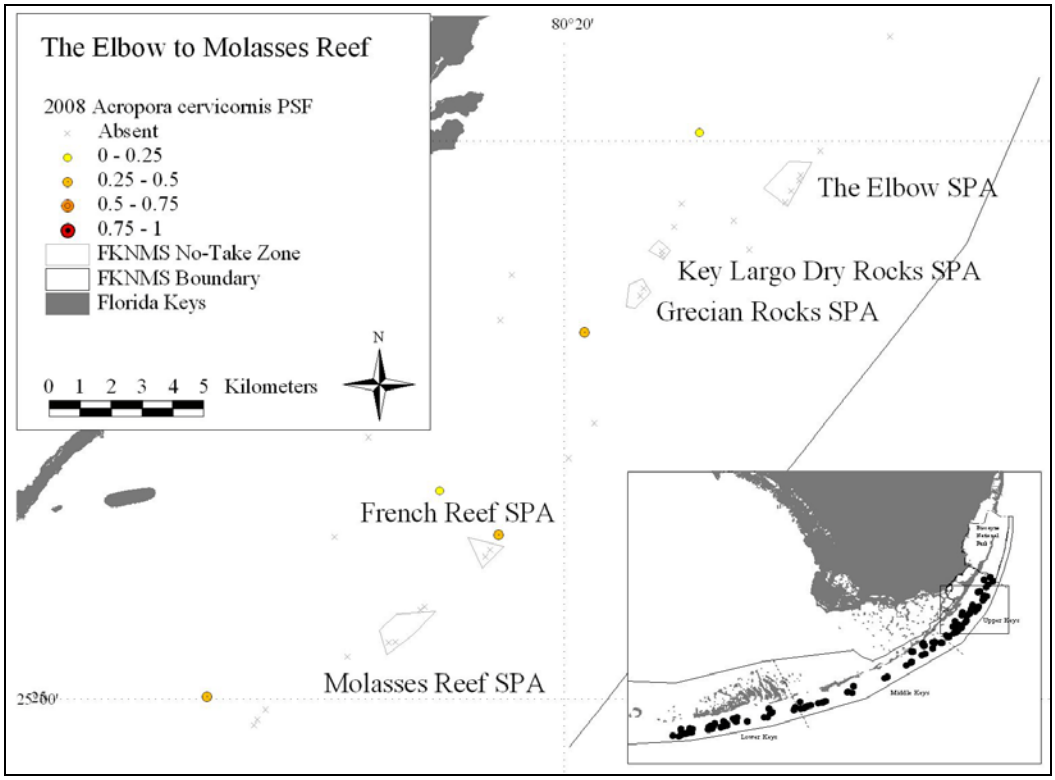


Figure 9. Staghorn coral (*Acropora cervicornis*) presence-absence and proportional transect frequency (% of transects present) in the upper Florida Keys from Elbow Reef to Pickles Reef (top) and in the middle Keys region during June-September 2008.



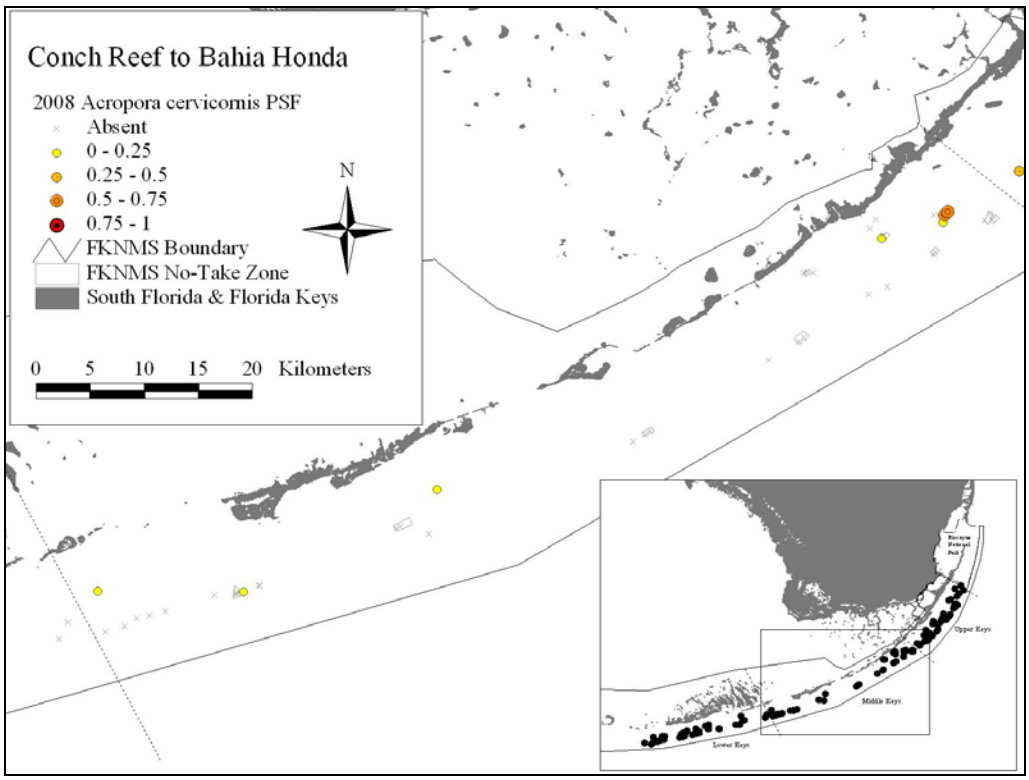


Figure 10. Staghorn coral (*Acropora cervicornis*) presence-absence and proportional transect frequency (% of transects present) in the middle Florida Keys from Conch Reef to Alligator Reef (top) and from Tennessee Reef to Coffins Patch (bottom) during June-September 2008.

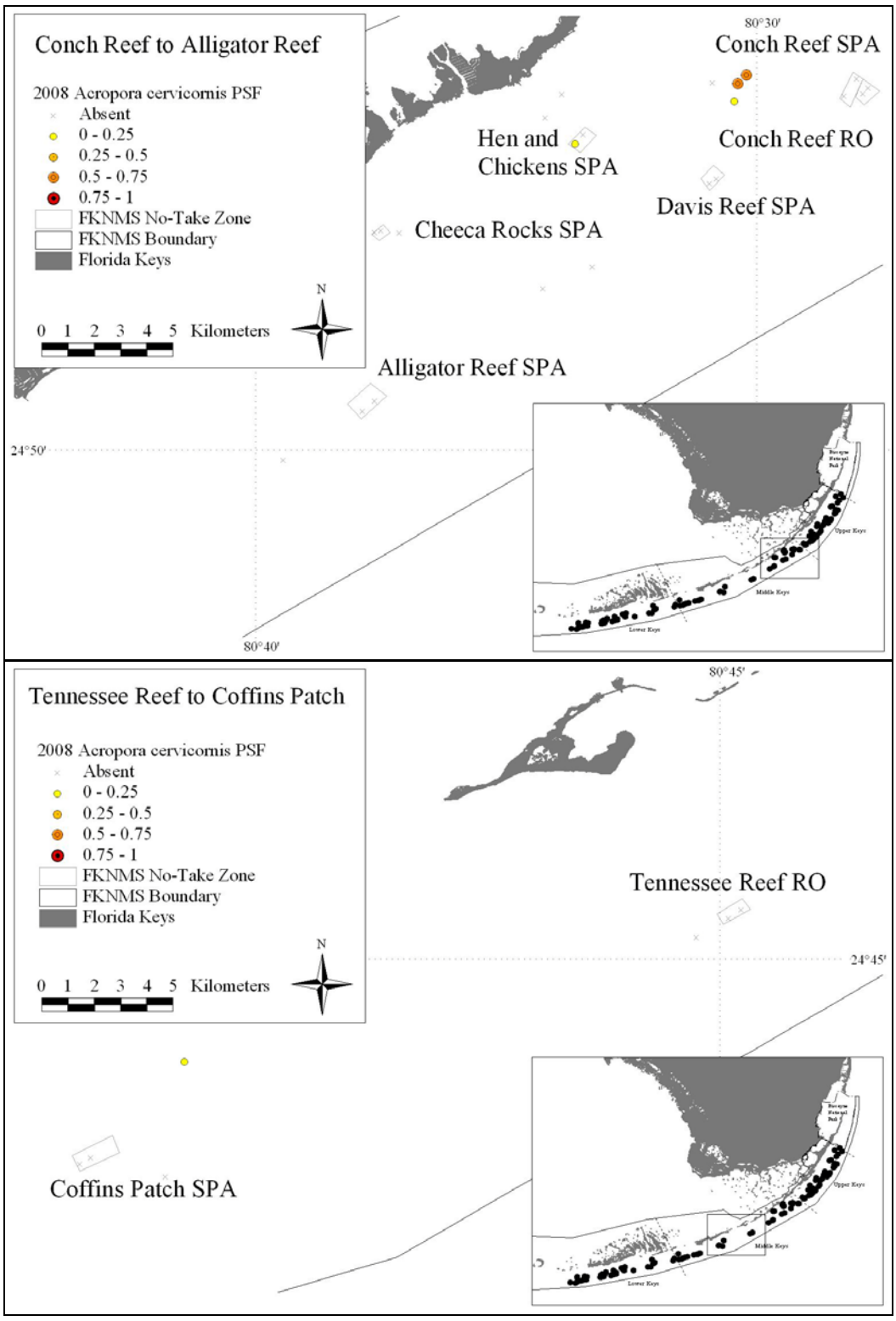
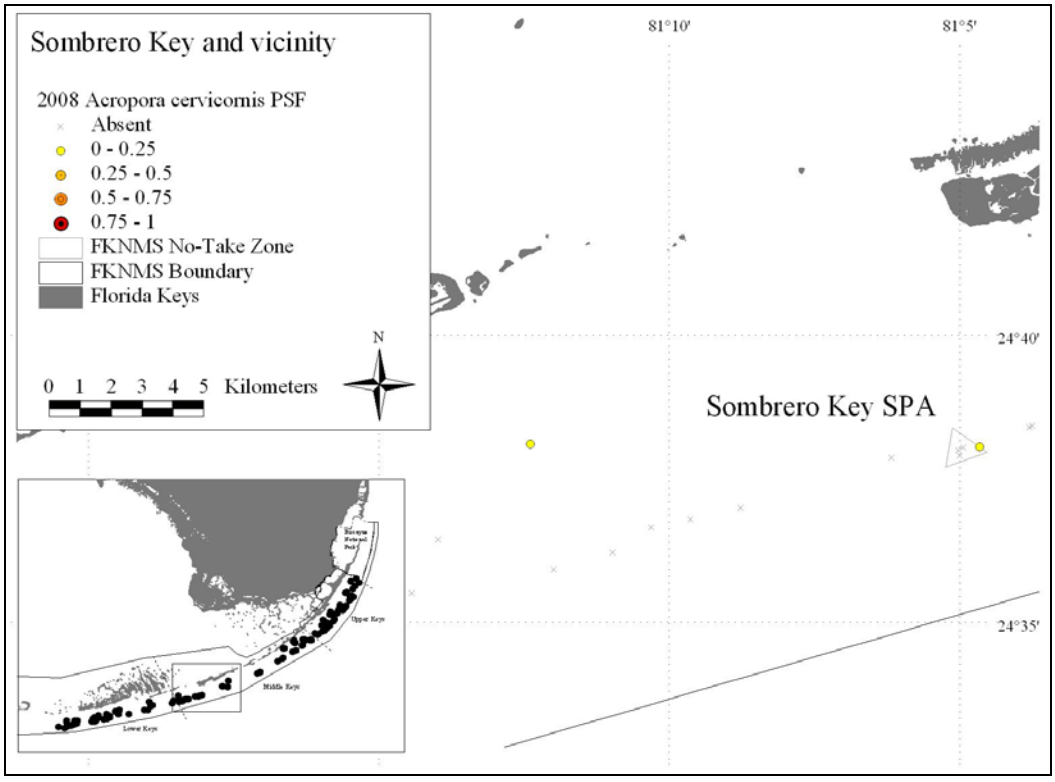


Figure 11. Staghorn coral (*Acropora cervicornis*) presence-absence and proportional transect frequency (% of transects present) in the middle Florida Keys from Sombrero Reef to Bahia Honda (top) and in the lower Florida Keys (bottom) during June-September 2008.



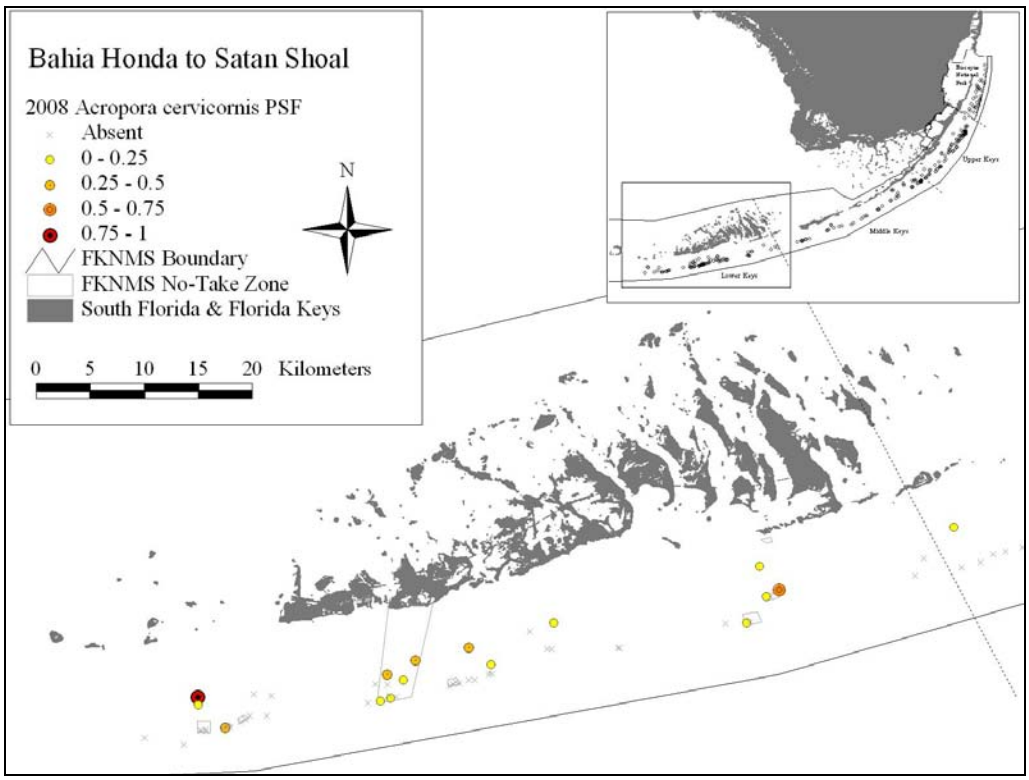


Figure 12. Staghorn coral (*Acropora cervicornis*) presence-absence and proportional transect frequency (% of transects present) in the lower Florida Keys from Bahia Honda to Looe Key (top) and from American Shoal to Western Sambo (bottom) during June-September 2008.

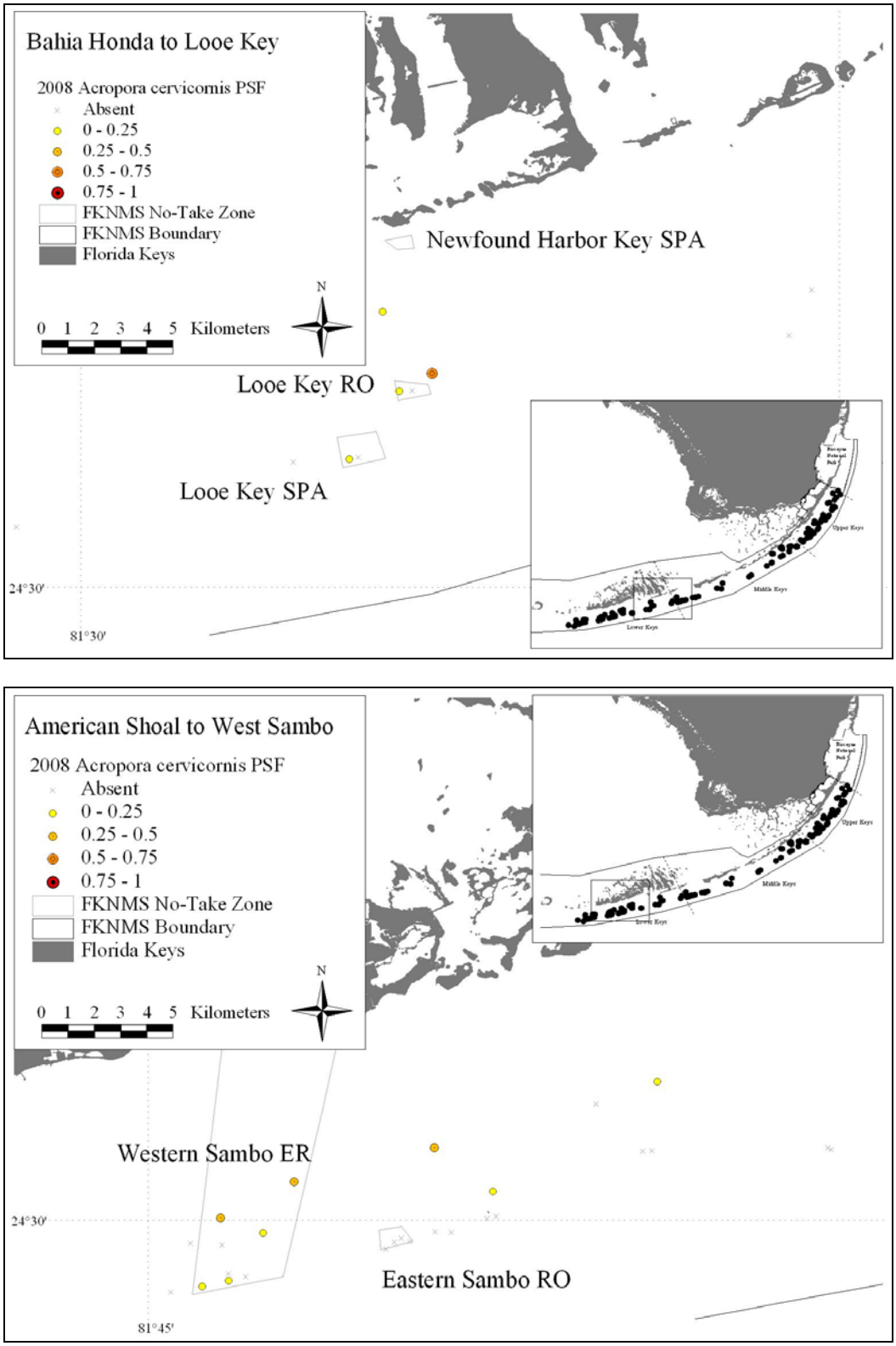


Figure 13. Staghorn coral (*Acropora cervicornis*) presence-absence and proportional transect frequency (% of transects present) in the lower Florida Keys from Eastern Dry Rocks to Sand Key during June-September 2008.

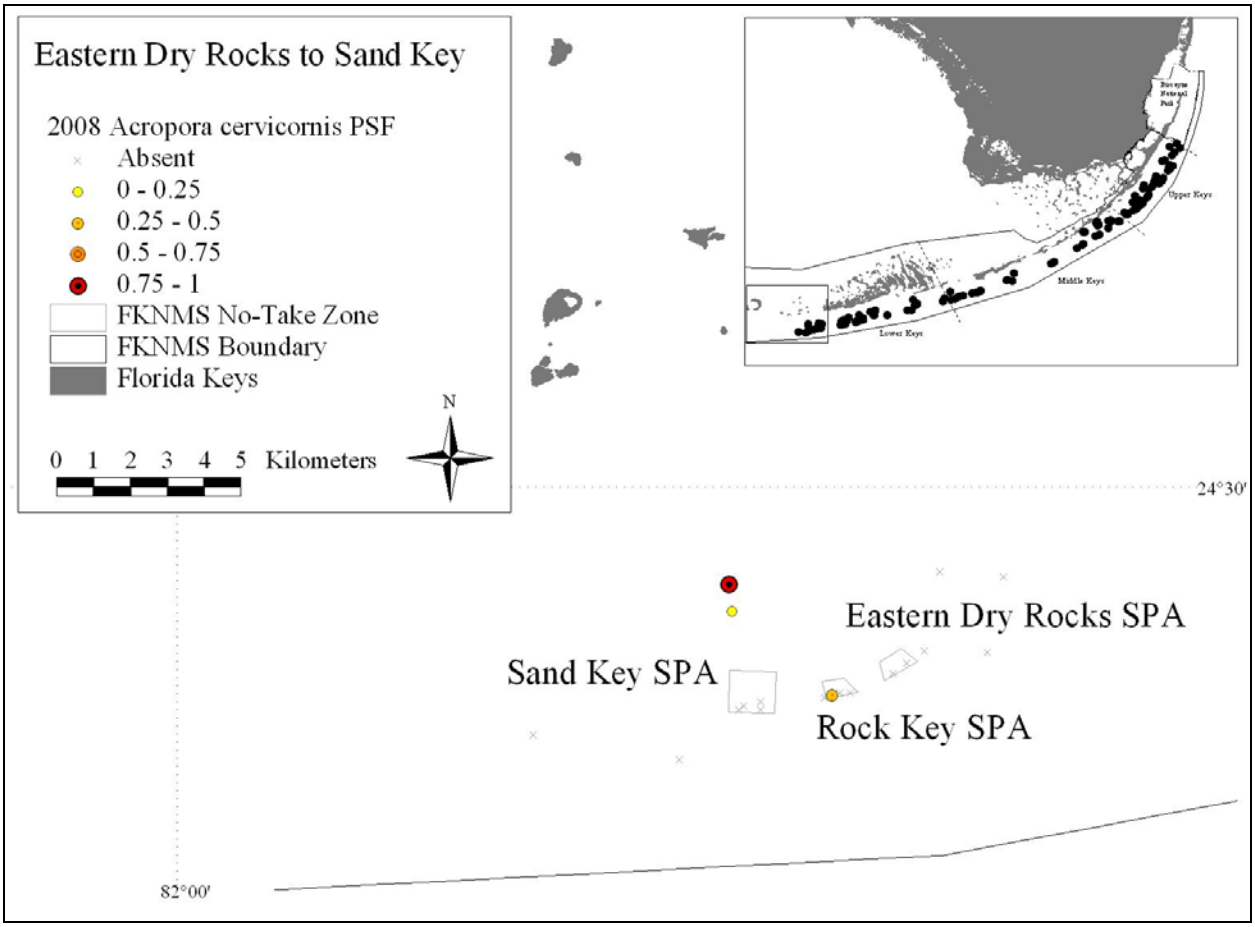
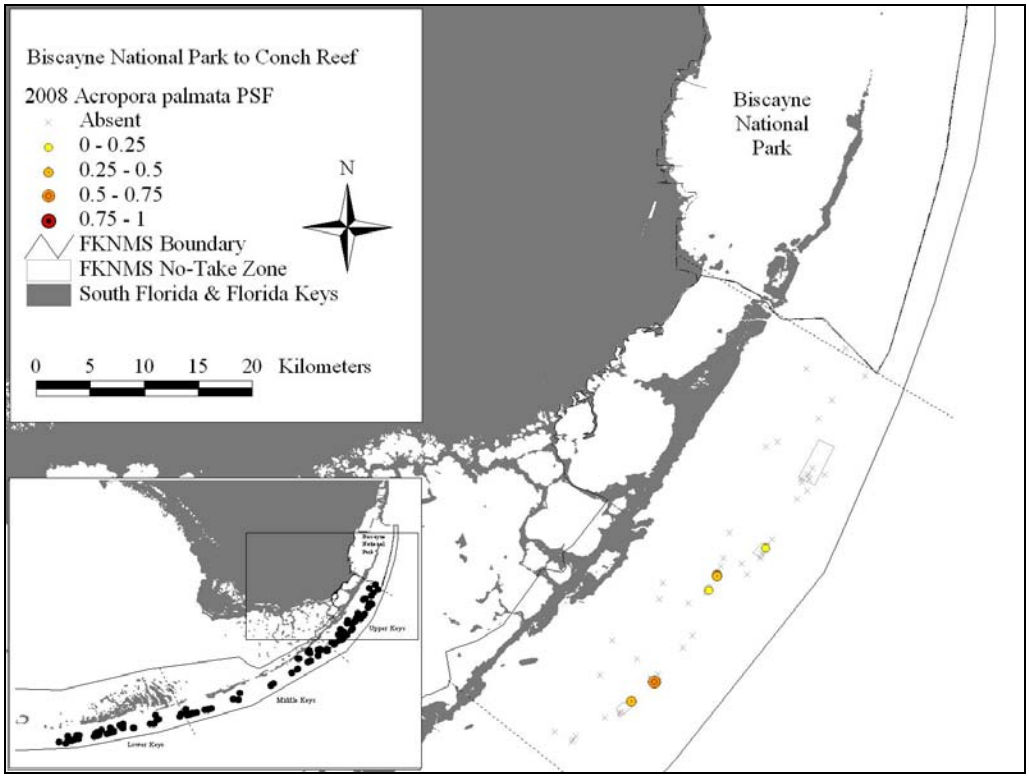


Figure 14. Elkhorn coral (*Acropora palmata*) presence-absence and proportional transect frequency (% of transects present) in the upper Florida Keys (top) and from the southern BNP boundary to Carysfort Reef (bottom) during June-September 2008.



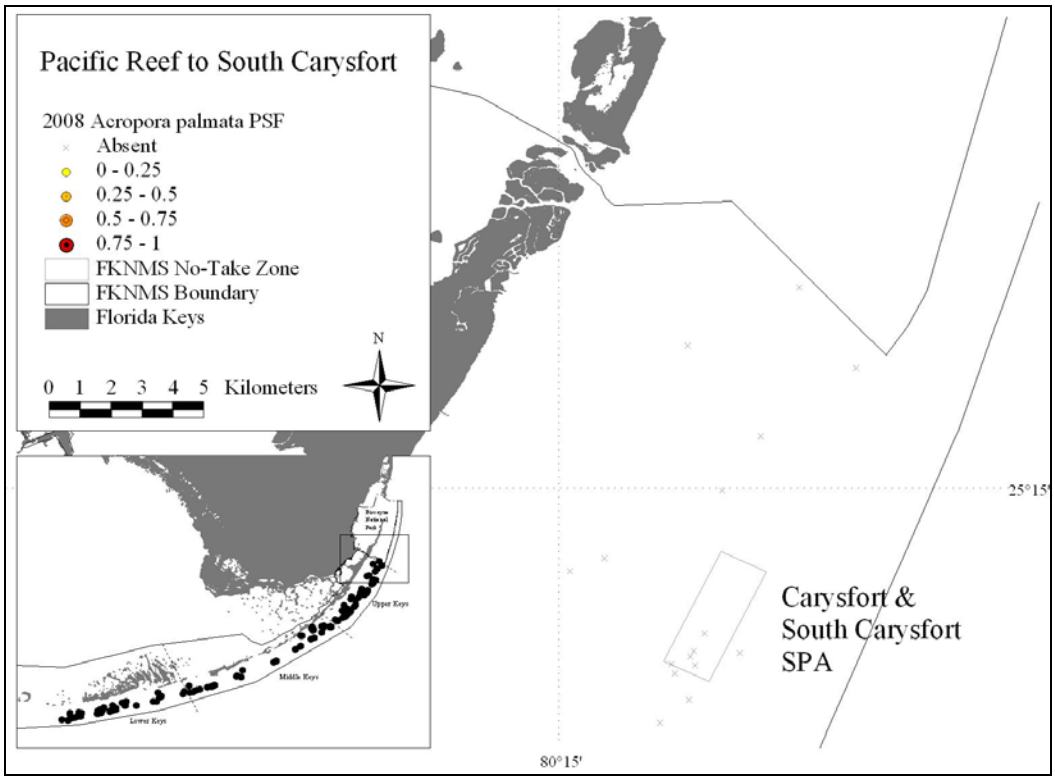
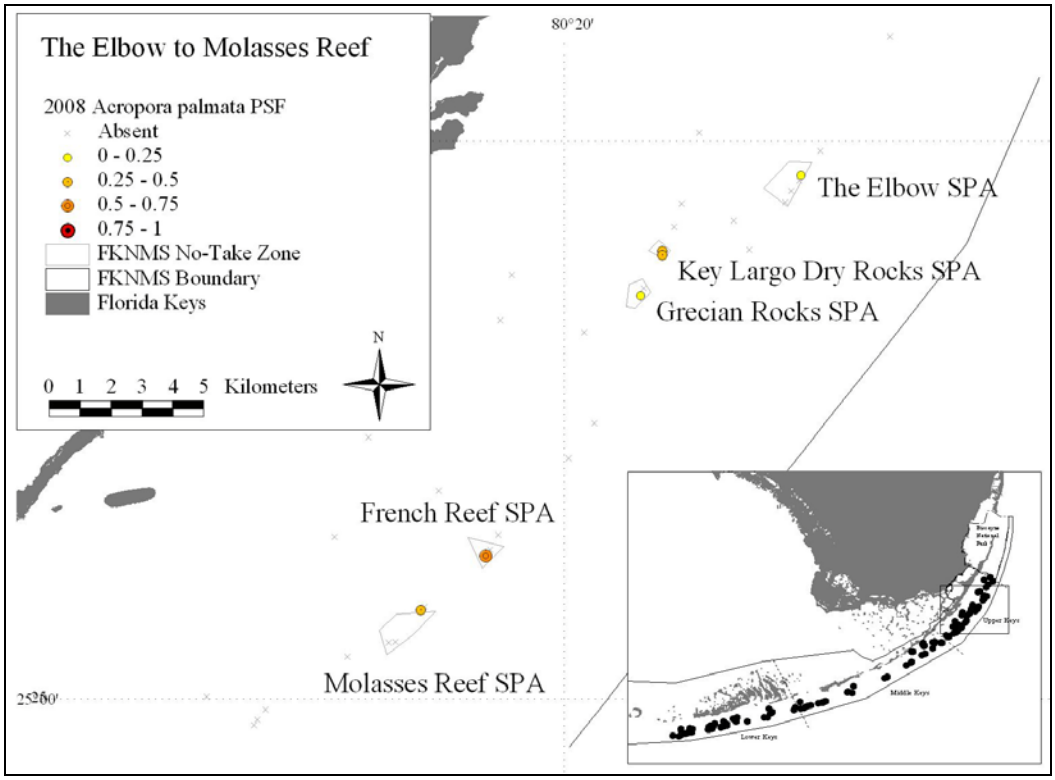


Figure 15. Elkhorn coral (*Acropora palmata*) presence-absence and proportional transect frequency (% of transects present) in the upper Florida Keys from Elbow Reef to Pickles Reef (top) and in the middle Florida Keys (bottom) during June-September 2008.



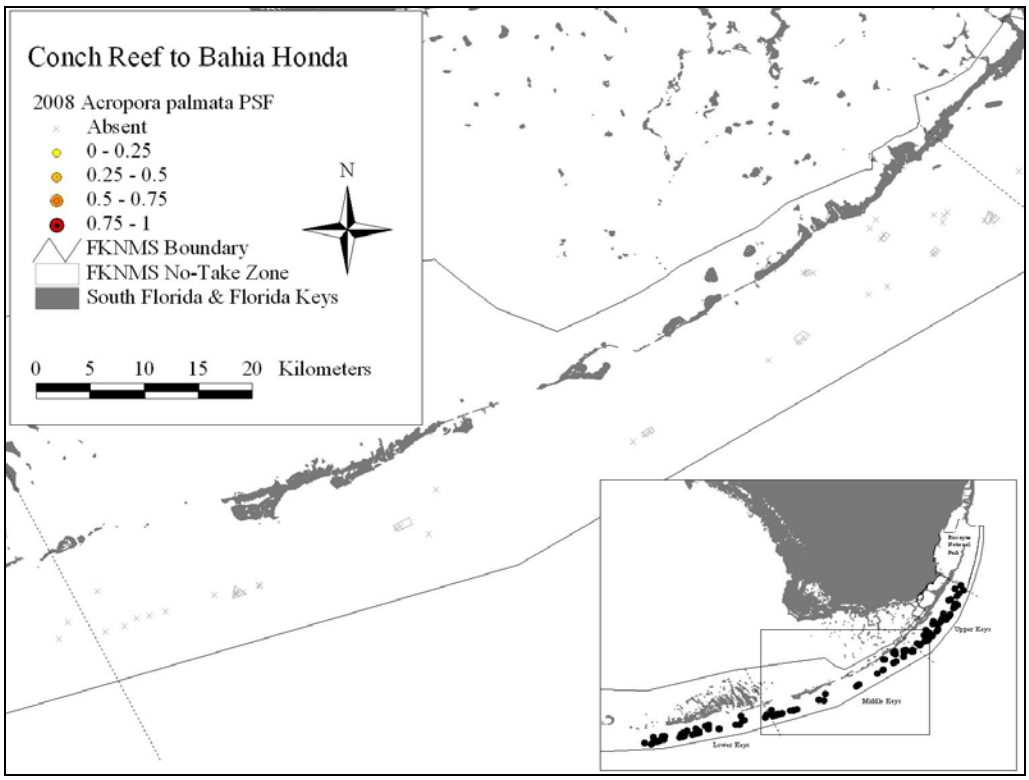


Figure 16. Elkhorn coral (*Acropora palmata*) presence-absence and proportional transect frequency (% of transects present) in the middle Florida Keys from Conch Reef to Alligator Reef (top) and from Tennessee Reef to Coffins Patch during June-September 2008.

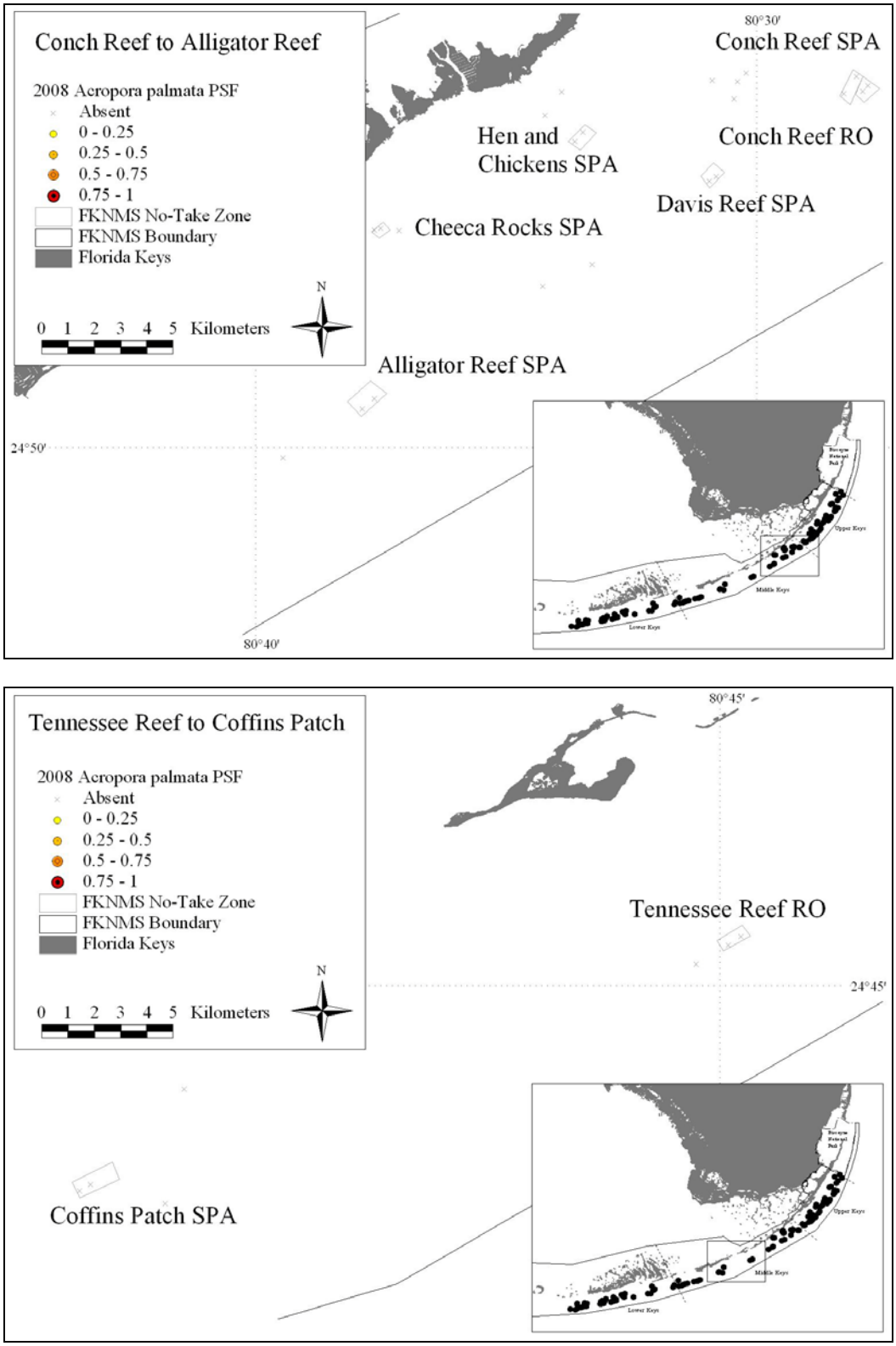
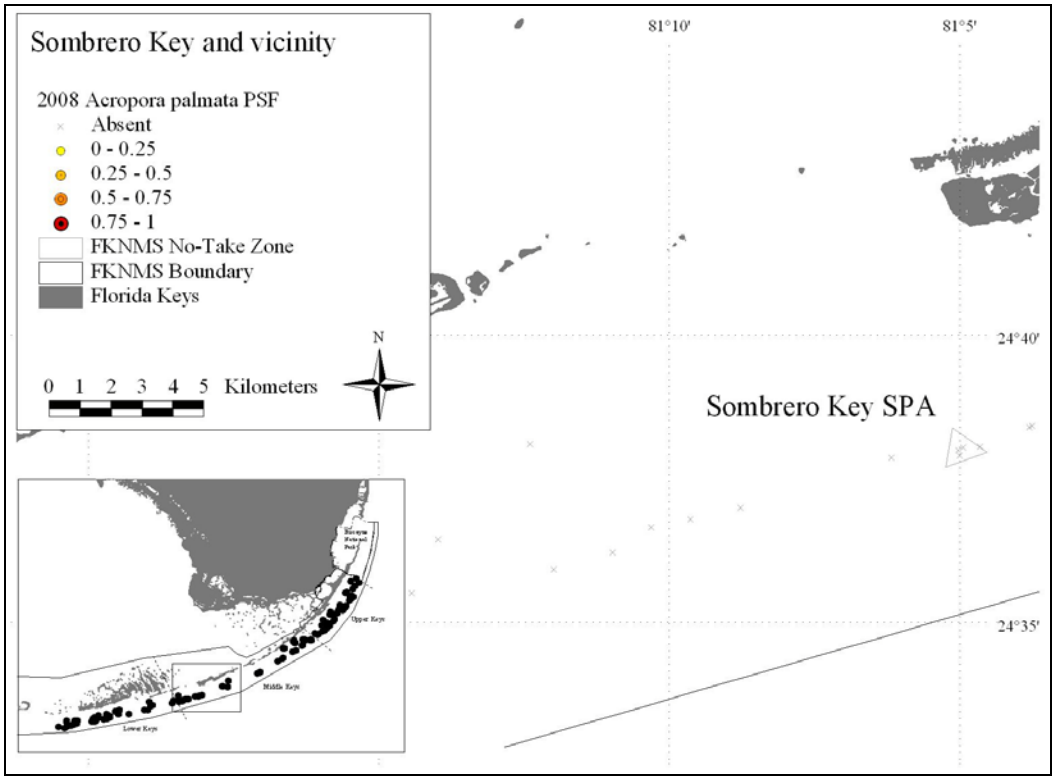


Figure 17. Elkhorn coral (*Acropora palmata*) presence-absence and proportional transect frequency (% of transects present) in the middle Florida Keys from Sombrero Reef to Bahia Honda (top) and in the lower Florida Keys (bottom) during June-September 2008.



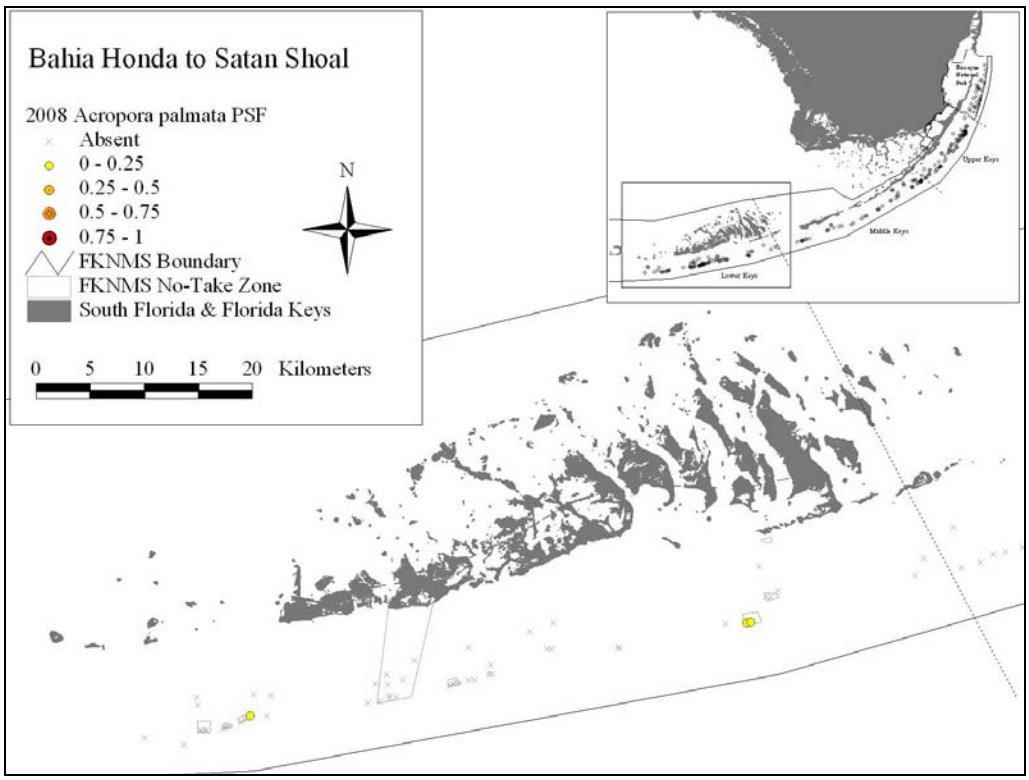


Figure 18. Elkhorn coral (*Acropora palmata*) presence-absence and proportional transect frequency (% of transects present) in the lower Florida Keys from Bahia Honda to Looe Key (top) and from American Shoal to Western Sambo during June-September 2008.

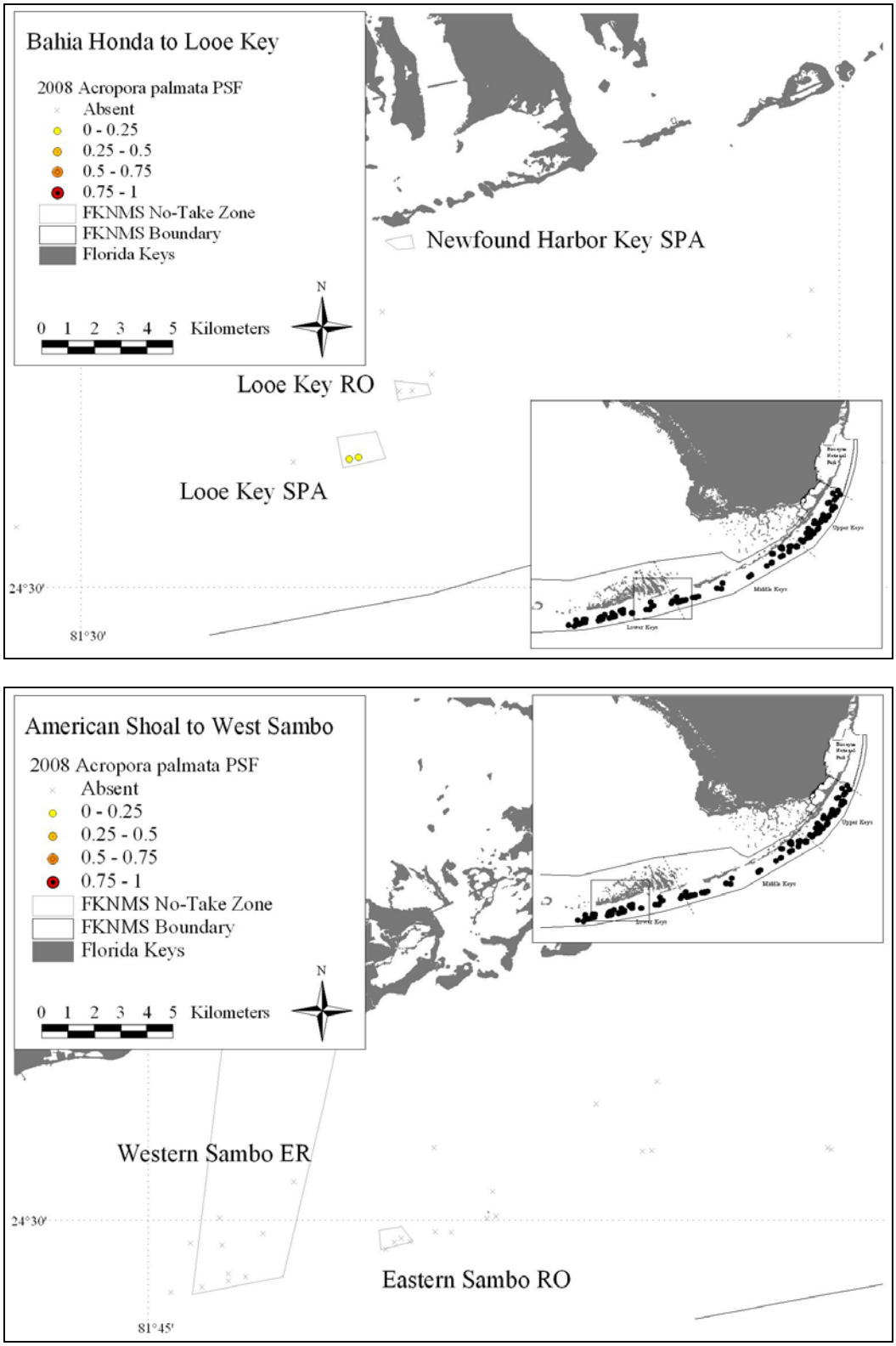


Figure 19. Elkhorn coral (*Acropora palmata*) presence-absence and proportional transect frequency (% of transects present) in the lower Florida Keys from Eastern Dry Rocks to Sand Key during June-September 2008.

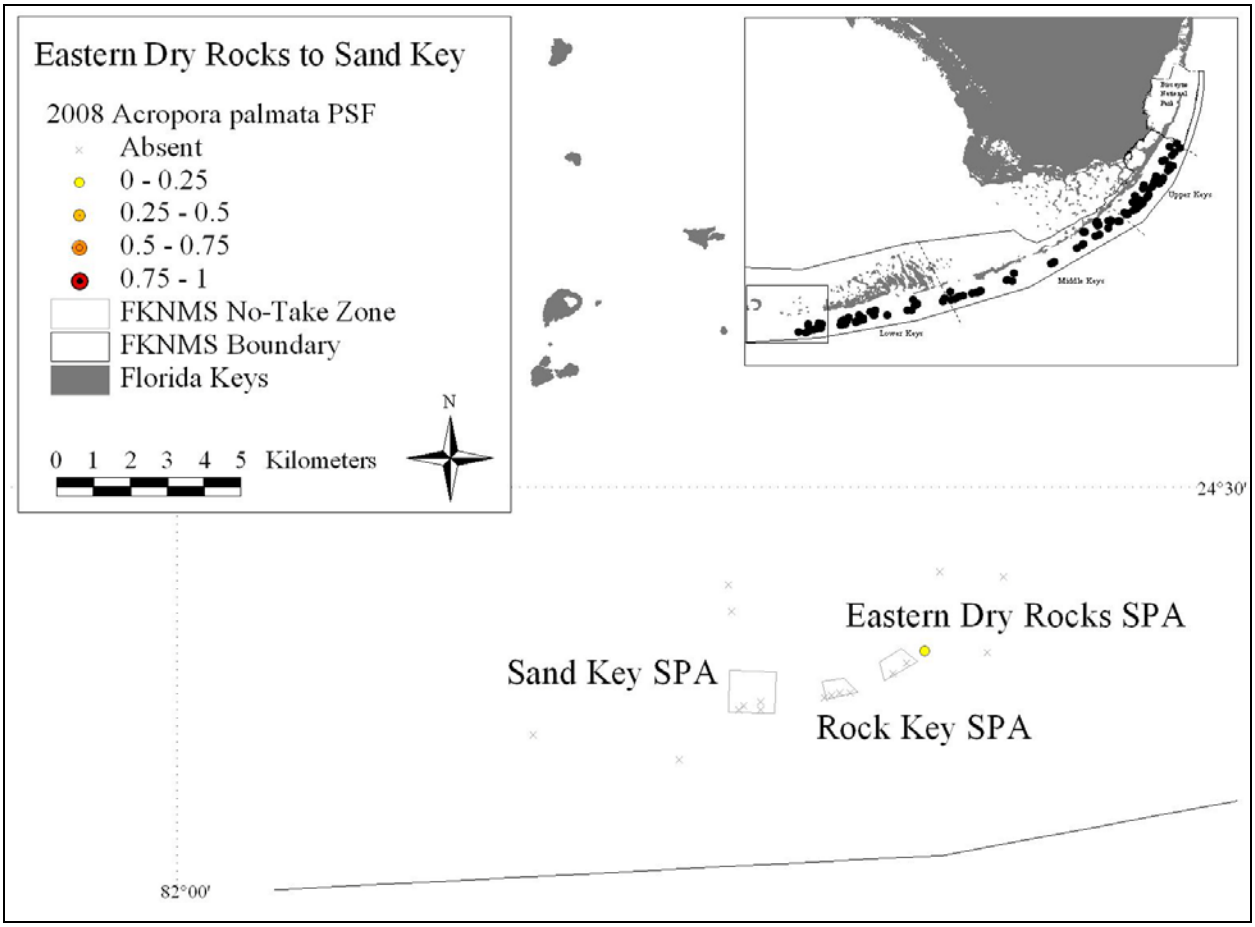


Table 5. Site presence (P) and proportional transect frequency (%) of staghorn coral (*Acropora cervicornis*) and elkhorn coral (*A. palmata*) in the Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m transects per site at 145 sites during June-September 2008. Values for regional sectors and habitat types are the percentages of sites where each species was observed. Sites are arranged by habitat from northeast to southwest. Asterisked locations (**) are Sanctuary Preservation Areas (SPA), Ecological Reserves (ER), or Research Only Areas (RO).

Site number/site location	***Acropora cervicornis***		***A. palmata***	
	Present at site	**% of Transects**	**Present at site**	**% of Transects**
Mid-channel patch reefs		0 ± 0		0 ± 0
Upper Florida Keys NMS		0 ± 0		0 ± 0
6 - Basin Hill Shoals		0 ± 0		0 ± 0
5 - Basin Hill Shoals		0 ± 0		0 ± 0
4 - Inshore of Grecian Rocks SPA		0 ± 0		0 ± 0
3 - South of Cannon Patch Reef		0 ± 0		0 ± 0
2 - Mosquito Bank		0 ± 0		0 ± 0
1 - Inshore of Molasses Reef		0 ± 0		0 ± 0
Upper Florida Keys Total (6)	0	0 ± 0	0	0 ± 0
Middle Florida Keys NMS				
56 - Tavernier Rocks		0 ± 0		0 ± 0
55 - Tavernier Rocks		0 ± 0		0 ± 0
59 - Hen and Chickens SPA**		0 ± 0		0 ± 0
58 - Hen and Chickens SPA**	P	25 ± 25		0 ± 0
61 - Cheeca Rocks SPA**		0 ± 0		0 ± 0
60 - Cheeca Rocks SPA**		0 ± 0		0 ± 0
57 - NE of Cheeca Rocks SPA		0 ± 0		0 ± 0
54 - South of Duck Key	P	25 ± 25		0 ± 0
53 - South of Ohio Key	P	25 ± 25		0 ± 0
Middle Florida Keys Total (9)	33.3	8.3 ± 4.2	0	0 ± 0
Lower Florida Keys NMS				
103 - North of Looe Key RO	P	25 ± 25		0 ± 0
102 - North of Maryland Shoal	P	25 ± 25		0 ± 0
101 - North of Maryland Shoal		0 ± 0		0 ± 0
100 - North of Eastern Sambo RO	P	50 ± 29		0 ± 0
105 - Western Sambo ER**	P	50 ± 29		0 ± 0
104 - Western Sambo ER**	P	50 ± 29		0 ± 0
99 - West of Western Sambo ER		0 ± 0		0 ± 0
98 - Middle Ground	P	100 ± 0		0 ± 0
97 - Middle Ground	P	25 ± 25		0 ± 0
Lower Florida Keys Total (9)	77.8	36.1 ± 10.3	0	0 ± 0
Mid-channel Patch Reef Total (24)	**41.7**	**16.7 ± 5.1**	**0**	**0 ± 0**
Offshore patch reefs				
Upper Florida Keys NMS				
12 - South of BNP boundary		0 ± 0		0 ± 0
41 - North of Carysfort Reef SPA		0 ± 0		0 ± 0
11 - North of Carysfort Reef SPA		0 ± 0		0 ± 0
14 - Carysfort Reef SPA**		0 ± 0		0 ± 0
13 - Carysfort Reef SPA**	P	25 ± 25		0 ± 0
10 - North of Dry Rocks SPA		0 ± 0		0 ± 0
9 - SW of Grecian Rocks SPA	P	50 ± 29		0 ± 0
8 - Inshore of French Reef SPA	P	25 ± 25		0 ± 0
7 - Inshore of Pickles Reef	P	50 ± 29		0 ± 0
Upper Florida Keys Total (9)	44.4	16.7 ± 7.2	0	0 ± 0
Middle Florida Keys NMS				
65 - North of Davis Reef SPA	P	75 ± 25		0 ± 0
64 - North of Davis Reef SPA		0 ± 0		0 ± 0
63 - North of Davis Reef SPA	P	75 ± 25		0 ± 0
62 - North of Davis Reef SPA	P	25 ± 25		0 ± 0

Site number/site location	*Acropora cervicornis*		*A. palmata*	
	Present at site	**% of Transects**	**Present at site**	**% of Transects**
89 - Coffins Patch SPA**		0 ± 0		0 ± 0
88 - Coffins Patch SPA**		0 ± 0		0 ± 0
Middle Florida Keys Total (6)	50.0	29.2 ± 15.0	0	0 ± 0
Lower Florida Keys NMS				
109 - East of Looe Key RO	P	75 ± 25		0 ± 0
110 - Looe Key Research Only**		0 ± 0		0 ± 0
111 - Looe Key Research Only**	P	25 ± 25		0 ± 0
107 - North of Pelican Shoal	P	25 ± 25		0 ± 0
112 - Western Sambo ER**	P	25 ± 25		0 ± 0
113 - Western Sambo ER**		0 ± 0		0 ± 0
106 - NE of E. Dry Rocks SPA		0 ± 0		0 ± 0
133 - NE of E. Dry Rocks SPA		0 ± 0		0 ± 0
Lower Florida Keys Total (8)	50.0	0 ± 0	0	0 ± 0
Offshore Patch Reef Total (23)	**47.8**	**18.8 ± 9.1**	**0**	**0 ± 0**
Inner line reef tract spur & groove				
Upper Florida Keys NMS				
32 - Turtle Rocks		0 ± 0		0 ± 0
31 - Inshore of Elbow Reef SPA	P	25 ± 25		0 ± 0
30 - North Dry Rocks		0 ± 0		0 ± 0
34 - Dry Rocks SPA**		0 ± 0	P	50 ± 29
33 - Dry Rocks SPA**		0 ± 0	P	50 ± 29
36 - Grecian Rocks SPA**		0 ± 0		0 ± 0
35 - Grecian Rocks SPA**		0 ± 0	P	25 ± 25
Upper Florida Keys Total (7)	14.3	3.6 ± 3.6	42.9	17.9 ± 9.0
Inner Line Spur & Groove Total (7)	**14.3**	**3.6 ± 3.6**	**42.9**	**17.9 ± 9.0**
High-relief spur & groove				
Upper Florida Keys NMS				
23 - Carysfort Reef SPA**		0 ± 0		0 ± 0
22 - Carysfort Reef SPA**		0 ± 0		0 ± 0
21 - Maitland grounding site		0 ± 0		0 ± 0
24 - Elbow Reef SPA**		0 ± 0	P	25 ± 25
223 - Elbow Reef SPA**		0 ± 0		0 ± 0
19 - North of French Reef SPA	P	50 ± 29		0 ± 0
25 - French Reef SPA**		0 ± 0		0 ± 0
26 - French Reef SPA**		0 ± 0	P	75 ± 25
20 - Sand Island		0 ± 0		0 ± 0
18 - Sand Island		0 ± 0	P	50 ± 29
28 - Molasses Reef SPA**		0 ± 0		0 ± 0
27 - Molasses Reef SPA**		0 ± 0		0 ± 0
17 - Pickles Reef		0 ± 0		0 ± 0
16 - Pickles Reef		0 ± 0		0 ± 0
15 - Pickles Reef		0 ± 0		0 ± 0
Upper Florida Keys Total (15)	6.7	3.3 ± 3.3	20.0	10.0 ± 5.9
Middle Florida Keys NMS				
67 - Delta Shoal		0 ± 0		0 ± 0
66 - Delta Shoal		0 ± 0		0 ± 0
69 - Sombrero Key SPA**		0 ± 0		0 ± 0
266 - Sombrero Key SPA**		0 ± 0		0 ± 0
Middle Florida Keys Total (4)	0	0 ± 0	0	0 ± 0
Lower Florida Keys NMS				
124 - Looe Key SPA**		0 ± 0	P	25 ± 25
123 - Looe Key SPA**	P	25 ± 25	P	25 ± 25
120 - American Shoal		0 ± 0		0 ± 0
122 - American Shoal		0 ± 0		0 ± 0
119 - Maryland Shoal		0 ± 0		0 ± 0
121 - Maryland Shoal		0 ± 0		0 ± 0
118 - Pelican Shoal		0 ± 0		0 ± 0

Site number/site location	*Acropora cervicornis*		*A. palmata*	
	Present at site	**% of Transects**	**Present at site**	**% of Transects**
117 - Pelican Shoal		0 ± 0		0 ± 0
116 - No Name Reef		0 ± 0		0 ± 0
322 - Eastern Sambo RO**		0 ± 0		0 ± 0
125 - Eastern Sambo RO**		0 ± 0		0 ± 0
127 - Western Sambo ER**		0 ± 0		0 ± 0
126 - Western Sambo ER**	P	25 ± 25		0 ± 0
115 - East of E. Dry Rocks SPA		0 ± 0	P	25 ± 25
129 - Eastern Dry Rocks SPA**		0 ± 0		0 ± 0
128 - Eastern Dry Rocks**		0 ± 0		0 ± 0
327 - Rock Key SPA**		0 ± 0		0 ± 0
130 - Rock Key SPA**	P	50 ± 29		0 ± 0
131 - Sand Key SPA**		0 ± 0		0 ± 0
328 - Sand Key SPA**		0 ± 0		0 ± 0
114 - Western Dry Rocks		0 ± 0		0 ± 0
Lower Florida Keys Total (21)	14.3	4.8 ± 2.8	14.3	3.6 ± 2.0
High-relief Spur & Groove Total (40)	**10.0**	**3.8 ± 1.9**	**15.0**	**5.6 ± 2.4**
Fore-reef (6-15 m)				
Upper Florida Keys NMS				
42 - South of BNP boundary		0 ± 0		0 ± 0
52 - Carysfort Reef SPA**		0 ± 0		0 ± 0
51 - Carysfort Reef SPA**		0 ± 0		0 ± 0
50 - SW of Carysfort Reef SPA		0 ± 0		0 ± 0
40 - SW of Carysfort Reef SPA		0 ± 0		0 ± 0
39 - North of Elbow Reef SPA		0 ± 0		0 ± 0
245 - Elbow Reef SPA**		0 ± 0		0 ± 0
46 - Elbow Reef SPA**		0 ± 0		0 ± 0
38 - SW of Elbow Reef SPA		0 ± 0		0 ± 0
49 - South of Elbow Reef SPA		0 ± 0		0 ± 0
37 - Dixie Shoal		0 ± 0		0 ± 0
48 - Dixie Shoal		0 ± 0		0 ± 0
47 - SW of Molasses Reef SPA		0 ± 0		0 ± 0
Upper Florida Keys Total (13)	0	0 ± 0	0	0 ± 0
Middle Florida Keys NMS				
81 - Conch Reef SPA**		0 ± 0		0 ± 0
80 - Conch Reef SPA**		0 ± 0		0 ± 0
82 - Conch Reef RO**		0 ± 0		0 ± 0
279 - Conch Reef RO**		0 ± 0		0 ± 0
84 - Davis Reef SPA**		0 ± 0		0 ± 0
83 - Davis Reef SPA**		0 ± 0		0 ± 0
79 - SW of Crocker Reef		0 ± 0		0 ± 0
78 - SW of Crocker Reef		0 ± 0		0 ± 0
85 - Alligator Reef SPA**		0 ± 0		0 ± 0
68 - Alligator Reef SPA**		0 ± 0		0 ± 0
77 - SW of Alligator Reef SPA		0 ± 0		0 ± 0
87 - Tennessee Reef RO**		0 ± 0		0 ± 0
86 - Tennessee Reef RO**		0 ± 0		0 ± 0
76 - NE of Tennessee Light		0 ± 0		0 ± 0
75 - East of Coffins Patch SPA		0 ± 0		0 ± 0
293 - Sombrero Key SPA**	P	25 ± 25		0 ± 0
96 - Sombrero Key SPA**		0 ± 0		0 ± 0
73 - West of Sombrero Key SPA		0 ± 0		0 ± 0
71 - South of Moser Channel		0 ± 0		0 ± 0
72 - South of Moser Channel		0 ± 0		0 ± 0
70 - South of Moser Channel		0 ± 0		0 ± 0
90 - South of Moser Channel		0 ± 0		0 ± 0
Middle Florida Keys Total (22)	4.6	1.1 ± 1.1	0	0 ± 0
Lower Florida Keys NMS				
136 - South of Bahia Honda Key		0 ± 0		0 ± 0

Site number/site location	*Acropora cervicornis*		*A. palmata*	
	Present at site	**% of Transects**	**Present at site**	**% of Transects**
138 - South of Bahia Honda Key		0 ± 0		0 ± 0
137 - South of Bahia Honda Key		0 ± 0		0 ± 0
135 - West of Looe Key SPA		0 ± 0		0 ± 0
134 - West of Pelican Shoal		0 ± 0		0 ± 0
139 - Eastern Sambo RO**		0 ± 0		0 ± 0
336 - Eastern Sambo RO**		0 ± 0		0 ± 0
141 - Western Sambo ER**		0 ± 0		0 ± 0
140 - Western Sambo ER**	P	25 ± 25		0 ± 0
143 - West of Western Sambo ER		0 ± 0		0 ± 0
132 - East of E. Dry Rocks SPA		0 ± 0		0 ± 0
346 - Rock Key SPA**		0 ± 0		0 ± 0
149 - Rock Key SPA**		0 ± 0		0 ± 0
347 - Sand Key SPA**		0 ± 0		0 ± 0
150 - Sand Key SPA**		0 ± 0		0 ± 0
142 - SW of Sand Key SPA		0 ± 0		0 ± 0
Lower Florida Keys Total (16)	6.3	1.6 ± 1.6	0	0 ± 0
Fore-reef Total (51)	**3.9**	**1.0 ± 0.7**	**0**	**0 ± 0**

IV. Density and size of gorgonians and *Cyphoma* snail predators

Background

Gorgonians (Octocorallia, Alcyonaria) occur at their greatest diversity in the wider Caribbean, often exceeding reef-building corals in species richness and colony density. They often dominate coral reef and hard-bottom communities and their contribution to spatial complexity can be substantial, particularly in sediment-rich areas and on reefs with lower stony coral cover (Wheaton and Jaap 1988; Chiappone and Sullivan 1997). Gorgonian distribution patterns are primarily influenced by physical environmental conditions such as substrate availability, water depth and flow, wave energy, and light intensity. Factors affecting gorgonian population dynamics include recruitment strategies, mortality due to toppling, predation, and disease. Additional factors such as episodic storms, anthropogenic impacts, reef morphology, and geographic setting also contribute to spatial and temporal variability.

Most gorgonian predators, such as ovulid gastropods like the flamingo tongue snail *Cyphoma gibbosum* Linnaeus (Figure 20), cause only partial colony mortality, ranging from consumption of the polyps to rasping of the axial coenochyme, sometimes to the depth of the proteinaceous axis (Harvell and Fenical 1989; Neudecker 1985). Usually found in male and female pairs, *C. gibbosum* is a generalist browser and has been the subject of numerous studies concerned with distribution and gorgonian occupancy patterns in the Caribbean (e.g. Birkeland and Gregory 1975; Hazlett and Bach 1982; Harvell and Suchanek 1987). Several hypotheses have been proposed to explain the factors that control *C. gibbosum* populations in typically prey-rich environments: recruitment limitation (which has yet to be adequately studied), predation by hogfish (*Lachnolaimus maximus*) and other predators (Randall and Warmke 1967; Shoup 1968), gorgonian structural defenses (Lewis and Von Wallis, 1991; Van Alstyne and Paul 1992; West 1997), and chemical defenses (Pawlik et al. 1987; Sammarco and Coll 1992; Pawlik and Fenical 1989; Van Alstyne and Paul 1992). Although food abundance may be expected to lead to significant prey preference, considerable variability exists in observed patterns of gorgonian host occupancy by *C. gibbosum*. These patterns range from preference of several species (Birkeland and Gregory, 1975; Lasker et al. 1988) to occupancy of gorgonian species in proportion to their availability (Kinzie 1970; Harvell and Suchanek 1987). The variability in experimental results may reflect temporal or geographic differences in preferences or variability in prey quality (Lasker et al., 1988). Gorgonian defenses such as sclerite content (Harvell and Suchanek, 1987; Van Alstyne and Paul, 1992; West, 1997) and secondary metabolites (Hazlett and Bach 1982; Pawlik et al. 1987; Sammarco and Coll 1992) do not clearly explain prey utilization patterns. *Cyphoma gibbosum* apparently tolerates high levels of gorgonian terpenes (Vrolijk and Targett 1992) and may sequester these compounds in its mantle, similar to other ovulid gastropods do (Coll et al. 1983).

2008 Survey Results

As a follow-up to similar surveys conducted during 1999-2001 and 2005 in the Florida Keys (Chiappone et al. 2003), we quantified gorgonian numbers and maximum colony heights for all 145 sites visited during 2008. Only branching gorgonians were identified to genus level, with the exception of *Briareum asbestinum* and *Gorgonia ventalina*, and thus the surveys excluded encrusting colonies of *B. asbestinum* and *Erythropodium caribaeorum*. The numbers, shell lengths, and gorgonian host occupation patterns of flamingo-tongue snails were also collected (Figure 20), similar to previous surveys in 2001. Gorgonians and *Cyphoma* snails were enumerated and measured in two 8-m x 1-m belt transects per site and a total area of 2,320 m^2 was surveyed for these organisms in 2008. Table 6 lists site-level densities for *Cyphoma* snails and total gorgonian densities, while Figures 21-26 illustrate the spatial distribution of total gorgonian densities in the Florida Keys study area. Tables 8-12 provided site-level, habitat, and regional density data by gorgonian genera.

A total of 32,801 branching gorgonians were identified to genus, counted, and measured for maximum colony height. Site-level mean (± 1 SE) colony densities ranged from 0.13 to 46.19 colonies per m^2 among the 145 sites (Table 6). Offshore patch reefs (18.92 ± 2.13 colonies per m^2) and inner line reef tract spur and groove (18.82 ± 2.23) yielded the greatest densities, while mid-channel patch reefs (12.75 ± 2.05) and high-relief spur and groove (10.35 ± 1.25) had the lowest. A total of 43 *Cyphoma* snails, represented by 41 *C. gibbosum* and two *C. signatum*, were recorded, with shell lengths (SL) ranging from 0.4 to 3.2 cm. For *C. gibbosum*, 95% of all individuals were between 2.0 and 3.9 cm SL (Table 7). *C. gibbosum* densities were greatest on offshore patch reefs (0.043 ± 0.017 per m^2) and high-relief spur and groove (0.031 ± 0.011) (Table 6). Thus, there was not complete correspondence between total gorgonian and *Cyphoma* snail densities by habitat. Of the 43 *Cyphoma* snails encountered, all were found on living gorgonian hosts (Table 7), representing a 0.13% gorgonian host occupancy percentage, much lower than that reported during 2001 (Chiappone et al. 2003). The most frequently occupied gorgonian genera by *Cyphoma* snails were *Plexaura* (27.9%), *Eunicea* (20.9%), and *Gorgonia* (16.3%). These three genera represented 6.9%, 9.6%, and 14.8% of the total gorgonians sampled, respectively (Tables 8-12), so it appears that some of the gorgonian hosts were occupied by *Cyphoma* disproportionately relative to their abundance (e.g. *Plexaura*, *Eunicea*, *Pseudopterogorgia*), while others were not (e.g. *Gorgonia*).

Regional variations in gorgonian densities and *Cyphoma* densities were evident, but not consistent among the habitats sampled in 2008 (Table 6). Many genera exhibited substantial habitat-level variability in density and height, as well as variability in these metrics among regions and between no-take zones and

reference areas (Tables 8-12). Mid-channel patch reefs in the lower Keys (20.60 ± 3.28 per m^2) yielded the highest densities of gorgonians compared to the upper and especially the middle Keys. Lower Keys sites were also the only mid-channel patch reefs where *Cyphoma* snails were recorded, all of which were encountered in reference areas outside of no-take zones. For offshore patch reefs, total gorgonian densities were roughly similar among the three regions, with mean total gorgonian densities ranging from 15.98 to 20.61 colonies per m^2. However, 94% of the *Cyphoma* found on offshore patch reefs were documented in the middle and lower Keys. In the lower Keys, *Cyphoma* were only encountered on reference patch reefs outside of no-fishing zones. In high-relief spur and groove, upper Keys sites yielded the greatest mean gorgonian density (15.18 ± 2.17 per m^2), which was 1.7-2.1 times greater than for the middle and lower Keys. For both the upper and lower Keys, the *Cyphoma* snails were only found in reference sites and not within no-fishing zones.

Discussion

During 2001, we assessed *Cyphoma* and gorgonians at 63 sites (Chiappone et al. 2003). Although considerable variability occurred between sites and years, *Cyphoma* densities were similar to those reported by Lasker and Coffroth (1988). In 2008, we found substantially lower snail densities compared to 2001, although there were similar patterns relative to habitat type and management zone. Chiappone et al. 2003 found that the snails exhibited a clumped distribution on gorgonian hosts, mirroring previous results from the Virgin Islands (Birkeland and Gregory 1975; Hazlett and Bach 1982) and Panama (Lasker and Coffroth 1988). Although more solitary individuals were found than pairs or aggregations, it is possible that these individuals were searching for mates (Ghiselin and Wilson 1966). Lasker and Coffroth (1988) proposed that the clumped distribution of *C. gibbosum* could be due to intra-colony variation in secondary metabolite content of gorgonians, while Gerhart (1986) stated that gregariousness is due to mucous trail following. All of the snails encountered during 2008 were found on gorgonian hosts. Birkeland and Gregory (1975) found only 1 % of individuals on the substratum, and Harvell and Suchanek (1987) showed that *C. gibbosum* generally avoids even the basal regions of gorgonians.

Our results indicate that Florida Keys gorgonian hosts are readily available and that *C. gibbosum* is probably not food-limited. The distribution patterns of *C. gibbosum* are produced by at least two independent processes: the movement of individuals to colonies (Lasker et al. 1988) and the time spent on a colony (Gerhart 1986; Lasker and Coffroth 1988). Considering the differences in gorgonian density patterns and management histories of the various regions surveyed in the Florida Keys, one may expect differences in snail densities among habitats, regions, and management zones. More snails were found on offshore patch reef and platform margin spur and groove sites. Snail densities did not correspond exactly

with total gorgonian densities, and this lack of correspondence, while not unexpected in a prey-rich environment, indicates that factors in addition to host availability affect *C. gibbosum* densities. For example, if fishing affects snail predators (such as hogfish, *Lachnolaimus maximus*) (Randall and Warmke 1967), it is possible that higher snail densities within the spur and groove habitat in particular regions could be explained by protection from fishing. Snail densities were lower in the upper Keys, which have been long-protected from spear-fishing, than in the lower Keys. This is interesting because spear-fishing is the preferred method for capturing *L. maximus* in the Florida Keys (Harper et al. 2000), and most snails within the upper Keys region were recorded from three sites at Pickles Reef, just southwest of the boundaries of Key Largo National Marine Sanctuary, where spear-fishing is permitted. Fishery-independent surveys of *L. maximums* during 2001 indicated a mean density of 0.122 individuals per sample in spur and groove, and 1.38 individuals per sample in hard-bottom, a pattern inversely related to *C. gibbosum* densities documented during 2001 (D. McClellan, NOAA/NMFS, pers. comm.; Chiappone et al. 2003). Similar patterns were observed in the spur and groove habitat between fished and protected sites for the lower Keys, where *C. gibbosum* densities were greater in fished sites and *L. maximus* densities were greater in protected sites.

Chiappone et al. (2003) found that most gorgonians were occupied in proportion to their abundance or were under-occupied by snails in their 2001 surveys, while a few species were occupied in disproportion to their availability, indicating possible host preference. Chiappone et al. (2003) found that the plexaurids *Eunicea tourneforti*, *Plexaura flexuosa*, *P. homomalla*, *Plexaurella dichotoma*, and *Pseudoplexaura porosa* were occupied preferentially relative to their densities. These results agree somewhat with previous studies, although increasing densities of these gorgonian hosts did not correlate with increased snail densities. The most common gorgonians occupied in Panama were *P. homomalla*, *Pseudoplexaura* spp., and *Pseudopterogorgia* spp. (Lasker and Coffroth 1988; Lasker et al. 1988), and Lasker and Coffroth (1988) found a strong bias for sea plumes and lesser preferences for other species. Strong preferences for Gorgoniidae, especially sea plumes and *G. ventalina*, were also documented in the Virgin Islands (Birkeland and Gregory 1975; Harvell and Suchanek 1987), but in the Florida Keys there was no strong preference for Gorgoniidae despite relatively high densities. Several mechanisms have been proposed to explain the host occupancy patterns of *C. gibbosum*, principally among them structural and chemical defenses of gorgonians. Harvell and Suchanek (1987) observed that foraging times were negatively correlated with the proportion and size of component sclerites in gorgonians. *Cyphoma gibbosum* seems capable of tolerating the unusually high levels of gorgonian chemical defenses (Pawlik et al. 1987; Sammarco and Coll 1992). For example, this snail is immune to prostaglandins produced by *Plexaura homomalla* (Gerhart 1986), one of the commonly occupied gorgonians in the Florida Keys.

Previous studies have concluded that predation, especially by *C. gibbosum*, imposes a minor effect on gorgonians relative to other factors such as colony toppling during storms, structural failure of the underlying substratum, and sediment scouring and burial. Predation by *C. gibbosum* played a negligible role in gorgonian mortality during a five-year study at two reefs on the southwest coast of Puerto Rico, even though individuals were noted frequently (Yoshioka and Yoshioka 1991). In the Florida Keys, of the 9,911 colonies assessed during 2001, approximately 0.5% was occupied by *C. gibbosum* (Chiappone et al. 2003). In 2008, over 32,000 colonies were counted, but only 0.13% was occupied by snails. Although lower occupancy rates were found in 2008, both sampling periods (2001 and 2008) yielded similar distribution patterns in snail host occupation, especially between no-fishing zones and reference areas. Targeted studies on the relationships between predators and prey, such as hogfish (*Lachnolaimus maximus*) and *C. gibbosum*, including detailed censuses of fishes and snails in multiple habitat types, and experimental work to document predation, will provide important insight into how changing fish communities in marine reserves help to structure the benthos. Other factors that may influence patterns of ovulid gastropods in the Florida Keys, and thus warrant further study, include recruitment variability and removal for by recreational and commercial aquarium (marine ornamental) collectors.

Figure 20. Flamingo-tongue snails (*Cyphoma gibbosum*) surveyed for density, size, and gorgonian host occupation patterns in the Florida Keys during 2008.

C. gibbosum predation on *Eunicea mammosa*

C. gibbosum on the substratum

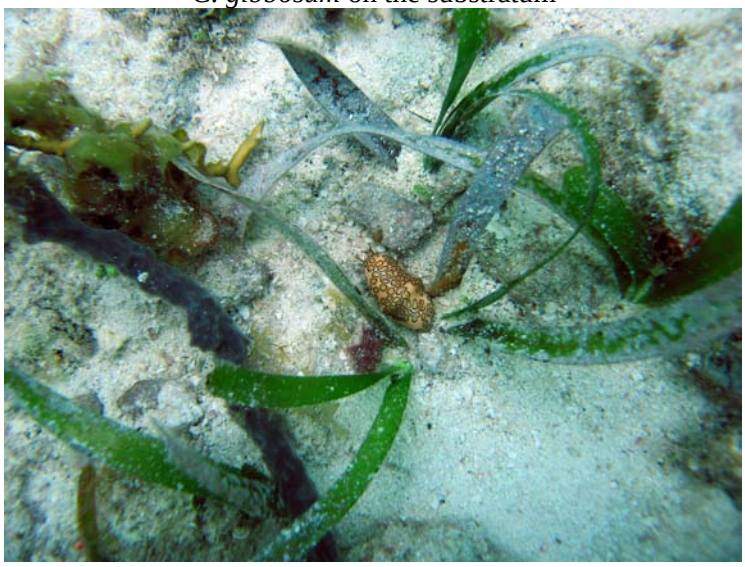
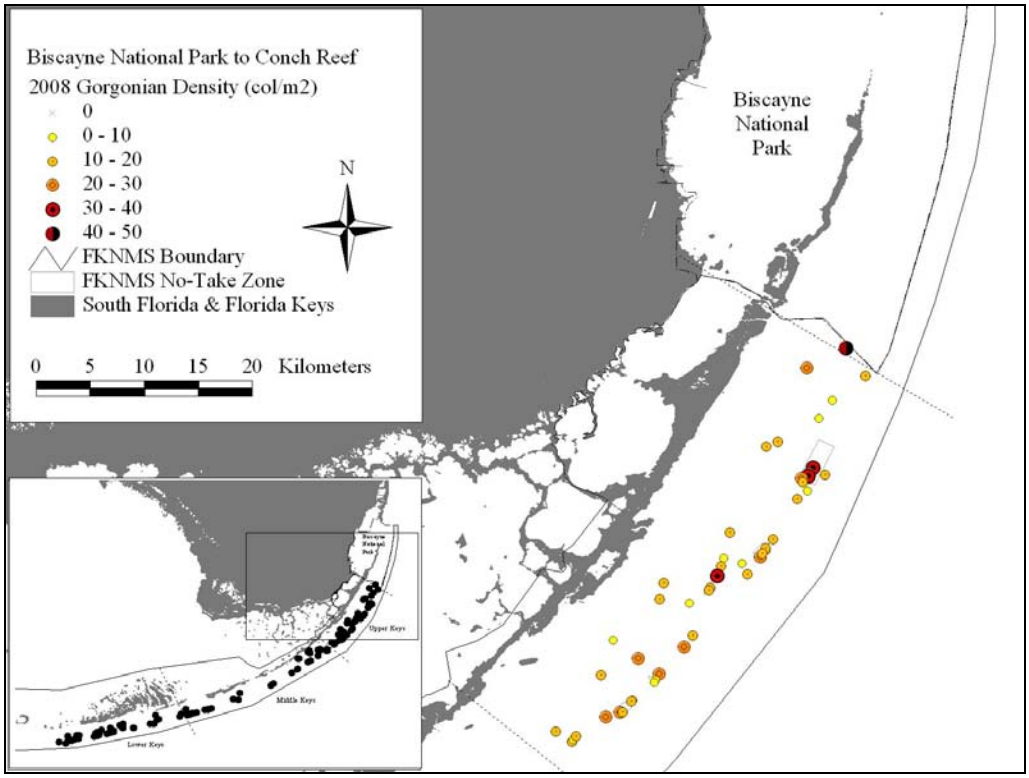


Figure 21. Total gorgonian densities (no. colonies per m^2) in the upper Florida Keys (top) and from the southern BNP boundary to Carysfort Reef (bottom) during June-September 2008.



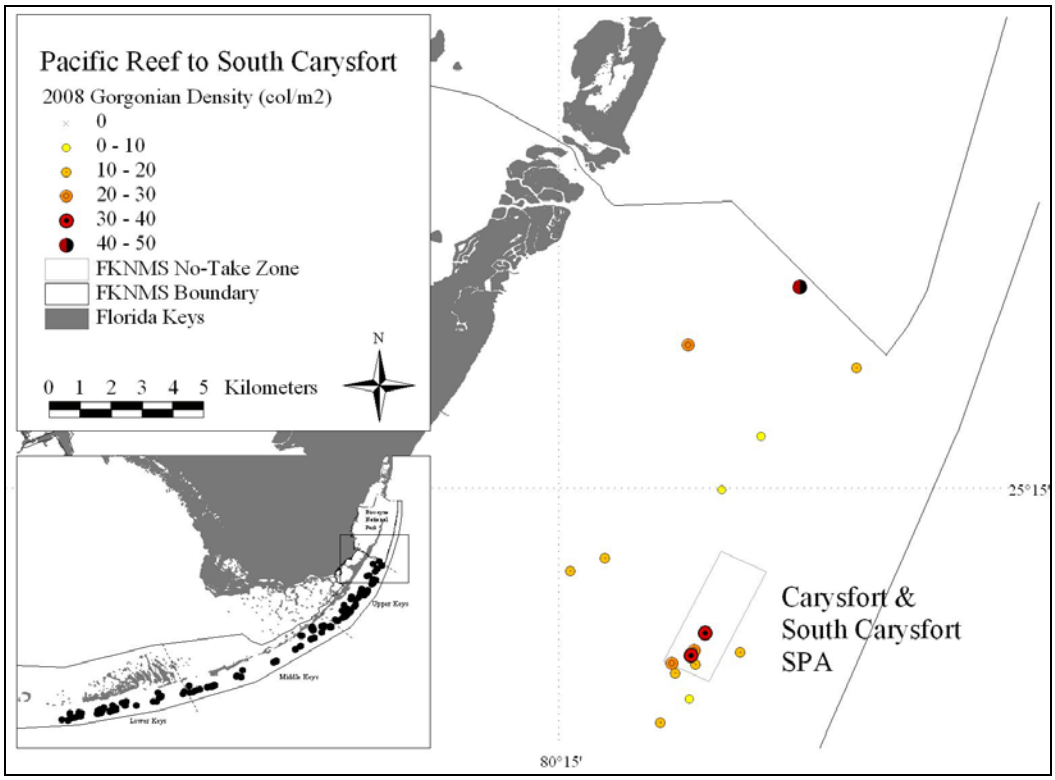


Figure 22. Total gorgonian densities (no. colonies per m^2) in the upper Florida Keys from Elbow Reef to Pickles Reef (top) and in the middle Florida Keys (bottom) during June-September 2008.

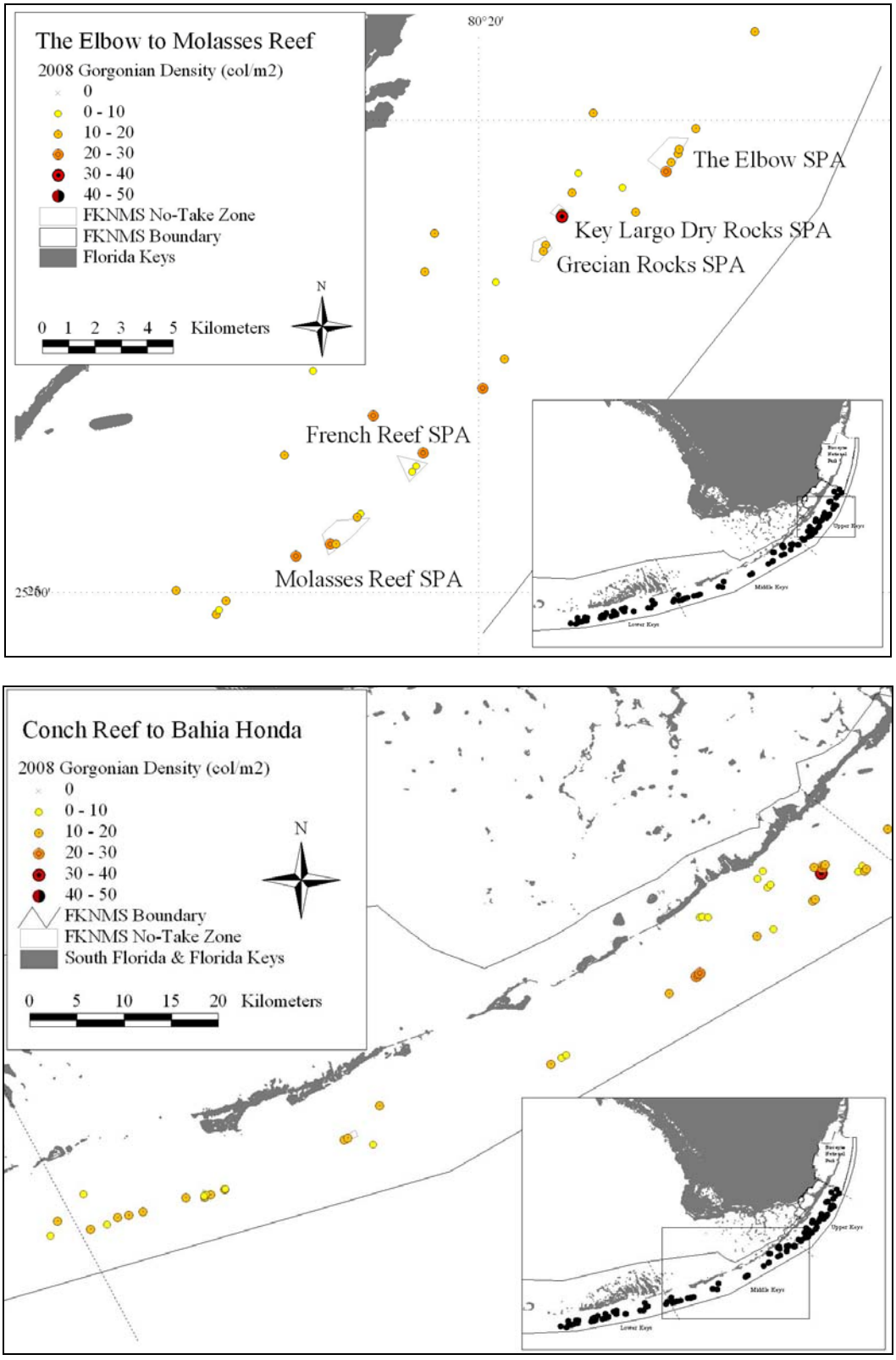


Figure 23. Total gorgonian densities (no. colonies per m^2) in the middle Florida Keys from Conch Reef to Alligator Reef (top) and from Tennessee Reef to Coffins Patch (bottom) during June-September 2008.

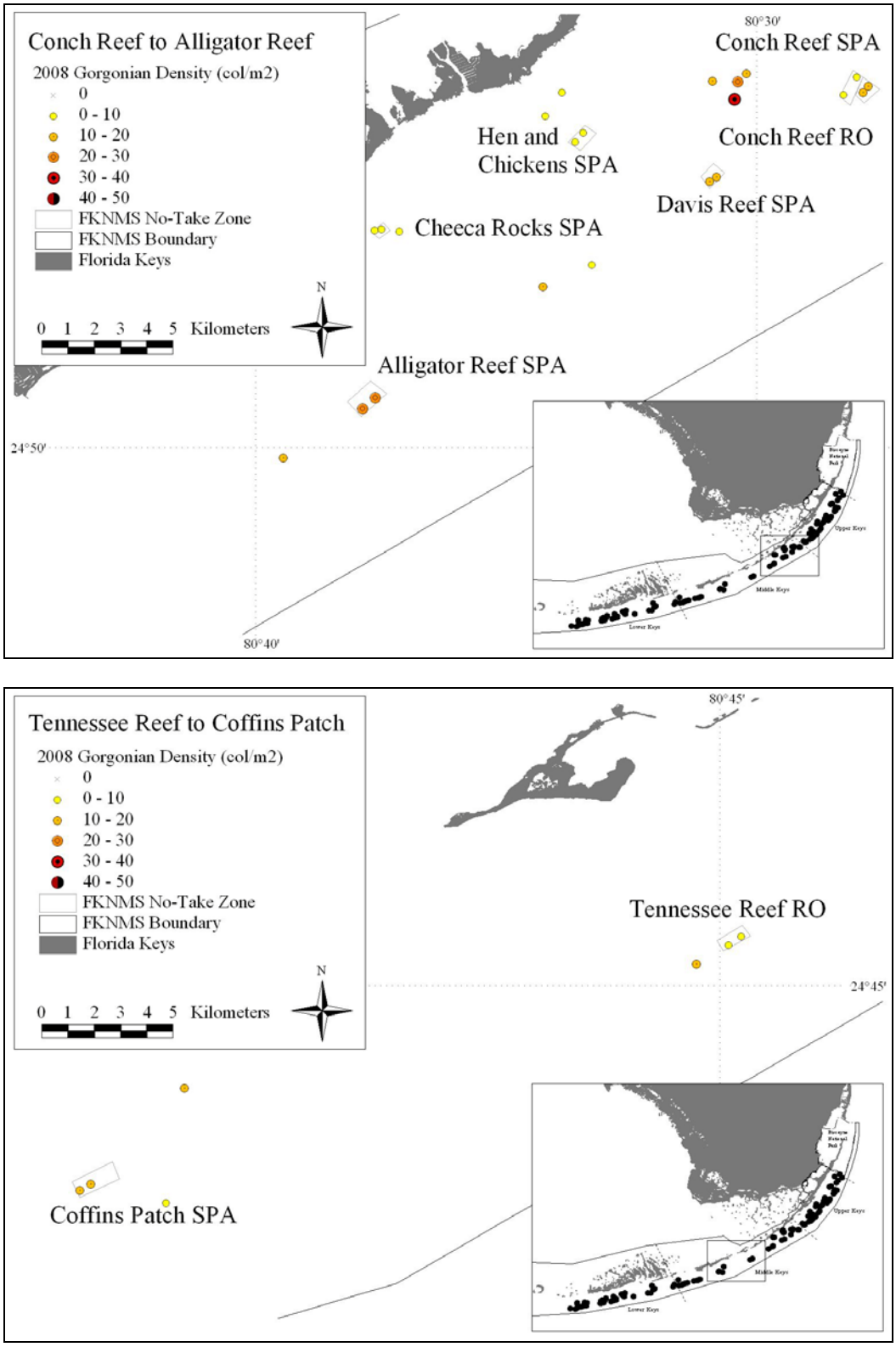


Figure 24. Total gorgonian densities (no. colonies per m^2) in the middle Florida Keys from Sombrero Reef to Bahia Honda (top) and in the lower Florida Keys (bottom) during June-September 2008.

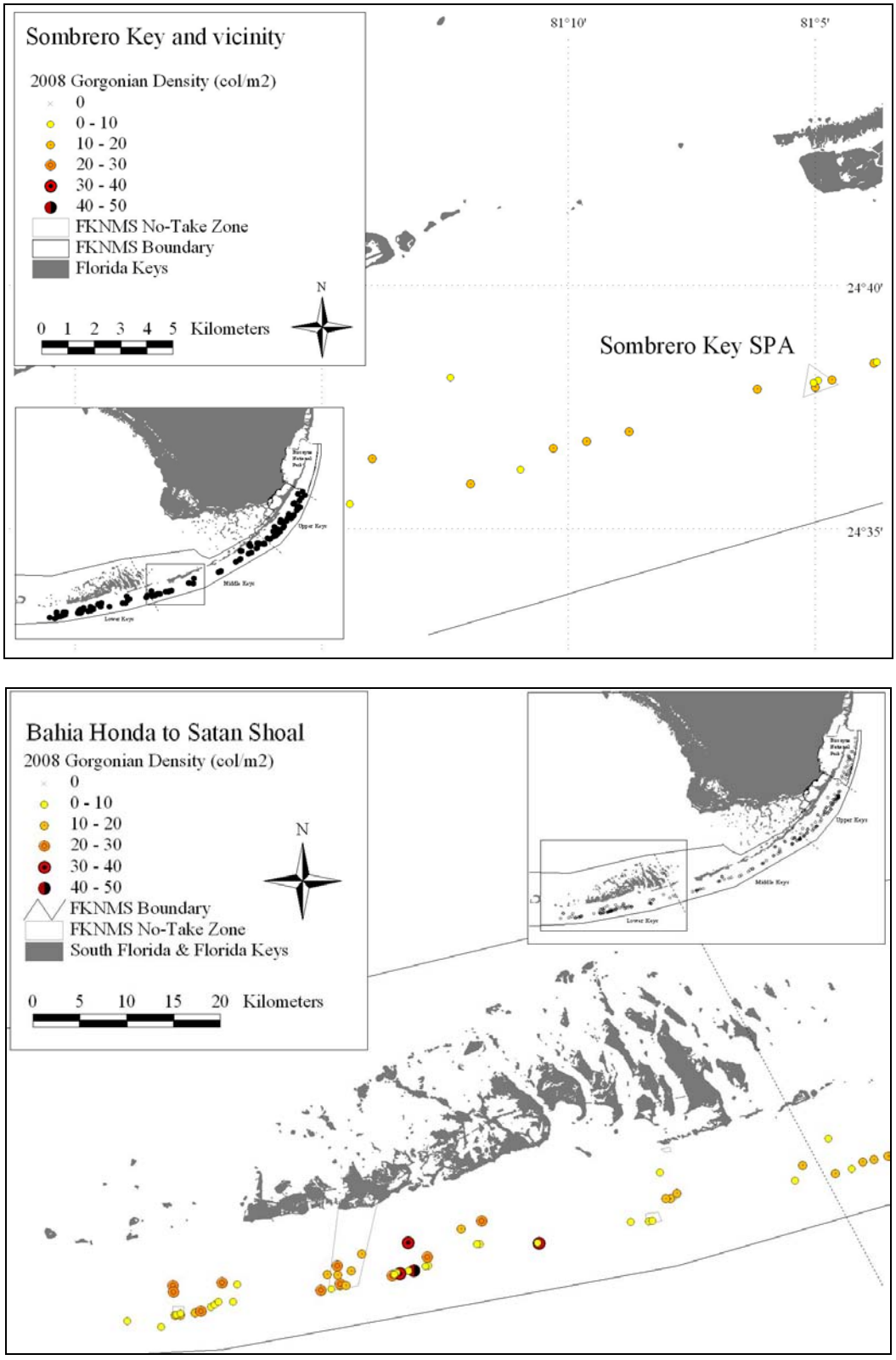


Figure 25. Total gorgonian densities (no. colonies per m^2) in the lower Florida Keys from Bahia Honda to Looe Key (top) and from Shoal to Western Sambo (bottom) during June-September 2008.

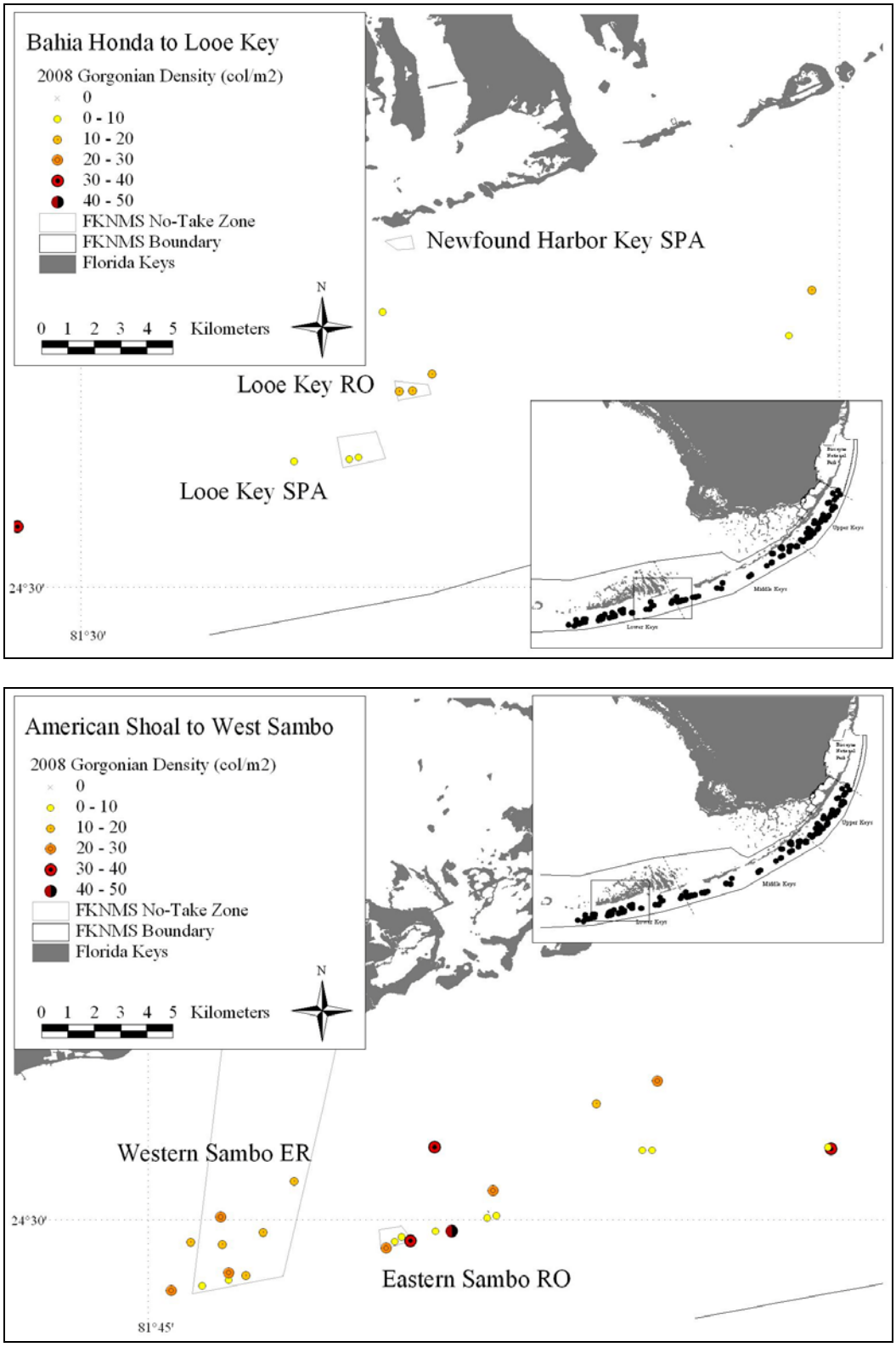


Figure 26. Total gorgonian densities (no. colonies per m^2) in the lower Florida Keys from Eastern Dry Rocks to Sand Key during June-September 2008.

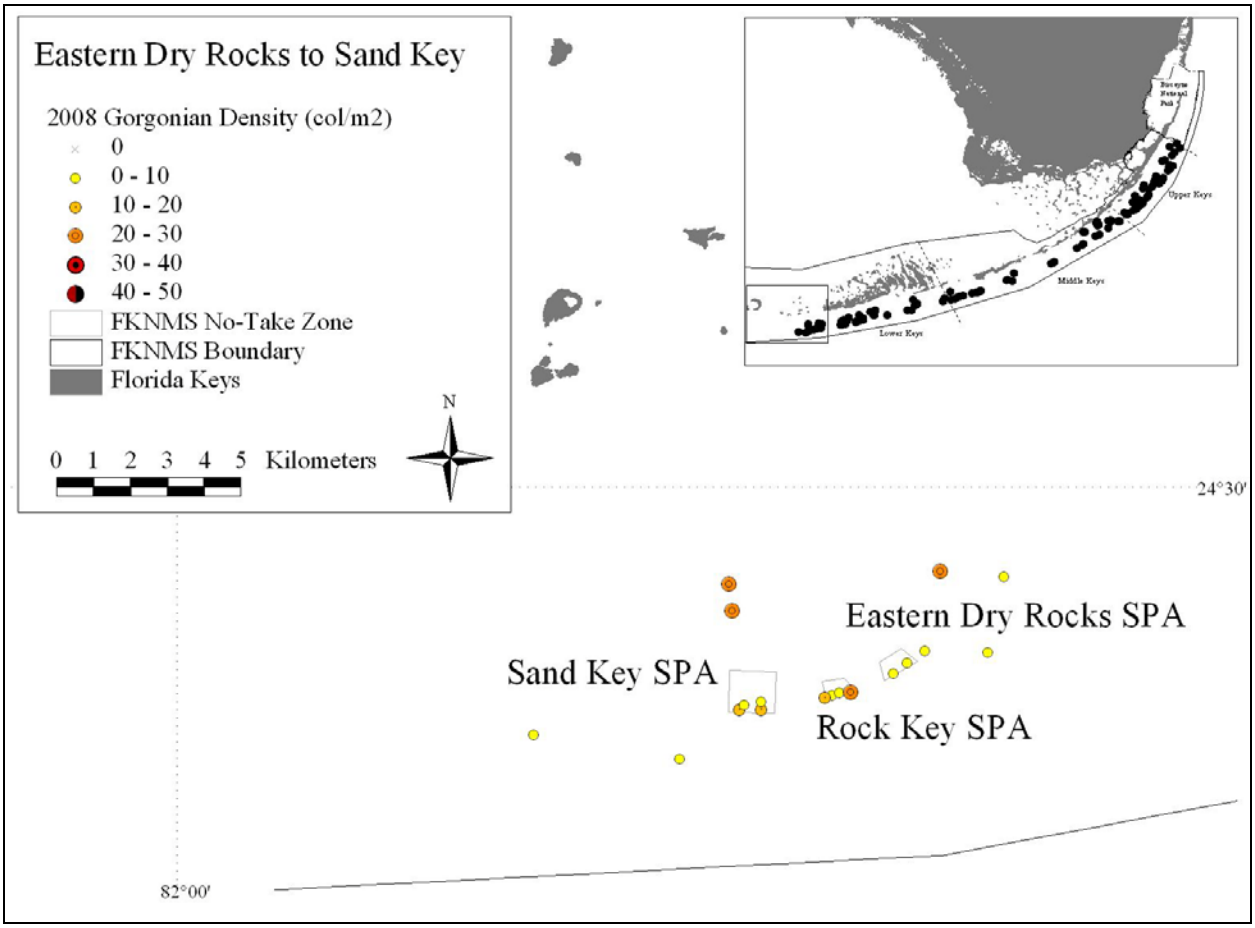


Table 6. Mean ± 1 SE densities (no. individuals per m^2) and total shell lengths (SL, cm) of flamingo-tongue snails (*Cyphoma gibbosum* and *C. signatum*) and total gorgonian in the Florida Keys National Marine Sanctuary, as determined from surveys of two 8-m x 1-m belt transects per site at 145 sites during June-September 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are Sanctuary Preservation Areas (SPA), Ecological Reserves (ER), or Research Only Areas (RO).

Site number/site location	***C. gibbosum***		***C. signatum***		**Total gorgonians**	
	No./m^2	SL (cm)	No./m^2	SL (cm)	N	No./m^2
Mid-channel patch reefs						
Upper Florida Keys NMS						
6 - Basin Hill Shoals	0 ± 0	0 ± 0	0 ± 0	0 ± 0	222	13.88 ± 3.00
5 - Basin Hill Shoals	0 ± 0	0 ± 0	0 ± 0	0 ± 0	224	14.00 ± 0.50
4 - Inshore of Grecian Rocks	0 ± 0	0 ± 0	0 ± 0	0 ± 0	282	17.63 ± 2.88
3 - South of Cannon Patch Reef	0 ± 0	0 ± 0	0 ± 0	0 ± 0	297	18.56 ± 7.06
2 - Mosquito Bank	0 ± 0	0 ± 0	0 ± 0	0 ± 0	151	9.44 ± 1.94
1 - Inshore of Molasses Reef	0 ± 0	0 ± 0	0 ± 0	0 ± 0	247	15.44 ± 9.56
Upper Florida Keys Total (6)	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1,423	14.82 ± 1.33
Middle Florida Keys NMS						
56 - Tavernier Rocks	0 ± 0	0 ± 0	0 ± 0	0 ± 0	20	1.25 ± 0.63
55 - Tavernier Rocks	0 ± 0	0 ± 0	0 ± 0	0 ± 0	8	0.50 ± 0.50
59 - Hen and Chickens SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	42	2.63 ± 0.63
58 - Hen and Chickens SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	76	4.75 ± 1.75
61 - Cheeca Rocks SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	9	0.56 ± 0.44
60 - Cheeca Rocks SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2	0.13 ± 0.00
57 - NE of Cheeca Rocks SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	16	1.00 ± 0.50
54 - South of Duck Key	0 ± 0	0 ± 0	0 ± 0	0 ± 0	175	10.94 ± 0.06
53 - South of Ohio Key	0 ± 0	0 ± 0	0 ± 0	0 ± 0	158	9.88 ± 0.88
Middle Florida Keys Total (9)	0 ± 0	0 ± 0	0 ± 0	0 ± 0	506	3.51 ± 1.39
Lower Florida Keys NMS						
103 - North of Looe Key RO	0 ± 0	0 ± 0	0 ± 0	0 ± 0	60	3.75 ± 2.63
102 - North of Maryland Shoal	0 ± 0	0 ± 0	0 ± 0	0 ± 0	445	27.81 ± 2.81
101 - North of Maryland Shoal	0.063 ± 0.063	2.1	0 ± 0	0 ± 0	236	14.75 ± 1.63
100 - North of Eastern Sambo	0 ± 0	0 ± 0	0 ± 0	0 ± 0	560	35.00 ± 5.38
105 - Western Sambo ER**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	245	15.31 ± 1.69
104 - Western Sambo ER**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	340	21.25 ± 7.13
99 - West of Western Sambo	0 ± 0	0 ± 0	0 ± 0	0 ± 0	196	12.25 ± 2.25
98 - Middle Ground	0.125 ± 0.125	2.7 ± 0.3	0 ± 0	0 ± 0	458	28.63 ± 10.63
97 - Middle Ground	0.063 ± 0.063	2.4	0 ± 0	0 ± 0	426	26.63 ± 8.25
Lower Florida Keys Total (9)	0.028 ± 0.026	2.4 ± 0.2	0 ± 0	0 ± 0	2,966	20.60 ± 3.28
Mid-channel Patch Reef (24)	**0.010 ± 0.006**	**2.4 ± 0.2**	**0 ± 0**	**0 ± 0**	**4,895**	**12.75 ± 2.09**
Offshore patch reefs						
Upper Florida Keys NMS						
12 - South of BNP boundary	0 ± 0	0 ± 0	0 ± 0	0 ± 0	739	46.19 ± 9.81
41 - North of Carysfort Reef	0 ± 0	0 ± 0	0 ± 0	0 ± 0	157	9.81 ± 0.19
11 - North of Carysfort Reef	0 ± 0	0 ± 0	0 ± 0	0 ± 0	148	9.25 ± 1.88
14 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	575	35.94 ± 8.31
13 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	458	28.63 ± 10.13
10 - North of Dry Rocks SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	143	8.94 ± 1.69
9 - SW of Grecian Rocks SPA	0.063 ± 0.063	3.0	0 ± 0	0 ± 0	158	9.88 ± 5.88
8 - Inshore of French Reef	0 ± 0	0 ± 0	0 ± 0	0 ± 0	387	24.19 ± 9.44
7 - Inshore of Pickles Reef	0 ± 0	0 ± 0	0 ± 0	0 ± 0	173	10.81 ± 1.19
Upper Florida Keys Total (9)	0.007 ± 0.007	3.0	0 ± 0	0 ± 0	2,938	20.40 ± 4.65
Middle Florida Keys NMS						
65 - North of Davis Reef SPA	0 ± 0	0 ± 0	0.063 ± 0.063	1.8	307	19.19 ± 2.94
64 - North of Davis Reef SPA	0.063 ± 0.063	2.7	0.063 ± 0.063	3.1	251	15.69 ± 4.81
63 - North of Davis Reef SPA	0.063 ± 0.063	2.4	0 ± 0	0 ± 0	388	24.25 ± 3.13
62 - North of Davis Reef SPA	0.188 ± 0.188	2.9 ± 0.2	0 ± 0	0 ± 0	607	37.94 ± 1.69
89 - Coffins Patch SPA**	0.188 ± 0.188	2.8 ± 0.1	0 ± 0	0 ± 0	189	11.81 ± 1.06
88 - Coffins Patch SPA**	0.125 ± 0.000	2.6 ± 0.2	0 ± 0	0 ± 0	237	14.81 ± 0.31

Site number/site location	*C. gibbosum*		*C. signatum*		Total gorgonians	
	No./m^2	SL (cm)	No./m^2	SL (cm)	N	No./m^2
Middle Florida Keys Total (6)	0.104 ± 0.031	2.7 ± 0.1	0.021 ± 0.013	2.5 ± 0.7	1,979	20.61 ± 3.88
Lower Florida Keys NMS						
109 - East of Looe Key RO	0 ± 0	0 ± 0	0 ± 0	0 ± 0	248	15.50 ± 2.13
110 - Looe Key RO**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	233	14.56 ± 2.94
111 - Looe Key RO**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	270	16.88 ± 4.63
107 - North of Pelican Shoal	0.313 ± 0.063	2.8 ± 0.2	0 ± 0	0 ± 0	351	21.94 ± 0.69
112 - Western Sambo ER**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	227	14.19 ± 3.31
113 - Western Sambo ER**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	215	13.44 ± 2.19
106 - NE of E. Dry Rocks SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	383	23.94 ± 5.31
133 - NE of E. Dry Rocks SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	119	7.44 ± 1.81
Lower Florida Keys Total (8)	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2,046	15.98 ± 1.82
Offshore Patch Reef Total (23)	**0.043 ± 0.017**	**2.8 ± 0.1**	**0.005 ± 0.004**	**2.5 ± 0.7**	**6,963**	**18.92 ± 2.13**
Inner line reef tract						
Upper Florida Keys NMS						
32 - Turtle Rocks	0 ± 0	0 ± 0	0 ± 0	0 ± 0	338	21.13 ± 3.25
31 - Inshore of Elbow Reef	0 ± 0	0 ± 0	0 ± 0	0 ± 0	295	18.44 ± 3.69
30 - North Dry Rocks	0 ± 0	0 ± 0	0 ± 0	0 ± 0	228	14.25 ± 9.00
34 - Dry Rocks SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	282	17.63 ± 5.25
33 - Dry Rocks SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	488	30.50 ± 4.75
36 - Grecian Rocks SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	282	17.63 ± 2.88
35 - Grecian Rocks SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	195	12.19 ± 5.44
Upper Florida Keys Total (7)	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2,108	18.82 ± 2.23
Inner Line Reef Total (7)	**0 ± 0**	**0 ± 0**	**0 ± 0**	**0 ± 0**	**2,108**	**18.82 ± 2.23**
High-relief spur & groove						
Upper Florida Keys NMS						
23 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	513	32.06 ± 9.69
22 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	439	27.44 ± 7.56
21 - Maitland grounding site	0 ± 0	0 ± 0	0 ± 0	0 ± 0	219	13.69 ± 6.94
24 - Elbow Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	251	15.69 ± 8.44
223 - Elbow Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	214	13.38 ± 6.25
19 - North of French Reef SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	417	26.06 ± 2.31
25 - French Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	38	2.38 ± 0.38
26 - French Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	148	9.25 ± 8.75
20 - Sand Island	0 ± 0	0 ± 0	0 ± 0	0 ± 0	138	8.63 ± 4.50
18 - Sand Island	0.063 ± 0.063	2.2	0 ± 0	0 ± 0	224	14.00 ± 0.88
28 - Molasses Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	204	12.75 ± 7.13
27 - Molasses Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	327	20.44 ± 2.31
17 - Pickles Reef	0.125 ± 0.125	2.8 ± 0.1	0 ± 0	0 ± 0	221	13.81 ± 5.81
16 - Pickles Reef	0.125 ± 0.125	2.7 ± 0.1	0 ± 0	0 ± 0	44	2.75 ± 0.75
15 - Pickles Reef	0.063 ± 0.063	2.8	0 ± 0	0 ± 0	246	15.38 ± 4.63
Upper Florida Keys Total (15)	0.025 ± 0.012	2.6 ± 0.1	0 ± 0	0 ± 0	3,643	15.18 ± 2.17
Middle Florida Keys NMS						
67 - Delta Shoal	0 ± 0	0 ± 0	0 ± 0	0 ± 0	108	6.75 ± 0.25
66 - Delta Shoal	0 ± 0	0 ± 0	0 ± 0	0 ± 0	282	17.63 ± 10.25
69 - Sombrero Key SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	89	5.56 ± 1.81
266 - Sombrero Key SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	73	4.56 ± 0.31
Middle Florida Keys Total (4)	0 ± 0	0 ± 0	0 ± 0	0 ± 0	552	8.63 ± 3.03
Lower Florida Keys NMS						
124 - Looe Key SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	87	5.44 ± 0.94
123 - Looe Key SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	100	6.25 ± 0.38
120 - American Shoal	0.125 ± 0.125	3.1 ± 0.2	0 ± 0	0 ± 0	112	7.00 ± 3.38
122 - American Shoal	0 ± 0	0 ± 0	0 ± 0	0 ± 0	502	31.38 ± 6.63
119 - Maryland Shoal	0.063 ± 0.063	3.2	0 ± 0	0 ± 0	19	1.19 ± 0.06
121 - Maryland Shoal	0.250 ± 0.250	2.6 ± 0.0	0 ± 0	0 ± 0	18	1.13 ± 0.63
118 - Pelican Shoal	0 ± 0	0 ± 0	0 ± 0	0 ± 0	55	3.44 ± 2.56
117 - Pelican Shoal	0 ± 0	0 ± 0	0 ± 0	0 ± 0	108	6.75 ± 0.00
116 - No Name Reef	0.250 ± 0.125	2.3 ± 0.3	0 ± 0	0 ± 0	68	4.25 ± 2.13

Site number/site location	*C. gibbosum*		*C. signatum*		Total gorgonians	
	No./m^2	SL (cm)	No./m^2	SL (cm)	N	No./m^2
322 - Eastern Sambo RO**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	104	6.50 ± 2.00
125 - Eastern Sambo RO**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	140	8.75 ± 0.88
127 - Western Sambo ER**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	230	14.38 ± 0.63
126 - Western Sambo ER**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	137	8.56 ± 0.81
115 - East of E. Dry Rocks	0 ± 0	0 ± 0	0 ± 0	0 ± 0	67	4.19 ± 0.44
129 - Eastern Dry Rocks SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	52	3.25 ± 2.00
128 - Eastern Dry Rocks SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	80	5.00 ± 0.25
327 - Rock Key SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	137	8.56 ± 1.19
130 - Rock Key SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	143	8.94 ± 7.31
131 - Sand Key SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	113	7.06 ± 3.06
328 - Sand Key SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	64	4.00 ± 0.25
114 - Western Dry Rocks	0.188 ± 0.188	2.5 ± 0.1	0 ± 0	0 ± 0	94	5.88 ± 1.00
Lower Florida Keys Total (21)	0.042 ± 0.018	2.7 ± 0.2	0 ± 0	0 ± 0	2,430	7.23 ± 1.37
Spur & Groove Total (40)	**0.031 ± 0.011**	**2.7 ± 0.1**	**0 ± 0**	**0 ± 0**	**6,625**	**10.35 ± 1.25**
Fore-reef (6-15 m)						
Upper Florida Keys NMS						
42 - South of BNP boundary	0 ± 0	0 ± 0	0 ± 0	0 ± 0	237	14.81 ± 3.81
52 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	243	15.19 ± 4.19
51 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	196	12.25 ± 0.75
50 - SW of Carysfort Reef SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	119	7.44 ± 0.69
40 - SW of Carysfort Reef SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	213	13.31 ± 1.81
39 - North of Elbow Reef SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	201	12.56 ± 0.81
245 - Elbow Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	237	14.81 ± 2.94
46 - Elbow Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	365	22.81 ± 5.19
38 - SW of Elbow Reef SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	119	7.44 ± 0.31
49 - South of Elbow Reef SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	161	10.06 ± 4.44
37 - Dixie Shoal	0 ± 0	0 ± 0	0 ± 0	0 ± 0	214	13.38 ± 4.13
48 - Dixie Shoal	0 ± 0	0 ± 0	0 ± 0	0 ± 0	348	21.75 ± 0.75
47 - SW of Molasses Reef SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	324	20.25 ± 6.75
Upper Florida Keys Total (13)	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2,977	14.31 ± 1.35
Middle Florida Keys NMS						
81 - Conch Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	119	7.44 ± 0.81
80 - Conch Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	101	6.31 ± 2.31
82 - Conch Reef RO**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	219	13.69 ± 3.06
279 - Conch Reef RO**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	218	13.63 ± 0.25
84 - Davis Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	199	12.44 ± 1.06
83 - Davis Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	192	12.00 ± 2.13
79 - SW of Crocker Reef	0 ± 0	0 ± 0	0 ± 0	0 ± 0	126	7.88 ± 1.38
78 - SW of Crocker Reef	0 ± 0	0 ± 0	0 ± 0	0 ± 0	215	13.44 ± 0.19
85 - Alligator Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	334	20.88 ± 2.75
68 - Alligator Reef SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	355	22.19 ± 1.81
77 - SW of Alligator Reef SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	202	12.63 ± 1.00
87 - Tennessee Reef RO**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	118	7.38 ± 1.25
86 - Tennessee Reef RO**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	159	9.94 ± 1.44
76 - NE of Tennessee Light	0 ± 0	0 ± 0	0 ± 0	0 ± 0	176	11.00 ± 1.88
75 - East of Coffins Patch SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	99	6.19 ± 1.69
293 - Sombrero Key SPA**	0.063 ± 0.063	0.4	0 ± 0	0 ± 0	223	13.94 ± 0.56
96 - Sombrero Key SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	286	17.88 ± 1.75
73 - West of Sombrero Key	0 ± 0	0 ± 0	0 ± 0	0 ± 0	260	16.25 ± 2.13
71 - South of Moser Channel	0 ± 0	0 ± 0	0 ± 0	0 ± 0	198	12.38 ± 3.38
72 - South of Moser Channel	0 ± 0	0 ± 0	0 ± 0	0 ± 0	231	14.44 ± 2.31
70 - South of Moser Channel	0 ± 0	0 ± 0	0 ± 0	0 ± 0	222	13.88 ± 3.63
90 - South of Moser Channel	0 ± 0	0 ± 0	0 ± 0	0 ± 0	110	6.88 ± 1.38
Middle Florida Keys Total (22)	0.003 ± 0.003	0.4	0 ± 0	0 ± 0	4,362	12.39 ± 0.94
Lower Florida Keys NMS						
136 - South of Bahia Honda Key	0 ± 0	0 ± 0	0 ± 0	0 ± 0	160	10.00 ± 2.25
138 - South of Bahia Honda Key	0 ± 0	0 ± 0	0 ± 0	0 ± 0	224	14.00 ± 2.13
137 - South of Bahia Honda Key	0 ± 0	0 ± 0	0 ± 0	0 ± 0	246	15.38 ± 1.00

Site number/site location	*C. gibbosum*		*C. signatum*		Total gorgonians	
	No./m^2	SL (cm)	No./m^2	SL (cm)	N	No./m^2
135 - West of Looe Key SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	140	8.75 ± 0.88
134 - West of Pelican Shoal	0 ± 0	0 ± 0	0 ± 0	0 ± 0	673	42.06 ± 7.06
139 - Eastern Sambo RO**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	544	34.00 ± 1.25
336 - Eastern Sambo RO**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	364	22.75 ± 3.88
141 - Western Sambo ER**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	327	20.44 ± 5.19
140 - Western Sambo ER**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	147	9.19 ± 9.19
143 - West of Western Sambo	0 ± 0	0 ± 0	0 ± 0	0 ± 0	454	28.38 ± 6.63
132 - East of E. Dry Rocks SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	159	9.94 ± 0.06
346 - Rock Key SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	457	28.56 ± 5.94
149 - Rock Key SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	266	16.63 ± 5.13
347 - Sand Key SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	292	18.25 ± 5.00
150 - Sand Key SPA**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	299	18.69 ± 0.06
142 - SW of Sand Key SPA	0 ± 0	0 ± 0	0 ± 0	0 ± 0	119	7.44 ± 1.06
Lower Florida Keys Total (16)	0 ± 0	0 ± 0	0 ± 0	0 ± 0	4,871	19.03 ± 2.50
Fore-reef Total (51)	**0.001 ± 0.001**	**0.4**	**0 ± 0**	**0 ± 0**	**12,210**	**14.96 ± 1.01**

Table 7. Size frequency distributions (top) and gorgonian host occupation patterns (bottom) of flamingo-tongue snails in the Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m belt transects per site at 145 sites during June-September 2008.

Shell Length Frequency

Total Shell Length (cm)	***Cyphoma gibbosum***		***C. signatum***	
	Frequency	% Total	Frequency	% Total
< 1.0	1	2.4	0	0
1-1.9	1	2.4	1	50.0
2-2.9	31	75.6	0	0
3-3.9	8	19.5	1	50.0
4-4.9	0	0	0	0
5-5.9	0	0	0	0
6-6.9	0	0	0	0
Total	**41**	**100.0**	**2**	**100.0**

Substratum Occupancy

Gorgonian host genera	***Cyphoma gibbosum***		***C. signatum***	
	Frequency	% Total	Frequency	% Total
Eunicea	9	22.0	0	0
Gorgonia	7	17.1	0	0
Muricea	1	2.4	0	0
Muriceopsis	1	2.4	0	0
Plexaura	12	29.3	0	0
Plexaurella	3	7.3	1	50.0
Pseudopterogorgia	8	19.5	1	50.0
Total	**41**	**100.0**	**2**	**100.0**

Table 8. Numbers of colonies (N), mean ± 1 SE colony densities (no. per m^2), and mean ± 1 SE colony heights for *Briareum asbestinum* and *Eunicea* gorgonians in the Florida Keys National Marine Sanctuary, as determined from surveys of two 8-m x 1-m transects per site at 145 locations during June-September 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are Sanctuary Preservation Areas (SPA), Ecological Reserves (ER), or Research Only Areas (RO).

Site number/site location	***Briareum asbestinum***			***Eunicea* spp.**		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
Mid-channel patch reefs						
Upper Florida Keys NMS						
6 - Basin Hill Shoals	2	0.13 ± 0.13	8.5 ± 2.5	12	0.75 ± 0.13	22.1 ± 6.0
5 - Basin Hill Shoals	2	0.13 ± 0.13	8.0 ± 1.0	4	0.25 ± 0.13	22.5 ± 4.6
4 - Inshore of Grecian Rocks SPA	2	0.13 ± 0.13	11.00 ± 1.0	8	0.50 ± 0.38	8.5 ± 1.5
3 - South of Cannon Patch Reef	6	0.38 ± 0.13	13.3 ± 3.1	35	2.19 ± 0.31	18.3 ± 2.7
2 - Mosquito Bank	0	0 ± 0	0 ± 0	2	0.13 ± 0.13	49.0 ± 3.0
1 - Inshore of Molasses Reef	4	0.25 ± 0.00	13.5 ± 3.2	11	0.69 ± 0.44	15.5 ± 3.6
Upper Florida Keys Total (6)	16	0.17 ± 0.05	10.9 ± 1.2	72	0.75 ± 0.30	22.7 ± 5.7
Middle Florida Keys NMS						
56 - Tavernier Rocks	0	0 ± 0	0 ± 0	6	0.38 ± 0.13	14.8 ± 2.7
55 - Tavernier Rocks	1	0.06 ± 0.06	30.0	4	0.25 ± 0.25	35.3 ± 12.0
59 - Hen and Chickens SPA**	4	0.25 ± 0	21.5 ± 10.4	1	0.06 ± 0.06	20.0
58 - Hen and Chickens SPA**	12	0.75 ± 0.25	14.6 ± 3.0	3	0.19 ± 0.06	24.0 ± 4.0
61 - Cheeca Rocks SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
60 - Cheeca Rocks SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
57 - NE of Cheeca Rocks SPA	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
54 - South of Duck Key	2	0.13 ± 0.13	13.0 ± 5.0	16	1.00 ± 0.13	20.9 ± 2.9
53 - South of Ohio Key	7	0.44 ± 0.31	13.4 ± 4.3	8	0.50 ± 0.25	20.3 ± 5.1
Middle Florida Keys Total (9)	26	0.18 ± 0.09	18.5 ± 3.3	38	0.26 ± 0.11	22.5 ± 2.8
Lower Florida Keys NMS						
103 - North of Looe Key RO	0	0 ± 0	0 ± 0	0.5	0.13 ± 0.13	2.5 ± 1.5
102 - North of Maryland Shoal	5	0.31 ± 0.06	13.8 ± 4.2	1.6	2.63 ± 1.13	16.9 ± 1.6
101 - North of Maryland Shoal	0	0 ± 0	0 ± 0	0.7	1.13 ± 0.00	8.1 ± 0.7
100 - North of Eastern Sambo RO	0	0 ± 0	0 ± 0	1.5	3.31 ± 1.06	13.3 ± 1.5
105 - Western Sambo ER**	0	0 ± 0	0 ± 0	8.8	0.38 ± 0.00	21.5 ± 8.8
104 - Western Sambo ER**	4	0.25 ± 0.13	19.3 ± 5.1	2.6	1.81 ± 0.81	22.3 ± 2.6
99 - West of Western Sambo ER	2	0.13 ± 0.13	13.0 ± 4.0	1.5	2.56 ± 1.69	16.5 ± 1.5
98 - Middle Ground	1	0.06 ± 0.06	25.0	1.6	3.81 ± 2.06	19.3 ± 1.6
97 - Middle Ground	0	0 ± 0	0 ± 0	2.0	2.31 ± 1.06	14.1 ± 2.0
Lower Florida Keys Total (9)	12	0.08 ± 0.04	17.8 ± 2.8	289	2.01 ± 0.42	14.9 ± 2.1
Mid-channel Patch Reef Total (24)	**54**	**0.14 ± 0.04**	**15.6 ± 1.7**	**399**	**1.04 ± 0.24**	**19.3 ± 2.1**
Offshore patch reefs						
Upper Florida Keys NMS						
12 - South of BNP boundary	0	0 ± 0	0 ± 0	28	1.75 ± 0.38	12.6 ± 2.0
41 - North of Carysfort Reef SPA	10	0.63 ± 0.63	10.6 ± 2.7	23	1.44 ± 0.31	19.8 ± 5.1
11 - North of Carysfort Reef SPA	1	0.06 ± 0.06	18.0	41	2.56 ± 1.06	16.4 ± 1.9
14 - Carysfort Reef SPA**	2	0.13 ± 0.13	6.5 ± 3.5	37	2.31 ± 1.81	16.7 ± 1.7
13 - Carysfort Reef SPA**	4	0.25 ± 0.25	6.0 ± 2.0	19	1.19 ± 0.19	16.9 ± 2.6
10 - North of Dry Rocks SPA	0	0 ± 0	0 ± 0	8	0.50 ± 0.00	20.3 ± 4.2
9 - SW of Grecian Rocks SPA	0	0 ± 0	0 ± 0	27	1.69 ± 1.69	14.2 ± 1.5
8 - Inshore of French Reef SPA	1	0.06 ± 0.06	12.0	32	2.00 ± 1.13	14.5 ± 1.7
7 - Inshore of Pickles Reef	0	0 ± 0	0 ± 0	16	1.00 ± 0.25	15.6 ± 3.3
Upper Florida Keys Total (9)	18	0.13 ± 0.07	10.6 ± 2.2	231	1.60 ± 0.22	16.3 ± 0.8
Middle Florida Keys NMS						
65 - North of Davis Reef SPA	0	0 ± 0	0 ± 0	2.0	3.06 ± 1.06	12.2 ± 2.0
64 - North of Davis Reef SPA	0	0 ± 0	0 ± 0	2.1	1.81 ± 0.56	10.2 ± 2.1
63 - North of Davis Reef SPA	0	0 ± 0	0 ± 0	1.2	6.44 ± 1.69	13.9 ± 1.2
62 - North of Davis Reef SPA	0	0 ± 0	0 ± 0	1.2	6.88 ± 0.50	14.7 ± 1.2
89 - Coffins Patch SPA**	0	0 ± 0	0 ± 0	1.6	1.88 ± 0.63	14.4 ± 1.6

Site number/site location	*Briareum asbestinum*			*Eunicea* spp.		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
88 - Coffins Patch SPA**	0	0 ± 0	0 ± 0	12	0.75 ± 0.13	22.3 ± 4.6
Middle Florida Keys Total (6)	0	0 ± 0	0 ± 0	333	3.47 ± 1.05	14.6 ± 1.7
Lower Florida Keys NMS						
109 - East of Looe Key RO	0	0 ± 0	0 ± 0	2.3	1.94 ± 0.44	15.8 ± 2.3
110 - Looe Key Research Only**	0	0 ± 0	0 ± 0	1.5	1.69 ± 1.31	12.0 ± 1.5
111 - Looe Key Research Only**	3	0.19 ± 0.19	9.0 ± 0.6	2.2	2.31 ± 0.69	15.7 ± 2.2
107 - North of Pelican Shoal	0	0 ± 0	0 ± 0	1.0	4.06 ± 0.31	9.8 ± 1.0
112 - Western Sambo ER**	6	0.38 ± 0.00	11.3 ± 2.9	1.4	3.00 ± 1.63	19.5 ± 1.4
113 - Western Sambo ER**	2	0.13 ± 0.00	20.5 ± 2.5	2.7	0.56 ± 0.56	13.4 ± 2.7
106 - NE of E. Dry Rocks SPA	5	0.31 ± 0.19	8.0 ± 1.5	1.0	7.06 ± 1.81	13.7 ± 1.0
133 - NE of E. Dry Rocks SPA	2	0.13 ± 0.00	19.0 ± 4.0	5.7	0.75 ± 0.38	29.0 ± 5.7
Lower Florida Keys Total (8)	18	0.14 ± 0.05	13.6 ± 2.6	342	2.67 ± 0.75	16.1 ± 2.1
Offshore Patch Reef Total (23)	**36**	**0.10 ± 0.03**	**12.1 ± 1.7**	**906**	**2.46 ± 0.40**	**15.8 ± 0.9**
Inner line reef tract spur & groove						
Upper Florida Keys NMS						
32 - Turtle Rocks	1	0.06 ± 0.06	1.0	1.4	3.38 ± 0.75	13.1 ± 1.4
31 - Inshore of Elbow Reef SPA	1	0.06 ± 0.06	21.0	1.6	2.19 ± 0.19	13.0 ± 1.6
30 - North Dry Rocks	0	0 ± 0	0 ± 0	5.6	0.75 ± 0.50	23.4 ± 5.6
34 - Dry Rocks SPA**	0	0 ± 0	0 ± 0	2.6	0.69 ± 0.56	14.2 ± 2.6
33 - Dry Rocks SPA**	0	0 ± 0	0 ± 0	2.5	0.88 ± 0.25	15.1 ± 2.5
36 - Grecian Rocks SPA**	1	0.06 ± 0.06	11.0	10.6	0.50 ± 0.25	15.9 ± 10.6
35 - Grecian Rocks SPA**	0	0 ± 0	0 ± 0	4.0	0.44 ± 0.19	16.9 ± 4.0
Upper Florida Keys Total (7)	3	0.03 ± 0.01	11.0 ± 5.8	141	1.26 ± 0.42	15.9 ± 1.4
Inner Line Spur & Groove Total (7)	**3**	**0.03 ± 0.01**	**11.0 ± 5.8**	**141**	**1.26 ± 0.42**	**15.9 ± 1.4**
High-relief spur & groove						
Upper Florida Keys NMS						
23 - Carysfort Reef SPA**	0	0 ± 0	0 ± 0	13	0.81 ± 0.06	12.5 ± 2.6
22 - Carysfort Reef SPA**	2	0.13 ± 0.13	12.0 ± 6.0	11	0.69 ± 0.06	18.9 ± 3.8
21 - Maitland grounding site	0	0 ± 0	0 ± 0	14	0.88 ± 0.25	14.9 ± 4.0
24 - Elbow Reef SPA**	0	0 ± 0	0 ± 0	5	0.31 ± 0.06	6.0 ± 1.8
223 - Elbow Reef SPA**	0	0 ± 0	0 ± 0	5	0.31 ± 0.06	8.2 ± 3.0
19 - North of French Reef SPA	0	0 ± 0	0 ± 0	27	1.69 ± 0.44	9.5 ± 1.1
25 - French Reef SPA**	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	8.0
26 - French Reef SPA**	3	0.19 ± 0.19	9.3 ± 3.3	0	0 ± 0	0 ± 0
20 - Sand Island	0	0 ± 0	0 ± 0	7	0.44 ± 0.19	12.4 ± 3.3
18 - Sand Island	0	0 ± 0	0 ± 0	5	0.31 ± 0.06	10.0 ± 1.8
28 - Molasses Reef SPA**	0	0 ± 0	0 ± 0	5	0.31 ± 0.31	14.2 ± 3.4
27 - Molasses Reef SPA**	0	0 ± 0	0 ± 0	3	0.19 ± 0.06	6.7 ± 1.2
17 - Pickles Reef	0	0 ± 0	0 ± 0	13	0.81 ± 0.44	8.8 ± 2.9
16 - Pickles Reef	0	0 ± 0	0 ± 0	5	0.31 ± 0.06	14.4 ± 3.0
15 - Pickles Reef	0	0 ± 0	0 ± 0	13	0.81 ± 0.19	14.1 ± 3.8
Upper Florida Keys Total (15)	5	0.02 ± 0.01	10.7 ± 1.3	127	0.53 ± 0.11	11.3 ± 1.0
Middle Florida Keys NMS						
67 - Delta Shoal	0	0 ± 0	0 ± 0	4	0.25 ± 0.00	10.5 ± 6.7
66 - Delta Shoal	0	0 ± 0	0 ± 0	47	2.94 ± 2.69	17.3 ± 1.5
69 - Sombrero Key SPA**	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	13.0
266 - Sombrero Key SPA**	0	0 ± 0	0 ± 0	2	0.13 ± 0.13	19.0 ± 11.0
Middle Florida Keys Total (4)	0	0 ± 0	0 ± 0	54	0.84 ± 0.70	14.9 ± 1.9
Lower Florida Keys NMS						
124 - Looe Key SPA**	4	0.25 ± 0.00	25.8 ± 8.3	4	0.25 ± 0.25	14.5 ± 5.9
123 - Looe Key SPA**	0	0 ± 0	0 ± 0	2	0.13 ± 0.00	4.5 ± 0
120 - American Shoal	0	0 ± 0	0 ± 0	6	0.38 ± 0.25	9.2 ± 2.0
122 - American Shoal	0	0 ± 0	0 ± 0	110	6.88 ± 2.00	12.4 ± 1.0
119 - Maryland Shoal	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	18.0
121 - Maryland Shoal	0	0 ± 0	0 ± 0	3	0.19 ± 0.06	11.0 ± 3.8
118 - Pelican Shoal	0	0 ± 0	0 ± 0	4	0.25 ± 0.13	12.5 ± 4.9
117 - Pelican Shoal	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	6.0

Site number/site location	*Briareum asbestinum*			*Eunicea* spp.		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
116 - No Name Reef	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	14.0
322 - Eastern Sambo RO**	0	0 ± 0	0 ± 0	3	0.19 ± 0.19	7.0 ± 0.6
125 - Eastern Sambo RO**	0	0 ± 0	0 ± 0	10	0.63 ± 0.13	9.7 ± 2.5
127 - Western Sambo ER**	0	0 ± 0	0 ± 0	16	1.00 ± 0.25	8.9 ± 1.5
126 - Western Sambo ER**	4	0.25 ± 0.25	9.5 ± 2.3	8	0.50 ± 0.38	13.0 ± 3.9
115 - East of E. Dry Rocks SPA	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
129 - Eastern Dry Rocks SPA**	0	0 ± 0	0 ± 0	3	0.19 ± 0.19	16.3 ± 3.4
128 - Eastern Dry Rocks**	0	0 ± 0	0 ± 0	9	0.56 ± 0.44	10.2 ± 2.2
327 - Rock Key SPA**	0	0 ± 0	0 ± 0	7	0.44 ± 0.44	11.9 ± 3.2
130 - Rock Key SPA**	0	0 ± 0	0 ± 0	15	0.94 ± 0.81	8.9 ± 1.1
131 - Sand Key SPA**	0	0 ± 0	0 ± 0	7	0.44 ± 0.19	7.9 ± 2.1
328 - Sand Key SPA**	0	0 ± 0	0 ± 0	2	0.13 ± 0.00	5.5 ± 0.5
114 - Western Dry Rocks	0	0 ± 0	0 ± 0	2	0.13 ± 0.13	16.0 ± 9.0
Lower Florida Keys Total (21)	8	0.02 ± 0.02	17.6 ± 8.1	214	0.64 ± 0.32	10.9 ± 0.8
High-relief Spur & Groove Total (40)	**11**	**0.02 ± 0.01**	**14.1 ± 3.9**	**395**	**0.62 ± 0.18**	**11.5 ± 0.6**
Fore-reef (6-15 m)						
Upper Florida Keys NMS						
42 - South of BNP boundary	0	0 ± 0	0 ± 0	56	3.50 ± 0.75	10.5 ± 0.8
52 - Carysfort Reef SPA**	4	0.25 ± 0.25	9.3 ± 3.6	30	1.88 ± 0.50	10.6 ± 0.8
51 - Carysfort Reef SPA**	10	0.63 ± 0.63	7.3 ± 2.3	1	0.06 ± 0.06	2.0
50 - SW of Carysfort Reef SPA	5	0.31 ± 0.31	13.6 ± 4.0	6	0.38 ± 0.13	19.2 ± 6.8
40 - SW of Carysfort Reef SPA	0	0 ± 0	13.3 ± 7.3	55	3.44 ± 0.69	21.1 ± 2.7
39 - North of Elbow Reef SPA	8	0.50 ± 0.50	8.6 ± 2.6	6	0.38 ± 0.00	11.5 ± 4.2
245 - Elbow Reef SPA**	0	0 ± 0	0 ± 0	5	0.31 ± 0.06	9.4 ± 1.9
46 - Elbow Reef SPA**	0	0 ± 0	0 ± 0	28	1.75 ± 0.00	8.0 ± 1.3
38 - SW of Elbow Reef SPA	0	0 ± 0	0 ± 0	16	1.00 ± 0.13	12.9 ± 3.2
49 - South of Elbow Reef SPA	0	0 ± 0	0 ± 0	12	0.75 ± 0.00	28.8 ± 5.5
37 - Dixie Shoal	2	0.13 ± 0.00	3.5 ± 1.5	14	0.88 ± 0.38	7.4 ± 1.1
48 - Dixie Shoal	16	1.00 ± 0.38	9.4 ± 1.4	31	1.94 ± 0.19	8.6 ± 0.9
47 - SW of Molasses Reef SPA	4	0.25 ± 0.25	13.8 ± 3.4	35	2.19 ± 1.19	6.0 ± 1.9
Upper Florida Keys Total (13)	49	0.24 ± 0.09	9.8 ± 1.3	295	1.42 ± 0.32	12.0 ± 2.0
Middle Florida Keys NMS						
81 - Conch Reef SPA**	1	0.06 ± 0.06	8.0	22	1.38 ± 0.25	9.2 ± 0.9
80 - Conch Reef SPA**	0	0 ± 0	0 ± 0	17	1.06 ± 0.56	11.1 ± 1.5
82 - Conch Reef RO**	11	0.69 ± 0.19	12.6 ± 3.7	7	0.44 ± 0.19	18.4 ± 8.9
279 - Conch Reef RO**	3	0.19 ± 0.06	12.0 ± 7.0	28	1.75 ± 0.88	11.2 ± 2.3
84 - Davis Reef SPA**	0	0 ± 0	0 ± 0	33	2.06 ± 1.44	7.0 ± 0.6
83 - Davis Reef SPA**	0	0 ± 0	0 ± 0	12	0.75 ± 0.25	8.0 ± 1.6
79 - SW of Crocker Reef	4	0.25 ± 0.13	5.8 ± 1.7	1	0.05 ± 0.06	2.0
78 - SW of Crocker Reef	0	0 ± 0	0 ± 0	14	0.88 ± 0.38	13.2 ± 4.6
85 - Alligator Reef SPA**	0	0 ± 0	0 ± 0	66	4.13 ± 0.50	13.7 ± 1.3
68 - Alligator Reef SPA**	0	0 ± 0	0 ± 0	66	4.13 ± 0.63	12.2 ± 1.1
77 - SW of Alligator Reef SPA	6	0.38 ± 0.13	7.5 ± 1.6	15	0.94 ± 0.44	9.6 ± 1.4
87 - Tennessee Reef RO**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
86 - Tennessee Reef RO**	0	0 ± 0	0 ± 0	6	0.38 ± 0.38	17.0 ± 7.0
76 - NE of Tennessee Light	0	0 ± 0	0 ± 0	12	0.75 ± 0.25	18.0 ± 3.6
75 - East of Coffins Patch SPA	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	12.0
293 - Sombrero Key SPA**	0	0 ± 0	0 ± 0	15	0.94 ± 0.19	10.9 ± 1.3
96 - Sombrero Key SPA**	0	0 ± 0	0 ± 0	25	1.56 ± 0.19	11.2 ± 1.2
73 - West of Sombrero Key SPA	0	0 ± 0	0 ± 0	16	1.00 ± 0.13	18.0 ± 2.7
71 - South of Moser Channel	0	0 ± 0	0 ± 0	13	0.81 ± 0.31	12.8 ± 3.2
72 - South of Moser Channel	0	0 ± 0	0 ± 0	13	0.81 ± 0.06	8.8 ± 1.5
70 - South of Moser Channel	0	0 ± 0	0 ± 0	11	0.69 ± 0.19	16.1 ± 3.4
90 - South of Moser Channel	0	0 ± 0	0 ± 0	8	0.50 ± 0.25	12.4 ± 6.0
Middle Florida Keys Total (22)	25	0.07 ± 0.04	9.2 ± 1.3	401	1.14 ± 0.23	12.0 ± 0.9
Lower Florida Keys NMS						
136 - South of Bahia Honda Key	0	0 ± 0	0 ± 0	9	0.56 ± 0.19	26.0 ± 6.1

Site number/site location	*Briareum asbestinum*			*Eunicea* spp.		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
138 - Looe Key SPA**	0	0 ± 0	0 ± 0	9	0.56 ± 0.19	26.0 ± 6.1
137 - Looe Key SPA**	0	0 ± 0	0 ± 0	30	1.88 ± 0.38	12.8 ± 1.9
135 - American Shoal	0	0 ± 0	0 ± 0	19	1.19 ± 0.31	11.4 ± 2.6
134 - American Shoal	3	0.19 ± 0.19	7.0 ± 1.0	22	1.38 ± 0.50	19.8 ± 4.1
139 - American Shoal	7	0.44 ± 0.19	8.4 ± 2.0	96	6.00 ± 1.13	9.7 ± 0.7
336 - American Shoal	10	0.63 ± 0.13	12.2 ± 2.2	83	5.19 ± 0.69	11.4 ± 1.4
141 - American Shoal	0	0 ± 0	0 ± 0	50	3.13 ± 0.25	11.6 ± 1.3
140 - East of Eastern Sambo RO	2	0.13 ± 0.13	7.5 ± 3.5	30	1.88 ± 0.63	8.4 ± 1.4
143 - Eastern Sambo RO**	1	0.06 ± 0.06	2.0	20	1.25 ± 1.25	14.8 ± 2.7
132 - Eastern Sambo RO**	0	0 ± 0	0 ± 0	52	3.25 ± 1.00	9.7 ± 0.8
346 - Middle Sambo Reef	0	0 ± 0	0 ± 0	17	1.06 ± 0.06	17.9 ± 4.5
149 - Middle Sambo Reef	2	0.13 ± 0.13	4.0 ± 1.0	58	3.63 ± 0.25	13.7 ± 1.7
347 - Western Sambo ER**	2	0.13 ± 0.13	14.0 ± 8.0	27	1.69 ± 0.81	11.9 ± 1.7
150 - Western Sambo ER**	4	0.25 ± 0.25	15.3 ± 4.1	18	1.13 ± 0.63	16.6 ± 2.6
142 - Western Sambo ER**	0	0 ± 0	0 ± 0	71	4.44 ± 0.31	13.8 ± 1.9
Lower Florida Keys Total (16)	31	0.12 ± 0.05	8.8 ± 1.7	612	2.39 ± 0.42	13.7 ± 1.1
Fore-reef Total (51)	**105**	**0.13 ± 0.03**	**9.3 ± 0.5**	**1,308**	**1.60 ± 0.20**	**12.6 ± 0.7**

Table 9. Numbers of colonies (N), mean ± 1 SE colony densities (no. per m^2), and mean ± 1 SE colony heights for *Gorgonia ventalina* and *Muricea* gorgonians in the Florida Keys National Marine Sanctuary, as determined from surveys of two 8-m x 1-m transects per site at 145 locations during June-September 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are Sanctuary Preservation Areas (SPA), Ecological Reserves (ER), or Research Only Areas (RO).

Site number/site location	***Gorgonia ventalina***			***Muricea* spp.**		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
Mid-channel patch reefs						
Upper Florida Keys NMS						
6 - Basin Hill Shoals	6	0.38 ± 0.00	14.8 ± 3.1	4	0.25 ± 0.13	5.0 ± 0.9
5 - Basin Hill Shoals	6	0.38 ± 0.13	32.8 ± 5.3	0	0 ± 0	0 ± 0
4 - Inshore of Grecian Rocks SPA	38	2.38 ± 0.63	22.8 ± 2.7	7	0.44 ± 0.06	12.0 ± 4.8
3 - South of Cannon Patch Reef	27	1.69 ± 1.69	14.1 ± 2.0	4	0.25 ± 0.25	10.8 ± 1.4
2 - Mosquito Bank	35	2.19 ± 0.69	28.7 ± 2.9	1	0.06 ± 0.06	23.0
1 - Inshore of Molasses Reef	19	1.29 ± 0.19	16.8 ± 1.9	9	0.56 ± 0.19	10.6 ± 1.6
Upper Florida Keys Total (6)	131	1.36 ± 0.36	21.7 ± 3.2	25	0.26 ± 0.09	12.3 ± 2.9
Middle Florida Keys NMS						
56 - Tavernier Rocks	0	0 ± 0	0 ± 0	4	0.25 ± 0.13	29.0 ± 12.0
55 - Tavernier Rocks	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
59 - Hen and Chickens SPA**	3	0.19 ± 0.06	37.3 ± 11.8	0	0 ± 0	0 ± 0
58 - Hen and Chickens SPA**	5	0.31 ± 0.19	40.0 ± 10.7	1	0.06 ± 0.06	27.0
61 - Cheeca Rocks SPA**	3	0.19 ± 0.19	34.7 ± 3.8	1	0.06 ± 0.06	10.0
60 - Cheeca Rocks SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
57 - NE of Cheeca Rocks SPA	5	0.31 ± 0.06	37.6 ± 3.7	0	0 ± 0	0 ± 0
54 - South of Duck Key	49	3.06 ± 0.19	39.5 ± 2.4	14	0.88 ± 0.63	21.3 ± 3.0
53 - South of Ohio Key	22	1.38 ± 0.13	45.3 ± 3.8	10	0.63 ± 0.00	29.3 ± 4.6
Middle Florida Keys Total (9)	87	0.60 ± 0.34	39.1 ± 1.5	30	0.21 ± 0.11	23.3 ± 3.6
Lower Florida Keys NMS						
103 - North of Looe Key RO	41	2.56 ± 1.56	19.5 ± 1.8	0.9	0.25 ± 0.25	3.3 ± 0.9
102 - North of Maryland Shoal	51	3.19 ± 1.56	30.6 ± 2.6	1.8	2.88 ± 1.13	22.9 ± 1.8
101 - North of Maryland Shoal	24	1.50 ± .63	8.0 ± 1.3	0.8	3.13 ± 0.88	12.3 ± 0.8
100 - North of Eastern Sambo RO	34	2.13 ± 0.13	12.8 ± 1.5	0.4	10.00 ± 2.75	13.4 ± 0.4
105 - Western Sambo ER**	17	1.06 ± 0.69	39.2 ± 4.7	1.8	2.44 ± 0.81	25.7 ± 1.8
104 - Western Sambo ER**	14	0.88 ± 0.00	27.4 ± 2.9	2.2	2.13 ± 1.00	22.6 ± 2.2
99 - West of Western Sambo ER	17	1.06 ± 0.06	22.0 ± 2.7	1.9	2.13 ± 0.75	13.5 ± 1.9
98 - Middle Ground	56	3.50 ± 1.63	23.1 ± 1.7	1.4	3.13 ± 1.25	18.3 ± 1.4
97 - Middle Ground	47	2.94 ± 0.56	23.5 ± 2.5	1.9	2.75 ± 0.25	15.5 ± 1.9
Lower Florida Keys Total (9)	301	2.09 ± 0.33	22.9 ± 3.1	461	3.20 ± 0.90	16.4 ± 2.3
Mid-channel Patch Reef Total (24)	**519**	**1.35 ± 0.24**	**27.2 ± 2.3**	**516**	**1.34 ± 0.45**	**17.1 ± 2.0**
Offshore patch reefs						
Upper Florida Keys NMS						
12 - South of BNP boundary	23	1.44 ± 0.56	18.1 ± 3.4	5	0.31 ± 0.06	12.7 ± 4.4
41 - North of Carysfort Reef SPA	6	0.38 ± 0.25	5.5 ± 0.8	2	0.13 ± 0.00	11.0 ± 5.0
11 - North of Carysfort Reef SPA	5	0.31 ± 0.19	4.8 ± 0.4	4	0.25 ± 0.00	16.5 ± 5.0
14 - Carysfort Reef SPA**	109	6.81 ± 1.31	24.8 ± 1.6	9	0.56 ± 0.31	16.7 ± 3.2
13 - Carysfort Reef SPA**	41	2.56 ± 1.56	20.2 ± 2.5	7	0.44 ± 0.19	7.7 ± 1.4
10 - North of Dry Rocks SPA	9	0.56 ± 0.06	7.4 ± 0.7	15	0.94 ± 0.19	17.5 ± 2.5
9 - SW of Grecian Rocks SPA	25	1.56 ± 0.31	19.4 ± 3.1	9	0.56 ± 0.19	14.8 ± 3.4
8 - Inshore of French Reef SPA	135	8.44 ± 1.19	27.8 ± 1.7	33	2.06 ± 1.19	14.9 ± 1.3
7 - Inshore of Pickles Reef	22	1.38 ± 0.00	6.9 ± 1.0	17	1.06 ± 0.31	20.6 ± 2.3
Upper Florida Keys Total (9)	375	2.60 ± 0.99	15.0 ± 3.0	101	0.70 ± 0.20	14.7 ± 1.3
Middle Florida Keys NMS						
65 - North of Davis Reef SPA	11	0.69 ± 0.31	3.5 ± 0.5	23	1.44 ± 0.19	11.9 ± 1.5
64 - North of Davis Reef SPA	44	2.75 ± 0.38	22.0 ± 1.8	8	0.50 ± 0.38	9.9 ± 3.1
63 - North of Davis Reef SPA	34	2.13 ± 0.25	17.1 ± 2.0	25	1.56 ± 0.69	13.2 ± 1.5
62 - North of Davis Reef SPA	21	1.31 ± 1.06	14.2 ± 2.2	56	3.50 ± 0.38	11.7 ± 1.0

Site number/site location	*Gorgonia ventalina*			*Muricea* spp.		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
88 - Coffins Patch SPA**	47	2.94 ± 0.19	32.2 ± 2.3	18	1.13 ± 0.38	16.7 ± 2.3
89 - Coffins Patch SPA**	39	2.44 ± 0.69	30.3 ± 2.2	25	1.56 ± 0.06	18.0 ± 1.9
Middle Florida Keys Total (6)	196	2.04 ± 0.36	19.9 ± 4.4	155	1.61 ± 0.41	13.6 ± 1.3
Lower Florida Keys NMS						
109 - East of Looe Key RO	48	3.00 ± 0.63	34.2 ± 2.6	29	1.81 ± 0.19	21.3 ± 1.8
110 - Looe Key Research Only**	20	1.25 ± 0.25	43.0 ± 4.6	17	1.06 ± 0.44	23.8 ± 2.6
111 - Looe Key Research Only**	45	2.81 ± 0.56	27.9 ± 2.6	27	1.69 ± 0.31	22.6 ± 2.0
107 - North of Pelican Shoal	18	1.13 ± 0.13	18.3 ± 3.9	75	4.69 ± 0.31	11.6 ± 1.0
112 - Western Sambo ER**	30	1.88 ± 0.25	35.2 ± 2.9	20	1.25 ± 0.88	25.6 ± 2.3
113 - Western Sambo ER**	3	0.19 ± 0.19	8.7 ± 2.3	55	3.44 ± 0.56	22.8 ± 1.8
106 - NE of E. Dry Rocks SPA	32	2.00 ± 0.00	19.3 ± 3.8	23	1.44 ± 0.19	18.3 ± 2.4
133 - NE of E. Dry Rocks SPA	10	0.63 ± 0.25	33.9 ± 5.7	16	1.00 ± 0.13	23.6 ± 3.5
Lower Florida Keys Total (8)	206	1.61 ± 0.35	27.6 ± 4.0	262	2.05 ± 0.47	21.2 ± 1.6
Offshore Patch Reef Total (23)	**777**	**2.11 ± 0.41**	**20.6 ± 2.3**	**518**	**1.41 ± 0.24**	**16.7 ± 1.1**
Inner line reef tract spur & groove						
Upper Florida Keys NMS						
32 - Turtle Rocks	24	1.50 ± 0.50	6.7 ± 0.9	7	0.44 ± 0.06	10.6 ± 3.0
31 - Inshore of Elbow Reef SPA	23	1.44 ± 0.81	4.7 ± 0.5	0	0 ± 0	0 ± 0
30 - North Dry Rocks	38	2.38 ± 0.75	22.2 ± 3.5	1	0.06 ± 0.06	14.0
34 - Dry Rocks SPA**	130	8.13 ± 0.00	17.5 ± 1.0	0	0 ± 0	0 ± 0
33 - Dry Rocks SPA**	216	13.5 ± 0.38	12.2 ± 0.7	2	0.13 ± 0.13	11.5 ± 0.5
36 - Grecian Rocks SPA**	87	5.44 ± 0.81	17.3 ± 15.9	4	0.25 ± 0.00	14.0 ± 6.0
35 - Grecian Rocks SPA**	97	6.06 ± 2.31	14.1 ± 1.6	1	0.06 ± 0.06	6.0
Upper Florida Keys Total (7)	615	5.49 ± 1.64	13.5 ± 2.4	15	0.13 ± 0.06	11.2 ± 1.5
Inner Line Spur & Groove Total (7)	**615**	**5.49 ± 1.64**	**13.5 ± 2.4**	**15**	**0.13 ± 0.06**	**11.2 ± 1.5**
High-relief spur & groove						
Upper Florida Keys NMS						
23 - Carysfort Reef SPA**	153	9.56 ± 1.44	20.4 ± 1.3	3	0.19 ± 0.19	13.0 ± 2.1
22 - Carysfort Reef SPA**	142	8.88 ± 2.63	18.0 ± 1.2	3	0.19 ± 0.06	27.0 ± 4.0
21 - Maitland grounding site	67	4.19 ± 1.56	19.7 ± 1.7	3	0.19 ± 0.19	29.0 ± 2.3
24 - Elbow Reef SPA**	88	5.50 ± 1.88	14.8 ± 1.2	4	0.25 ± 0.25	7.5 ± 0.9
223 - Elbow Reef SPA**	53	3.31 ± 0.81	22.4 ± 2.7	1	0.06 ± 0.06	7.0
19 - North of French Reef SPA	227	14.19 ± 0.94	20.2 ± 1.1	13	0.81 ± 0.19	12.5 ± 2.9
25 - French Reef SPA**	18	1.13 ± 0.00	11.1 ± 1.9	0	0 ± 0	0 ± 0
26 - French Reef SPA**	7	0.44 ± 0.31	5.7 ± 1.7	0	0 ± 0	0 ± 0
20 - Sand Island	35	2.19 ± 0.94	6.9 ± 0.9	1	0.06 ± 0.06	24.0
18 - Sand Island	74	4.63 ± 0.13	10.7 ± 1.2	2	0.13 ± 0.13	6.0 ± 0.0
28 - Molasses Reef SPA**	118	7.38 ± 4.63	27.5 ± 1.4	0	0 ± 0	0 ± 0
27 - Molasses Reef SPA**	56	3.50 ± 0.63	19.7 ± 2.2	0	0 ± 0	0 ± 0
17 - Pickles Reef	82	5.13 ± 0.88	11.1 ± 1.5	4	0.25 ± 0.00	13.3 ± 3.1
16 - Pickles Reef	24	1.50 ± 0.38	28.5 ± 3.9	0	0 ± 0	0 ± 0
15 - Pickles Reef	58	3.63 ± 2.75	4.0 ± 0.8	3	0.19 ± 0.19	13.7 ± 3.7
Upper Florida Keys Total (15)	1,202	5.01 ± 0.95	16.0 ± 2.0	37	0.15 ± 0.05	15.3 ± 2.7
Middle Florida Keys NMS						
67 - Delta Shoal	74	4.63 ± 0.13	14.7 ± 1.3	6	0.38 ± 0.13	17.5 ± 4.7
66 - Delta Shoal	39	2.44 ± 0.31	11.9 ± 1.9	27	1.69 ± 1.44	16.2 ± 1.5
69 - Sombrero Key SPA**	63	3.94 ± 1.19	17.2 ± 2.1	1	0.06 ± 0.06	21.0
266 - Sombrero Key SPA**	46	2.88 ± 0.38	25.7 ± 1.9	1	0.06 ± 0.06	15.0
Middle Florida Keys Total (4)	222	3.47 ± 0.50	17.4 ± 3.0	35	0.55 ± 0.39	17.4 ± 1.3
Lower Florida Keys NMS						
124 - Looe Key SPA**	15	0.94 ± 0.31	17.5 ± 2.9	0	0 ± 0	0 ± 0
123 - Looe Key SPA**	8	0.50 ± 0.13	7.0 ± 2.0	0	0 ± 0	0 ± 0
120 - American Shoal	66	4.13 ± 1.38	21.6 ± 2.2	11	0.69 ± 0.56	11.3 ± 2.1
122 - American Shoal	25	1.56 ± 0.69	9.4 ± 2.5	83	5.19 ± 0.44	13.8 ± 0.8
119 - Maryland Shoal	4	0.25 ± 0.25	15.0 ± 3.4	0	0 ± 0	0 ± 0
121 - Maryland Shoal	10	0.63 ± 0.63	23.3 ± 4.3	0	0 ± 0	0 ± 0

Site number/site location	*Gorgonia ventalina*			*Muricea* spp.		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
118 - Pelican Shoal	22	1.38 ± 0.88	170 ± 4.7	7	0.44 ± 0.19	11.9 ± 2.5
117 - Pelican Shoal	60	3.75 ± 0.25	13.6 ± 2.0	5	0.31 ± 0.19	14.4 ± 4.0
116 - No Name Reef	20	1.25 ± 0.25	14.7 ± 3.6	1	0.06 ± 0.06	30.0
322 - Eastern Sambo RO**	37	2.31 ± 0.44	10.5 ± 2.0	0	0 ± 0	0 ± 0
125 - Eastern Sambo RO**	52	3.25 ± 1.50	12.0 ± 1.5	7	0.44 ± 0.44	11.7 ± 2.3
127 - Western Sambo ER**	99	6.19 ± 2.19	10.2 ± 1.0	10	0.63 ± 0.13	9.3 ± 1.8
126 - Western Sambo ER**	51	3.19 ± 0.69	12.1 ± 1.4	4	0.25 ± 0.13	7.3 ± 1.1
115 - East of E. Dry Rocks SPA	27	1.69 ± 0.44	12.8 ± 2.8	0	0 ± 0	0 ± 0
129 - Eastern Dry Rocks SPA**	33	2.06 ± 1.31	13.6 ± 2.8	2	0.13 ± 0	25.5 ± 3.5
128 - Eastern Dry Rocks**	47	2.94 ± 0.56	9.8 ± 1.3	6	0.38 ± 0	8.5 ± 2.2
327 - Rock Key SPA**	75	4.69 ± 2.31	11.3 ± 1.3	1	0.06 ± 0.06	6.0
130 - Rock Key SPA**	81	5.06 ± 3.94	6.8 ± 0.8	1	0.06 ± 0.06	7.0
131 - Sand Key SPA**	60	3.75 ± 2.38	14.4 ± 1.7	4	0.25 ± 0.25	12.0 ± 7.0
328 - Sand Key SPA**	47	2.94 ± 0.19	14.7 ± 2.0	0	0 ± 0	0 ± 0
114 - Western Dry Rocks	33	2.06 ± 0.31	15.5 ± 2.1	0	0 ± 0	0 ± 0
Lower Florida Keys Total (21)	872	2.60 ± 0.35	13.5 ± 0.9	142	0.42 ± 0.24	13.0 ± 2.0
High-relief Spur & Groove Total (40)	**2,296**	**3.59 ± 0.44**	**14.8 ± 0.9**	**214**	**0.33 ± 0.13**	**14.5 ± 1.4**
Fore-reef (6-15 m)						
Upper Florida Keys NMS						
42 - South of BNP boundary	5	0.31 ± 0.06	3.8 ± 0.6	19	1.19 ± 0.56	17.9 ± 1.6
52 - Carysfort Reef SPA**	5	0.31 ± 0.19	5.0 ± 0.5	6	0.38 ± 0.25	9.2 ± 0.5
51 - Carysfort Reef SPA**	5	0.31 ± 0.06	9.8 ± 3.8	5	0.31 ± 0.06	12.2 ± 1.9
50 - SW of Carysfort Reef SPA	5	0.31 ± 0.06	7.8 ± 1.9	1	0.06 ± 0.06	13.0
40 - SW of Carysfort Reef SPA	1	0.06 ± 0.06	6.0	10	0.63 ± 0.38	14.4 ± 3.3
39 - North of Elbow Reef SPA	2	0.13 ± 0.00	9.0 ± 3.0	0	0 ± 0	0 ± 0
245 - Elbow Reef SPA**	21	1.31 ± 0.56	5.1 ± 0.5	0	0 ± 0	0 ± 0
46 - Elbow Reef SPA**	18	1.31 ± 0.25	4.3 ± 0.6	2	0.13 ± 0.13	11.0 ± 2.0
38 - SW of Elbow Reef SPA	6	0.38 ± 0.13	4.2 ± 0.5	10	0.63 ± 0.13	19.3 ± 2.6
49 - South of Elbow Reef SPA	3	0.19 ± 0.06	3.3 ± 0.7	1	0.06 ± 0.06	2.0
37 - Dixie Shoal	3	0.19 ± 0.19	2.3 ± 0.3	11	0.69 ± 0.44	6.5 ± 1.7
48 - Dixie Shoal	8	0.50 ± 0.13	4.6 ± 0.5	10	0.63 ± 0.00	7.7 ± 1.6
47 - SW of Molasses Reef SPA	16	1.00 ± 0.75	3.3 ± 0.2	5	0.31 ± 0.31	13.2 ± 3.0
Upper Florida Keys Total (13)	98	0.47 ± 0.11	5.3 ± 0.6	80	0.38 ± 0.10	11.5 ± 1.5
Middle Florida Keys NMS						
81 - Conch Reef SPA**	2	0.13 ± 0.13	4.0 ± 0.0	14	0.88 ± 0.50	20.6 ± 2.2
80 - Conch Reef SPA**	0	0 ± 0	0 ± 0	4	0.25 ± 0.13	23.5 ± 6.3
82 - Conch Reef RO**	3	0.19 ± 0.19	6.0 ± 2.0	1	0.06 ± 0.06	13.0
279 - Conch Reef RO**	7	0.44 ± 0.31	4.7 ± 0.4	4	0.25 ± 0.13	7.0 ± 1.8
84 - Davis Reef SPA**	3	0.19 ± 0.19	4.0 ± 0.6	8	0.50 ± 0.25	7.3 ± 1.6
83 - Davis Reef SPA**	4	0.25 ± 0.00	2.8 ± 0.5	8	0.50 ± 0.25	14.1 ± 2.7
79 - SW of Crocker Reef	26	1.63 ± 0.50	8.6 ± 1.7	1	0.06 ± 0.06	13.0
78 - SW of Crocker Reef	15	0.94 ± 0.19	4.7 ± 0.4	5	0.31 ± 0.06	11.4 ± 2.7
85 - Alligator Reef SPA**	6	0.38 ± 0.25	2.7 ± 0.2	51	3.19 ± 0.06	17.4 ± 1.1
68 - Alligator Reef SPA**	7	0.44 ± 0.19	3.4 ± 0.4	31	1.94 ± 0.69	10.8 ± 0.9
77 - SW of Alligator Reef SPA	19	1.19 ± 0.06	8.3 ± 2.4	3	0.19 ± 0.06	12.3 ± 3.4
87 - Tennessee Reef RO**	10	0.63 ± 0.25	12.3 ± 2.8	16	1.00 ± 0.25	18.8 ± 3.1
86 - Tennessee Reef RO**	30	1.88 ± 0.38	18.7 ± 3.0	19	1.19 ± 0.06	12.1 ± 1.8
76 - NE of Tennessee Light	18	1.13 ± 0.25	17.9 ± 3.7	12	0.75 ± 0.00	20.1 ± 3.5
75 - East of Coffins Patch SPA	1	0.06 ± 0.06	7.0	0	0 ± 0	0 ± 0
293 - Sombrero Key SPA**	13	0.81 ± 0.06	5.3 ± 1.2	14	0.88 ± 0.25	12.9 ± 1.3
96 - Sombrero Key SPA**	5	0.31 ± 0.06	4.2 ± 0.7	34	2.13 ± 0.13	18.2 ± 1.4
73 - West of Sombrero Key SPA	10	0.63 ± 0.00	7.5 ± 2.5	6	0.38 ± 0.00	17.3 ± 3.8
71 - South of Moser Channel	10	0.63 ± 0.38	7.6 ± 1.8	11	0.69 ± 0.56	14.3 ± 1.5
72 - South of Moser Channel	21	1.31 ± 0.94	4.7 ± 0.4	7	0.44 ± 0.19	12.9 ± 3.3
70 - South of Moser Channel	3	0.19 ± 0.06	11.7 ± 8.2	11	0.69 ± 0.19	13.7 ± 2.7
90 - South of Moser Channel	2	0.13 ± 0.00	3.0 ± 1.0	0	0 ± 0	0 ± 0
Middle Florida Keys Total (22)	215	0.61 ± 0.11	7.1 ± 1.0	260	0.74 ± 0.17	14.5 ± 1.0
Lower Florida Keys NMS						

Site number/site location	*Gorgonia ventalina*			*Muricea* spp.		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
136 - South of Bahia Honda Key	0	0 ± 0	0 ± 0	6	0.38 ± 0.25	17.3 ± 4.7
138 - Looe Key SPA**	13	0.81 ± 0.31	8.9 ± 1.9	29	1.81 ± 0.44	10.8 ± 1.4
137 - Looe Key SPA**	14	0.88 ± 0.50	7.2 ± 2.3	14	0.88 ± 0.25	11.8 ± 1.5
135 - American Shoal	12	0.75 ± 0.25	4.7 ± 0.5	15	0.94 ± 0.19	9.6 ± 1.2
134 - American Shoal	37	2.31 ± 0.56	3.6 ± 0.2	78	4.88 ± 0.38	10.7 ± 0.7
139 - American Shoal	46	2.88 ± 0.75	3.7 ± 0.3	74	4.63 ± 0.88	11.9 ± 0.7
336 - American Shoal	55	3.44 ± 0.69	4.5 ± 0.2	46	2.88 ± 0.75	9.3 ± 0.9
141 - American Shoal	13	0.81 ± 0.44	3.5 ± 0.7	39	2.44 ± 1.06	8.6 ± 0.8
140 - East of Eastern Sambo RO	4	0.25 ± 0.25	4.5 ± 0.3	14	0.88 ± 0.88	10.2 ± 1.2
143 - Eastern Sambo RO**	28	1.75 ± 0.50	3.3 ± 0.2	62	3.88 ± 0.50	11.1 ± 0.8
132 - Eastern Sambo RO**	10	0.63 ± 0.25	4.2 ± 0.8	11	0.69 ± 0.06	12.6 ± 1.3
346 - Middle Sambo Reef	29	1.81 ± 0.69	3.6 ± 0.4	43	2.69 ± 0.06	10.7 ± 0.9
149 - Middle Sambo Reef	36	2.25 ± 0.63	5.1 ± 0.4	26	1.63 ± 1.25	8.7 ± 0.6
347 - Western Sambo ER**	3	0.19 ± 0.06	5.0 ± 0.6	10	0.63 ± 0.38	8.7 ± 0.9
150 - Western Sambo ER**	18	1.13 ± 0.88	3.9 ± 0.4	25	1.56 ± 0.69	7.8 ± 0.8
142 - Western Sambo ER**	11	0.69 ± 0.06	7.6 ± 1.9	8	0.50 ± 0.38	13.3 ± 2.7
Lower Florida Keys Total (16)	329	1.29 ± 0.25	4.9 ± 0.4	500	1.95 ± 0.37	10.8 ± 0.6
Fore-reef Total (51)	**642**	**0.79 ± 0.11**	**5.9 ± 0.5**	**840**	**1.03 ± 0.16**	**12.6 ± 0.6**

Table 10. Numbers of colonies (N), mean ± 1 SE colony densities (no. per m^2), and mean ± 1 SE colony heights for *Muriceopsis flavida* and *Plexaura* gorgonians in the Florida Keys National Marine Sanctuary, as determined from surveys of two 8-m x 1-m transects per site at 145 locations during June-September 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are Sanctuary Preservation Areas (SPA), Ecological Reserves (ER), or Research Only Areas (RO).

Site number/site location	***Muriceopsis flavida***			***Plexaura* spp.**		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
Mid-channel patch reefs						
Upper Florida Keys NMS						
6 - Basin Hill Shoals	27	1.69 ± 0.19	31.3 ± 3.0	19	1.19 ± 0.56	22.1 ± 4.4
5 - Basin Hill Shoals	8	0.50 ± 0.00	37.3 ± 7.6	8	0.50 ± 0.00	18.0 ± 3.7
4 - Inshore of Grecian Rocks SPA	1	0.06 ± 0.06	20.0	62	3.88 ± 0.25	22.5 ± 1.9
3 - South of Cannon Patch Reef	1	0.06 ± 0.06	25.	45	2.81 ± 0.69	32.9 ± 3.1
2 - Mosquito Bank	0	0 ± 0	0 ± 0	58	3.63 ± 0.25	44.5 ± 2.7
1 - Inshore of Molasses Reef	23	1.44 ± 1.19	15.6 ± 1.9	9	0.56 ± 0.31	43.9 ± 9.9
Upper Florida Keys Total (6)	60	0.63 ± 0.31	25.8 ± 3.9	201	2.09 ± 0.63	30.7 ± 4.7
Middle Florida Keys NMS						
56 - Tavernier Rocks	0	0 ± 0	0 ± 0	3	0.19 ± 0.06	34.0 ± 11.5
55 - Tavernier Rocks	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
59 - Hen and Chickens SPA**	0	0 ± 0	0 ± 0	4	0.25 ± 0.00	27.5 ± 10.7
58 - Hen and Chickens SPA**	0	0 ± 0	0 ± 0	7	0.44 ± 0.06	42.1 ± 11.1
61 - Cheeca Rocks SPA**	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	67.0
60 - Cheeca Rocks SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
57 - NE of Cheeca Rocks SPA	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	55.0
54 - South of Duck Key	0.06	0.06 ± 0.06	26.0	12	0.75 ± 0.38	37.4 ± 6.4
53 - South of Ohio Key	0	0 ± 0	0 ± 0	15	0.94 ± 0.31	26.3 ± 5.6
Middle Florida Keys Total (9)	1	0.01 ± 0.01	26.0	43	0.30 ± 0.11	41.3 ± 5.6
Lower Florida Keys NMS						
103 - North of Looe Key RO	0	0 ± 0	0 ± 0	3	0.19 ± 0.06	8.3 ± 3.0
102 - North of Maryland Shoal	0	0 ± 0	0 ± 0	110	6.88 ± 0.00	31.1 ± 1.7
101 - North of Maryland Shoal	0	0 ± 0	0 ± 0	23	1.44 ± 0.06	13.5 ± 2.4
100 - North of Eastern Sambo RO	0	0 ± 0	0 ± 0	77	4.81 ± 0.69	18.2 ± 1.8
105 - Western Sambo ER**	1	0.06 ± 0.06	20.0	79	4.94 ± 0.06	31.9 ± 2.0
104 - Western Sambo ER**	15	0.94 ± 0.31	24.9 ± 2.5	98	6.13 ± 2.38	29.1 ± 1.6
99 - West of Western Sambo ER	4	0.25 ± 0.00	17.5 ± 10.9	41	2.56 ± 0.56	19.5 ± 2.2
98 - Middle Ground	6	0.38 ± 0.13	18.7 ± 3.3	85	5.31 ± 2.19	24.3 ± 1.7
97 - Middle Ground	8	0.50 ± 0.00	20.1 ± 3.3	83	5.19 ± 2.06	17.4 ± 1.4
Lower Florida Keys Total (9)	34	0.24 ± 0.11	20.2 ± 1.3	599	4.16 ± 0.75	21.5 ± 2.7
Mid-channel Patch Reef Total (24)	**95**	**0.25 ± 0.10**	**23.3 ± 2.4**	**843**	**2.20 ± 0.48**	**30.3 ± 3.0**
Offshore patch reefs						
Upper Florida Keys NMS						
12 - South of BNP boundary	9	0.56 ± 0.19	15.4 ± 4.3	24	1.50 ± 0.50	10.7 ± 1.5
41 - North of Carysfort Reef SPA	12	0.75 ± 0.13	25.5 ± 4.0	13	0.81 ± 0.19	23.7 ± 7.0
11 - North of Carysfort Reef SPA	3	0.19 ± 0.06	6.3 ± 1.9	25	1.56 ± 0.56	21.4 ± 3.0
14 - Carysfort Reef SPA**	12	0.75 ± 0.63	11.3 ± 1.2	20	1.25 ± 0.25	35.0 ± 5.3
13 - Carysfort Reef SPA**	19	1.19 ± 0.31	18.1 ± 3.7	8	0.50 ± 0.25	35.6 ± 7.4
10 - North of Dry Rocks SPA	5	0.31 ± 0.19	13.4 ± 7.3	6	0.38 ± 0.00	20.3 ± 5.9
9 - SW of Grecian Rocks SPA	9	0.56 ± 0.44	10.9 ± 2.8	16	1.00 ± 0.38	25.9 ± 4.5
8 - Inshore of French Reef SPA	34	2.13 ± 1.25	15.6 ± 1.7	29	1.81 ± 1.56	17.3 ± 2.4
7 - Inshore of Pickles Reef	3	0.19 ± 0.06	2.7 ± 0.3	10	0.63 ± 0.38	20.6 ± 5.5
Upper Florida Keys Total (9)	106	0.74 ± 0.20	13.2 ± 2.2	151	1.05 ± 0.17	23.4 ± 2.7
Middle Florida Keys NMS						
65 - North of Davis Reef SPA	14	0 ± 0	0 ± 0	6.6	0.88 ± 0.25	25.4 ± 6.6
64 - North of Davis Reef SPA	17	1.19 ± 0.31	14.8 ± 3.4	4.1	1.06 ± 0.69	28.5 ± 4.1
63 - North of Davis Reef SPA	28	1.06 ± 0.19	10.2 ± 1.5	3.3	1.75 ± 0.38	21.0 ± 3.3
62 - North of Davis Reef SPA	62	0.81 ± 0.06	8.0 ± 1.6	2.1	3.88 ± 1.88	16.7 ± 2.1
89 - Coffins Patch SPA**	17	0.06 ± 0.06	16.0	4.1	1.06 ± 0.44	21.6 ± 4.1

Site number/site location	*Muriceopsis flavida*			*Plexaura* spp.		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
88 - Coffins Patch SPA**	9	0.56 ± 0.06	18.3 ± 4.3	18	1.13 ± 0.38	19.9 ± 4.3
Middle Florida Keys Total (6)	59	0.61 ± 0.20	13.5 ± 1.9	156	1.63 ± 0.47	22.2 ± 1.7
Lower Florida Keys NMS						
109 - East of Looe Key RO	2	0.13 ± 0.13	5.5 ± 0.5	37	2.31 ± 0.06	25.2 ± 2.2
110 - Looe Key Research Only**	2	0.13 ± 0.00	24.0 ± 9.0	65	4.06 ± 0.56	29.2 ± 2.4
111 - Looe Key Research Only**	14	0.88 ± 0.13	21.0 ± 2.7	45	2.81 ± 0.56	23.0 ± 2.3
107 - North of Pelican Shoal	12	0.75 ± 0.50	14.3 ± 2.5	48	3.00 ± 1.38	11.8 ± 1.5
112 - Western Sambo ER**	4	0.25 ± 0.00	27.3 ± 5.5	48	3.00 ± 0.75	29.1 ± 2.1
113 - Western Sambo ER**	22	1.38 ± 0.00	18.1 ± 2.3	34	2.13 ± 0.13	22.4 ± 1.8
106 - NE of E. Dry Rocks SPA	6	0.38 ± 0.00	13.3 ± 3.9	78	4.88 ± 2.25	24.4 ± 1.9
133 - NE of E. Dry Rocks SPA	8	0.50 ± 0.38	32.6 ± 4.5	27	1.69 ± 0.19	25.0 ± 2.4
Lower Florida Keys Total (8)	70	0.55 ± 0.15	19.5 ± 3.0	382	2.98 ± 0.37	23.8 ± 1.9
Offshore Patch Reef Total (23)	**235**	**0.64 ± 0.11**	**15.6 ± 1.6**	**689**	**1.87 ± 0.25**	**23.2 ± 1.3**
Inner line reef tract spur & groove						
Upper Florida Keys NMS						
32 - Turtle Rocks	0	0 ± 0	0 ± 0	93	5.81 ± 1.56	20.1 ± 1.5
31 - Inshore of Elbow Reef SPA	11	0.69 ± 0.31	31.3 ± 5.4	17	1.06 ± 0.44	14.6 ± 2.9
30 - North Dry Rocks	10	0.63 ± 0.25	15.8 ± 2.9	12	0.75 ± 0.50	22.1 ± 4.5
34 - Dry Rocks SPA**	43	2.69 ± 1.69	11.7 ± 1.5	4	0 .25± 0.13	29.0 ± 12.2
33 - Dry Rocks SPA**	80	5.00 ± 1.00	12.2 ± 1.0	4	0.25 ± 0.00	27.8 ± 18.1
36 - Grecian Rocks SPA**	53	3.31 ± 0.69	8.7 ± 5.0	2	0.13 ± 0.13	17.5 ± 13.4
35 - Grecian Rocks SPA**	36	2.25 ± 1.75	9.1 ± 1.5	8	0.50 ± 0.25	29.8 ± 8.6
Upper Florida Keys Total (7)	233	2.08 ± 0.67	14.8 ± 3.5	140	1.25 ± 0.77	23.0 ± 2.3
Inner Line Spur & Groove Total (7)	**233**	**2.08 ± 0.67**	**14.8 ± 3.5**	**140**	**1.25 ± 0.77**	**23.0 ± 2.3**
High-relief spur & groove						
Upper Florida Keys NMS						
23 - Carysfort Reef SPA**	5	0.31 ± 0.31	15.6 ± 1.1	3	0.19 ± 0.06	20.7 ± 4.7
22 - Carysfort Reef SPA**	6	0.38 ± 0.13	16.2 ± 3.6	8	0.50 ± 0.25	34.1 ± 8.7
21 - Maitland grounding site	1	0.06 ± 0.06	33.0	4	0.25 ± 0.13	45.0 ± 9.4
24 - Elbow Reef SPA**	1	0.06 ± 0.06	16.0 ± 0	4	0.25 ± 0.25	23.8 ± 10.9
223 - Elbow Reef SPA**	3	0.19 ± 0.19	8.7 ± 1.8	0	0 ± 0	0 ± 0
19 - North of French Reef SPA	2	0.13 ± 0.13	23.0 ± 2.0	4	0.25 ± 0.13	30.5 ± 5.9
25 - French Reef SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
26 - French Reef SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
20 - Sand Island	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	3.0
18 - Sand Island	2	0.13 ± 0.00	10.0 ± 1.0	3	0.19 ± 0.06	19.7 ± 8.4
28 - Molasses Reef SPA**	0	0 ± 0	0 ± 0	5	0.31 ± 0.31	42.2 ± 10.2
27 - Molasses Reef SPA**	0	0 ± 0	0 ± 0	2	0.13 ± 0.00	27.0 ± 19.0
17 - Pickles Reef	1	0.06 ± 0.06	22.0	3	0.19 ± 0.19	17.0 ± 5.0
16 - Pickles Reef	0	0 ± 0	0 ± 0	7	0.44 ± 0.06	14.4 ± 6.1
15 - Pickles Reef	3	0.19 ± 0.19	16.0 ± 4.0	0	0 ± 0	0 ± 0
Upper Florida Keys Total (15)	24	0.10 ± 0.03	17.8 ± 2.5	44	0.18 ± 0.04	25.2 ± 3.7
Middle Florida Keys NMS						
67 - Delta Shoal	1	0.06 ± 0.06	12.0	1	0.06 ± 0.06	39.0
66 - Delta Shoal	8	0.50 ± 0.00	10.5 ± 4.0	4	0.25 ± 0.13	26.5 ± 8.0
69 - Sombrero Key SPA**	3	0.19 ± 0.19	2.7 ± 0.3	1	0.06 ± 0.06	35.0
266 - Sombrero Key SPA**	3	0.19 ± 0.19	8.3 ± 2.2	1	0.06 ± 0.06	7.0
Middle Florida Keys Total (4)	15	0.23 ± 0.09	8.4 ± 2.0	7	0.11 ± 0.05	26.9 ± 7.1
Lower Florida Keys NMS						
124 - Looe Key SPA**	0	0 ± 0	0 ± 0	7.4	0.31 ± 0.06	40.2 ± 7.4
123 - Looe Key SPA**	0	0 ± 0	0 ± 0	11.7	0.25 ± 0.00	57.3 ± 11.7
120 - American Shoal	0	0 ± 0	0 ± 0	9.1	0.25 ± 0.13	24.5 ± 9.1
122 - American Shoal	17	1.06 ± 0.06	15.6 ± 3.2	2.9	2.31 ± 0.06	20.3 ± 2.9
119 - Maryland Shoal	0	0 ± 0	0 ± 0	5.6	0.75 ± 0.25	27.7 ± 5.6
121 - Maryland Shoal	0	0 ± 0	0 ± 0	1.2	0.19 ± 0.06	22.3 ± 1.2
118 - Pelican Shoal	1	0.06 ± 0.06	2.0	0.5	0.13 ± 0.13	8.5 ± 0.5
117 - Pelican Shoal	1	0.06 ± 0.06	7.0	2.1	0.81 ± 0.44	10.3 ± 2.1

Site number/site location	*Muriceopsis flavida*			*Plexaura* spp.		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
116 - No Name Reef	0	0 ± 0	0 ± 0	5	0.31 ± 0.06	16.4 ± 5.9
322 - Eastern Sambo RO**	0	0 ± 0	0 ± 0	11	0.69 ± 0.06	18.8 ± 5.0
125 - Eastern Sambo RO**	2	0.13 ± 0.13	13.5 ± 4.5	4	0.25 ± 0.13	6.5 ± 2.3
127 - Western Sambo ER**	0	0 ± 0	0 ± 0	6	0.38 ± 0.25	5.8 ± 2.5
126 - Western Sambo ER**	0	0 ± 0	0 ± 0	4	0.25 ± 0.25	1.0 ± 0.0
115 - East of E. Dry Rocks SPA	0	0 ± 0	0 ± 0	4	0.25 ± 0.00	25.3 ± 13.8
129 - Eastern Dry Rocks SPA**	0	0 ± 0	0 ± 0	5	0.31 ± 0.06	11.4 ± 4.9
128 - Eastern Dry Rocks**	0	0 ± 0	0 ± 0	3	0.19 ± 0.19	1.7 ± 0.3
327 - Rock Key SPA**	0	0 ± 0	0 ± 0	10	0.63 ± 0.00	13.2 ± 4.3
130 - Rock Key SPA**	0	0 ± 0	0 ± 0	10	0.63 ± 0.25	11.2 ± 3.8
131 - Sand Key SPA**	0	0 ± 0	0 ± 0	6	0.38 ± 0.25	6.5 ± 2.1
328 - Sand Key SPA**	0	0 ± 0	0 ± 0	2	0.13 ± 0.13	16.5 ± 15.5
114 - Western Dry Rocks	0	0 ± 0	0 ± 0	2	0.13 ± 0.13	22.5 ± 19.5
Lower Florida Keys Total (21)	21	0.06 ± 0.05	9.5 ± 3.1	152	0.45 ± 0.10	17.5 ± 2.9
High-relief Spur & Groove Total (40)	**60**	**0.09 ± 0.03**	**13.7 ± 1.9**	**203**	**0.32 ± 0.06**	**20.9 ± 2.2**
Fore-reef (6-15 m)						
Upper Florida Keys NMS						
42 - South of BNP boundary	27	1.69 ± 1.19	27.1 ± 2.7	6	0.38 ± 0.25	29.0 ± 10.7
52 - Carysfort Reef SPA**	2	0.13 ± 0.13	11.5 ± 2.5	5	0.31 ± 0.31	14.4 ± 6.5
51 - Carysfort Reef SPA**	1	0.06 ± 0.06	4.0	0	0 ± 0	0 ± 0
50 - SW of Carysfort Reef SPA	0	0 ± 0	0 ± 0	2	0.13 ± 0.00	50.5 ± 7.5
40 - SW of Carysfort Reef SPA	33	2.06 ± 0.44	21.8 ± 2.0	13	0.81 ± 0.56	21.5 ± 2.4
39 - North of Elbow Reef SPA	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	2.0
245 - Elbow Reef SPA**	1	0.06 ± 0.06	4.0	1	0.06 ± 0.06	2.0
46 - Elbow Reef SPA**	4	0.25 ± 0.25	5.5 ± 0.9	6	0.38 ± 0.13	19.2 ± 8.4
38 - SW of Elbow Reef SPA	7	0.44 ± 0.06	23.1 ± 4.2	4	0 .25± 0.13	13.8 ± 6.6
49 - South of Elbow Reef SPA	1	0.06 ± 0.06	15.0	0	0 ± 0	0 ± 0
37 - Dixie Shoal	0	0 ± 0	0 ± 0	6	0.38 ± 0.00	18.2 ± 6.4
48 - Dixie Shoal	7	0.44 ± 0.31	5.1 ± 1.5	6	0.38 ± 0.13	9.2 ± 1.9
47 - SW of Molasses Reef SPA	0	0 ± 0	0 ± 0	3	0.19 ± 0.19	7.7 ± 2.0
Upper Florida Keys Total (13)	83	0.40 ± 0.19	13.0 ± 3.0	53	0.25 ± 0.06	17.0 ± 4.2
Middle Florida Keys NMS						
81 - Conch Reef SPA**	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	48.0
80 - Conch Reef SPA**	4	0.25 ± 0.25	22.0 ± 4.1	0	0 ± 0	0 ± 0
82 - Conch Reef RO**	0	0 ± 0	0 ± 0	2	0.13 ± 0.00	28.0 ± 6/0
279 - Conch Reef RO**	6	0.38 ± 0.13	20.0 ± 5.1	2	0.13 ± 0.13	5.5 ± 0.5
84 - Davis Reef SPA**	1	0.06 ± 0.06	5.0	2	0.13 ± 0.13	41.5 ± 40.5
83 - Davis Reef SPA**	4	0.25 ± 0.13	19.3 ± 15.3	0	0 ± 0	0 ± 0
79 - SW of Crocker Reef	1	0.06 ± 0.06	6.0	0	0 ± 0	0 ± 0
78 - SW of Crocker Reef	0	0 ± 0	0 ± 0	3	0.19 ± 0.06	21.3 ± 16.3
85 - Alligator Reef SPA**	6	0.38 ± 0.25	14.7 ± 4.7	6	0.38 ± 0.00	23.0 ± 4.6
68 - Alligator Reef SPA**	10	0.63 ± 0.00	14.0 ± 5.3	8	0.50 ± 0.38	17.4 ± 3.6
77 - SW of Alligator Reef SPA	3	0.19 ± 0.06	15.0 ± 6.2	2	0.13 ± 0.13	26.5 ± 4.5
87 - Tennessee Reef RO**	5	0.31 ± 0.06	28.2 ± 5.5	4	0.25 ± 0.13	24.5 ± 11.5
86 - Tennessee Reef RO**	12	0.75 ± 0.38	3.5 ± 0.6	3	0.19 ± 0.06	11.3 ± 3.8
76 - NE of Tennessee Light	3	0.19 ± 0.19	9.0 ± 1.7	3	0.19 ± 0.19	45.3 ± 3.5
75 - East of Coffins Patch SPA	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	23.0
293 - Sombrero Key SPA**	1	0.06 ± 0.06	13.0	7	0.44 ± 0.31	15.6 ± 5.1
96 - Sombrero Key SPA**	7	0.44 ± 0.31	22.3 ± 8.7	3	0.19 ± 0.06	9.0 ± 5.1
73 - West of Sombrero Key SPA	4	0.25 ± 0.25	31.5 ± 11.9	4	0.25 ± 0.25	28.0 ± 3.9
71 - South of Moser Channel	1	0.06 ± 0.06	3.0	6	0.38 ± 0.38	10.0 ± 3.4
72 - South of Moser Channel	0	0 ± 0	0 ± 0	5	0.31 ± 0.31	17.2 ± 6.9
70 - South of Moser Channel	3	0.19 ± 0.19	28.7 ± 4.4	6	0.38 ± 0.38	43.8 ± 13.7
90 - South of Moser Channel	0	0 ± 0	0 ± 0	4	0.25 ± 0.25	22.8 ± 10.3
Middle Florida Keys Total (22)	71	0.20 ± 0.05	15.9 ± 2.3	72	0.20 ± 0.03	24.3 ± 2.9
Lower Florida Keys NMS						
136 - South of Bahia Honda Key	1	0.06 ± 0.06	9.0	4	0.25 ± 0.13	19.0 ± 8.6

Site number/site location	*Muriceopsis flavida*			*Plexaura* spp.		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
138 - South of Bahia Honda Key	4	0.25 ± 0.25	18.5 ± 6.8	7.4	0.63 ± 0.13	36.9 ± 7.4
137 - South of Bahia Honda Key	10	0.63 ± 0.13	16.8 ± 3.4	1.6	0.31 ± 0.06	9.2 ± 1.6
135 - West of Looe Key SPA	2	0.13 ± 0.13	14.0 ± 2.0	4.2	0.63 ± 0.13	20.6 ± 4.2
134 - West of Pelican Shoal	6	0.38 ± 0.25	5.2 ± 1.2	1.7	3.25 ± 1.25	8.9 ± 1.7
139 - Eastern Sambo RO**	1	0.06 ± 0.06	9.0	1.5	2.44 ± 0.19	7.0 ± 1.5
336 - Eastern Sambo RO**	3	0.19 ± 0.06	5.0 ± 0.6	3.2	1.00 ± 0.38	8.1 ± 3.2
141 - Western Sambo ER**	0	0 ± 0	0 ± 0	4.8	0.63 ± 0.50	11.9 ± 4.8
140 - Western Sambo ER**	8	0.50 ± 0.50	16.9 ± 5.4	10.7	0.25 ± 0.25	20.3 ± 10.7
143 - West of Western Sambo	15	0.94 ± 0.44	16.0 ± 3.3	3.4	1.75 ± 0.25	12.9 ± 3.4
132 - East of E. Dry Rocks SPA	1	0.06 ± 0.06	42.0	2.9	0.88 ± 0.00	16.3 ± 2.9
346 - Rock Key SPA**	1	0.06 ± 0.06	6.0	2.7	1.63 ± 0.63	15.6 ± 2.7
149 - Rock Key SPA**	1	0.06 ± 0.06	4.0	4.0	0.13 ± 0.00	13.0 ± 4.0
347 - Sand Key SPA**	1	0.06 ± 0.06	3.0	2.4	0.75 ± 0.50	11.8 ± 2.4
150 - Sand Key SPA**	4	0.25 ± 0.00	6.8 ± 1.8	2.8	0.75 ± 0.63	10.3 ± 2.8
142 - SW of Sand Key SPA	1	0.06 ± 0.06	5.0	4.9	0.19 ± 0.06	14.3 ± 4.9
Lower Florida Keys Total (16)	59	0.23 ± 0.06	11.8 ± 2.6	247	0.96 ± 0.22	14.7 ± 1.8
Fore-reef Total (51)	**213**	**0.26 ± 0.06**	**13.7 ± 1.5**	**372**	**0.46 ± 0.09**	**19.2 ± 1.8**

Table 11. Numbers of colonies (N), mean ± 1 SE colony densities (no. per m^2), and mean ± 1 SE colony heights for *Plexaurella* and *Pseudoplexaura* gorgonians in the Florida Keys National Marine Sanctuary, as determined from surveys of two 8-m x 1-m transects per site at 145 locations during June-September 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are Sanctuary Preservation Areas (SPA), Ecological Reserves (ER), or Research Only Areas (RO).

Site number/site location	***Plexaurella* spp.**			***Pseudoplexaura* spp.**		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
Mid-channel patch reefs						
Upper Florida Keys NMS						
6 - Basin Hill Shoals	21	1.31 ± 0.06	18.6 ± 2.8	47	2.94 ± 0.94	18.0 ± 2.4
5 - Basin Hill Shoals	5	0.31 ± 0.19	29.6 ± 8.2	51	3.19 ± 0.31	38.0 ± 3.5
4 - Inshore of Grecian Rocks SPA	15	0.94 ± 0.19	44.5 ± 6.0	64	4.00 ± 0.63	34.8 ± 4.3
3 - South of Cannon Patch Reef	3	0.19 ± 0.06	12.3 ± 6.6	83	5.19 ± 2.44	21.5 ± 2.0
2 - Mosquito Bank	7	0.44 ± 0.06	40.4 ± 5.1	27	1.69 ± 0.19	33.9 ± 4.1
1 - Inshore of Molasses Reef	4	0.25 ± 0.25	18.0 ± 5.7	5	0.31 ± 0.31	8.2 ± 1.1
Upper Florida Keys Total (6)	55	0.57 ± 0.18	27.3 ± 5.4	277	2.89 ± 0.70	25.7 ± 4.8
Middle Florida Keys NMS						
56 - Tavernier Rocks	0	0 ± 0	0 ± 0	3	0.19 ± 0.19	34.0 ± 4.0
55 - Tavernier Rocks	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	111.0
59 - Hen and Chickens SPA**	0	0 ± 0	0 ± 0	12	0.75 ± 0.00	56.6 ± 10.4
58 - Hen and Chickens SPA**	0	0 ± 0	0 ± 0	18	1.13 ± 0.50	58.6 ± 9.7
61 - Cheeca Rocks SPA**	0	0 ± 0	0 ± 0	4	0.25 ± 0.25	75.0 ± 9.6
60 - Cheeca Rocks SPA**	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	14.0
57 - NE of Cheeca Rocks SPA	0	0 ± 0	0 ± 0	8	0.50 ± 0.25	62.1 ± 8.7
54 - South of Duck Key	10	0.63 ± 0.13	36.3 ± 6.6	17	1.06 ± 0.19	45.5 ± 7.1
53 - South of Ohio Key	2	0.13 ± 0.13	36.0 ± 7.0	31	1.94 ± 0.31	39.9 ± 4.3
Middle Florida Keys Total (9)	12	0.08 ± 0.07	36.2 ± 0.1	95	0.66 ± 0.21	55.2 ± 9.2
Lower Florida Keys NMS						
103 - North of Looe Key RO	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
102 - North of Maryland Shoal	6	0.38 ± 0.13	25.0 ± 6.3	106	6.63 ± 1.50	34.6 ± 2.4
101 - North of Maryland Shoal	1	0.06 ± 0.06	5.0 ± 0	8	0.50 ± 0.25	10.8 ± 2.2
100 - North of Eastern Sambo RO	9	0.56 ± 0.06	16.9 ± 2.6	36	2.25 ± 0.63	18.5 ± 2.4
105 - Western Sambo ER**	6	0.38 ± 0.25	25.7 ± 3.7	51	3.19 ± 0.81	54.1 ± 4.5
104 - Western Sambo ER**	13	0.81 ± 0.06	29.3 ± 3.9	76	4.75 ± 1.00	35.9 ± 2.4
99 - West of Western Sambo ER	1	0.06 ± 0.06	39.0 ± 0	34	2.13 ± 0.38	25.7 ± 3.0
98 - Middle Ground	16	1.00 ± 0.25	31.3 ± 5.5	75	4.69 ± 1.56	16.9 ± 0.8
97 - Middle Ground	5	0.31 ± 0.06	9.0 ± 2.3	52	3.25 ± 1.13	18.5 ± 2.1
Lower Florida Keys Total (9)	57	0.40 ± 0.12	22.6 ± 3.8	438	3.04 ± 0.70	26.9 ± 4.7
Mid-channel Patch Reef Total (24)	**124**	**0.32 ± 0.08**	**26.1 ± 3.2**	**810**	**2.11 ± 0.40**	**37.7 ± 5.2**
Offshore patch reefs						
Upper Florida Keys NMS						
12 - South of BNP boundary	2	0.13 ± 0.00	6.7 ± 1.0	15	0.94 ± 0.06	11.1 ± 2.4
41 - North of Carysfort Reef SPA	11	0.69 ± 0.06	20.4 ± 3.4	1	0.06 ± 0.06	14.0 ± 0
11 - North of Carysfort Reef SPA	3	0.19 ± 0.06	11.3 ± 8.8	13	0.81 ± 0.44	16.3 ± 4.2
14 - Carysfort Reef SPA**	1	0.06 ± 0.06	30.0 ± 0	0	0 ± 0	0 ± 0
13 - Carysfort Reef SPA**	3	0.19 ± 0.06	18.0 ± 3.6	1	0.06 ± 0.06	5.0 ± 0
10 - North of Dry Rocks SPA	22	1.38 ± 0.63	6.5 ± 0.9	0	0 ± 0	0 ± 0
9 - SW of Grecian Rocks SPA	6	0.38± 0.25	16.5 ± 4.3	9	0.56 ± 0.44	8.8 ± 1.4
8 - Inshore of French Reef SPA	1	0.06 ± 0.06	8.0 ± 0	8	0.50 ± 0.13	11.4 ± 2.4
7 - Inshore of Pickles Reef	31	1.94 ± 0.69	8.5 ± 1.0	4	0.25 ± 0.13	7.3 ± 1.3
Upper Florida Keys Total (9)	80	0.56 ± 0.22	14.0 ± 2.6	51	0.35 ± 0.12	10.5 ± 1.5
Middle Florida Keys NMS						
65 - North of Davis Reef SPA	15	0.94 ± 0.19	6.4 ± 1.8	13	0.81 ± 0.44	2.7 ± 0.6
64 - North of Davis Reef SPA	32	2.00 ± 1.25	10.1 ± 2.2	13	0.81 ± 0.44	8.4 ± 2.0
63 - North of Davis Reef SPA	80	05.0 ± 1.00	12.5 ± 1.0	12	0.75 ± 0.00	7.4 ± 1.1
62 - North of Davis Reef SPA	181	11.31 ± 0.06	9.0 ± 0.4	9	0.56 ± 0.06	8.0 ± 1.7
89 - Coffins Patch SPA**	10	0.63 ± 0.13	10.1 ± 2.1	9	0.56 ± 0.31	11.4 ± 2.1

Site number/site location	***Plexaurella* spp.**			***Pseudoplexaura* spp.**		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
88 - Coffins Patch SPA**	10	0.63 ± 0.25	18.5 ± 6.8	3	0.19 ± 0.06	17.0 ± 8.5
Middle Florida Keys Total (6)	328	3.42 ± 1.72	11.1 ± 1.7	59	0.61 ± 0.10	9.2 ± 1.9
Lower Florida Keys NMS						
109 - East of Looe Key RO	7	0.44 ± 0.19	28.1 ± 5.2	43	2.69 ± 0.19	40.0 ± 3.7
110 - Looe Key Research Only**	5	0.31 ± 0.06	33.0 ± 6.0	40	2.50 ± 1.13	47.5 ± 4.9
111 - Looe Key Research Only**	6	0.38 ± 0.25	28.2 ± 0	37	2.31 ± 0.19	29.9 ± 4.3
107 - North of Pelican Shoal	8	0.50 ± 0.00	7.9 ± 2.3	28	1.75 ± 0.25	18.1 ± 3.7
112 - Western Sambo ER**	4	0.25 ± 0.00	30.5 ± 8.0	26	1.63 ± 1.00	22.3 ± 2.8
113 - Western Sambo ER**	15	0.94 ± 0.44	25.5 ± 4.4	27	1.69 ± 1.06	27.6 ± 3.9
106 - NE of E. Dry Rocks SPA	7	0.44 ± 0.31	26.3 ± 5.2	59	3.69 ± 0.44	30.5 ± 2.9
133 - NE of E. Dry Rocks SPA	1	0.06 ± 0.06	48.0	20	1.25 ± 0.13	39.7 ± 6.6
Lower Florida Keys Total (8)	53	0.41 ± 0.09	28.4 ± 3.9	280	2.19 ± 0.28	32.0 ± 3.5
Offshore Patch Reef Total (23)	**461**	**1.25 ± 0.51**	**18.3 ± 2.3**	**390**	**1.06 ± 0.21**	**18.3 ± 2.8**
Inner line reef tract spur & groove						
Upper Florida Keys NMS						
32 - Turtle Rocks	11	0.69 ± 0.44	22.5 ± 6.3	57	3.56 ± 0.06	7.5 ± 0.6
31 - Inshore of Elbow Reef SPA	7	0.44 ± 0.31	21.9 ± 3.2	4	0.25 ± 0.25	6.5 ± 3.2
30 - North Dry Rocks	1	0.06 ± 0.06	27.0	1	0.06 ± 0.06	18.0
34 - Dry Rocks SPA**	1	0.06 ± 0.06	9.0	1	0.06 ± 0.06	3.0
33 - Dry Rocks SPA**	5	0.31 ± 0.06	11.6 ± 3.9	4	0.25 ± 0.25	5.8 ± 2.5
36 - Grecian Rocks SPA**	2	0.13 ± 0.00	15.0 ± 5.7	2	0.13 ± 0.00	11.5 ± 6.4
35 - Grecian Rocks SPA**	1	0.06 ± 0.06	13.0	2	0.13 ± 0.13	8.5 ± 4.5
Upper Florida Keys Total (7)	28	0.25 ± 0.09	17.1 ± 2.5	71	0.63 ± 0.49	8.7 ± 1.8
Inner Line Spur & Groove Total (7)	**28**	**0.25 ± 0.09**	**17.1 ± 2.5**	**71**	**0.63 ± 0.49**	**8.7 ± 1.8**
High-relief spur & groove						
Upper Florida Keys NMS						
23 - Carysfort Reef SPA**	1	0.06 ± 0.06	42.0	0	0 ± 0	0 ± 0
22 - Carysfort Reef SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
21 - Maitland grounding site	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	11.0
24 - Elbow Reef SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
223 - Elbow Reef SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
19 - North of French Reef SPA	1	0.06 ± 0.06	1.0	1	0.06 ± 0.06	3.0
25 - French Reef SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
26 - French Reef SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
20 - Sand Island	1	0.06 ± 0.06	6.0	1	0.06 ± 0.06	3.0
18 - Sand Island	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
28 - Molasses Reef SPA**	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	6.0
27 - Molasses Reef SPA**	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	14.0
17 - Pickles Reef	2	0.13 ± 0.00	12.0 ± 10.0	6	0.38 ± 0.13	21.2 ± 8.5
16 - Pickles Reef	1	0.06 ± 0.06	4.0	0	0 ± 0	0 ± 0
15 - Pickles Reef	0	0 ± 0	0 ± 0	8	0.50 ± 0.25	4.5 ± 1.4
Upper Florida Keys Total (15)	6	0.03 ± 0.01	13.0 ± 7.5	19	0.08 ± 0.04	9.0 ± 2.6
Middle Florida Keys NMS						
67 - Delta Shoal	0	0 ± 0	0 ± 0	3	0.19 ± 0.06	14.0 ± 3.0
66 - Delta Shoal	2	0.13 ± 0.13	4.5 ± 1.5	22	1.38 ± 0.88	8.6 ± 1.0
69 - Sombrero Key SPA**	1	0.06 ± 0.06	5.0	4	0.25 ± 0.00	20.3 ± 3.6
266 - Sombrero Key SPA**	0	0 ± 0	0 ± 0	3	0.19 ± 0.19	12.3 ± 0.3
Middle Florida Keys Total (4)	3	0.05 ± 0.03	4.8 ± 0.3	32	0.50 ± 0.29	13.8 ± 2.4
Lower Florida Keys NMS						
124 - Looe Key SPA**	0	0 ± 0	0 ± 0	8	0.50 ± 0.38	25.3 ± 3.9
123 - Looe Key SPA**	0	0 ± 0	0 ± 0	9	0.56 ± 0.31	25.1 ± 8.5
120 - American Shoal	1	0.06 ± 0.06	5.0	3	0.19 ± 0.06	31.0 ± 15.8
122 - American Shoal	33	2.06 ± 0.81	17.1 ± 2.5	39	2.44 ± 0.94	7.5 ± 0.9
119 - Maryland Shoal	0	0 ± 0	0 ± 0	2	0.13 ± 0.00	16.5 ± 0.5
121 - Maryland Shoal	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
118 - Pelican Shoal	3	0.19 ± 0.19	9.0 ± 2.9	3	0.19 ± 0.19	18.0 ± 4.6
117 - Pelican Shoal	0	0 ± 0	0 ± 0	8	0.19 ± 0.06	26.3 ± 15.9

Site number/site location	*Plexaurella* spp.			*Pseudoplexaura* spp.		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
116 - No Name Reef	0	0 ± 0	0 ± 0	7	0.44 ± 0.06	12.9 ± 3.4
322 - Eastern Sambo RO**	0	0 ± 0	0 ± 0	2	0.13 ± 0.00	44.0 ± 20.0
125 - Eastern Sambo RO**	0	0 ± 0	0 ± 0	5	0.31 ± 0.31	11.8 ± 4.8
127 - Western Sambo ER**	0	0 ± 0	0 ± 0	2	0.13 ± 0.13	7.5 ± 2.5
126 - Western Sambo ER**	1	0.06 ± 0.06	44.0	5	0.31 ± 0.06	11.8 ± 5.3
115 - East of E. Dry Rocks SPA	0	0 ± 0	0 ± 0	3	0.19 ± 0.19	7.0 ± 3.1
129 - Eastern Dry Rocks SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
128 - Eastern Dry Rocks**	1	0.06 ± 0.06	13.0	7	0.44 ± 0.44	12.7 ± 3.8
327 - Rock Key SPA**	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	8.0
130 - Rock Key SPA**	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	5.0
131 - Sand Key SPA**	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	26.0
328 - Sand Key SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
114 - Western Dry Rocks	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
Lower Florida Keys Total (21)	39	0.12 ± 0.10	17.6 ± 6.9	101	0.30 ± 0.11	17.4 ± 2.6
High-relief Spur & Groove Total (40)	**48**	**0.08 ± 0.05**	**13.6 ± 4.2**	**152**	**0.24 ± 0.07**	**14.8 ± 1.8**
Fore-reef (6-15 m)						
Upper Florida Keys NMS						
42 - South of BNP boundary	4	0.25 ± 0.00	24.5 ± 7.6	2	0.13 ± 0.13	6.5 ± 2.5
52 - Carysfort Reef SPA**	1	0.06 ± 0.06	3.0	0	0 ± 0	0 ± 0
51 - Carysfort Reef SPA**	4	0.25 ± 0.13	2.5 ± 0.6	0	0 ± 0	0 ± 0
50 - SW of Carysfort Reef SPA	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
40 - SW of Carysfort Reef SPA	17	1.06 ± 0.06	25.7 ± 4.0	1	0.06 ± 0.06	6.0 ± 0
39 - North of Elbow Reef SPA	4	0.25 ± 0.13	29.0 ± 0	3	0.19 ± 0.06	9.3 ± 1.2
245 - Elbow Reef SPA**	1	0.06 ± 0.06	57.0	0	0 ± 0	0 ± 0
46 - Elbow Reef SPA**	2	0.13 ± 0.00	5.5 ± 1.5	4	0.25 ± 0.13	4.0 ± 1.5
38 - SW of Elbow Reef SPA	22	1.38 ± 0.50	30.5 ± 4.2	0	0 ± 0	0 ± 0
49 - South of Elbow Reef SPA	0	0 ± 0	0 ± 0	4	0.25 ± 0.13	7.3 ± 1.0
37 - Dixie Shoal	4	0.25 ± 0.13	20.5 ± 8.6	3	0.19 ± 0.06	4.7 ± 1.5
48 - Dixie Shoal	10	0.63 ± 0.00	35.1 ± 6.1	3	0.19 ± 0.19	3.0 ± 1.0
47 - SW of Molasses Reef SPA	10	0.63 ± 0.38	19.2 ± 4.7	8	0.50 ± 0.00	4.4 ± 0.6
Upper Florida Keys Total (13)	79	0.38 ± 0.12	23.0 ± 4.8	28	0.13 ± 0.04	5.6 ± 0.7
Middle Florida Keys NMS						
81 - Conch Reef SPA**	10	0.63 ± 0.13	15.5 ± 4.6	3	0.19 ± 0.06	5.3 ± 0.7
80 - Conch Reef SPA**	9	0.56 ± 0.19	16.8 ± 4.3	2	0.13 ± 0.00	7.5 ± 1.5
82 - Conch Reef RO**	0	0 ± 0	0 ± 0	3	0.19 ± 0.19	5.0 ± 1.5
279 - Conch Reef RO**	4	0.25 ± 0.00	31.0 ± 6.2	1	0.06 ± 0.06	6.0
84 - Davis Reef SPA**	5	0.31 ± 0.06	34.6 ± 6.5	12	0.75 ± 0.13	4.8 ± 1.6
83 - Davis Reef SPA**	5	0.31 ± 0.06	25.8 ± 6.1	9	0.56 ± 0.06	3.6 ± 0.6
79 - SW of Crocker Reef	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
78 - SW of Crocker Reef	5	0.31 ± 0.06	25.8 ± 6.2	5	0.31 ± 0.19	4.6 ± 1.1
85 - Alligator Reef SPA**	17	1.06 ± 0.19	20.2 ± 5.2	14	0.88 ± 0.25	9.1 ± 1.0
68 - Alligator Reef SPA**	14	0.88 ± 0.38	42.1 ± 8.1	17	1.06 ± 0.06	7.9 ± 1.1
77 - SW of Alligator Reef SPA	6	0.38 ± 0.13	29.3 ± 5.7	0	0 ± 0	0 ± 0
87 - Tennessee Reef RO**	6	0.38 ± 0.13	23.3 ± 6.9	1	0.06 ± 0.06	1.0
86 - Tennessee Reef RO**	7	0.44 ± 0.06	31.4 ± 9.8	1	0.06 ± 0.06	4.0
76 - NE of Tennessee Light	7	0.44 ± 0.19	19.3 ± 7.5	1	0.06 ± 0.06	80.0
75 - East of Coffins Patch SPA	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
293 - Sombrero Key SPA**	3	0.19 ± 0.19	15.3 ± 5.4	6	0.38 ± 0.25	5.5 ± 1.0
96 - Sombrero Key SPA**	11	0.69 ± 0.44	12.0 ± 2.9	11	0.69 ± 0.31	8.5 ± 1.4
73 - West of Sombrero Key SPA	19	1.19 ± 0.06	26.5 ± 3.9	6	0.38 ± 0.13	8.8 ± 2.2
71 - South of Moser Channel	6	0.38 ± 0.13	9.8 ± 2.4	0	0 ± 0	0 ± 0
72 - South of Moser Channel	21	1.31 ± 0.44	12.5 ± 1.9	6	0.38 ± 0.25	5.3 ± 0.7
70 - South of Moser Channel	21	1.31 ± 0.19	17.4 ± 2.6	9	0.56 ± 0.31	8.4 ± 1.9
90 - South of Moser Channel	9	0.56 ± 0.31	37.4 ± 8.2	1	0.06 ± 0.06	5.0
Middle Florida Keys Total (22)	185	0.53 ± 0.09	23.5 ± 2.1	108	0.31 ± 0.07	10.0 ± 4.1
Lower Florida Keys NMS						
136 - South of Bahia Honda Key	3	0.19 ± 0.06	31.3 ± 10.2	9	0.56 ± 0.06	10.6 ± 4.9

Site number/site location	*Plexaurella* spp.			*Pseudoplexaura* spp.		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
138 - South of Bahia Honda Key	20	1.25 ± 0.50	39.5 ± 5.4	7	0.44 ± 0.19	13.3 ± 2.6
137 - South of Bahia Honda Key	5	0.31 ± 0.06	12.0 ± 4.6	9	0.56 ± 0.06	4.4 ± 0.5
135 - West of Looe Key SPA	4	0.25 ± 0.13	13.8 ± 4.2	6	0.38 ± 0.13	11.2 ± 4.0
134 - West of Pelican Shoal	22	1.38 ± 0.75	25.1 ± 4.3	41	2.56 ± 0.19	4.2 ± 0.3
139 - Eastern Sambo RO**	14	0.88 ± 0.38	18.9 ± 4.3	33	2.06 ± 0.31	6.0 ± 0.5
336 - Eastern Sambo RO**	3	0.19 ± 0.06	17.0 ± 4.9	7	0.44 ± 0.19	6.4 ± 1.1
141 - Western Sambo ER**	4	0.25 ± 0.25	34.5 ± 19.2	10	0.63 ± 0.25	6.2 ± 2.4
140 - Western Sambo ER**	3	0.19 ± 0.19	57.0 ± 5.0	3	0.19 ± 0.19	10.3 ± 2.0
143 - West of Western Sambo	3	0.19 ± 0.06	7.7 ± 0.9	24	1.50 ± 1.00	7.0 ± 1.9
132 - East of E. Dry Rocks SPA	2	0.13 ± 0.13	47.0 ± 18.0	2	0.13 ± 0.00	7.0 ± 3.0
346 - Rock Key SPA**	1	0.06 ± 0.06	11.0	6	0.38 ± 0.13	5.5 ± 1.0
149 - Rock Key SPA**	1	0.06 ± 0.06	2.0	7	0.44 ± 0.44	4.1 ± 0.6
347 - Sand Key SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
150 - Sand Key SPA**	6	0.38 ± 0.13	43.5 ± 9.6	7	0.44 ± 0.06	6.0 ± 0.5
142 - SW of Sand Key SPA	0	0 ± 0	0 ± 0	1	0.06 ± 0.06	11.0
Lower Florida Keys Total (16)	91	0.36 ± 0.11	25.7 ± 4.5	172	0.67 ± 0.18	7.6 ± 0.8
Fore-reef Total (51)	**355**	**0.44 ± 0.06**	**24.1 ± 2.0**	**308**	**0.38 ± 0.07**	**8.3 ± 1.8**

Table 12. Numbers of colonies (N), mean ± 1 SE colony densities (no. per m^2), and mean ± 1 SE colony heights for *Pseudopterogorgia* and *Pterogorgia* gorgonians in the Florida Keys National Marine Sanctuary, as determined from surveys of two 8-m x 1-m transects per site at 145 locations during June-September 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are Sanctuary Preservation Areas (SPA), Ecological Reserves (ER), or Research Only Areas (RO).

Site number/site location	***Pseudopterogorgia* spp.**			***Pterogorgia* spp.**		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
Mid-channel patch reefs						
Upper Florida Keys NMS						
6 - Basin Hill Shoals	1.9	5.19 ± 1.44	18.7 ± 1.9	1	0.06 ± 0.06	18.0
5 - Basin Hill Shoals	1.1	8.75 ± 0.50	19.7 ± 1.1	0	0 ± 0	0 ± 0
4 - Inshore of Grecian Rocks SPA	1.6	5.31 ± 1.44	22.5 ± 1.6	0	0 ± 0	0 ± 0
3 - South of Cannon Patch Reef	1.4	5.81 ± 2.56	17.8 ± 1.4	0	0 ± 0	0 ± 0
2 - Mosquito Bank	3.5	1.31 ± 1.31	22.4 ± 3.5	0	0 ± 0	0 ± 0
1 - Inshore of Molasses Reef	1.0	10.19 ± 7.06	16.1 ± 1.0	0	0 ± 0	0 ± 0
Upper Florida Keys Total (6)	585	6.09 ± 1.27	19.5 ± 1.0	1	0.01 ± 0.01	18.0
Middle Florida Keys NMS						
56 - Tavernier Rocks	3	0.19 ± 0.19	21.7 ± 9.4	1	0.06 ± 0.06	13.0
55 - Tavernier Rocks	2	0.13 ± 0.13	52.0 ± 37.0	0	0 ± 0	0 ± 0
59 - Hen and Chickens SPA**	18	1.13 ± 0.75	27.8 ± 3.6	0	0 ± 0	0 ± 0
58 - Hen and Chickens SPA**	30	1.88 ± 0.75	30.3 ± 2.6	0	0 ± 0	0 ± 0
61 - Cheeca Rocks SPA**	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
60 - Cheeca Rocks SPA**	1	0.06 ± 0.06	51.0	0	0 ± 0	0 ± 0
57 - NE of Cheeca Rocks SPA	2	0.13 ± 0.13	51.5 ± 1.5	0	0 ± 0	0 ± 0
54 - South of Duck Key	54	3.38 ± 0.13	31.7 ± 2.4	0	0 ± 0	0 ± 0
53 - South of Ohio Key	63	3.94 ± 0.31	32.2 ± 2.5	0	0 ± 0	0 ± 0
Middle Florida Keys Total (9)	173	1.20 ± 0.51	37.3 ± 4.3	1	0.01 ± 0.01	13.0
Lower Florida Keys NMS						
103 - North of Looe Key RO	9	0.56 ± 0.56	7.1 ± 1.5	3.0	0.06 ± 0.06	3.0
102 - North of Maryland Shoal	79	4.94 ± 0.56	35.6 ± 7.7		0 ± 0	0 ± 0
101 - North of Maryland Shoal	111	6.94 ± 1.69	15.1 ± 0.8	12.0	0.06 ± 0.06	12.0
100 - North of Eastern Sambo RO	191	11.94 ± 3.06	13.6 ± 0.8		0 ± 0	0 ± 0
105 - Western Sambo ER**	46	2.88 ± 0.75	38.5 ± 2.1		0 ± 0	0 ± 0
104 - Western Sambo ER**	57	3.56 ± 1.44	25.8 ± 1.9		0 ± 0	0 ± 0
99 - West of Western Sambo ER	22	1.38 ± 0.63	30.8 ± 4.0		0 ± 0	0 ± 0
98 - Middle Ground	107	6.69 ± 1.69	23.0 ± 1.4	10.0	0.06 ± 0.06	10.0
97 - Middle Ground	150	9.38 ± 3.63	22.5 ± 1.0		0 ± 0	0 ± 0
Lower Florida Keys Total (9)	772	5.36 ± 1.25	23.6 ± 3.5	3	0.02 ± 0.01	8.3 ± 2.4
Mid-channel Patch Reef Total (24)	**1,530**	**3.98 ± 0.74**	**27.3 ± 2.6**	**5**	**0.01 ± 0.01**	**11.2 ± 2.4**
Offshore patch reefs						
Upper Florida Keys NMS						
12 - South of BNP boundary	605	37.81 ± 9.31	13.1 ± 0.3	28	1.75 ± 0.88	10.4 ± 0.7
41 - North of Carysfort Reef SPA	79	4.94 ± 0.31	16.6 ± 1.2	0	0 ± 0	0 ± 0
11 - North of Carysfort Reef SPA	51	3.19 ± 0.06	25.7 ± 2.2	2	0.13 ± 0.13	10.5 ± 0.5
14 - Carysfort Reef SPA**	385	24.06 ± 4.06	13.9 ± 0.5	0	0 ± 0	0 ± 0
13 - Carysfort Reef SPA**	355	22.19 ± 7.81	13.3 ± 0.5	1	0.06 ± 0.06	4.0
10 - North of Dry Rocks SPA	53	3.31 ± 0.31	23.2 ± 2.0	25	1.56 ± 0.44	7.4 ± 0.6
9 - SW of Grecian Rocks SPA	53	3.31 ± 1.94	22.2 ± 2.3	4	0.25 ± 0.25	8.3 ± 2.1
8 - Inshore of French Reef SPA	108	6.75 ± 3.38	18.5 ± 1.4	6	0.38 ± 0.38	8.0 ± 1.0
7 - Inshore of Pickles Reef	67	4.19 ± 0.56	13.1 ± 1.1	3	0.19 ± 0.06	6.7 ± 1.2
Upper Florida Keys Total (9)	1,756	12.19 ± 4.22	17.7 ± 1.6	69	0.48 ± 0.23	7.9 ± 0.8
Middle Florida Keys NMS						
65 - North of Davis Reef SPA	182	11.38 ± 1.28	13.9 ± 0.8		0 ± 0	0 ± 0
64 - North of Davis Reef SPA	87	5.44 ± 1.31	16.5 ± 1.5	2.5	0.13 ± 0.13	17.5 ± 2.5
63 - North of Davis Reef SPA	85	5.31 ± 0.19	16.3 ± 1.3	1.7	0.25 ± 0.25	9.3 ± 1.7
62 - North of Davis Reef SPA	149	9.31 ± 0.44	17.4 ± 1.3	2.5	0.38 ± 0.00	9.0 ± 2.5
89 - Coffins Patch SPA**	55	3.44 ± 0.81	26.9 ± 2.3	0.5	0.13 ± 0.13	13.5 ± 0.5

Site number/site location	***Pseudopterogorgia* spp.**			***Pterogorgia* spp.**		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
88 - Coffins Patch SPA**	120	7.50 ± 0.50	22.7 ± 1.4	1	0.06 ± 0.06	10.0
Middle Florida Keys Total (6)	678	7.06 ± 1.19	18.9 ± 2.0	15	0.16 ± 0.06	11.9 ± 1.6
Lower Florida Keys NMS						
109 - East of Looe Key RO	48	3.00 ± 0.25	28.3 ± 2.2	3	0.19 ± 0.19	16.7 ± 4.1
110 - Looe Key Research Only**	57	3.56 ± 0.44	30.4 ± 2.6	0	0 ± 0	0 ± 0
111 - Looe Key Research Only**	56	3.50 ± 2.38	26.5 ± 2.3	0	0 ± 0	0 ± 0
107 - North of Pelican Shoal	86	5.38 ± 2.00	15.9 ± 1.3	11	0.69 ± 0.69	13.2 ± 2.4
112 - Western Sambo ER**	41	2.56 ± 0.81	28.7 ± 2.6	0	0 ± 0	0 ± 0
113 - Western Sambo ER**	48	3.00 ± 0.75	27.2 ± 2.5	0	0 ± 0	0 ± 0
106 - NE of E. Dry Rocks SPA	60	3.75 ± 1.50	27.8 ± 2.0	0	0 ± 0	0 ± 0
133 - NE of E. Dry Rocks SPA	23	1.44 ± 0.31	30.3 ± 2.5	0	0 ± 0	0 ± 0
Lower Florida Keys Total (8)	419	3.27 ± 0.40	26.9 ± 1.6	14	0.11 ± 0.09	14.9 ± 1.7
Offshore Patch Reef Total (23)	**2,853**	**7.75 ± 1.82**	**21.2 ± 1.3**	**98**	**0.27 ± 0.10**	**10.3 ± 1.0**
Inner line reef tract spur & groove						
Upper Florida Keys NMS						
32 - Turtle Rocks	91	5.69 ± 0.06	11.3 ± 0.9	0	0 ± 0	0 ± 0
31 - Inshore of Elbow Reef SPA	197	12.31 ± 2.31	16.8 ± 1.0	0	0 ± 0	0 ± 0
30 - North Dry Rocks	148	9.25 ± 6.63	21.2 ± 1.3	5	0.31 ± 0.31	6.6 ± 1.2
34 - Dry Rocks SPA**	92	5.75 ± 3.00	13.3 ± 0.9	0	0 ± 0	0 ± 0
33 - Dry Rocks SPA**	163	10.19 ± 3.19	11.5 ± 0.7	0	0 ± 0	0 ± 0
36 - Grecian Rocks SPA**	123	7.69 ± 1.69	15.2 ± 12.5	0	0 ± 0	0 ± 0
35 - Grecian Rocks SPA**	42	2.63 ± 0.75	16.8 ± 2.2	1	0.06 ± 0.06	11.0
Upper Florida Keys Total (7)	856	7.64 ± 1.23	15.2 ± 1.3	6	0.05 ± 0.04	8.8 ± 2.2
Inner Line Spur & Groove Total (7)	**856**	**7.64 ± 1.23**	**15.2 ± 1.3**	**6**	**0.05 ± 0.04**	**8.8 ± 2.2**
High-relief spur & groove						
Upper Florida Keys NMS						
23 - Carysfort Reef SPA**	335	20.94 ± 7.56	13.7 ± 0.5	0	0 ± 0	0 ± 0
22 - Carysfort Reef SPA**	267	16.69 ± 4.81	11.7 ± 0.5	0	0 ± 0	0 ± 0
21 - Maitland grounding site	118	7.38 ± 6.00	16.2 ± 1.0	11	0.69 ± 0.44	6.0 ± 0.7
24 - Elbow Reef SPA**	149	9.31 ± 5.94	12.3 ± 0.7	0	0 ± 0	0 ± 0
223 - Elbow Reef SPA**	152	9.50 ± 5.13	15.1 ± 0.8	0	0 ± 0	0 ± 0
19 - North of French Reef SPA	53	3.31 ± 0.69	13.0 ± 1.3	89	5.56 ± 2.19	6.7 ± 0.3
25 - French Reef SPA**	19	1.19 ± 0.31	16.5 ± 2.9	0	0 ± 0	0 ± 0
26 - French Reef SPA**	138	8.63 ± 8.25	13.1 ± 0.9	0	0 ± 0	0 ± 0
20 - Sand Island	77	4.81 ± 2.31	18.4 ± 1.4	15	0.94 ± 0.94	6.2 ± 1.3
18 - Sand Island	138	8.63 ± 1.00	19.7 ± 1.1	0	0 ± 0	0 ± 0
28 - Molasses Reef SPA**	75	4.69 ± 2.44	11.6 ± 0.9	0	0 ± 0	0 ± 0
27 - Molasses Reef SPA**	262	16.38 ± 1.88	12.8 ± 0.6	3	0.19 ± 0.19	5.0 ± 1.2
17 - Pickles Reef	51	3.19 ± 1.56	18.3 ± 2.1	59	3.69 ± 3.19	6.4 ± 0.4
16 - Pickles Reef	4	0.25 ± 0.25	18.0 ± 8.3	3	0.19 ± 0.19	4.0 ± 0.6
15 - Pickles Reef	139	8.69 ± 1.81	16.8 ± 1.0	22	1.38 ± 0.00	7.7 ± 0.8
Upper Florida Keys Total (15)	1,977	8.24 ± 1.53	15.1 ± 0.7	202	0.84 ± 0.42	6.0 ± 0.5
Middle Florida Keys NMS						
67 - Delta Shoal	19	1.19 ± 0.06	16.6 ± 2.2	0	0 ± 0	0 ± 0
66 - Delta Shoal	110	6.88 ± 3.25	19.3 ± 1.4	1.44	1.44 ± 1.44	9.7 ± 1.0
69 - Sombrero Key SPA**	15	0.94 ± 0.31	25.5 ± 4.3	0	0 ± 0	0 ± 0
266 - Sombrero Key SPA**	17	1.06 ± 0.56	18.2 ± 2.1	0	0 ± 0	0 ± 0
Middle Florida Keys Total (4)	161	2.52 ± 1.45	19.9 ± 1.9	23	0.36 ± 0.36	9.7
Lower Florida Keys NMS						
124 - Looe Key SPA**	51	3.19 ± 0.44	15.2 ± 1.6	0	0 ± 0	0 ± 0
123 - Looe Key SPA**	77	4.81 ± 0.06	14.3 ± 1.3	0	0 ± 0	0 ± 0
120 - American Shoal	21	1.31 ± 1.06	18.9 ± 2.6	0	0 ± 0	0 ± 0
122 - American Shoal	145	9.06 ± 1.94	14.0 ± 0.8	0.81	0.81 ± 0.19	8.5 ± 1.3
119 - Maryland Shoal	0	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0
121 - Maryland Shoal	2	0.13 ± 0.13	19.0 ± 10.0	0	0 ± 0	0 ± 0
118 - Pelican Shoal	12	0.75 ± 0.75	19.3 ± 2.5	0.06	0.06 ± 0.06	5.0
117 - Pelican Shoal	25	1.56 ± 0.44	15.5 ± 1.4	0	0 ± 0	0 ± 0

Site number/site location	***Pseudopterogorgia* spp.**			***Pterogorgia* spp.**		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
116 - No Name Reef	34	2.13 ± 1.75	19.3 ± 1.9	0	0 ± 0	0 ± 0
322 - Eastern Sambo RO**	51	3.19 ± 2.19	19.5 ± 1.7	0	0 ± 0	0 ± 0
125 - Eastern Sambo RO**	46	2.88 ± 0.38	18.2 ± 1.9	14	0.88 ± 0.88	8.8 ± 0.9
127 - Western Sambo ER**	95	5.94 ± 1.94	12.7 ± 0.9	2	0.13 ± 0.13	9.5 ± 5.5
126 - Western Sambo ER**	60	3.75 ± 0.50	16.0 ± 1.3	0	0 ± 0	0 ± 0
115 - East of E. Dry Rocks SPA	33	2.06 ± 0.19	22.9 ± 2.9	0	0 ± 0	0 ± 0
129 - Eastern Dry Rocks SPA**	9	0.56 ± 0.44	17.2 ± 3.6	0	0 ± 0	0 ± 0
128 - Eastern Dry Rocks**	7	0.44 ± 0.06	11.9 ± 1.3	0	0 ± 0	0 ± 0
327 - Rock Key SPA**	43	2.69 ± 0.69	18.0 ± 1.7	0	0 ± 0	0 ± 0
130 - Rock Key SPA**	22	1.38 ± 1.38	13.6 ± 0.9	13	0.81 ± 0.81	7.0 ± 0.8
131 - Sand Key SPA**	35	2.19 ± 0.06	16.3 ± 1.8	0	0 ± 0	0 ± 0
328 - Sand Key SPA**	13	0.81 ± 0.56	16.9 ± 2.0	0	0 ± 0	0 ± 0
114 - Western Dry Rocks	57	3.56 ± 1.06	13.5 ± 0.7	0	0 ± 0	0 ± 0
Lower Florida Keys Total (21)	838	2.49 ± 0.47	16.6 ± 0.6	43	0.13 ± 0.06	7.7 ± 0.8
High-relief Spur & Groove Total (40)	**2,976**	**4.65 ± 0.77**	**16.4 ± 0.5**	**268**	**0.42 ± 0.17**	**7.0 ± 0.5**
Fore-reef (6-15 m)						
Upper Florida Keys NMS						
42 - South of BNP boundary	91	5.69 ± 0.06	18.8 ± 1.3	27	1.69 ± 1.19	8.9 ± 0.7
52 - Carysfort Reef SPA**	188	11.75 ± 3.00	13.4 ± 0.6	2	0.13 ± 0.00	5.0 ± 0.0
51 - Carysfort Reef SPA**	169	10.56 ± 1.31	15.1 ± 0.7	1	0.06 ± 0.06	4.0
50 - SW of Carysfort Reef SPA	100	6.25 ± 1.00	22.8 ± 1.3	0	0 ± 0	0 ± 0
40 - SW of Carysfort Reef SPA	79	4.94 ± 1.44	18.5 ± 1.2	0	0 ± 0	0 ± 0
39 - North of Elbow Reef SPA	132	8.25 ± 0.25	13.1 ± 0.7	45	2.81 ± 0.81	6.9 ± 0.4
245 - Elbow Reef SPA**	204	12.75 ± 2.25	10.0 ± 0.6	4	0.25 ± 0.13	8.3 ± 1.8
46 - Elbow Reef SPA**	296	18.50 ± 4.88	11.1 ± 0.5	5	0.31 ± 0.31	5.8 ± 0.9
38 - SW of Elbow Reef SPA	43	2.69 ± 0.19	18.8 ± 2.0	11	0.69 ± 0.19	42.1 ± 4.9
49 - South of Elbow Reef SPA	140	8.75 ± 4.38	11.7 ± 0.7	0	0 ± 0	0 ± 0
37 - Dixie Shoal	171	10.69 ± 3.06	13.7 ± 0.7	0	0 ± 0	0 ± 0
48 - Dixie Shoal	256	16.00 ± 0.63	11.5 ± 0.5	1	0.06 ± 0.06	9.0
47 - SW of Molasses Reef SPA	243	15.19 ± 3.69	12.3 ± 0.6	0	0 ± 0	0 ± 0
Upper Florida Keys Total (13)	2,112	10.15 ± 1.30	14.7 ± 1.1	96	0.46 ± 0.24	11.2 ± 4.5
Middle Florida Keys NMS						
81 - Conch Reef SPA**	66	4.13 ± 0.38	17.4 ± 1.6	0	0 ± 0	0 ± 0
80 - Conch Reef SPA**	38	2.38 ± 1.38	18.8 ± 2.1	27	1.69 ± 0.31	13.6 ± 3.6
82 - Conch Reef RO**	192	12.00 ± 3.13	15.0 ± 1.0	0	0 ± 0	0 ± 0
279 - Conch Reef RO**	152	9.50 ± 0.88	15.5 ± 0.9	11	0.69 ± 0.44	6.5 ± 0.5
84 - Davis Reef SPA**	135	8.44 ± 0.06	14.6 ± 1.1	0	0 ± 0	0 ± 0
83 - Davis Reef SPA**	150	9.38 ± 2.25	16.5 ± 1.5	0	0 ± 0	0 ± 0
79 - SW of Crocker Reef	93	5.81 ± 1.19	19.2 ± 1.4	0	0 ± 0	0 ± 0
78 - SW of Crocker Reef	166	10.38 ± 0.63	15.4 ± 0.9	2	0.13 ± 0.13	5.5 ± 2.5
85 - Alligator Reef SPA**	157	9.81 ± 1.56	17.6 ± 1.0	11	0.69 ± 0.19	9.7 ± 2.9
68 - Alligator Reef SPA**	202	12.63 ± 1.25	15.9 ± 0.6	0	0 ± 0	0 ± 0
77 - SW of Alligator Reef SPA	148	9.25 ± 1.50	18.1 ± 1.0	0	0 ± 0	0 ± 0
87 - Tennessee Reef RO**	75	4.69 ± 0.44	24.6 ± 2.1	1	0.06 ± 0.06	7.0
86 - Tennessee Reef RO**	81	5.06 ± 0.19	19.5 ± 1.8	0	0 ± 0	0 ± 0
76 - NE of Tennessee Light	120	7.50 ± 1.63	25.1 ± 1.5	0	0 ± 0	0 ± 0
75 - East of Coffins Patch SPA	96	6.00 ± 1.63	30.3 ± 1.3	0	0 ± 0	0 ± 0
293 - Sombrero Key SPA**	164	10.25 ± 0.00	19.9 ± 0.9	0	0 ± 0	0 ± 0
96 - Sombrero Key SPA**	188	11.75 ± 1.13	15.5 ± 1.1	2	0.13 ± 0.13	10.0 ± 1.0
73 - West of Sombrero Key SPA	195	12.19 ± 1.69	17.0 ± 1.0	0	0 ± 0	0 ± 0
71 - South of Moser Channel	151	9.44 ± 3.94	11.9 ± 0.7	0	0 ± 0	0 ± 0
72 - South of Moser Channel	158	9.88 ± 0.25	16.1 ± 1.0	0	0 ± 0	0 ± 0
70 - South of Moser Channel	158	9.88 ± 3.63	12.9 ± 0.8	0	0 ± 0	0 ± 0
90 - South of Moser Channel	86	5.38 ± 0.63	12.5 ± 1.3	0	0 ± 0	0 ± 0
Middle Florida Keys Total (22)	2,971	8.44 ± 0.62	17.7 ± 0.9	54	0.15 ± 0.08	8.7 ± 1.2
Lower Florida Keys NMS						
136 - South of Bahia Honda Key	128	8.00 ± 2.50	12.6 ± 1.1	0	0 ± 0	0 ± 0

Site number/site location	***Pseudopterogorgia* spp.**			***Pterogorgia* spp.**		
	N	No./m^2	Height (cm)	N	No./m^2	Height (cm)
138 - South of Bahia Honda Key	111	6.94 ± 1.31	20.4 ± 1.4	0	0 ± 0	0 ± 0
137 - South of Bahia Honda Key	170	10.63 ± 0.25	17.4 ± 0.9	0	0 ± 0	0 ± 0
135 - West of Looe Key SPA	69	4.31 ± 0.19	19.8 ± 1.5	0	0 ± 0	0 ± 0
134 - West of Pelican Shoal	320	20.00 ± 3.50	10.5 ± 0.4	18	1.13 ± 1.13	11.2 ± 1.5
139 - Eastern Sambo RO**	247	15.44 ± 0.56	12.7 ± 0.6	0	0 ± 0	0 ± 0
336 - Eastern Sambo RO**	174	10.88 ± 1.50	14.3 ± 0.8	0	0 ± 0	0 ± 0
141 - Western Sambo ER**	220	13.75 ± 2.00	12.5 ± 0.6	1	0.06 ± 0.06	5.0
140 - Western Sambo ER**	89	5.56 ± 5.56	16.7 ± 0.8	0	0 ± 0	0 ± 0
143 - West of Western Sambo	227	14.19 ± 3.19	9.8 ± 0.4	14	0.88 ± 0.25	11.1 ± 1.3
132 - East of E. Dry Rocks SPA	102	6.38 ± 0.25	14.0 ± 1.0	0	0 ± 0	0 ± 0
346 - Rock Key SPA**	293	18.31 ± 4.69	16.5 ± 0.7	0	0 ± 0	0 ± 0
149 - Rock Key SPA**	164	10.25 ± 1.75	14.4 ± 0.7	0	0 ± 0	0 ± 0
347 - Sand Key SPA**	246	15.38 ± 3.50	15.8 ± 0.7	0	0 ± 0	0 ± 0
150 - Sand Key SPA**	152	9.50 ± 1.25	15.5 ± 0.9	0	0 ± 0	0 ± 0
142 - SW of Sand Key SPA	83	5.19 ± 1.56	24.3 ± 1.6	2	0.13 ± 0.13	9.5 ± 0.5
Lower Florida Keys Total (16)	2,795	10.92 ± 1.21	15.4 ± 0.9	35	0.14 ± 0.09	9.2 ± 1.5
Fore-reef Total (51)	**7,878**	**9.65 ± 0.58**	**16.2 ± 0.6**	**185**	**0.23 ± 0.08**	**10.0 ± 2.0**

V. Urchin density and size distribution

Background

The 1983-84 Caribbean-wide mass mortality of the long-spined sea urchin *Diadema antillarum* represents one of the most spatially expansive and prolonged disturbances to reef ecosystems in the region (Carpenter 1988; Lessios 1988, 2005). Prior to the mass mortality event, *D. antillarum* attained high (>20 per m^2) densities in many Caribbean reef areas (Lessios 1988), but urchin abundances declined by several orders of magnitude and have remained in this state over two decades later (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 has had severe consequences in terms of coral-algal dominance patterns (Carpenter 1988; Lessios 1988). In the Florida Keys, the few historical data available prior to 1983-84 indicate that *Diadema antillarum* densities were lower (up to 4 to 5 per m^2) (Kier and Grant 1965; Bauer 1976, 1980) than found elsewhere throughout the Caribbean. Still, a general trend of greater algal cover was apparent after the urchin mortality at several Florida Keys reefs (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, and 2) the regional die-off of acroporid corals from white-band disease occurred at the same time, which opened up large amounts of dead coral substrate for algal recruitment. Interestingly, 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 this pattern of poor recovery (Chiappone et al. 2002a,b).

Since the mass mortality, limited to moderate recovery in *Diadema antillarum* populations has been reported in some Caribbean reef areas (Lessios 2005; Carpenter and Edmunds 2006; Debrot and Nagelkerken 2006), but this has not occurred in the Florida Keys (Chiappone et al. 2002a, in press; Lazar et al. 2005). It is anticipated 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), but disease, bleaching, and overfishing may counteract any positive influences of increased urchin grazing. Still, there is keen interest in the spatial and temporal patterns of recovery in the Florida Keys, as there are expectations that urchin recovery will perhaps help to reduce algal cover, which will facilitate more coral recruitment, and perhaps reverse continuing declines in reef-

building corals. In addition, the slow and incomplete recovery of this urchin raises the question of factors limiting 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. in press). Below is a summary of the 2008 results for density and sizes of all urchins encountered during the surveys of 145 sites in the Florida Keys.

2008 Survey Results

During June-September, a total of 8,700 m^2 of benthic habitat among 145 sites was surveyed in the Florida Keys for urchin numbers and test sizes. Six species were encountered within transects: *Diadema antillarum*, *Echinometra lucunter*, *E. viridis*, *Eucidaris tribuloides*, *Lytechinus variegatus*, and *Tripneustes ventricosus* (Figure 27). Tables 13-15 summarize site-level densities for each species and Table 16 provides the mean and ranges in test diameters (TD) by habitat and for the entire sampling domain. Of the six urchin species and 1,691 individuals encountered, the most abundant species were *E. viridis* (810 individuals, 47.9% of all individuals) and *E. tribuloides* (623 individuals, 36.8%), followed by *D. antillarum* (144 individuals, 8.5%), *E. lucunter* (106 individuals, 6.3%), *L. variegatus* (6 individuals, 0.4%), and *T. ventricosus* (2 individuals, 0.1%).

A total of 144 individuals of *Diadema antillarum* were recorded, with individuals distributed among all five habitats sampled, albeit at different densities and sizes (Table 14). The maximum site-level density of 0.267 individuals/m^2 occurred at an offshore patch reef inshore of Pickles Reef (site #7). Relative to similar surveys dating back to 1999, we noticed an appreciable increase in the number of sites where *D. antillarum* was found and a general trend towards larger test sizes, especially on patch reefs. Figures 28-33 illustrate the spatial distribution of *D. antillarum* densities throughout the Florida Keys study area. Habitat-level mean (± 1 SE) densities were greatest on offshore patch reefs (0.051 ± 0.017 per m^2), followed by mid-channel patch reefs (0.027 ± 0.013 per m^2) (Table 13). In both habitat types, greater densities were found in reference sites outside of no-fishing zones (Figures 34-37). In high-relief spur and groove, densities were relatively similar to previous years, and on the deeper fore-reef, lower densities (< 0.08 individuals per m^2) persist (Figures 36-37). *D. antillarum* test sizes ranged from 0.6 to 10.7 cm and averaged 4.7 ± 0.2 cm, nearly 1 cm larger on average than the 3.6 ± 0.1 cm documented in 2007 (Table 16) and much larger than that reported in 1999-2001 (Chiappone et al. 2002a,b). The test sizes of the

individuals in 2008 indicated a mixed distribution, with not only abundant recruits, but also over 53% of individuals greater than 5.0 cm TD (Figure 38). Offshore patch reefs yielded the largest average size (5.4 cm) and maximum size (10.7 cm), while the deeper fore-reef had the lowest average size (3.0 cm) (Table 16).

Two species of *Echinometra* were encountered during the 2008 surveys. *E. lucunter* was the less abundant of the two species, with 106 individuals recorded among all of the habitats except the deeper fore-reef (Table 13). Nearly 76% of *E. lucunter* were recorded from high-relief spur and groove, with densities as high as 1.2 individuals per m^2 at one of three sites at Maryland Shoal (site #121) (Table 13). Similar to its congener, *E. viridis* was widely distributed among the five habitat types, but was especially abundant on mid-channel patch reefs, with 755 (93%) of the 810 individuals recorded from this habitat. Figures 39-44 illustrate the spatial distribution of *E. viridis* densities throughout the Florida Keys study area. A mean (± 1 SE) habitat-level density of 0.55 ± 0.22 individuals per m^2 was recorded from mid-channel patch reefs, a density 27 times greater than for the other four habitats. Site-level densities of *E. viridis* were as high as 4.8 individuals per m^2 on mid-channel patch reefs and were relatively higher in the upper and lower Keys (Table 14 and Figure 45). On offshore patch reefs, densities in the middle Keys tended to be greater, especially in reference areas (Figure 46), while no discernible regional pattern was evident for high-relief spur and groove or the deeper fore-reef (Figures 47-48). The test diameter (TD) of individuals ranged from 0.7 cm to 5.0 cm and averaged 2.8 cm (Figure 38) among the 145 sites, with mid-channel patch reefs yielding the largest average size (2.8 cm) and the largest maximum size (5.0 cm) (Table 16).

Eucidaris tribuloides was recorded from all five habitats and exhibited a habitat distribution pattern similar to historical surveys. A total of 623 individuals were counted in 2008, with the highest site-level density estimate of 0.82 ± 0.25 individuals/m^2 recorded from an offshore patch reef north of Pelican Shoal (site #107) (Table 14). Figures 49-54 illustrate the spatial distribution of *E. tribuloides* densities throughout the Florida Keys study area. Densities tended to be greatest on offshore patch reefs and high-relief spur and groove habitats, with obvious regional variations in density apparent for most of the habitats (Figures 55-58). Of the 623 individuals encountered, test diameters ranged from 0.6 cm to 4.0 cm, averaged 2.2 cm (Table 16), and showed a modal size class between 2.0 and 2.9 cm (Figure 38). A slightly larger average size was recorded from patch reefs and the deeper fore-reef (2.4-2.6 cm) compared to shallower, high-relief spur and groove (2.0-2.1 cm), although overall size ranges were similar among the five habitats (Table 16).

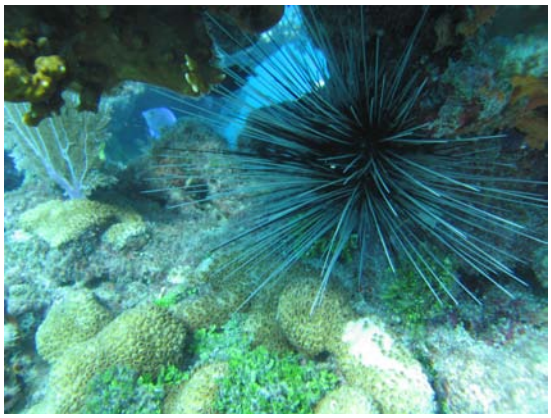
Discussion

Large-scale surveys encompassing hundreds of sites across the south Florida shelf since 1999 indicate that the *Diadema antillarum* population exists at densities well below values reported before the two mortality events in 1983-84 and 1991 (Kier and Grant 1965; Bauer 1980; Forcucci 1994). For the Florida Keys there has been an increase in the proportion of sites with *D. antillarum* present from Key West northwards, as well an increase in mean test size, with a greater proportion of larger individuals in the population. Earlier reports and recent observations indicate that other urchin species show density and habitat distribution patterns similar to pre-1983 observations, indicating that other species have 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) *Diadema antillarum*, there are obvious effects of grazing on the substratum, particularly the removal of turf and macroalgae and exposure of the substraum (Chiappone et al. 2001). It remains unclear at this time whether increasing urchin densities and sizes will lead to other changes such as increased coral recruitment.

The slow and prolonged recovery in the Florida Keys, especially compared to several recent studies in other Caribbean reef areas, raises several questions pertaining to the possible factors inhibiting recovery. Lessios (1988) and others have discussed the merits of hypotheses concerning population recovery, among them 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, even after the 1991 mortality event (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 1999-2007 indicate post-settlement recruits have poor survivorship, perhaps due to predation pressure or physical disturbance from storms. Because *D. antillarum* was historically significant as a grazer it will be important to monitor it is recruitment, potential for recovery, and effects on community structure in the Florida Keys.

Figure 27. Long-spined sea urchins (*Diadema antillarum*) and other urchin species surveyed for density and size (test diameter) in the Florida Keys during 2008. Not shown are *Echinometra lucunter* (rock boring urchin), *Lytechinus variegatus*, and *Tripneustes ventricosus*.

Diadema antillarum

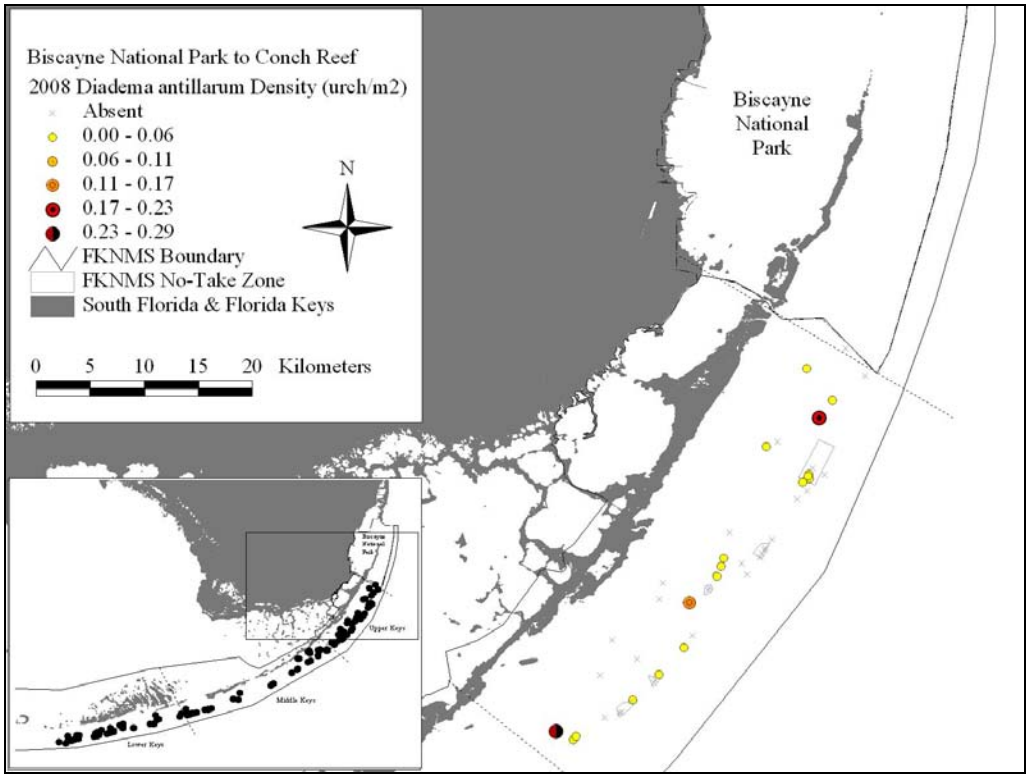


Juvenile *Diadema antillarum*

Echinometra viridis

Eucidaris tribuloides

Figure 28. Densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) in the upper Florida Keys (top) and from the southern BNP boundary to Carysfort Reef (bottom) during June-September 2008.



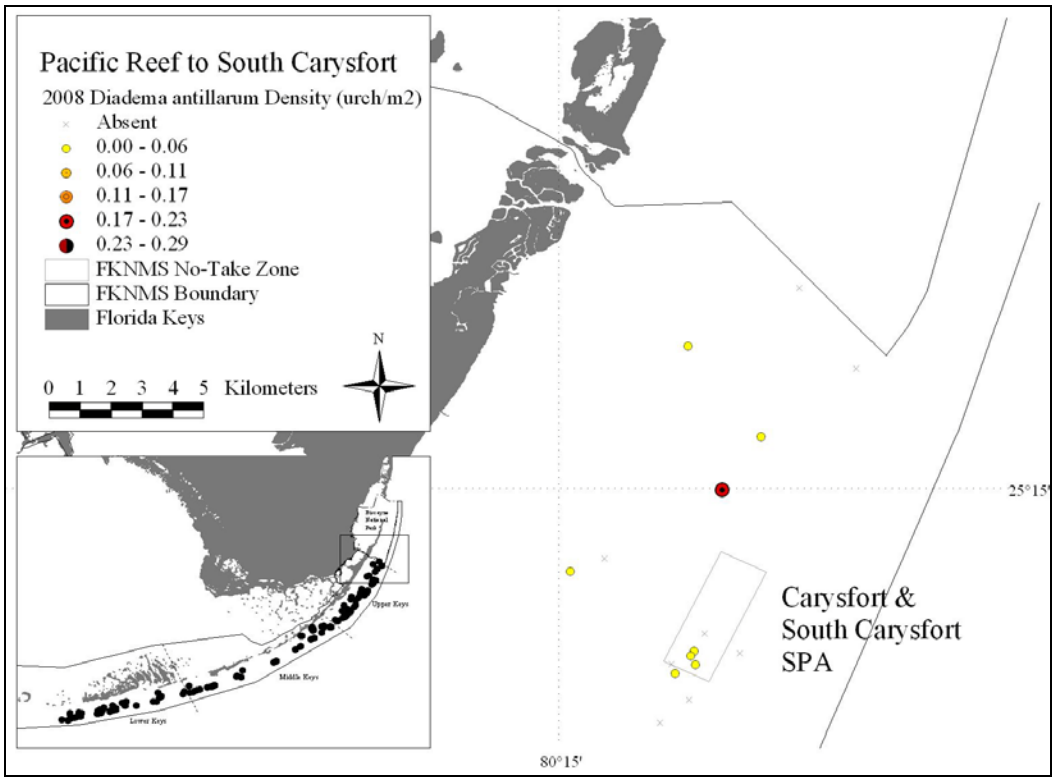


Figure 29. Densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) in the upper Florida Keys from Elbow Reef to Pickles Reef (top) and in the middle Florida Keys during June-September 2008.

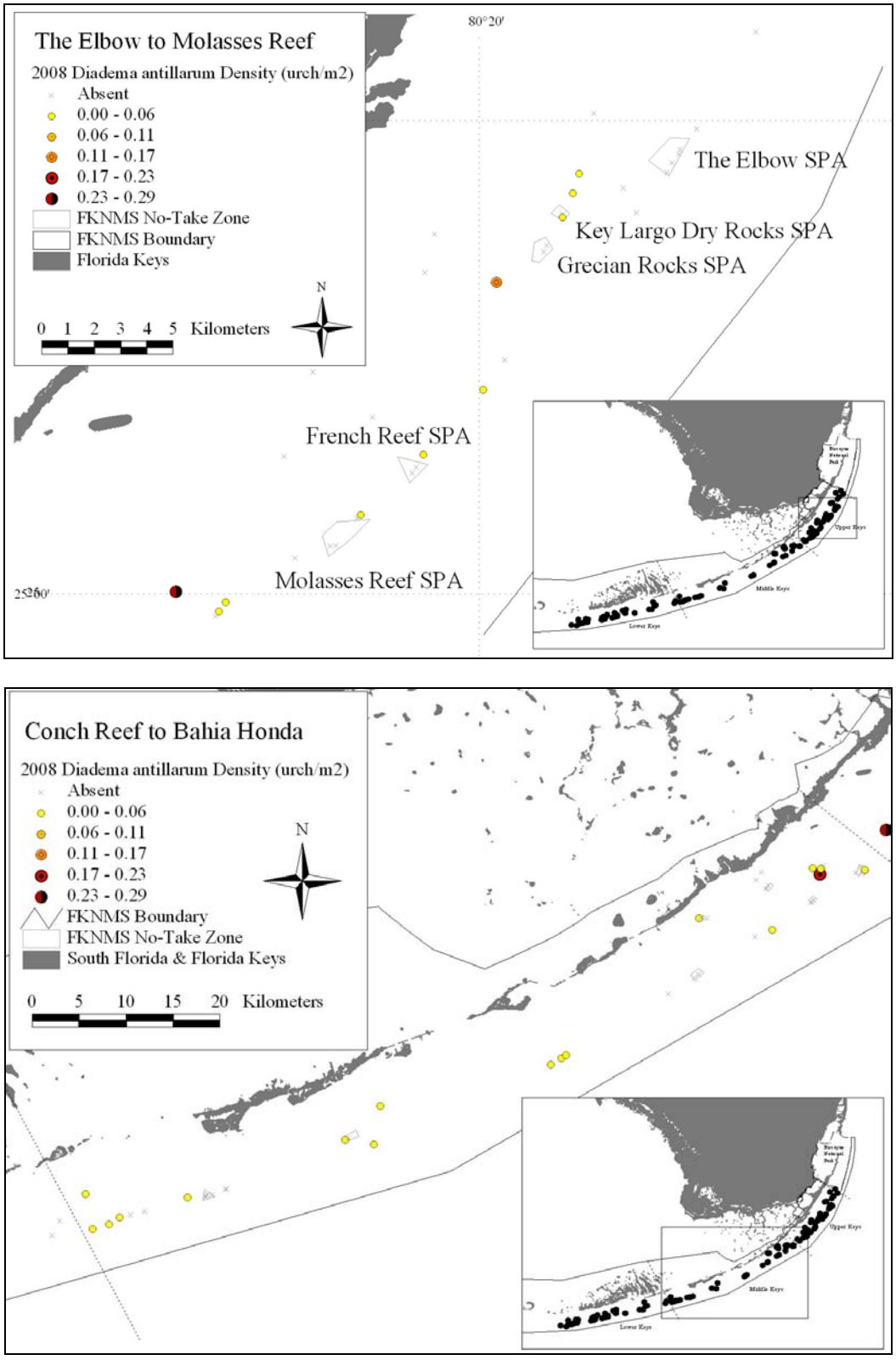
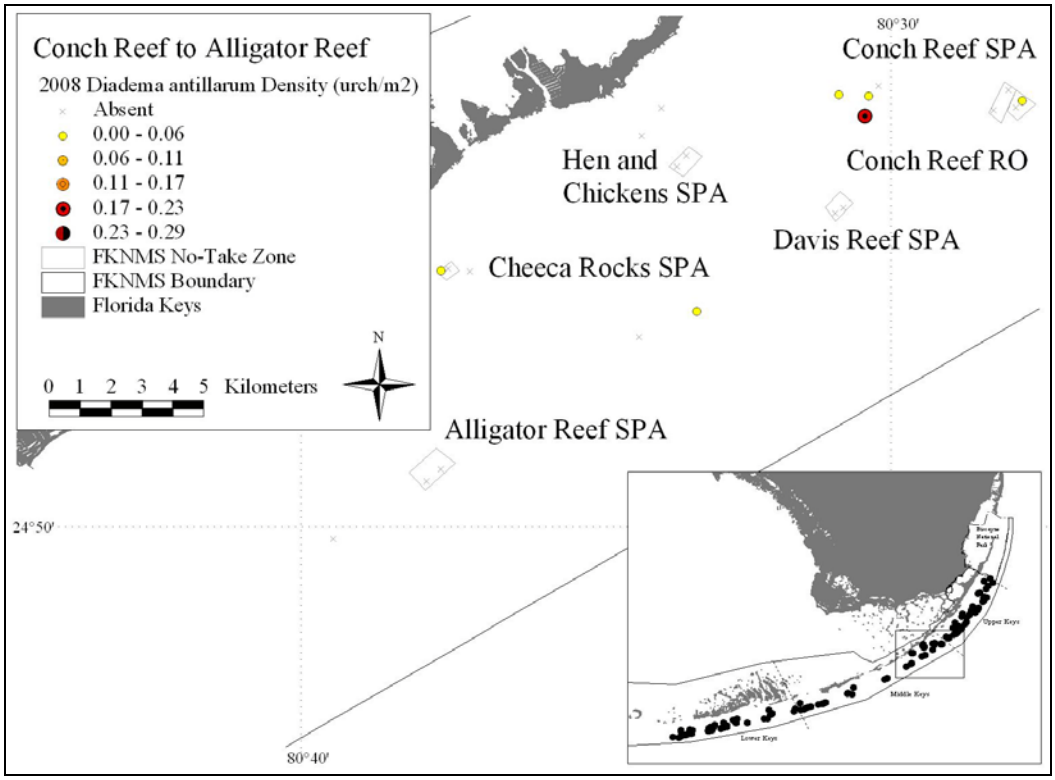


Figure 30. Densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) in the middle Florida Keys from Conch Reef to Alligator Reef (top) and from Tennessee Reef to Coffins Patch (bottom) during June-September 2008.



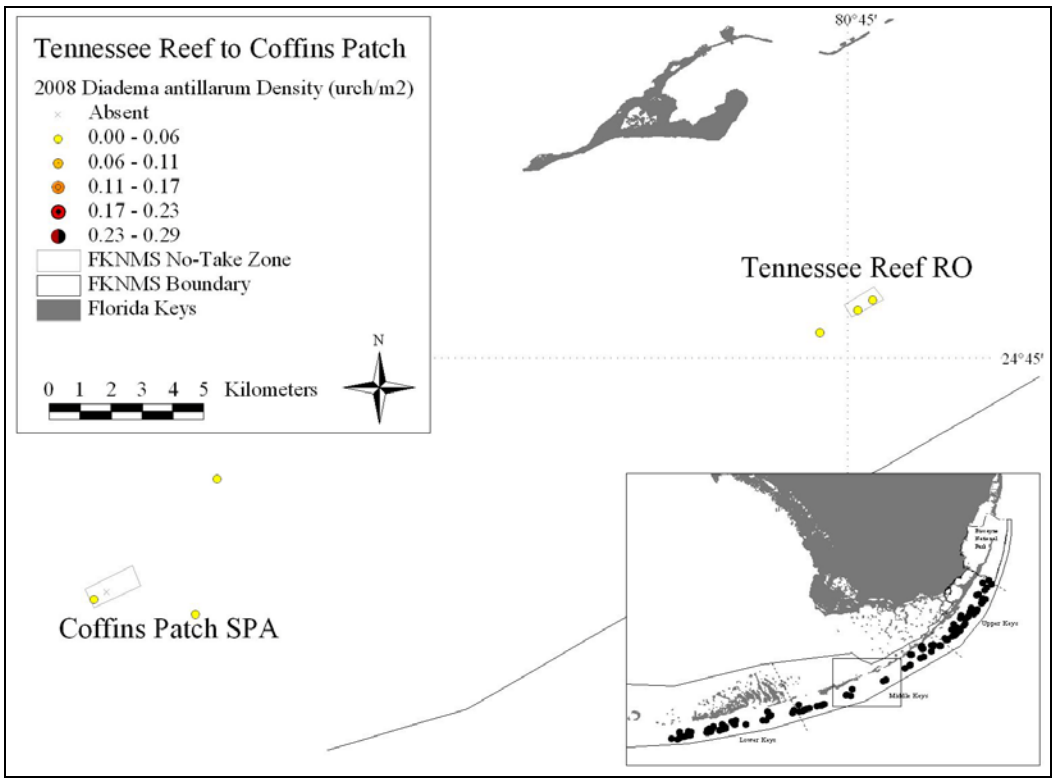


Figure 31. Densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) in the middle Florida Keys from Sombrero Reef to Bahia Honda (top) and in the lower Florida Keys (bottom) during June-September 2008.

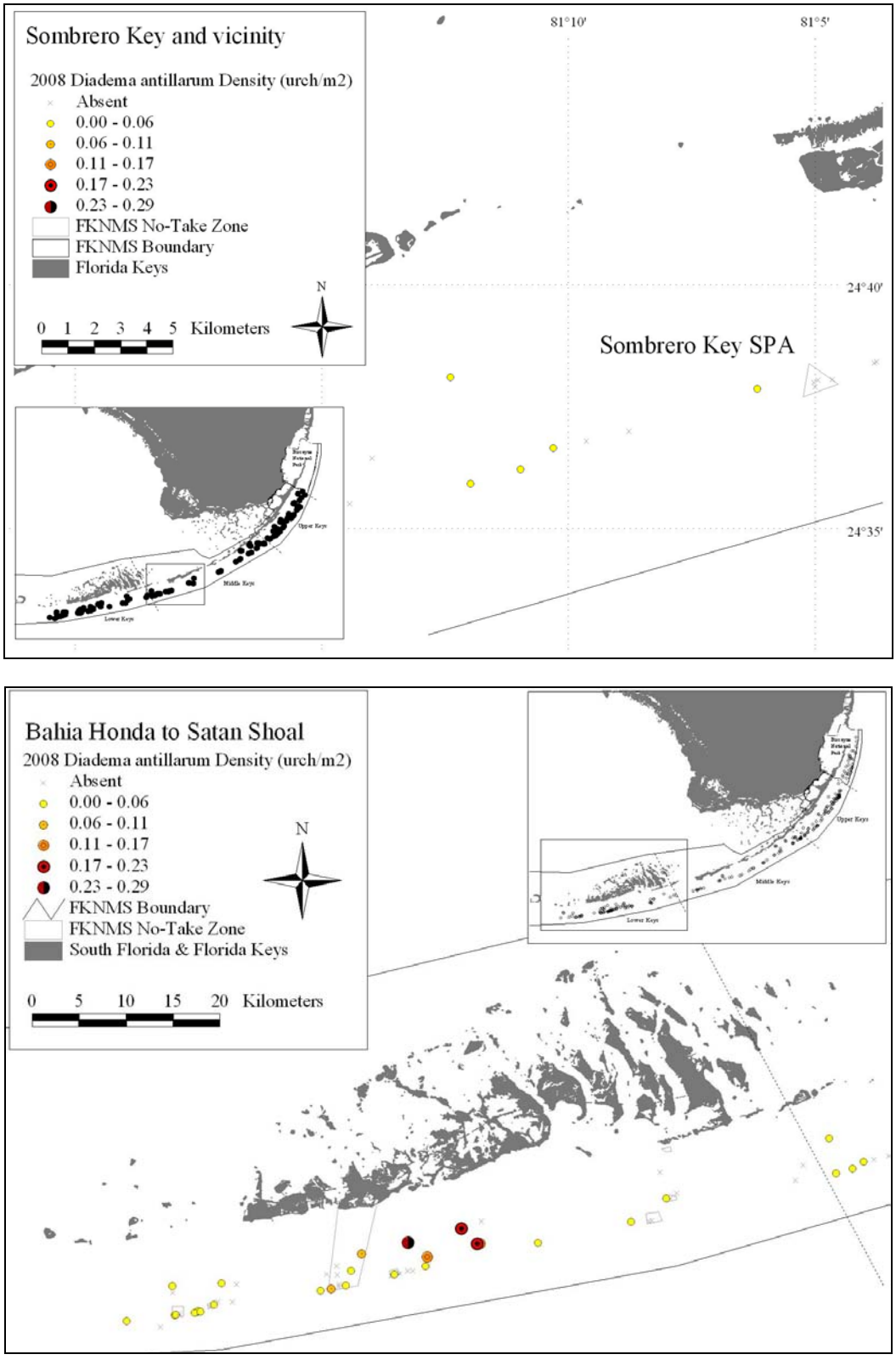


Figure 32. Densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) in the lower Florida Keys from Bahia Honda to Looe Key (top) and from American Shoal to Western Sambo (bottom) during June-September 2008.

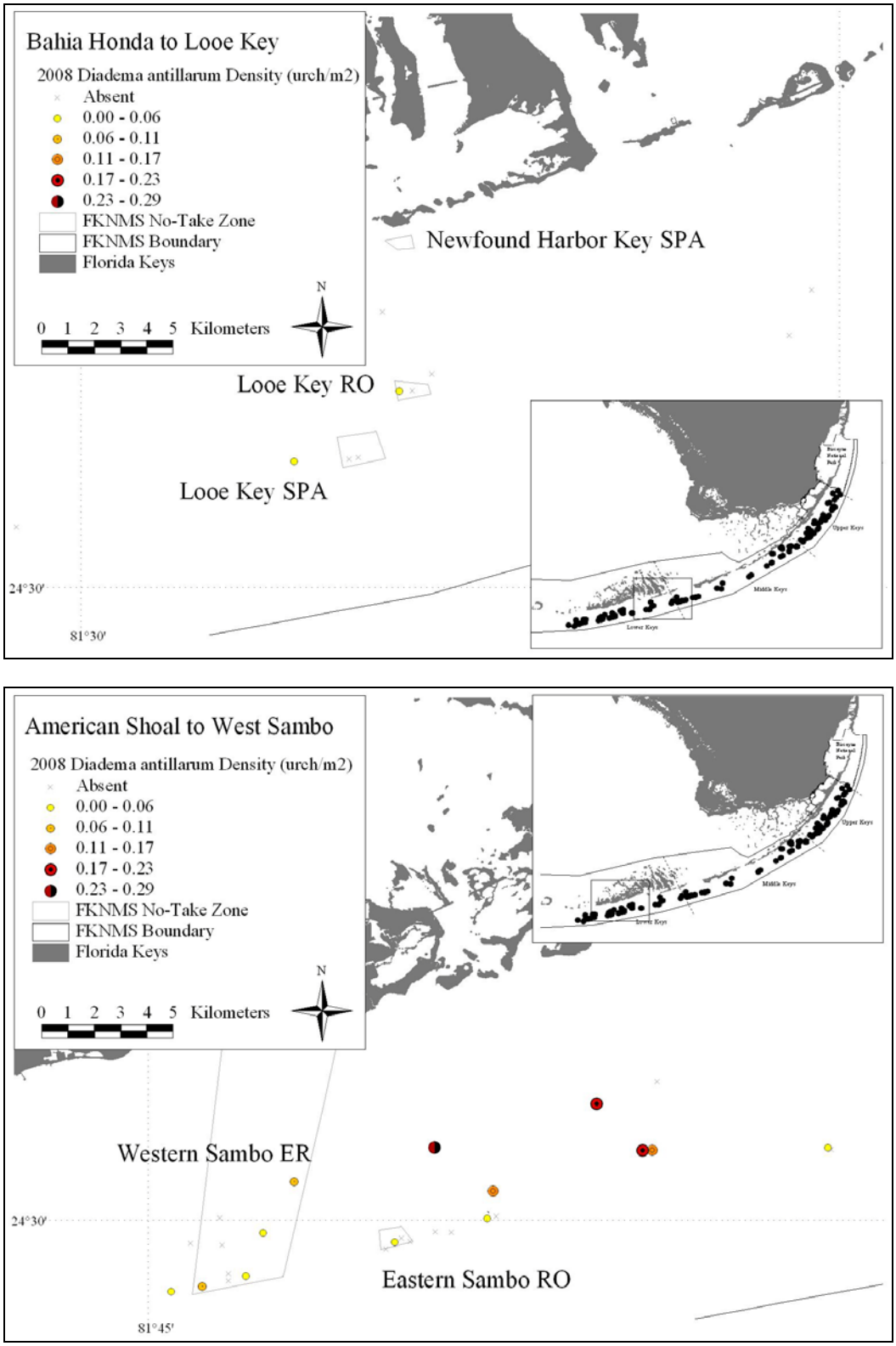


Figure 33. Densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) in the lower Florida Keys from Eastern Dry Rocks to Sand Key during June-September 2008.

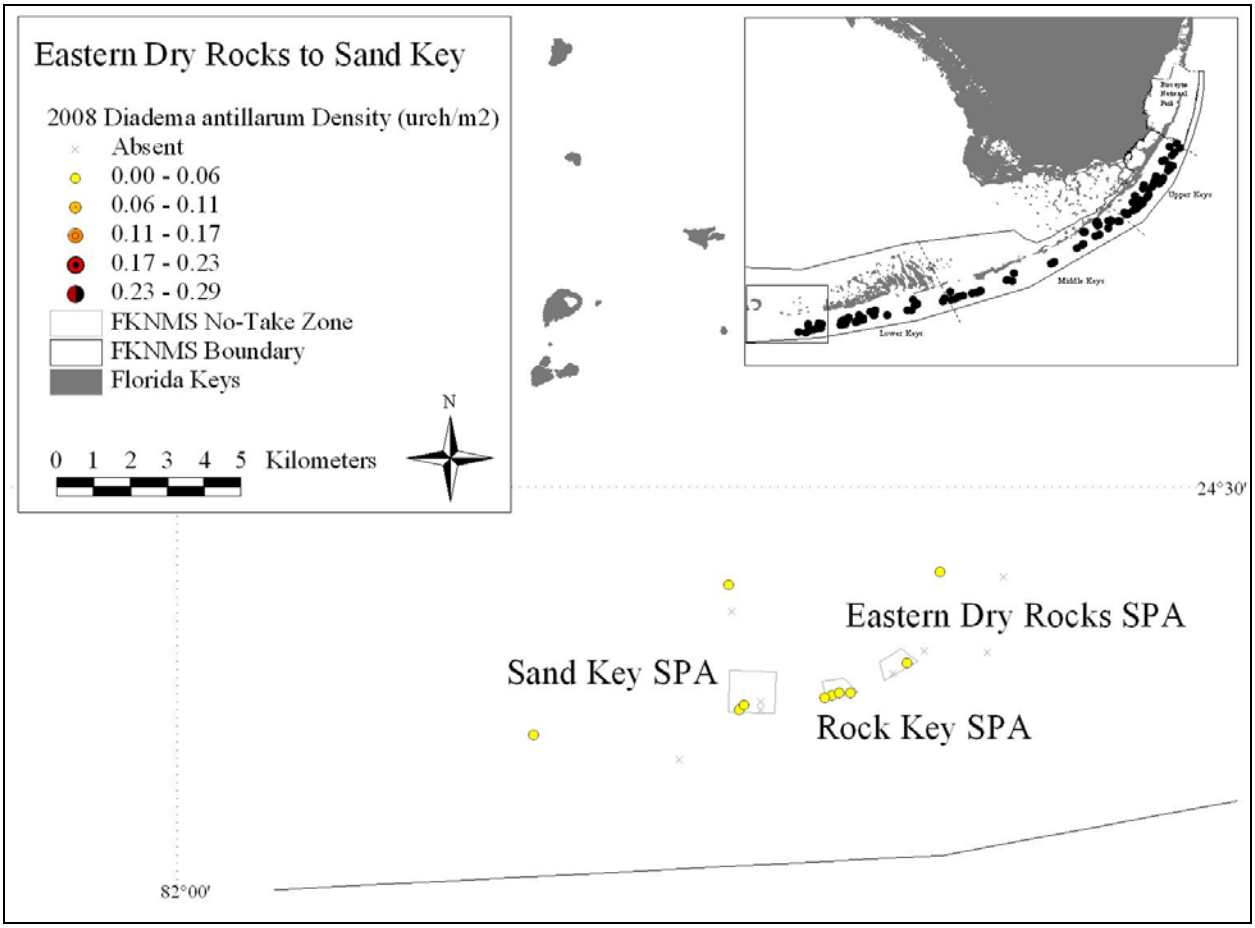


Figure 34. Mean (+ 1 SE) densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) on mid-channel patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

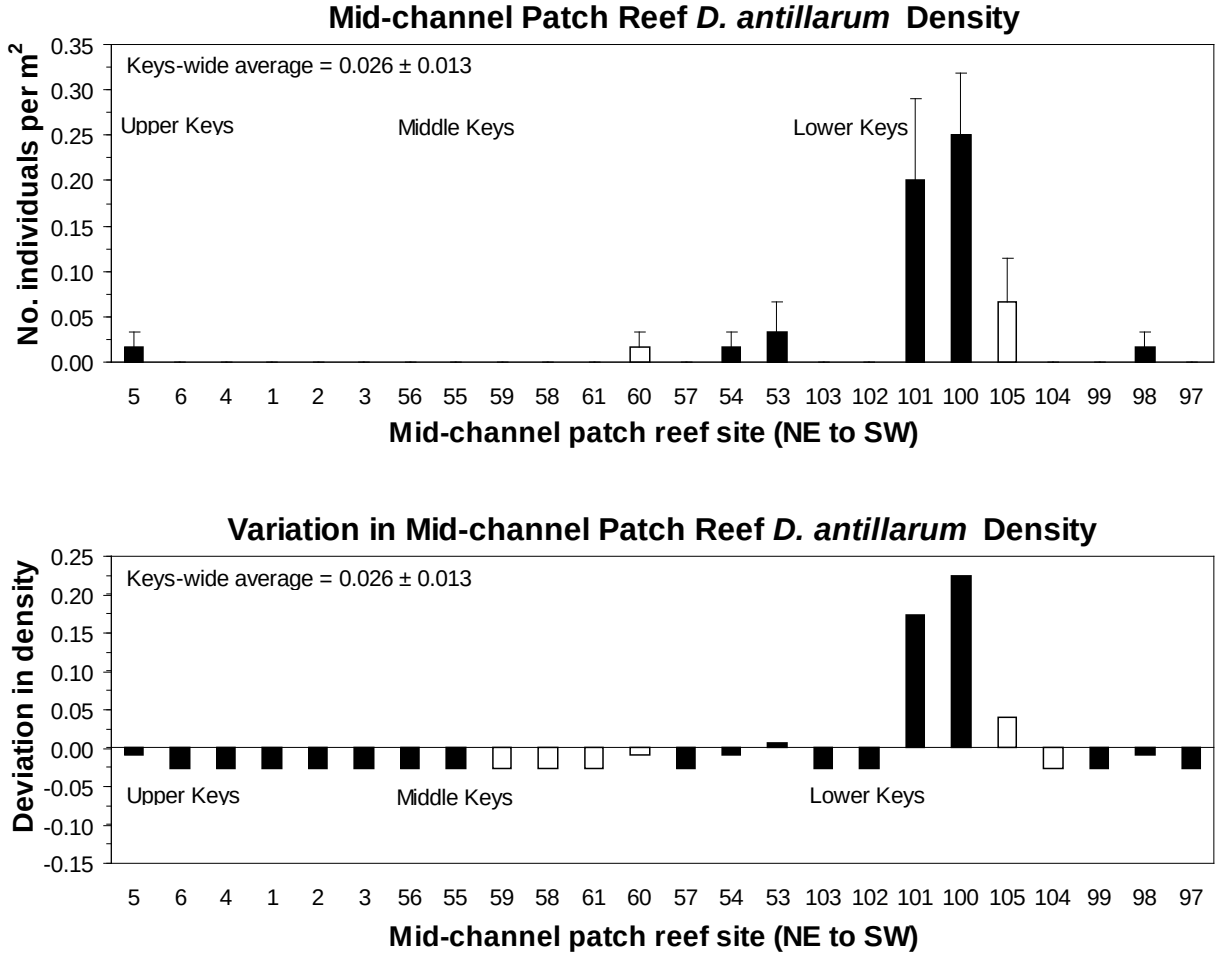


Figure 35. Mean (+ 1 SE) densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) on offshore patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

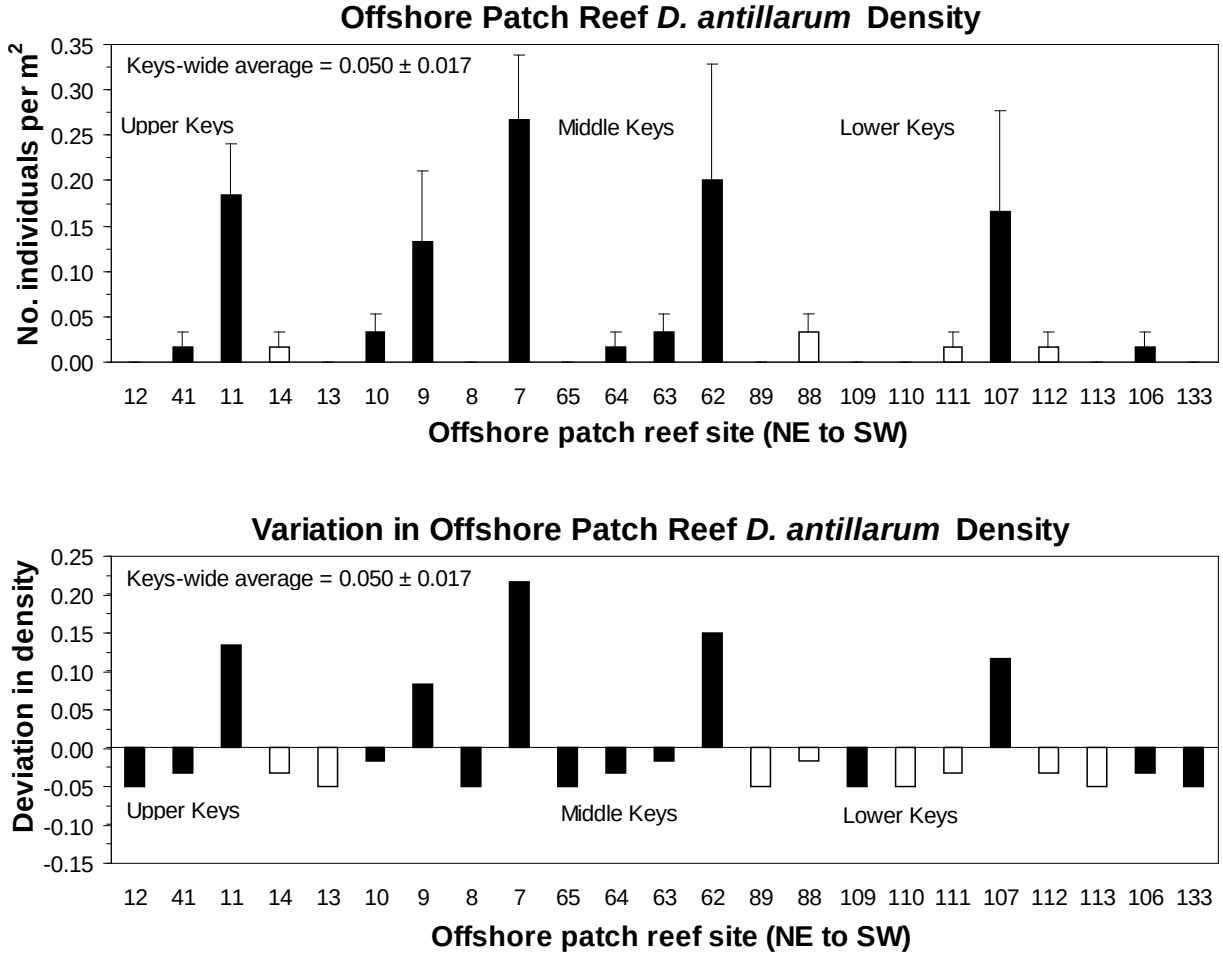


Figure 36. Mean (+ 1 SE) densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) on shallow (< 6 m), high-relief spur and groove reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

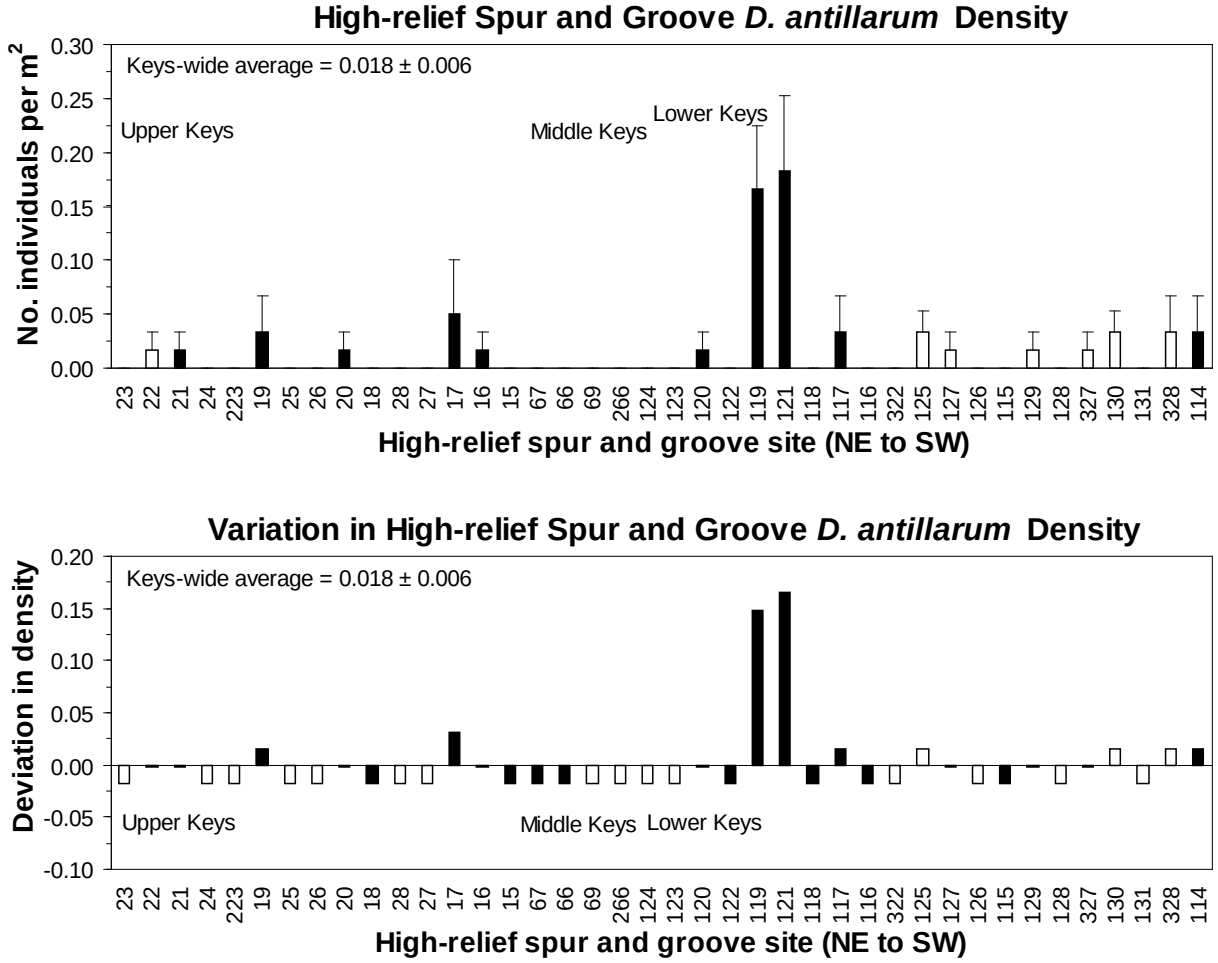


Figure 37. Mean (+ 1 SE) densities (no. per m^2) of long-spined sea urchins (*Diadema antillarum*) on deeper (6-15 m) fore-reef sites (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

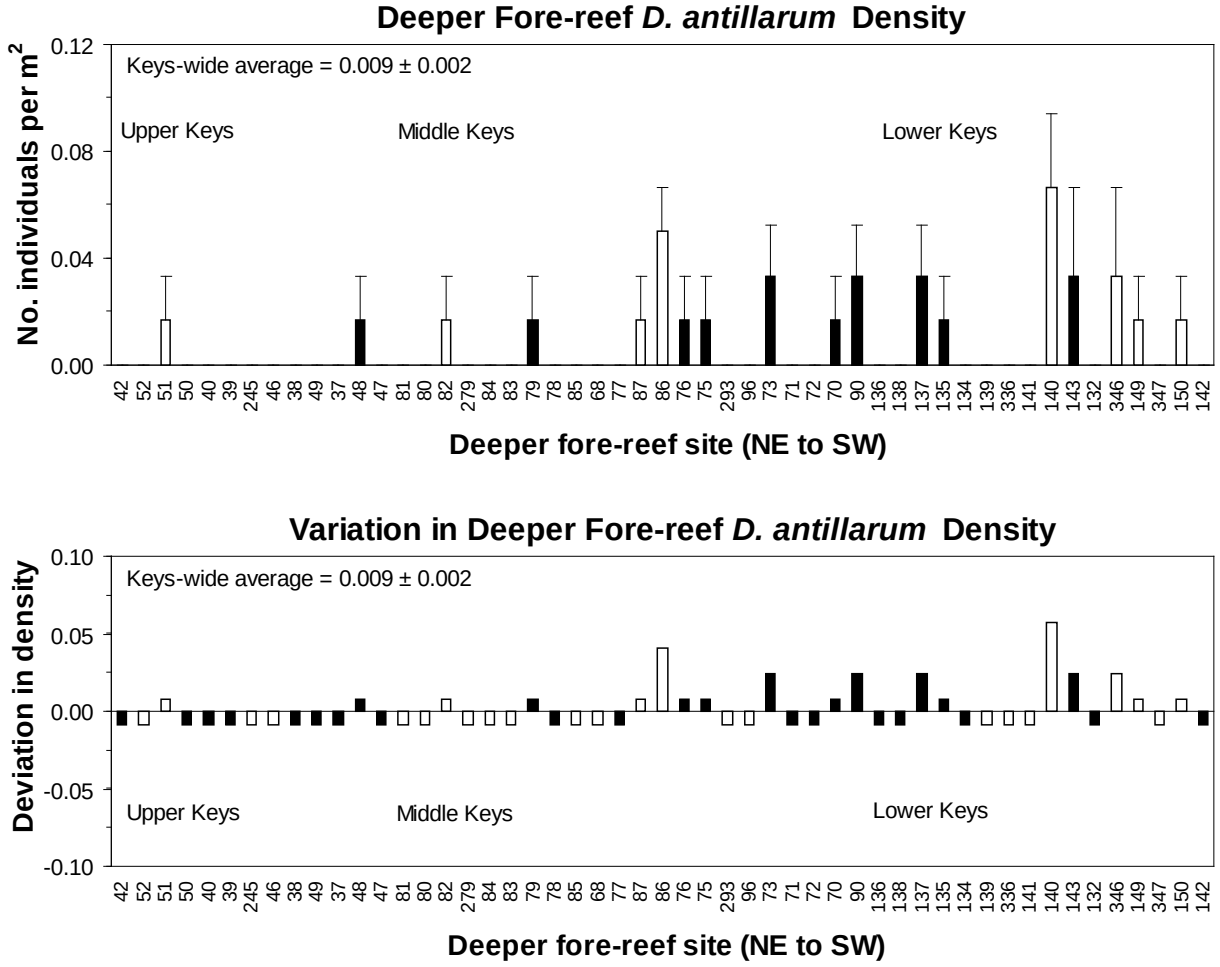
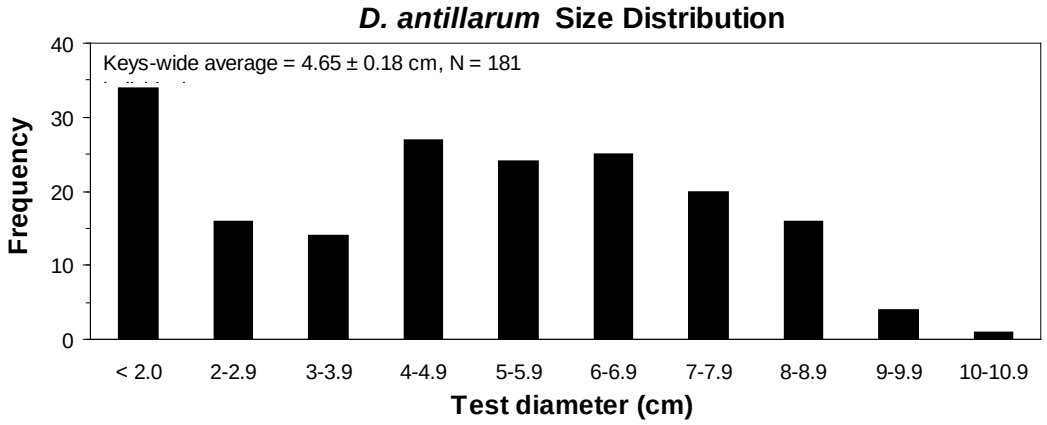
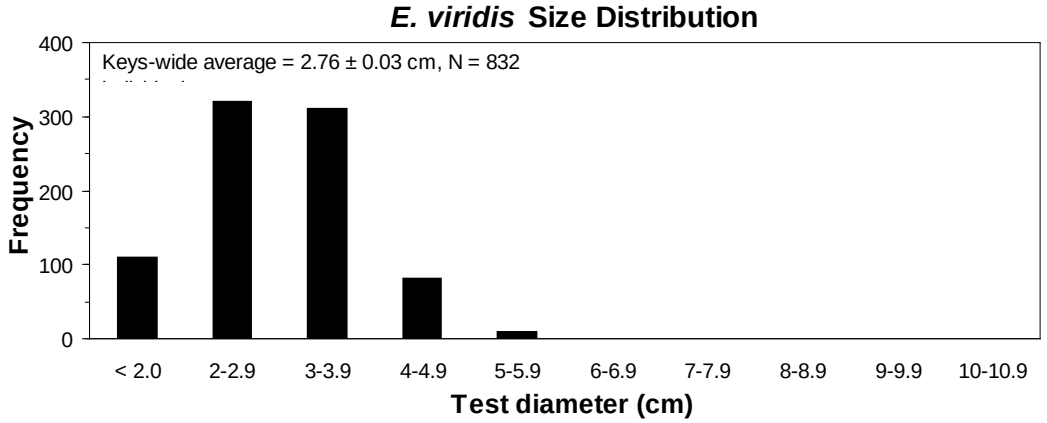


Figure 38. Urchin size distributions for *Diadema antillarum*, *Echinometra viridis*, and *Eucidaris tribuloides* in the Florida Keys National Marine Sanctuary during June-September 2008 at 145 hard-bottom and coral reef sites.





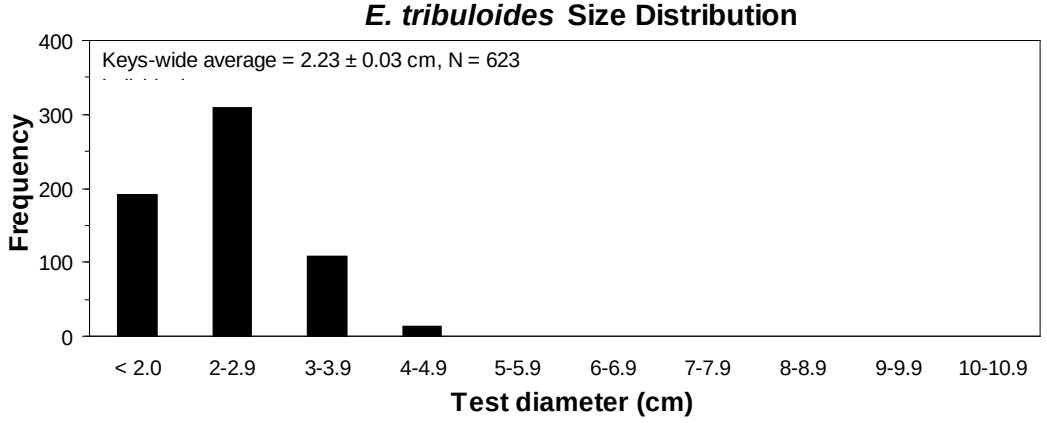
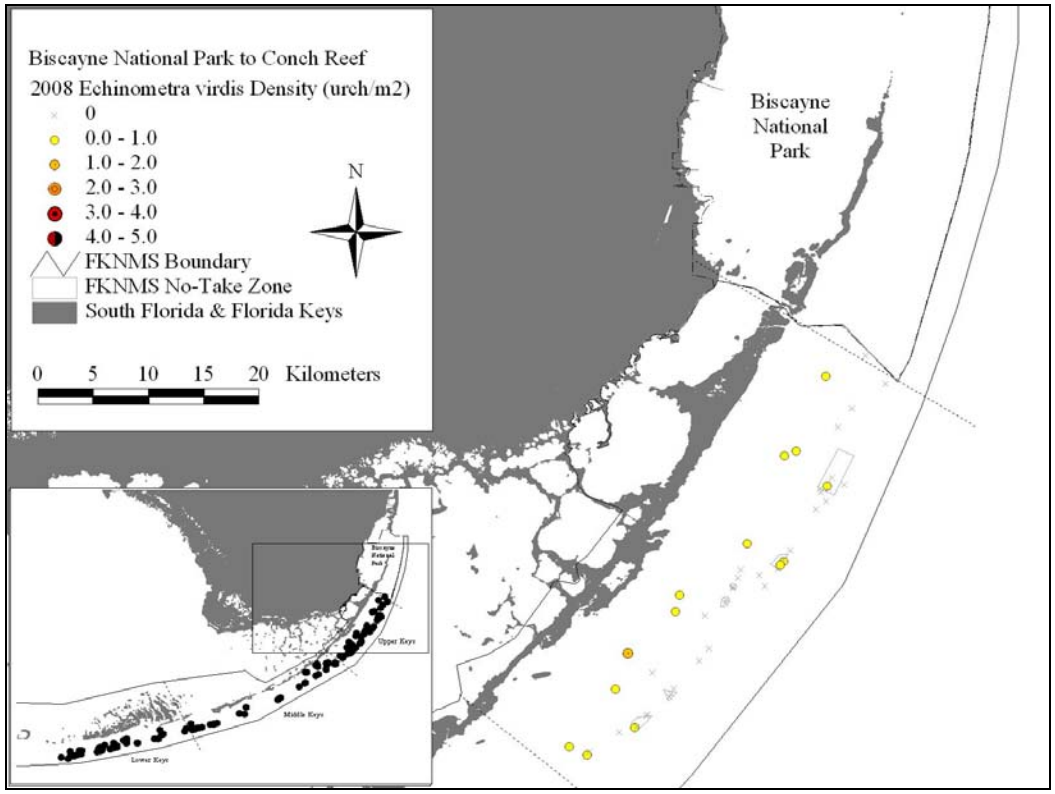


Figure 39. Densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) in the upper Florida Keys (top) and from the southern BNP boundary to Carysfort Reef (bottom) during June-September 2008.



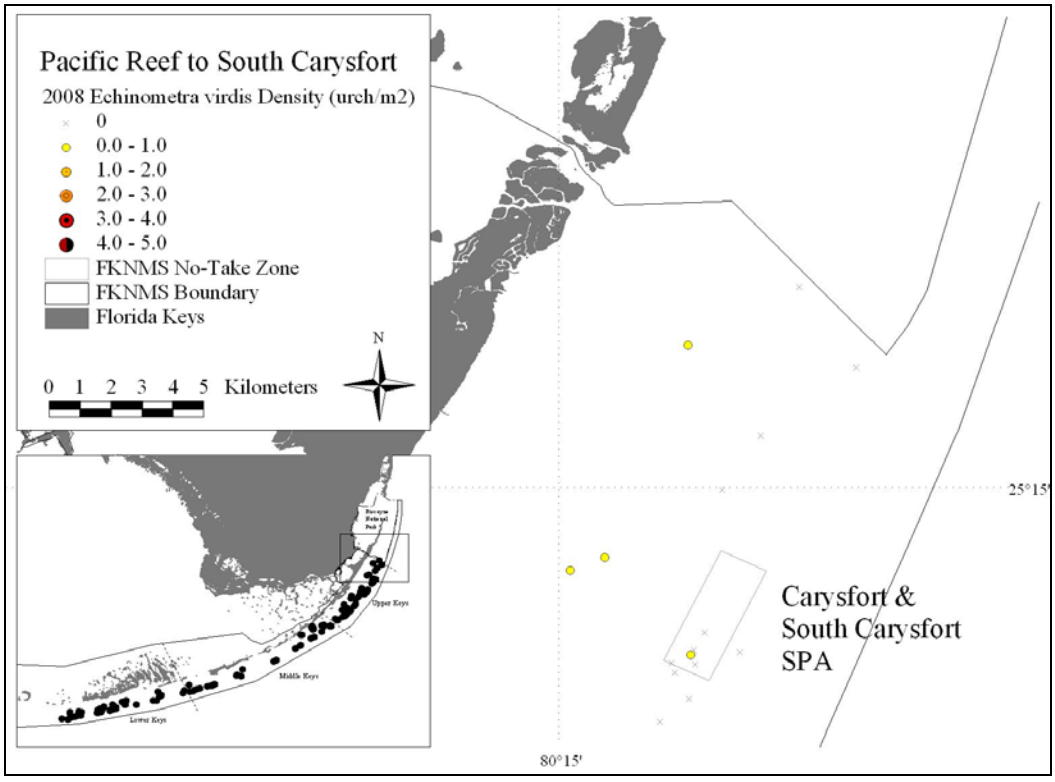
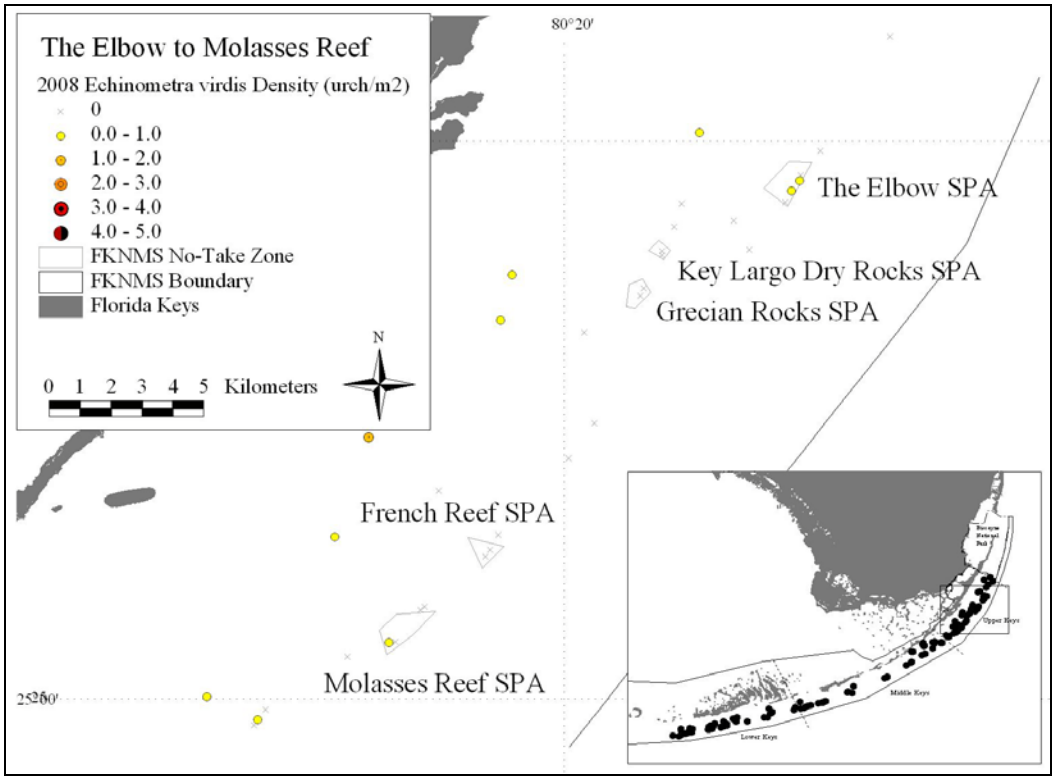


Figure 40. Densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) in the upper Florida Keys from Elbow Reef to Pickles Reef (top) and in the middle Florida Keys (bottom) during June-September 2008.



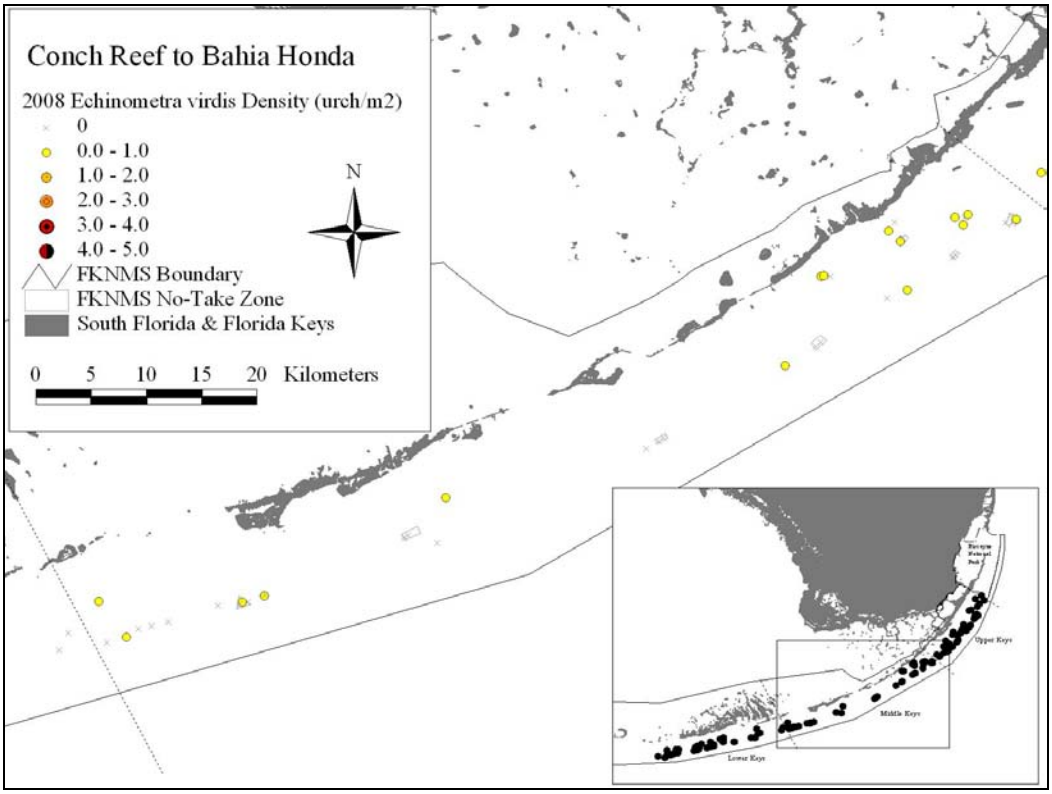
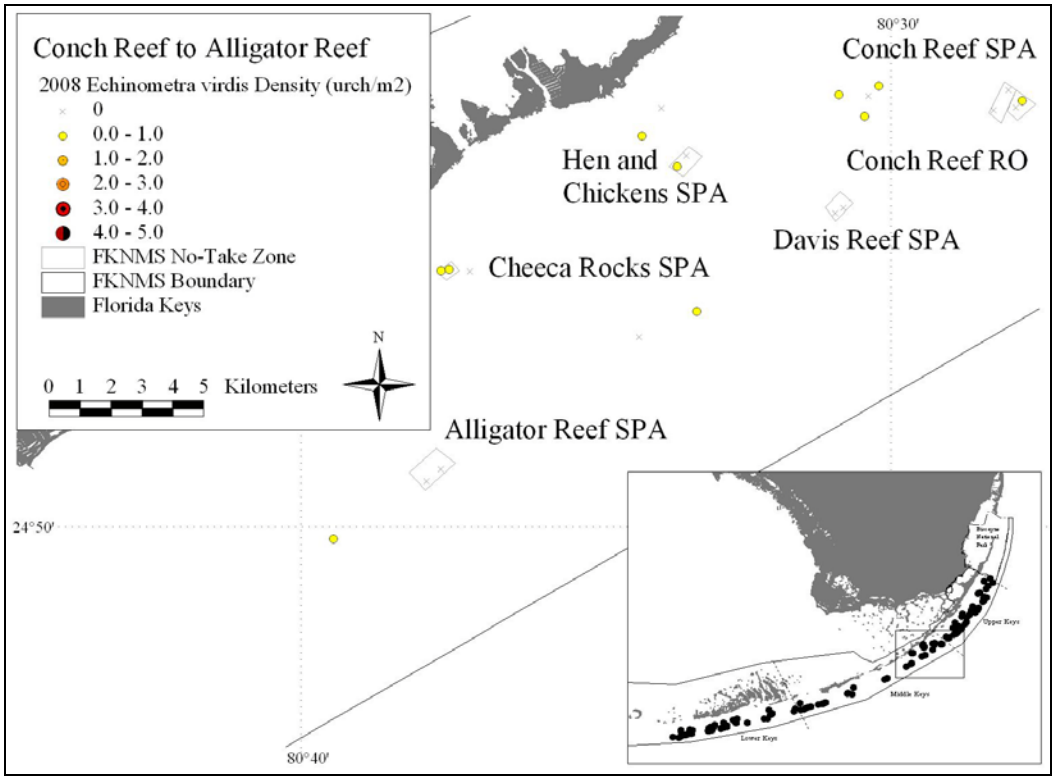


Figure 41. Densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) in the middle Florida Keys from Conch Reef to Alligator Reef (top) and from Tennessee Reef to Coffins Patch (bottom) during June-September 2008.



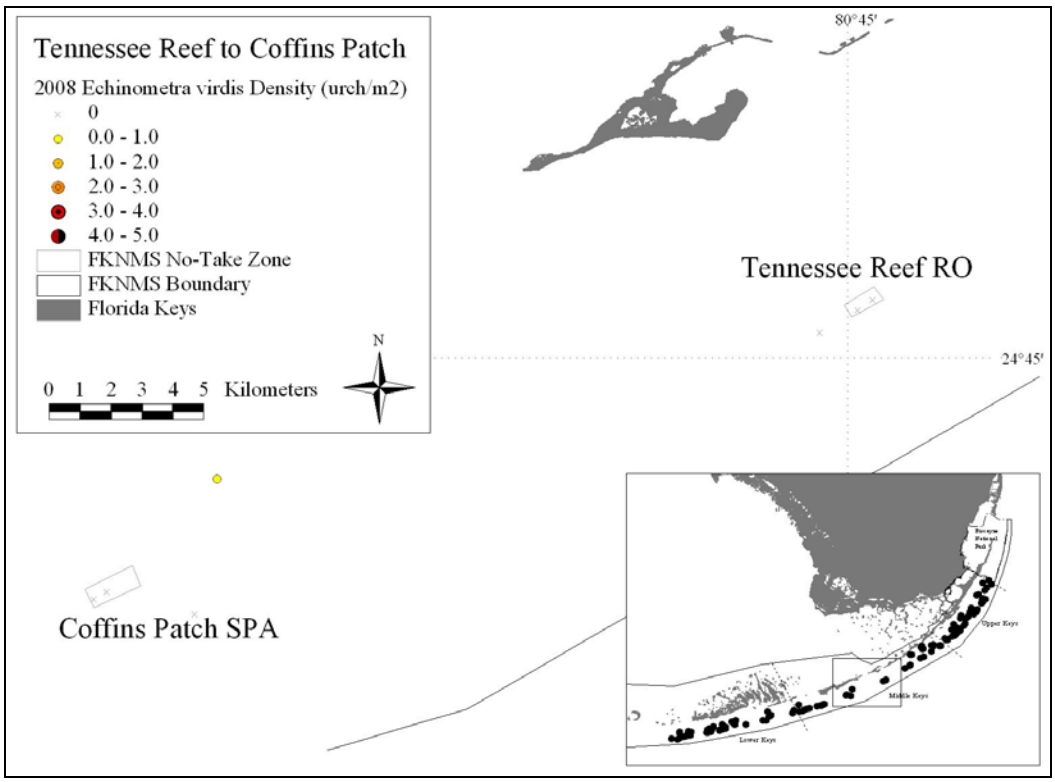


Figure 42. Densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) in the middle Florida Keys from Sombrero Reef to Bahia Honda (top) and in the lower Florida Keys (bottom) during June-September 2008.

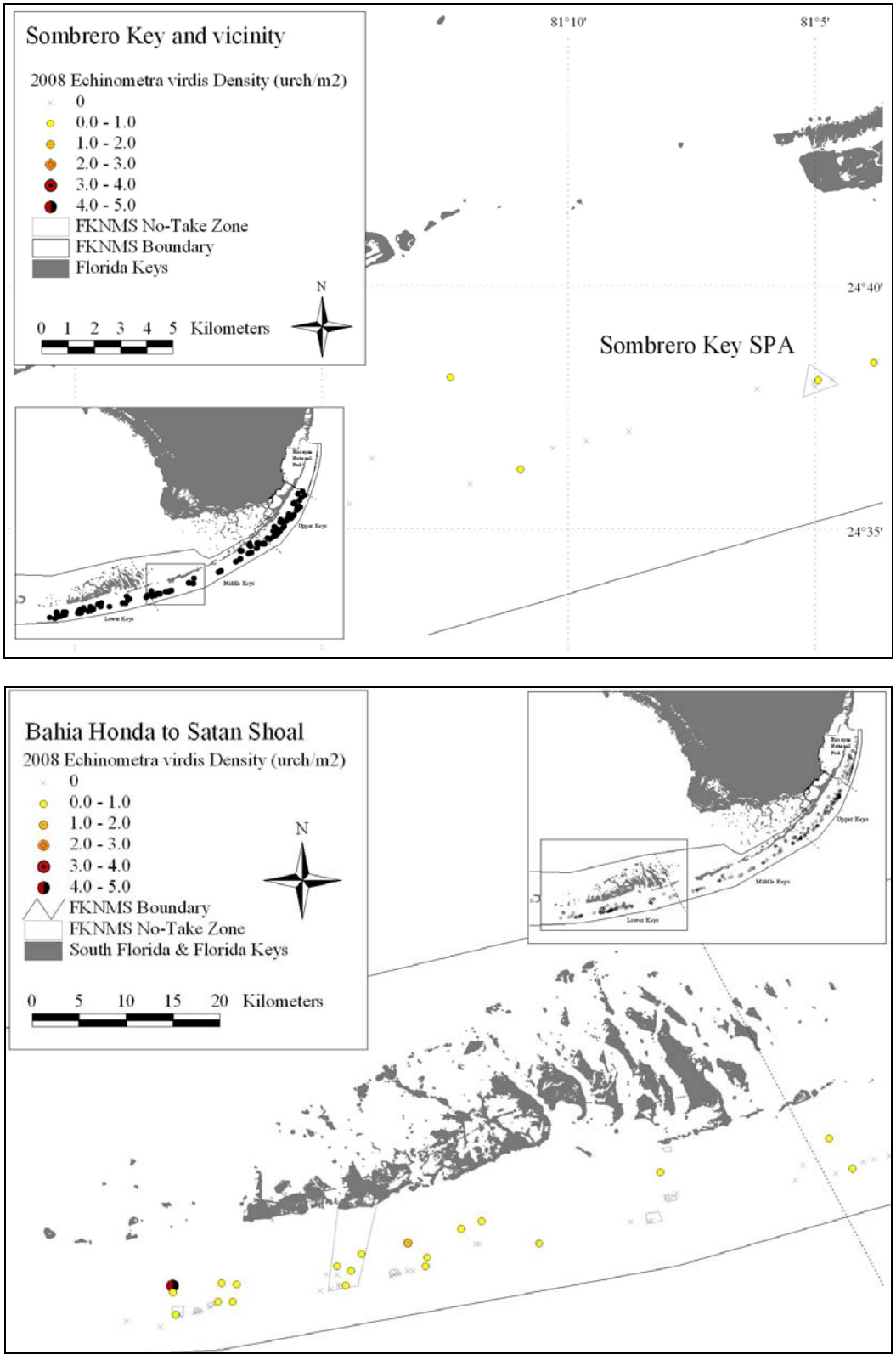


Figure 43. Densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) in the lower Florida Keys from Bahia Honda to Looe Key (top) and from American Shoal to Western Sambo (bottom) during June-September 2008.

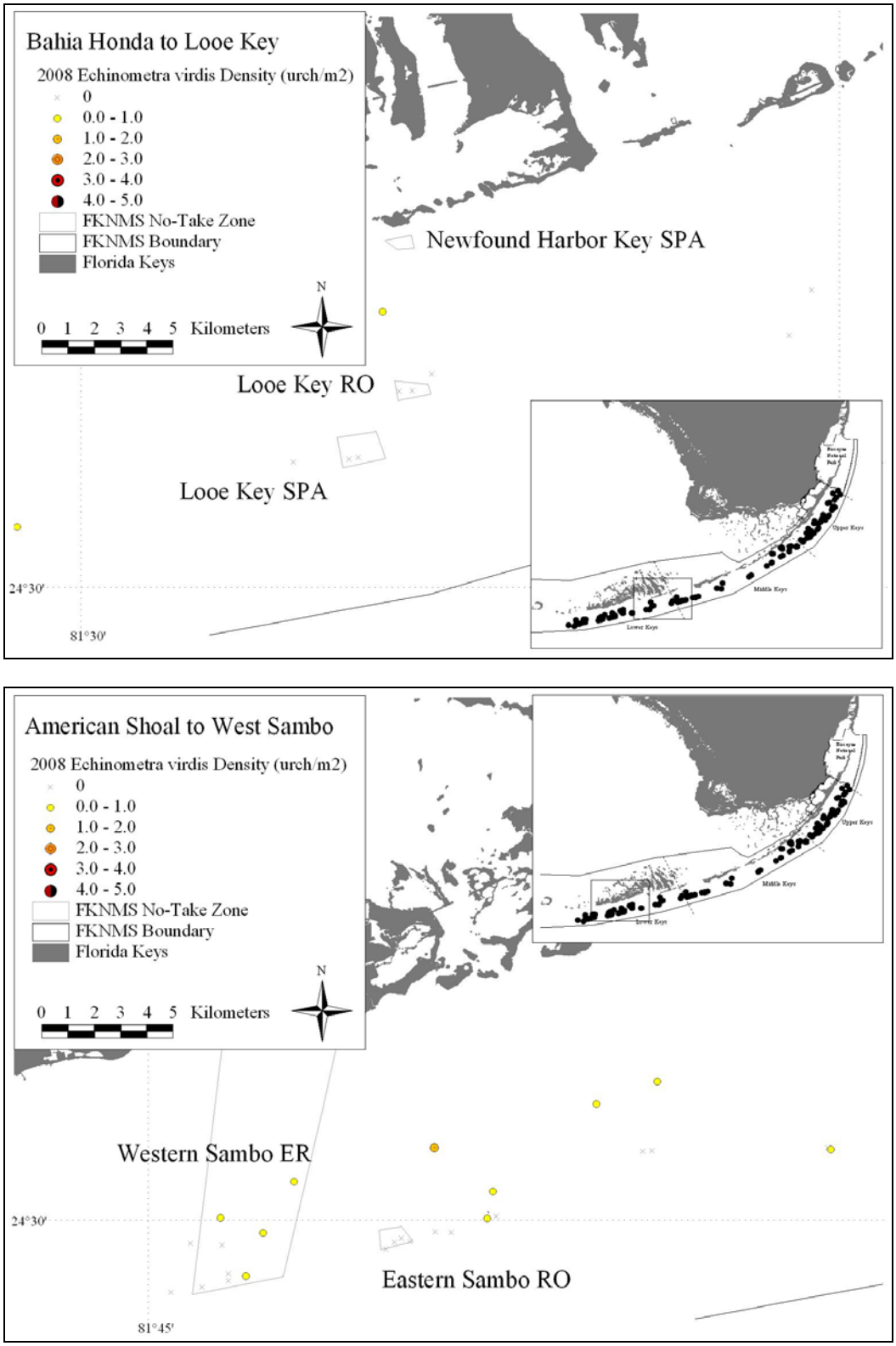


Figure 44. Densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) in the lower Florida Keys from Eastern Dry Rocks to Sand Key during June-September 2008.

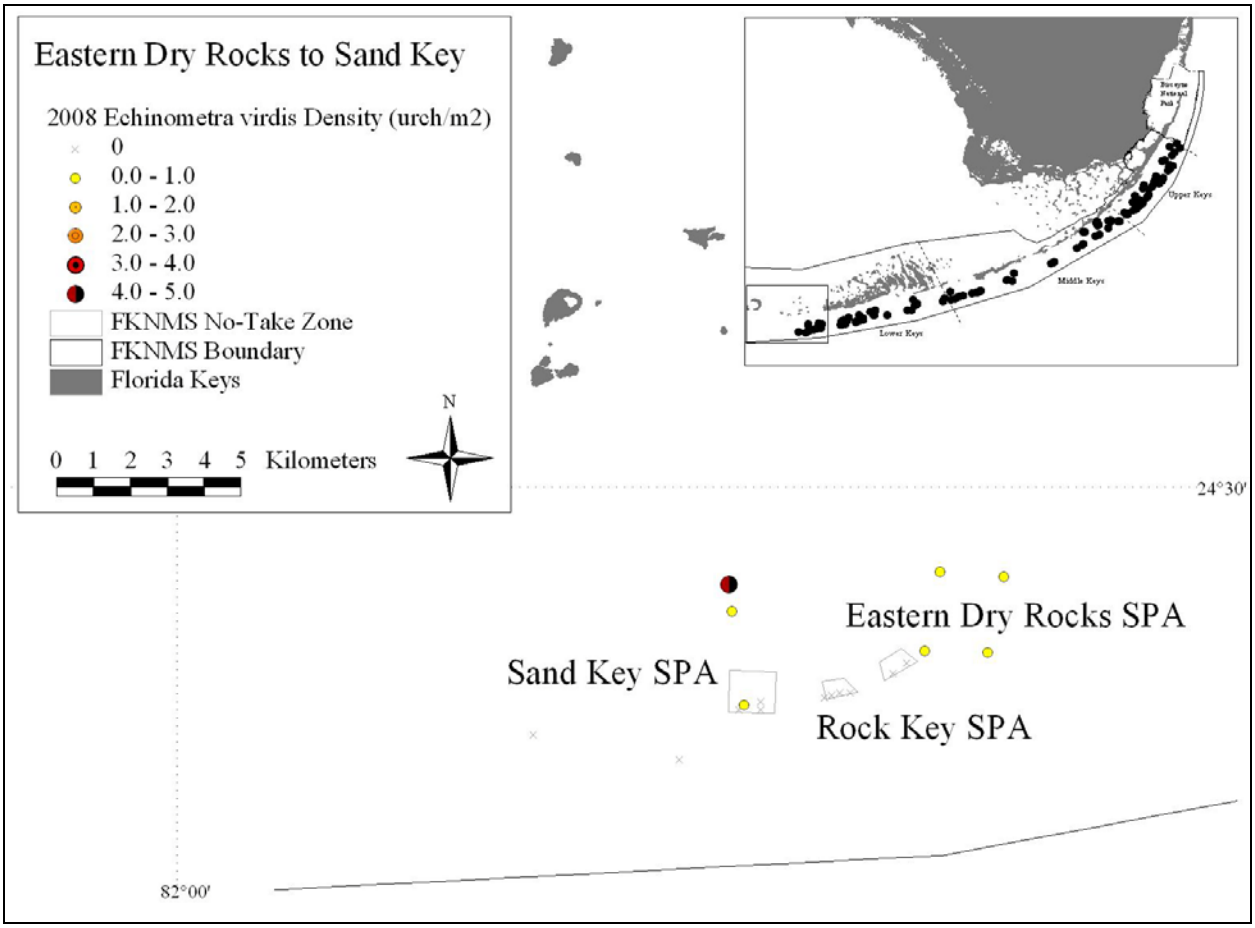


Figure 45. Mean (+ 1 SE) densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) on mid-channel patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

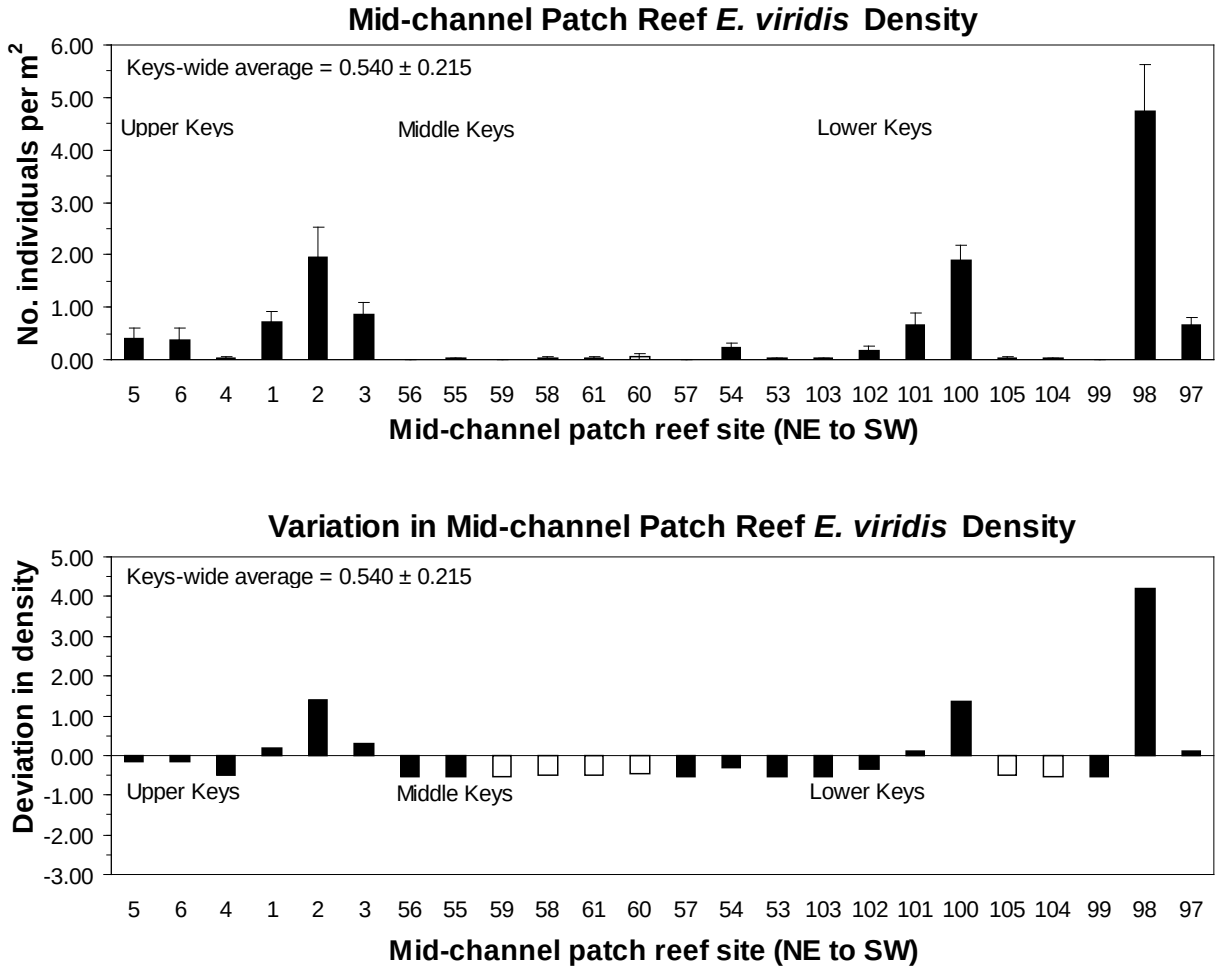


Figure 46. Mean (+ 1 SE) densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) on offshore patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

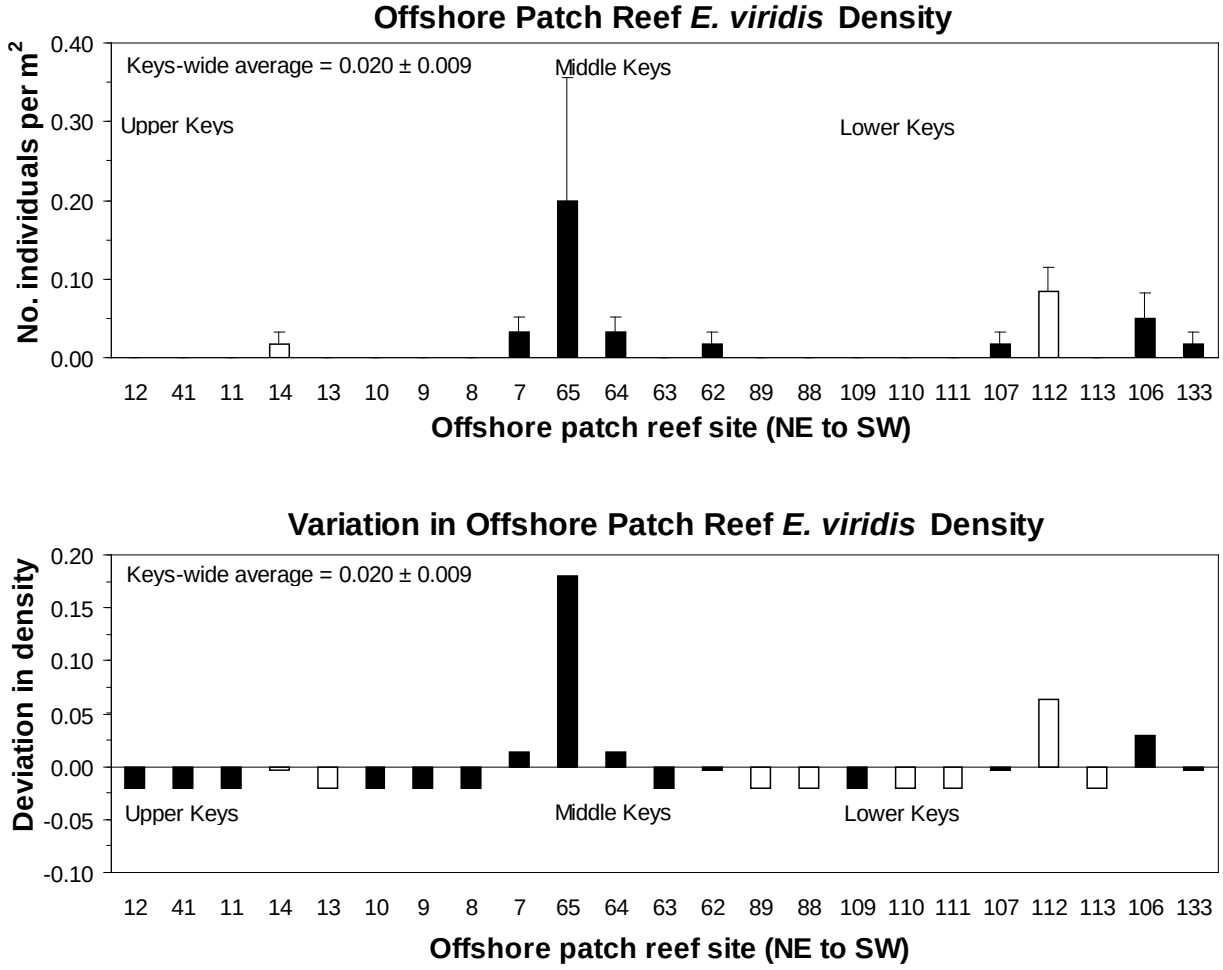


Figure 47. Mean (+ 1 SE) densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) on shallow (< 6 m), high-relief spur and groove reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

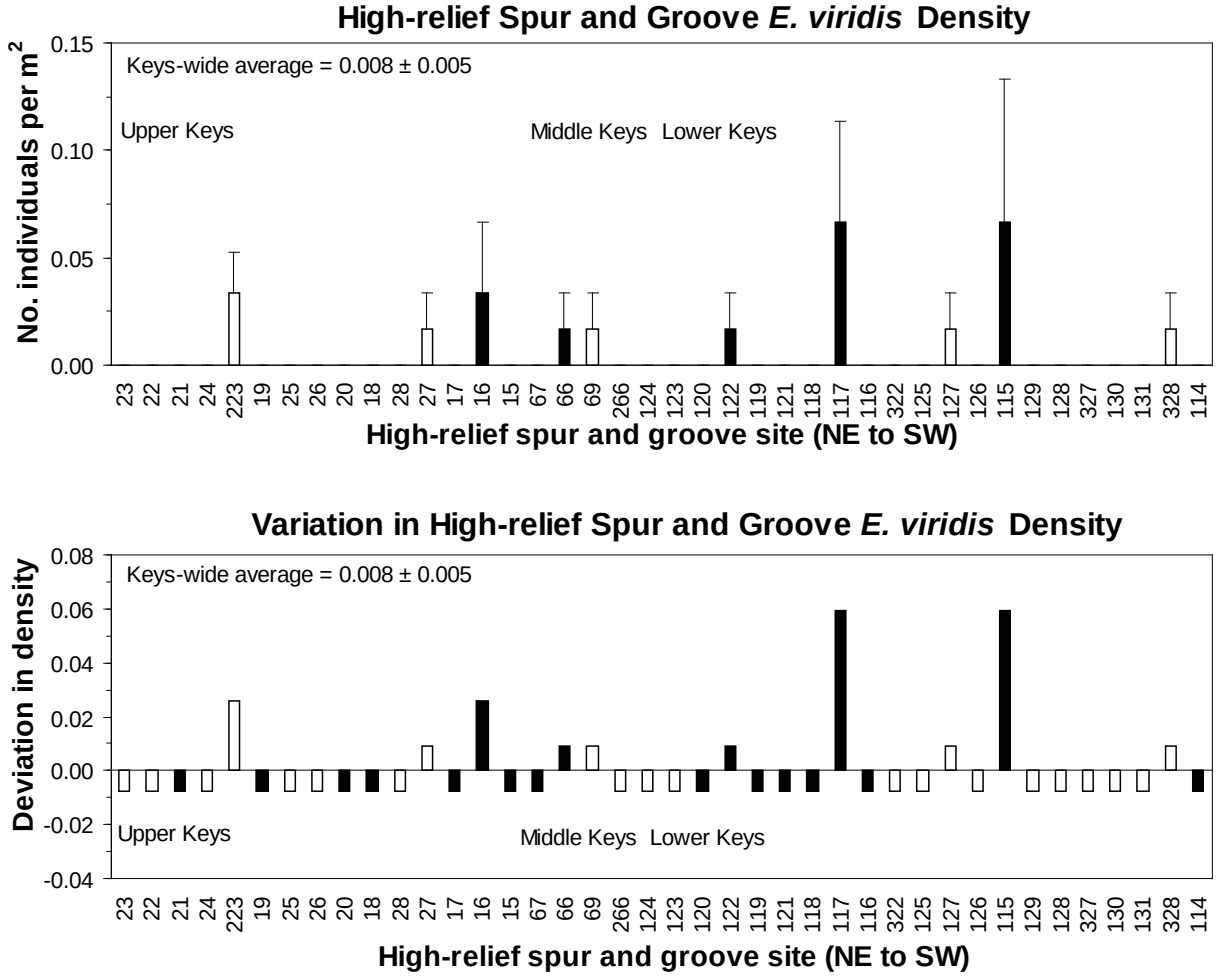


Figure 48. Mean (+ 1 SE) densities (no. per m^2) of green rock-boring urchins (*Echinometra viridis*) on deeper (6-15 m) fore-reef sites (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

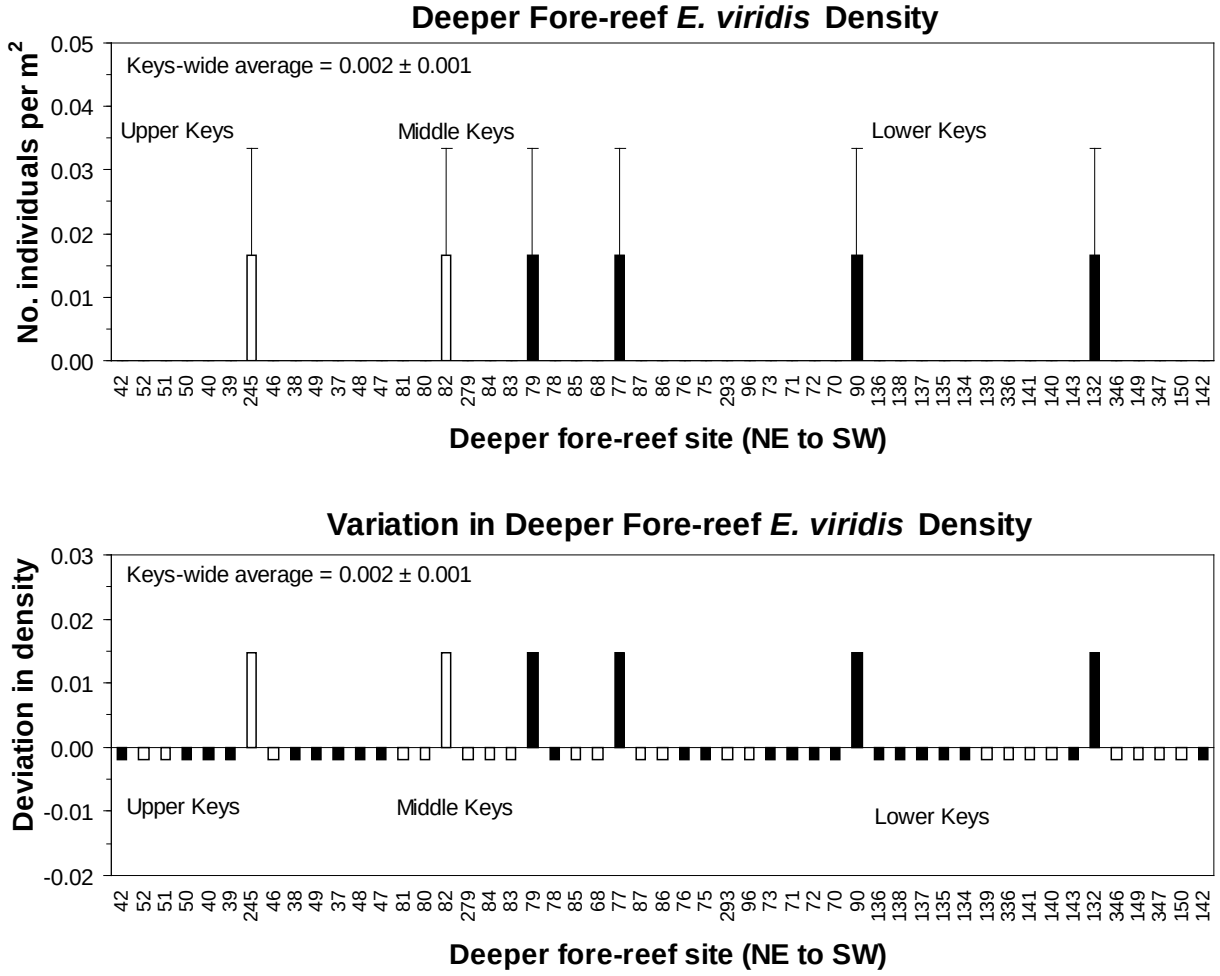


Figure 49. Densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) in the upper Florida Keys (top) and from the southern BNP boundary to Carysfort Reef (bottom) during June-September 2008.

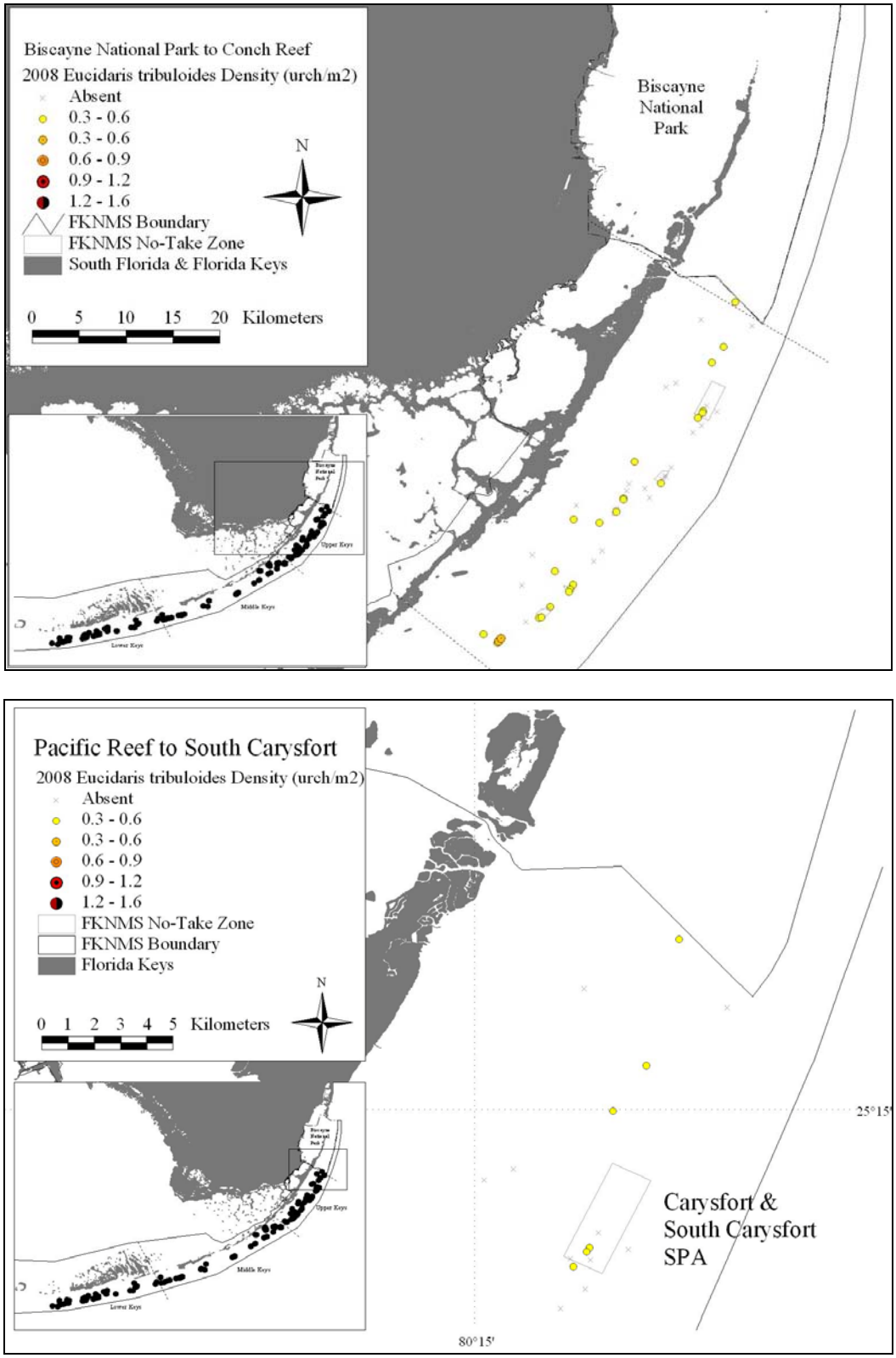
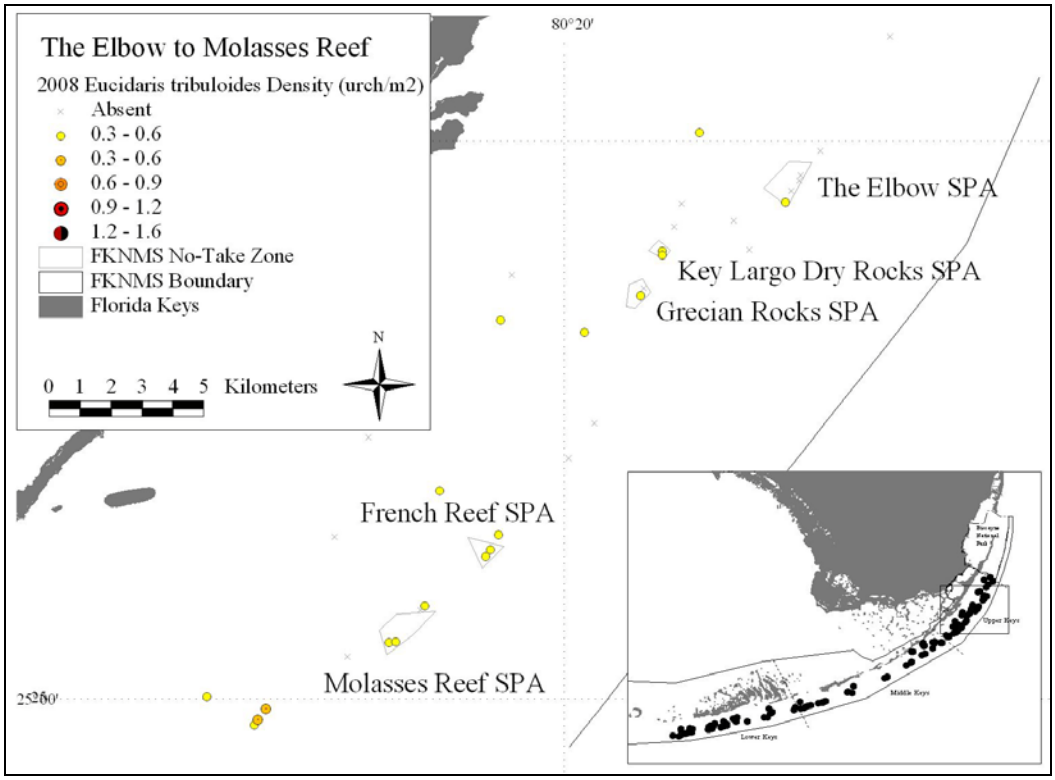


Figure 50. Densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) in the upper Florida Keys from Elbow Reef to Pickles Reef (top) and in the middle Florida Keys (bottom) during June-September 2008.



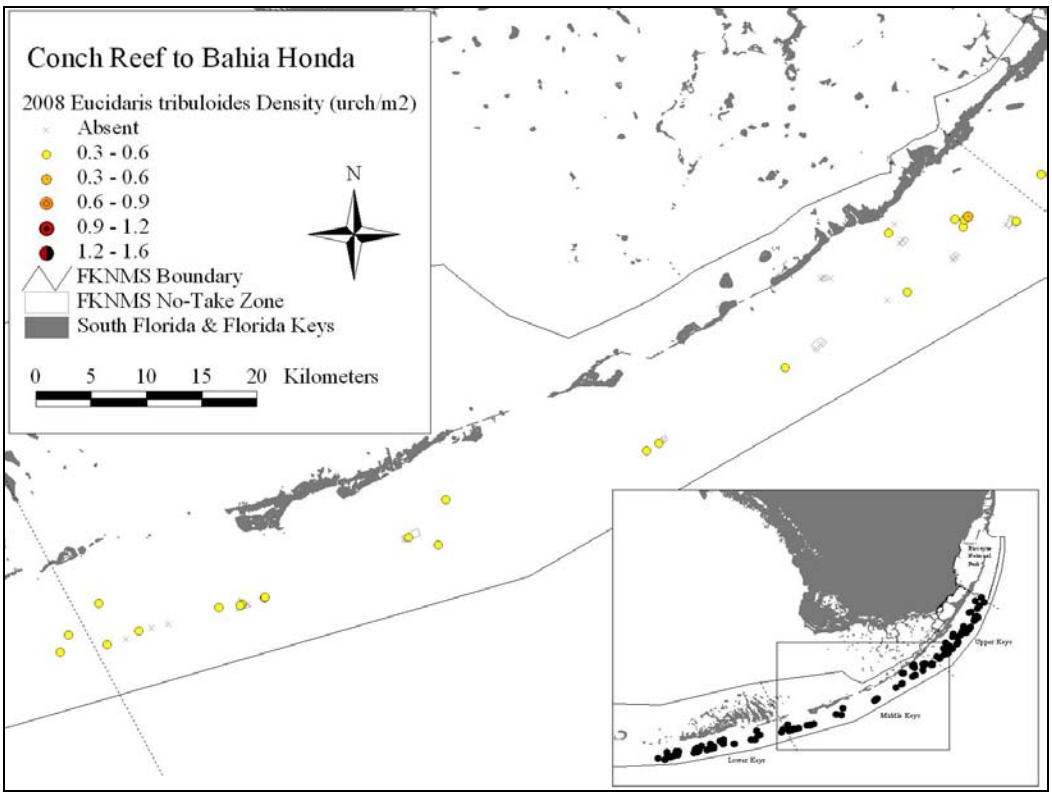
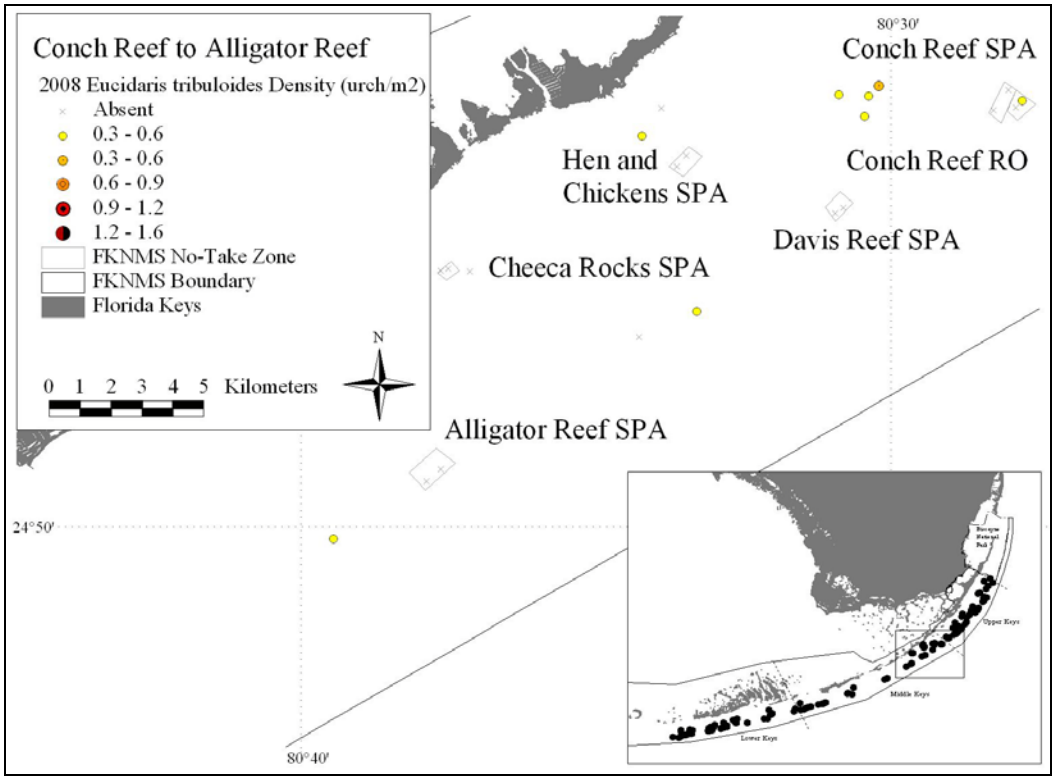


Figure 51. Densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) in the middle Florida Keys from Conch Reef to Alligator Reef (top) and from Tennessee Reef to Coffins Patch (bottom) during June-September 2008.



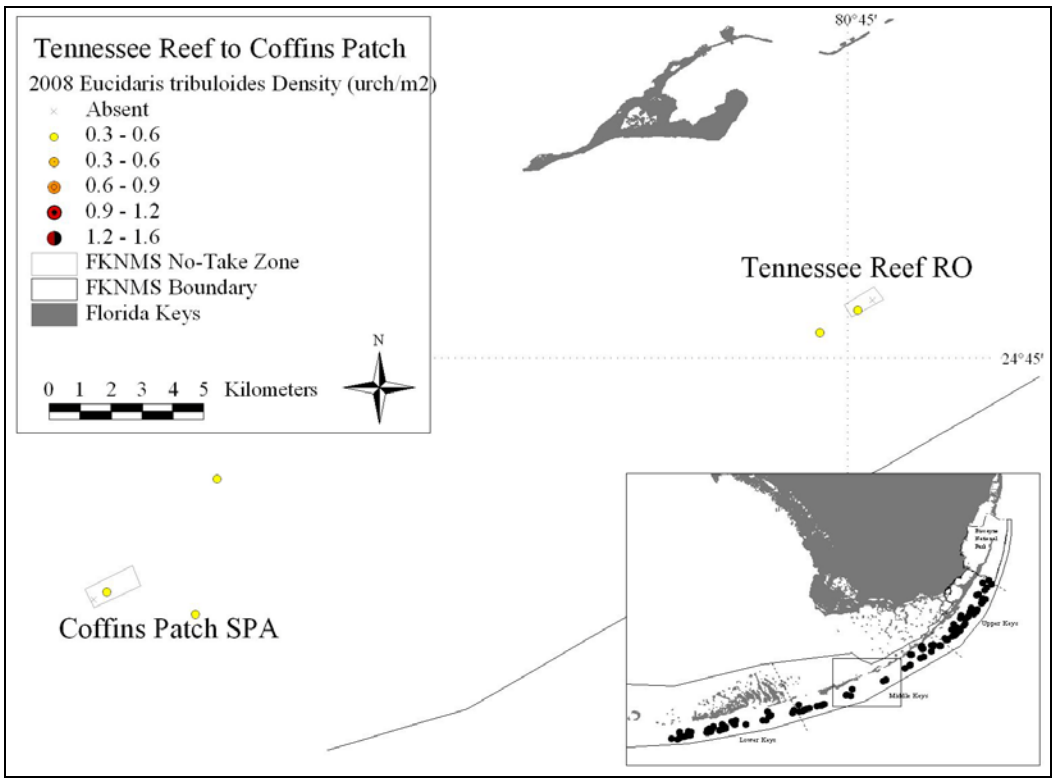


Figure 52. Densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) in the middle Florida Keys from Sombrero Reef to Bahia Honda (top) and in the lower Florida Keys (bottom) during June-September 2008.

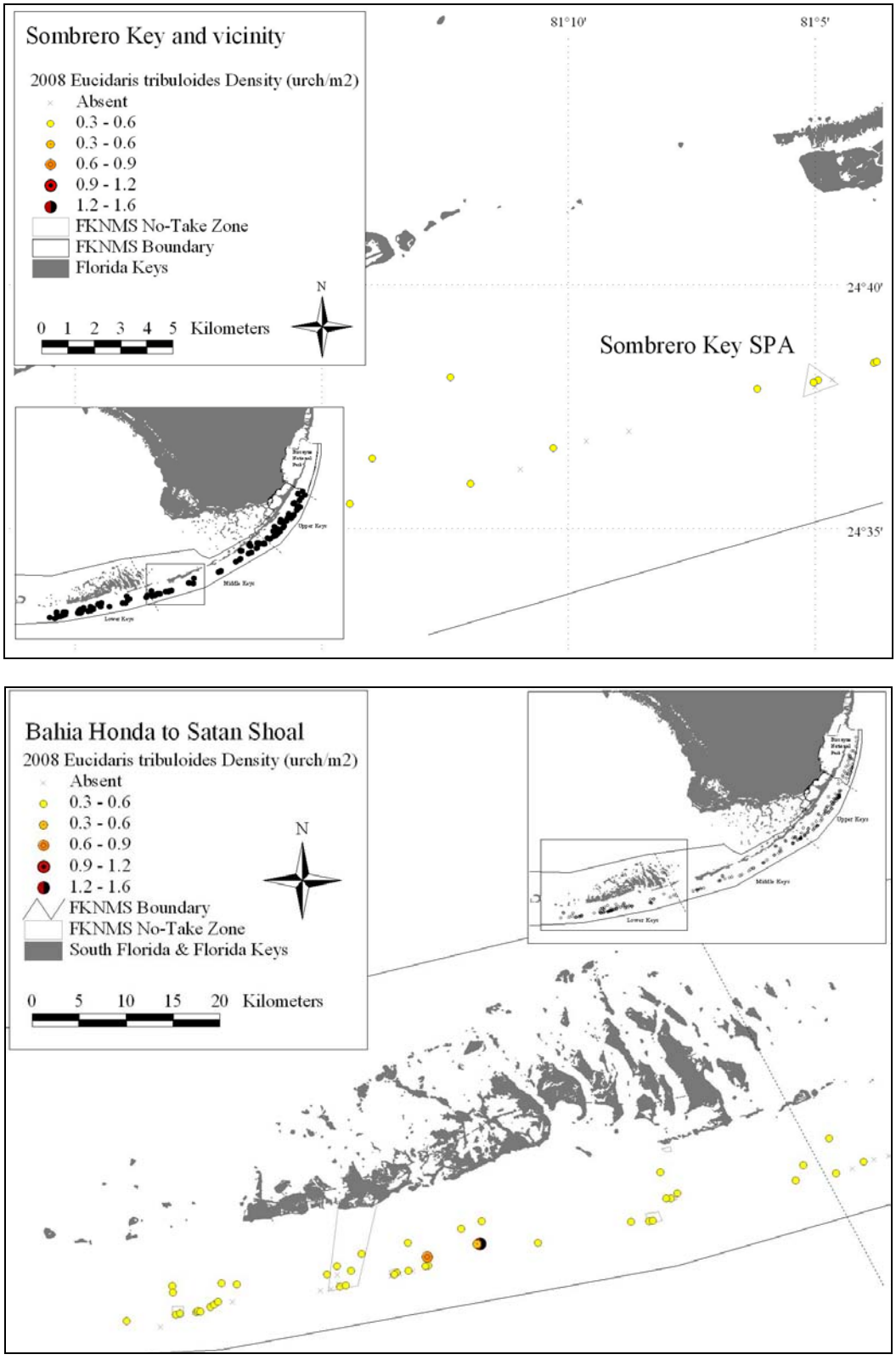


Figure 53. Densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) in the lower Florida Keys from Bahia Honda to Looe Key (top) and from American Shoal to Western Sambo (bottom) during June-September 2008.

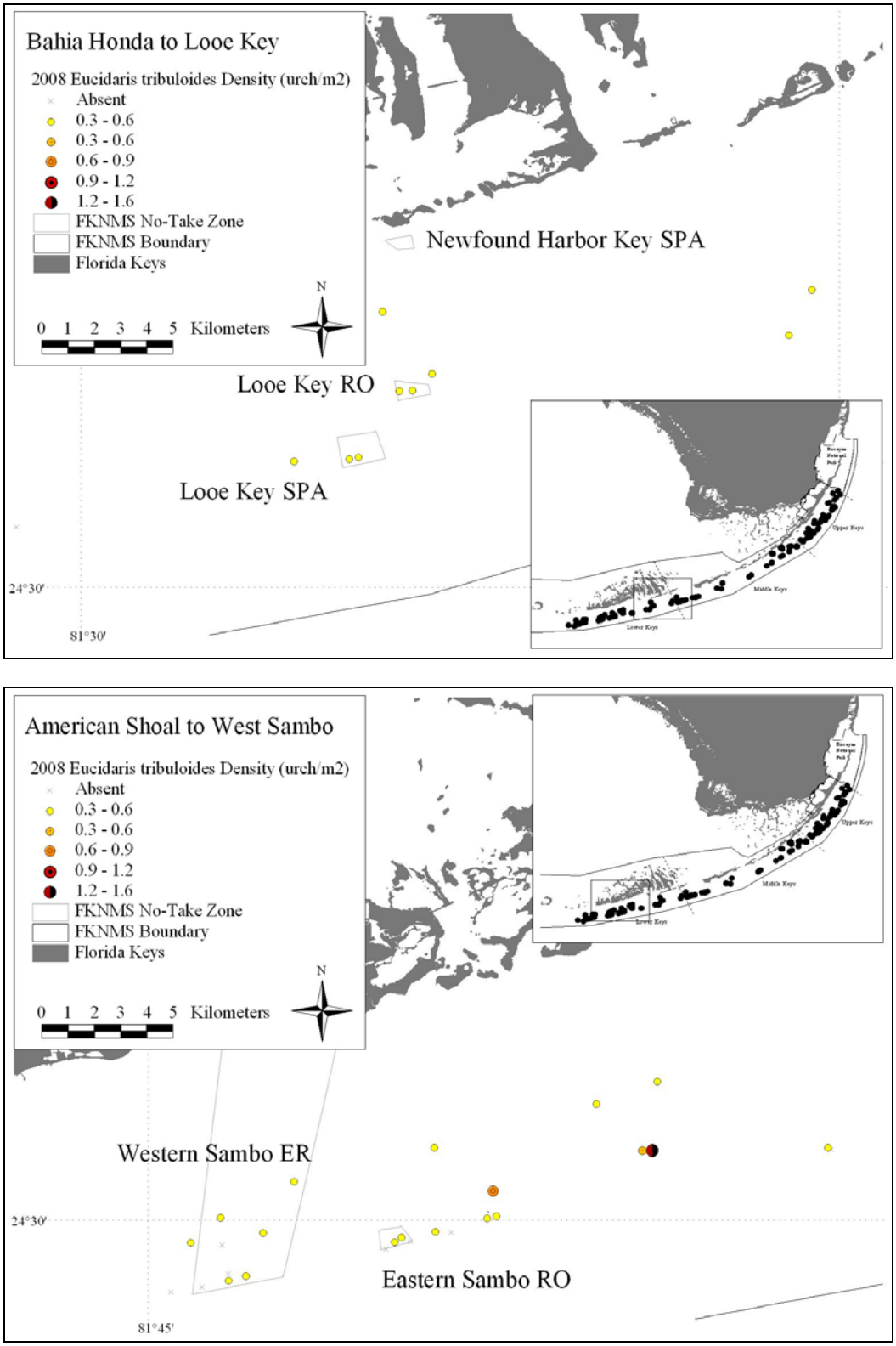


Figure 54. Densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) in the lower Florida Keys from Eastern Dry Rocks to Sand Key during June-September 2008.

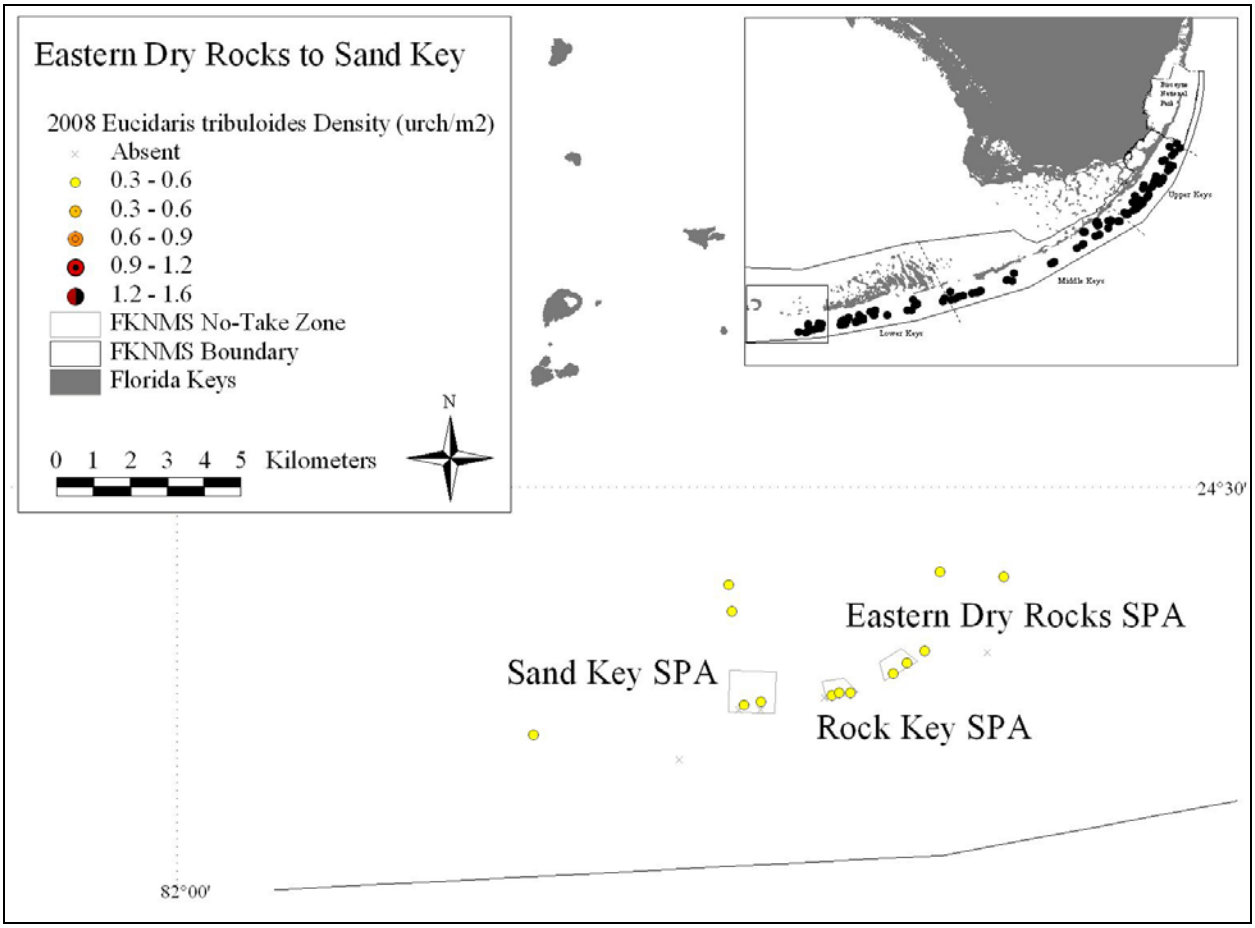


Figure 55. Mean (+ 1 SE) densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) on mid-channel patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

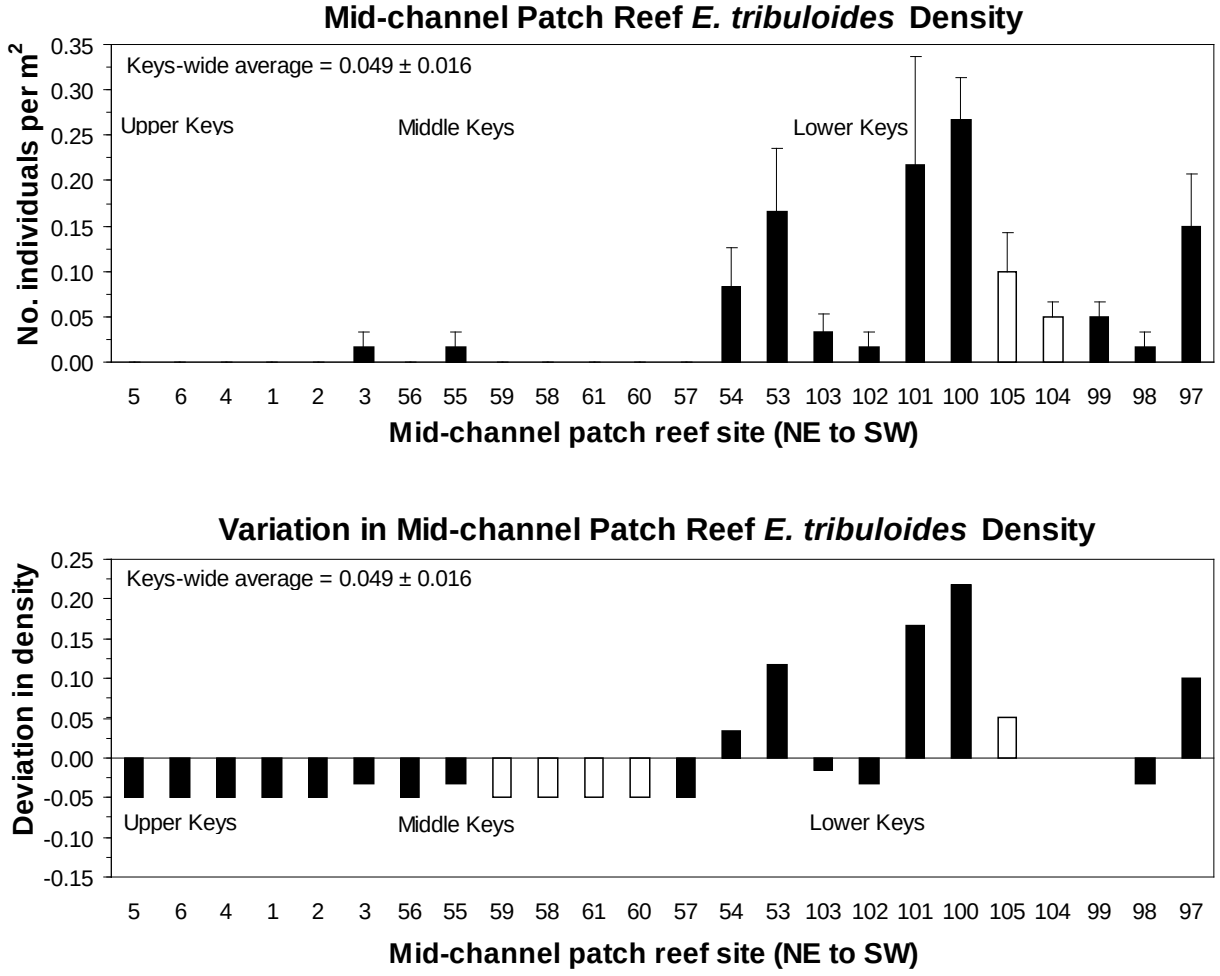


Figure 56. Mean (+ 1 SE) densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) on offshore patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

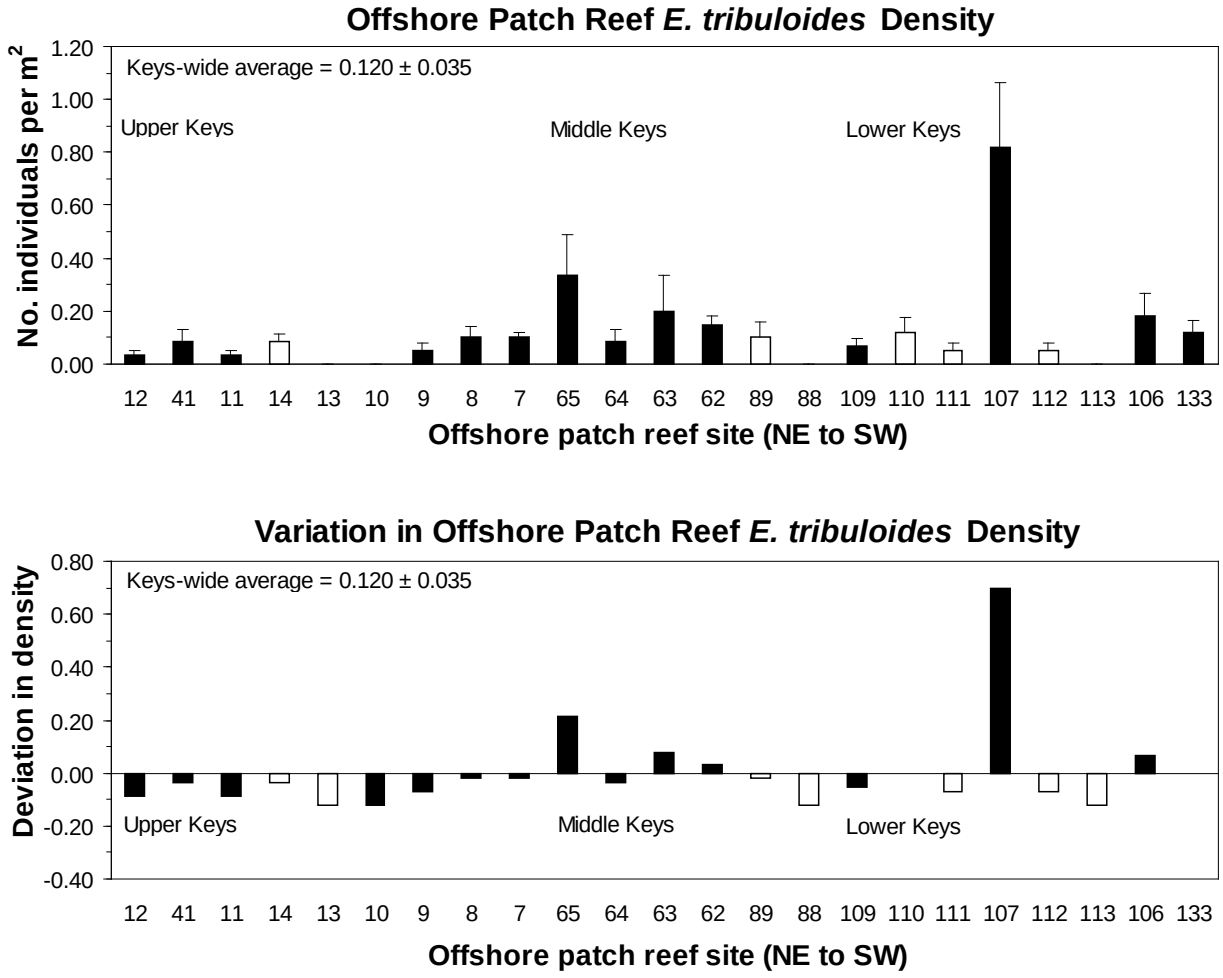


Figure 57. Mean (+ 1 SE) densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) on shallow (< 6 m), high-relief spur and groove reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

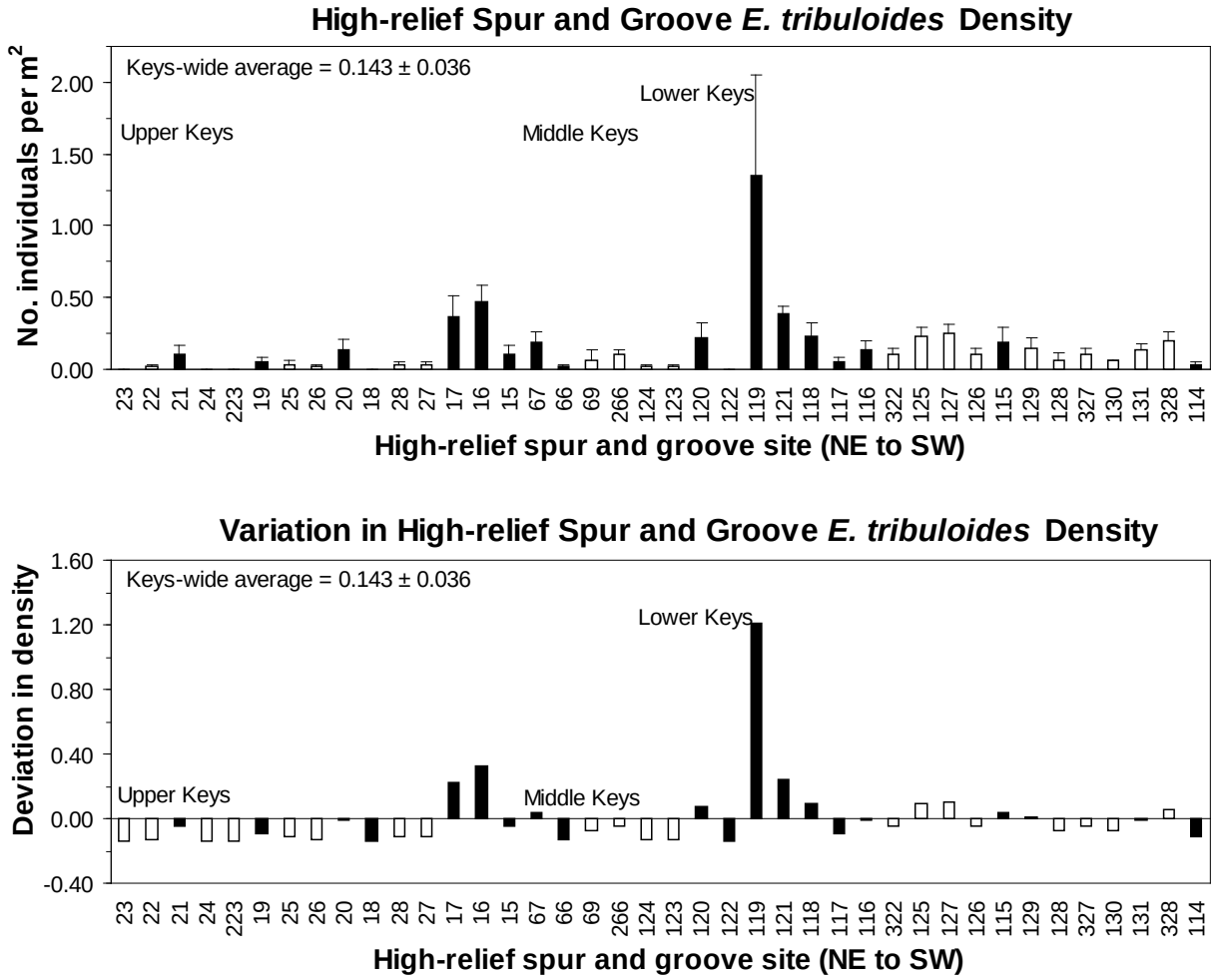


Figure 58. Mean (+ 1 SE) densities (no. per m^2) of slate pencil urchins (*Eucidaris tribuloides*) on deeper (6-15 m) fore-reef sites (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

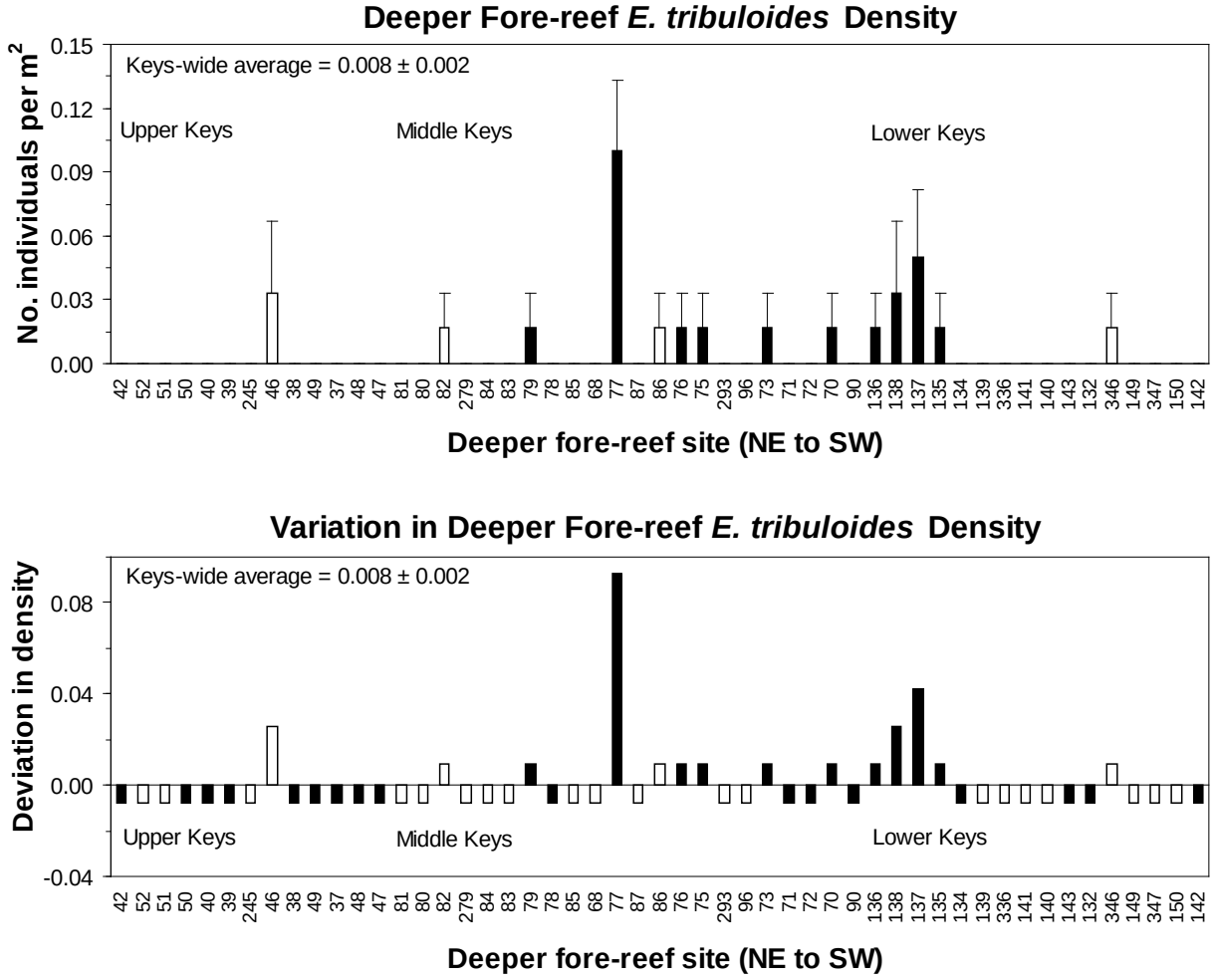


Table 13. Mean ± 1 SE densities (no. individuals per m^2), test diameter (TD, cm), and numbers of individuals (N) sampled for the urchins *Diadema antillarum* and *Echinometra lucunter* in the Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m belt transects per site at 145 sites during June-September 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are no-take marine reserves.

Site number/site location	***Diadema antillarum***			***Echinometra lucunter***		
	No./m^2	**TD (cm)**	**N**	**No./m^2**	**TD (cm)**	**N**
Mid-channel patch reefs						
Upper Florida Keys NMS						
6 - Basin Hill Shoals	0 ± 0	0 ± 0	0	0.033 ± 0.033	2.3 ± 0.3	2
5 - Basin Hill Shoals	0.017 ± 0.017	2.1	1	0 ± 0	0 ± 0	0
4 - Inshore of Grecian Rocks SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
3 - South of Cannon Patch Reef	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
2 - Mosquito Bank	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
1 - Inshore of Molasses Reef	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Upper Florida Keys Total (6)	0.003 ± 0.003	2.1	1	0.006 ± 0.006	2.3	2
Middle Florida Keys NMS						
56 - Tavernier Rocks	0 ± 0		0	0 ± 0	0 ± 0	0
55 - Tavernier Rocks	0 ± 0		0	0 ± 0	0 ± 0	0
59 - Hen and Chickens SPA**	0 ± 0		0	0 ± 0	0 ± 0	0
58 - Hen and Chickens SPA**	0 ± 0		0	0 ± 0	0 ± 0	0
61 - Cheeca Rocks SPA**	0 ± 0		0	0 ± 0	0 ± 0	0
60 - Cheeca Rocks SPA**	0.017 ± 0.017	5.0	1	0 ± 0	0 ± 0	0
57 - NE of Cheeca Rocks SPA	0 ± 0		0	0 ± 0	0 ± 0	0
54 - South of Duck Key	0.017 ± 0.017	4.0	1	0 ± 0	0 ± 0	0
53 - South of Ohio Key	0.033 ± 0.033	0.9 ± 0.00	2	0 ± 0	0 ± 0	0
Middle Florida Keys Total (9)	0.007 ± 0.004	3.3 ± 1.3	4	0 ± 0	0 ± 0	0
Lower Florida Keys NMS						
103 - North of Looe Key RO	0 ± 0		0	0 ± 0	0 ± 0	0
102 - North of Maryland Shoal	0 ± 0		0	0 ± 0	0 ± 0	0
101 - North of Maryland Shoal	0.200 ± 0.090	4.6 ± 0.7	12	0.317 ± 0.126	1.2 ± 0.1	19
100 - North of Eastern Sambo RO	0.250 ± 0.069	4.6 ± 0.6	15	0.033 ± 0.019	3.0 ± 2.1	2
105 - Western Sambo ER**	0.067 ± 0.047	5.0 ± 1.2	4	0 ± 0	0 ± 0	0
104 - Western Sambo ER**	0 ± 0		0	0 ± 0	0 ± 0	0
99 - West of Western Sambo ER	0 ± 0		0	0 ± 0	0 ± 0	0
98 - Middle Ground	0.017 ± 0.017	6.0	1	0 ± 0	0 ± 0	0
97 - Middle Ground	0 ± 0		0	0 ± 0	0 ± 0	0
Lower Florida Keys Total (9)	0.059 ± 0.032	5.0 ± 0.3	32	0.039 ± 0.035	2.1 ± 0.9	21
Mid-channel Patch Reef Total (24)	**0.026 ± 0.013**	**4.0 ± 0.6**	**37**	**0.016 ± 0.013**	**2.1 ± 0.5**	**23**
Offshore patch reefs						
Upper Florida Keys NMS						
12 - South of BNP boundary	0 ± 0		0	0 ± 0	0	0
41 - North of Carysfort Reef SPA	0.017 ± 0.017	1.3	1	0.017 ± 0.017	0.017	1
11 - North of Carysfort Reef SPA	0.183 ± 0.057	4.8 ± 0.5	11	0 ± 0	0	0
14 - Carysfort Reef SPA**	0.017 ± 0.017	1.6	1	0.017 ± 0.017	0.017	1
13 - Carysfort Reef SPA**	0 ± 0		0	0 ± 0	0	0
10 - North of Dry Rocks SPA	0.033 ± 0.019	5.2 ± 0.6	2	0 ± 0	0	0
9 - SW of Grecian Rocks SPA	0.133 ± 0.077	7.7 ± 0.5	8	0 ± 0	0	0
8 - Inshore of French Reef SPA	0 ± 0		0	0 ± 0	0	0
7 - Inshore of Pickles Reef	0.267 ± 0.072	6.2 ± 0.4	16	0 ± 0	0	0
Upper Florida Keys Total (9)	0.072 ± 0.040	4.5 ± 1.0	39	0.004 ± 0.003	2.5 ± 1.6	2
Middle Florida Keys NMS						0
65 - North of Davis Reef SPA	0 ± 0	0 ± 0	0	0.017 ± 0.017	1.0	1
64 - North of Davis Reef SPA	0.017 ± 0.017	1.0	1	0 ± 0	0 ± 0	0

Site number/site location	*Diadema antillarum*			*Echinometra lucunter*		
	No./m^2	**TD (cm)**	**N**	**No./m^2**	**TD (cm)**	**N**
63 - North of Davis Reef SPA	0.033 ± 0.019	6.4 ± 1.6	2	0 ± 0	0 ± 0	0
62 - North of Davis Reef SPA	0.200 ± 0.128	6.0 ± 0.6	12	0 ± 0	0 ± 0	0
89 - Coffins Patch SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
88 - Coffins Patch SPA**	0.033 ± 0.019	3.7 ± 0.4	2	0 ± 0	0 ± 0	0
Middle Florida Keys Total (6)	0 ± 0	4.3 ± 1.2	17	0.003 ± 0.003	1.0	1
Lower Florida Keys NMS						
109 - East of Looe Key RO	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
110 - Looe Key Research Only**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
111 - Looe Key Research Only**	0.017 ± 0.017	0.8	1	0 ± 0	0 ± 0	0
107 - North of Pelican Shoal	0.167 ± 0.111	4.3 ± 0.4	10	0 ± 0	0 ± 0	0
112 - Western Sambo ER**	0.017 ± 0.017	5.0	1	0 ± 0	0 ± 0	0
113 - Western Sambo ER**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
106 - NE of E. Dry Rocks SPA	0.017 ± 0.017	8.0	1	0 ± 0	0 ± 0	0
133 - NE of E. Dry Rocks SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Lower Florida Keys Total (8)	0.027 ± 0.019	4.5 ± 1.5	13	0 ± 0	0 ± 0	0
Offshore Patch Reef Total (23)	**0.051 ± 0.017**	**4.4 ± 0.6**	**69**	**0.002 ± 0.001**	**2.0 ± 1.0**	**3**
Inner line reef tract spur & groove						
Upper Florida Keys NMS						
32 - Turtle Rocks	0.017 ± 0.017	2.0	1	0.033 ± 0.019	1.7 ± 0.7	2
31 - Inshore of Elbow Reef SPA	0 ± 0		0	0 ± 0	0 ± 0	0
30 - North Dry Rocks	0.017 ± 0.017	7.2	1	0 ± 0	0 ± 0	0
34 - Dry Rocks SPA**	0 ± 0		0	0 ± 0	0 ± 0	0
33 - Dry Rocks SPA**	0.017 ± 0.017	5.0	1	0 ± 0	0 ± 0	0
36 - Grecian Rocks SPA**	0 ± 0		0	0 ± 0	0 ± 0	0
35 - Grecian Rocks SPA**	0 ± 0		0	0 ± 0	0 ± 0	0
Upper Florida Keys Total (7)	0.007 ± 0.003	4.7 ± 1.5	3	0.005 ± 0.005	1.7	2
Inner Line Spur & Groove Total (7)	**0.007 ± 0.003**	**4.7 ± 1.5**	**3**	**0.005 ± 0.005**	**1.7**	**2**
High-relief spur & groove						
Upper Florida Keys NMS						
23 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
22 - Carysfort Reef SPA**	0.017 ± 0.017	1.5	1	0 ± 0	0 ± 0	0
21 - Maitland grounding site	0.017 ± 0.017	5.8	1	0 ± 0	0 ± 0	0
24 - Elbow Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
223 - Elbow Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
19 - North of French Reef SPA	0.033 ± 0.033	4.8 ± 0.3	2	0 ± 0	0 ± 0	0
25 - French Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
26 - French Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
20 - Sand Island	0.017 ± 0.017	1.0	1	0 ± 0	0 ± 0	0
18 - Sand Island	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
28 - Molasses Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
27 - Molasses Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
17 - Pickles Reef	0.050 ± 0.050	4.2 ± 0.1	3	0 ± 0	0 ± 0	0
16 - Pickles Reef	0.017 ± 0.017	0.9	1	0.017 ± 0.017	0.8	1
15 - Pickles Reef	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Upper Florida Keys Total (15)	0 ± 0	3.0 ± 0.9	**9**	0.001 ± 0.001	0.8	1
Middle Florida Keys NMS						
67 - Delta Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
66 - Delta Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
69 - Sombrero Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
266 - Sombrero Key SPA**	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
Lower Florida Keys NMS						

Site number/site location	*Diadema antillarum*			*Echinometra lucunter*		
	No./m^2	**TD (cm)**	**N**	**No./m^2**	**TD (cm)**	**N**
124 - Looe Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
123 - Looe Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
120 - American Shoal	0.017 ± 0.017	1.5	1	0 ± 0	0 ± 0	0
122 - American Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
119 - Maryland Shoal	0.167 ± 0.058	5.8 ± 0.6	10	0.050 ± 0.032	1.1 ± 0.2	3
121 - Maryland Shoal	0.183 ± 0.069	6.8 ± 0.6	11	1.183 ± 0.362	2.0 ± 0.1	71
118 - Pelican Shoal	0 ± 0	0 ± 0	0	0.017 ± 0.017	1.0 ± 0	1
117 - Pelican Shoal	0.033 ± 0.033	3.7 ± 1.2	2	0 ± 0	0 ± 0	0
116 - No Name Reef	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
322 - Eastern Sambo RO**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
125 - Eastern Sambo RO**	0.033 ± 0.019	1.3 ± 0.7	2	0 ± 0	0 ± 0	0
127 - Western Sambo ER**	0.017 ± 0.017	3.5	1	0.017 ± 0.017	1.8	1
126 - Western Sambo ER**	0 ± 0	0 ± 0	0	0.033 ± 0.033	1.1 ± 0.3	2
115 - East of E. Dry Rocks SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
129 - Eastern Dry Rocks SPA**	0.017 ± 0.017	3.0	1	0 ± 0	0 ± 0	0
128 - Eastern Dry Rocks**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
327 - Rock Key SPA**	0.017 ± 0.017	3.0	1	0 ± 0	0 ± 0	0
130 - Rock Key SPA**	0.033 ± 0.019	3.5 ± 0.5	2	0.017 ± 0.017	3.0	1
131 - Sand Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
328 - Sand Key SPA**	0.033 ± 0.033	2.5 ± 0.0	2	0 ± 0	0 ± 0	0
114 - Western Dry Rocks	0.033 ± 0.033	4.2 ± 2.1	2	0 ± 0	0 ± 0	0
Lower Florida Keys Total (21)	0.028 ± 0.011	3.5 ± 0.5	35	0.063 ± 0.056	1.7 ± 0.3	79
High-relief Spur & Groove Total (40)	**0.018 ± 0.006**	**3.3 ± 0.4**	**44**	**0.033 ± 0.030**	**1.5 ± 0.3**	**80**
Fore-reef (6-15 m)						
Upper Florida Keys NMS						
42 - South of BNP boundary	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
52 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
51 - Carysfort Reef SPA**	0.017 ± 0.017	1.0	1	0 ± 0	0 ± 0	0
50 - SW of Carysfort Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
40 - SW of Carysfort Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
39 - North of Elbow Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
245 - Elbow Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
46 - Elbow Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
38 - SW of Elbow Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
49 - South of Elbow Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
37 - Dixie Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
48 - Dixie Shoal	0.017 ± 0.017	3.8	1	0 ± 0	0 ± 0	0
47 - SW of Molasses Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Upper Florida Keys Total (13)	0.003 ± 0.002	2.4 ± 1.4	2	0 ± 0	0 ± 0	0
Middle Florida Keys NMS						
81 - Conch Reef SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
80 - Conch Reef SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
82 - Conch Reef RO**	0.017 ± 0.017	1.5	1	0 ± 0	0 ± 0	0
279 - Conch Reef RO**	0 ± 0	0	0	0 ± 0	0 ± 0	0
84 - Davis Reef SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
83 - Davis Reef SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
79 - SW of Crocker Reef	0.017 ± 0.017	2.0	1	0 ± 0	0 ± 0	0
78 - SW of Crocker Reef	0 ± 0	0	0	0 ± 0	0 ± 0	0
85 - Alligator Reef SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
68 - Alligator Reef SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
77 - SW of Alligator Reef SPA	0 ± 0	0	0	0 ± 0	0 ± 0	0
87 - Tennessee Reef RO**	0.017 ± 0.017	6.0	1	0 ± 0	0 ± 0	0
86 - Tennessee Reef RO**	0.050 ± 0.017	4.4 ± 1.7	3	0 ± 0	0 ± 0	0
76 - NE of Tennessee Light	0.017 ± 0.017	5.2	1	0 ± 0	0 ± 0	0
75 - East of Coffins Patch SPA	0.017 ± 0.017	1.5	1	0 ± 0	0 ± 0	0
293 - Sombrero Key SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
96 - Sombrero Key SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0

Site number/site location	*Diadema antillarum*			*Echinometra lucunter*		
	No./m^2	**TD (cm)**	**N**	**No./m^2**	**TD (cm)**	**N**
73 - West of Sombrero Key SPA	0.033 ± 0.019	1.2 ± 0.3	2	0 ± 0	0 ± 0	0
71 - South of Moser Channel	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
72 - South of Moser Channel	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
70 - South of Moser Channel	0.017 ± 0.017	1.5	1	0 ± 0	0 ± 0	0
90 - South of Moser Channel	0.033 ± 0.019	2.0 ± 0.0	2	0 ± 0	0 ± 0	0
Middle Florida Keys Total (22)	0.010 ± 0.003	2.8 ± 0.6	13	0 ± 0	0 ± 0	0
Lower Florida Keys NMS						
136 - South of Bahia Honda Key	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
138 - South of Bahia Honda Key	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
137 - South of Bahia Honda Key	0.033 ± 0.019	4.4 ± 1.6	2	0 ± 0	0 ± 0	0
135 - West of Looe Key SPA	0.017 ± 0.017	1.1	1	0 ± 0	0 ± 0	0
134 - West of Pelican Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
139 - Eastern Sambo RO**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
336 - Eastern Sambo RO**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
141 - Western Sambo ER**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
140 - Western Sambo ER**	0.067 ± 0.027	3.2 ± 1.5	4	0 ± 0	0 ± 0	0
143 - West of Western Sambo	0.033 ± 0.033	1.8 ± 0.3	2	0 ± 0	0 ± 0	0
132 - East of E. Dry Rocks SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
346 - Rock Key SPA**	0.033 ± 0.033	3.9 ± 3.0	2	0 ± 0	0 ± 0	0
149 - Rock Key SPA**	0.017 ± 0.017	8.0	1	0 ± 0	0 ± 0	0
347 - Sand Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
150 - Sand Key SPA**	0.017 ± 0.017	1.0	1	0 ± 0	0 ± 0	0
142 - SW of Sand Key SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Lower Florida Keys Total (16)	0.014 ± 0.005	3.3 ± 0.9	13	0 ± 0	0 ± 0	0
Fore-reef Total (51)	**0.009 ± 0.002**	**3.0 ± 0.5**	**28**	**0 ± 0**	**0 ± 0**	**0**

Table 14. Mean ± 1 SE densities (no. individuals per m^2), test diameter (TD, cm), and numbers of individuals (N) sampled for the urchins *Echinometra viridis* and *Eucidaris tribuloides* in the Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m belt transects per site at 145 sites during June-September 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are no-take marine reserves.

Site number/site location	***Echinometra viridis***			***Eucidaris tribuloides***		
	No./m^2	TD (cm)	N	No./m^2	TD (cm)	N
Mid-channel patch reefs						
Upper Florida Keys NMS						
6 - Basin Hill Shoals	0.367 ± 0.229	3.2 ± 0.2	22	0 ± 0	0 ± 0	0
5 - Basin Hill Shoals	0.400 ± 0.198	3.0 ± 0.2	24	0 ± 0	0 ± 0	0
4 - Inshore of Grecian Rocks SPA	0.033 ± 0.019	1.4 ± 0.5	2	0 ± 0	0 ± 0	0
3 - South of Cannon Patch Reef	0.850 ± 0.242	2.7 ± 0.1	51	0.017 ± 0.017	2.5	1
2 - Mosquito Bank	1.950 ± 0.590	3.0 ± 0.1	117	0 ± 0	0 ± 0	0
1 - Inshore of Molasses Reef	0.717 ± 0.193	2.5 ± 0.1	43	0 ± 0	0 ± 0	0
Upper Florida Keys Total (6)	0.719 ± 0.273	2.6 ± 0.3	259	0.003 ± 0.003	2.5	1
Middle Florida Keys NMS						
56 - Tavernier Rocks	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
55 - Tavernier Rocks	0.017 ± 0.017	2.0	1	0.017 ± 0.017	3.5	1
59 - Hen and Chickens SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
58 - Hen and Chickens SPA**	0.033 ± 0.033	1.8 ± 0.3	2	0 ± 0	0 ± 0	0
61 - Cheeca Rocks SPA**	0.033 ± 0.033	2.1 ± 0.9	2	0 ± 0	0 ± 0	0
60 - Cheeca Rocks SPA**	0.067 ± 0.047	1.7 ± 0.2	4	0 ± 0	0 ± 0	0
57 - NE of Cheeca Rocks SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
54 - South of Duck Key	0.233 ± 0.079	2.5 ± 0.2	14	0.083 ± 0.042	2.5 ± 0.2	5
53 - South of Ohio Key	0.017 ± 0.017	2.2	1	0.167 ± 0.069	2.5 ± 0.2	10
Middle Florida Keys Total (9)	0.044 ± 0.025	2.0 ± 0.1	24	0.030 ± 0.019	2.8 ± 0.3	16
Lower Florida Keys NMS						
103 - North of Looe Key RO	0.017 ± 0.017	2.0	1	0.033 ± 0.019	2.5 ± 0.5	2
102 - North of Maryland Shoal	0.183 ± 0.074	2.4 ± 0.2	11	0.017 ± 0.017	2.9	1
101 - North of Maryland Shoal	0.667 ± 0.226	2.5 ± 0.1	40	0.217 ± 0.120	3.0 ± 0.2	13
100 - North of Eastern Sambo RO	1.900 ± 0.278	2.9 ± 0.1	114	0.267 ± 0.047	2.4 ± 0.2	16
105 - Western Sambo ER**	0.033 ± 0.019	2.5 ± 0.5	2	0.100 ± 0.043	2.9 ± 0.1	6
104 - Western Sambo ER**	0.017 ± 0.017	1.0	1	0.050 ± 0.017	2.5 ± 0.5	3
99 - West of Western Sambo ER	0 ± 0	0 ± 0	0	0.050 ± 0.017	1.9 ± 0.4	3
98 - Middle Ground	4.750 ± 0.872	2.9 ± 0.0	285	0.017 ± 0.017	2.0	1
97 - Middle Ground	0.667 ± 0.136	2.8 ± 0.1	40	0.150 ± 0.057	2.3 ± 0.2	9
Lower Florida Keys Total (9)	0.915 ± 0.521	2.4 ± 0.2	494	0.100 ± 0.031	2.5 ± 0.1	54
Mid-channel Patch Reef Total (24)	**0.540 ± 0.215**	**2.3 ± 0.1**	**777**	**0.049 ± 0.016**	**2.6 ± 0.1**	**71**
Offshore patch reefs						
Upper Florida Keys NMS						
12 - South of BNP boundary	0 ± 0	0	0	0.033 ± 0.019	3.1 ± 1.0	2
41 - North of Carysfort Reef SPA	0 ± 0	0	0	0.083 ± 0.050	2.1 ± 0.3	5
11 - North of Carysfort Reef SPA	0 ± 0	0	0	0.083 ± 0.019	2.8 ± 0.3	2
14 - Carysfort Reef SPA**	0.017 ± 0.017	1.0	1	0.083 ± 0.032	2.5 ± 0.2	5
13 - Carysfort Reef SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
10 - North of Dry Rocks SPA	0 ± 0	0	0	0 ± 0	0 ± 0	0
9 - SW of Grecian Rocks SPA	0 ± 0	0	0	0.050 ± 0.032	2.2 ± 0.2	3
8 - Inshore of French Reef SPA	0 ± 0	0	0	0.100 ± 0.043	2.2 ± 0.1	6
7 - Inshore of Pickles Reef	0.033 ± 0.019	1.0 ± 0.1	2	0.100 ± 0.019	2.0 ± 0.2	6
Upper Florida Keys Total (9)	0.006 ± 0.005	1.0 ± 0.0	3	0.054 ± 0.016	2.4 ± 0.2	29
Middle Florida Keys NMS						
65 - North of Davis Reef SPA	0.200 ± 0.156	2.0 ± 0.3	12	0.333 ± 0.156	2.2 ± 0.1	20
64 - North of Davis Reef SPA	0.033 ± 0.019	3.0 ± 0.0	2	0.083 ± 0.050	3.2 ± 0.1	5

Site number/site location	*Echinometra viridis*			*Eucidaris tribuloides*		
	No./m^2	TD (cm)	N	No./m^2	TD (cm)	N
63 - North of Davis Reef SPA	0 ± 0	0 ± 0	0	0.200 ± 0.136	2.8 ± 0.2	12
62 - North of Davis Reef SPA	0.017 ± 0.017	0.8	1	0.150 ± 0.032	2.6 ± 0.2	9
89 - Coffins Patch SPA**	0 ± 0	0 ± 0	0	0.100 ± 0.058	2.4 ± 0.2	6
88 - Coffins Patch SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Middle Florida Keys Total (6)	0.042 ± 0.032	1.9 ± 0.6	15	0.144 ± 0.047	2.6 ± 0.2	52
Lower Florida Keys NMS						
109 - East of Looe Key RO	0 ± 0	0 ± 0	0	0.067 ± 0.027	2.3 ± 0.2	4
110 - Looe Key Research Only**	0 ± 0	0 ± 0	0	0.117 ± 0.057	2.5 ± 0.3	7
111 - Looe Key Research Only**	0 ± 0	0 ± 0	0	0.050 ± 0.032	1.6 ± 0.4	3
107 - North of Pelican Shoal	0.017 ± 0.017	2.0	1	0.817 ± 0.246	3.0 ± 0.1	49
112 - Western Sambo ER**	0.083 ± 0.032	1.6 ± 0.4	5	0.050 ± 0.032	2.7 ± 0.2	3
113 - Western Sambo ER**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
106 - NE of E. Dry Rocks SPA	0.050 ± 0.032	2.8 ± 0.6	3	0.183 ± 0.083	2.1 ± 0.1	11
133 - NE of E. Dry Rocks SPA	0.017 ± 0.017	1.6	1	0.117 ± 0.050	2.7 ± 0.3	7
Lower Florida Keys Total (8)	0.021 ± 0.010	2.0 ± 0.3	10	0.175 ± 0.088	2.4 ± 0.2	84
Offshore Patch Reef Total (23)	**0.020 ± 0.009**	**1.8 ± 0.3**	**28**	**0.117 ± 0.035**	**2.4 ± 0.1**	**165**
Inner line reef tract spur & groove						
Upper Florida Keys NMS						
32 - Turtle Rocks	0.017 ± 0.017	1.4	1	0 ± 0	0 ± 0	0
31 - Inshore of Elbow Reef SPA	0.033 ± 0.019	2.3 ± 0.3	2	0.100 ± 0.043	2.4 ± 0.3	6
30 - North Dry Rocks	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
34 - Dry Rocks SPA**	0 ± 0	0 ± 0	0	0.050 ± 0.032	2.0 ± 0.5	3
33 - Dry Rocks SPA**	0 ± 0	0 ± 0	0	0.117 ± 0.057	2.1 ± 0.2	7
36 - Grecian Rocks SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
35 - Grecian Rocks SPA**	0 ± 0	0 ± 0	0	0.067 ± 0.047	1.8 ± 0.3	4
Upper Florida Keys Total (7)	0.007 ± 0.005	1.8 ± 0.4	3	0.048 ± 0.019	2.1 ± 0.1	20
Inner Line Spur & Groove Total (7)	**0.077 ± 0.005**	**1.8 ± 0.4**	**3**	**0.048 ± 0.019**	**2.1 ± 0.1**	**0**
High-relief spur & groove						
Upper Florida Keys NMS						
23 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
22 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0	0.017 ± 0.017	3.0	1
21 - Maitland grounding site	0 ± 0	0 ± 0	0	0.100 ± 0.064	1.9 ± 0.1	6
24 - Elbow Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
223 - Elbow Reef SPA**	0.033 ± 0.019	2.5 ± 0.5	2	0 ± 0	0 ± 0	0
19 - North of French Reef SPA	0 ± 0	0 ± 0	0	0.050 ± 0.032	2.7 ± 0.2	3
25 - French Reef SPA**	0 ± 0	0 ± 0	0	0.033 ± 0.033	1.5 ± 0.6	2
26 - French Reef SPA**	0 ± 0	0 ± 0	0	0.017 ± 0.017	1.9	1
20 - Sand Island	0 ± 0	0 ± 0	0	0.133 ± 0.072	1.7 ± 0.2	8
18 - Sand Island	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
28 - Molasses Reef SPA**	0 ± 0	0 ± 0	0	0.033 ± 0.019	1.6 ± 0.5	2
27 - Molasses Reef SPA**	0.017 ± 0.017	1.5	1	0.033 ± 0.019	1.6 ± 0.4	2
17 - Pickles Reef	0 ± 0	0 ± 0	0	0.367 ± 0.145	1.8 ± 0.1	22
16 - Pickles Reef	0.033 ± 0.033	1.0 ± 0.3	2	0.467 ± 0.119	1.8 ± 0.1	28
15 - Pickles Reef	0 ± 0	0 ± 0	0	0.100 ± 0.064	2.0 ± 0.2	6
Upper Florida Keys Total (15)	0.006 ± 0.003	1.7 ± 0.4	5	0.090 ± 0.036	1.9 ± 0.1	81
Middle Florida Keys NMS						
67 - Delta Shoal	0 ± 0	0 ± 0	0	0.183 ± 0.083	1.7 ± 0.2	11
66 - Delta Shoal	0.017 ± 0.017	3.0	1	0.017 ± 0.017	1.9	1
69 - Sombrero Key SPA**	0.017 ± 0.017	2.3	1	0.067 ± 0.067	1.9 ± 0.3	4
266 - Sombrero Key SPA**	0 ± 0	0 ± 0	0	0.100 ± 0.033	1.9 ± 0.2	6
Middle Florida Keys Total (4)	0.008 ± 0.005	2.7 ± 0.3	2	0.092 ± 0.035	1.8 ± 0.1	22
Lower Florida Keys NMS						

Site number/site location	*Echinometra viridis*			*Eucidaris tribuloides*		
	No./m^2	TD (cm)	N	No./m^2	TD (cm)	N
124 - Looe Key SPA**	0 ± 0	0 ± 0	0	0.017 ± 0.017	2.5	1
123 - Looe Key SPA**	0 ± 0	0 ± 0	0	0.017 ± 0.017	3.0	1
120 - American Shoal	0 ± 0	0 ± 0	0	0.217 ± 0.107	2.0 ± 0.1	13
122 - American Shoal	0.017 ± 0.017	1.9	1	0 ± 0	0 ± 0	0
119 - Maryland Shoal	0 ± 0	0 ± 0	0	1.350 ± 0.703	2.3 ± 0.1	81
121 - Maryland Shoal	0 ± 0	0 ± 0	0	0.383 ± 0.057	2.4 ± 0.1	23
118 - Pelican Shoal	0 ± 0	0 ± 0	0	0.233 ± 0.088	1.8 ± 0.1	14
117 - Pelican Shoal	0.067 ± 0.047	1.6 ± 0.3	4	0.050 ± 0.032	2.1 ± 0.4	3
116 - No Name Reef	0 ± 0	0 ± 0	0	0.133 ± 0.061	1.5 ± 0.1	8
322 - Eastern Sambo RO**	0 ± 0	0 ± 0	0	0.100 ± 0.043	2.1 ± 0.3	6
125 - Eastern Sambo RO**	0 ± 0	0 ± 0	0	0.233 ± 0.058	2.0 ± 0.1	14
127 - Western Sambo ER**	0.017 ± 0.017	0.9	1	0.250 ± 0.069	1.8 ± 0.1	15
126 - Western Sambo ER**	0 ± 0	0 ± 0	0	0.100 ± 0.043	1.6 ± 0.3	6
115 - East of E. Dry Rocks SPA	0.067 ± 0.067	1.3 ± 0.3	4	0.183 ± 0.107	1.4 ± 0.1	11
129 - Eastern Dry Rocks SPA**	0 ± 0	0 ± 0	0	0 ± 0	1.9 ± 0.2	9
128 - Eastern Dry Rocks**	0 ± 0	0 ± 0	0	0.067 ± 0.047	2.5 ± 0.3	4
327 - Rock Key SPA**	0 ± 0	0 ± 0	0	0.100 ± 0.043	2.0 ± 0.2	6
130 - Rock Key SPA**	0 ± 0	0 ± 0	0	0.067 ± 0.000	1.8 ± 0.3	4
131 - Sand Key SPA**	0 ± 0	0 ± 0	0	0.133 ± 0.047	2.0 ± 0.2	8
328 - Sand Key SPA**	0.017 ± 0.017	3.0	1	0.200 ± 0.061	2.1 ± 0.2	12
114 - Western Dry Rocks	0 ± 0	0 ± 0	0	0.033 ± 0.019	1.6 ± 0.4	2
Lower Florida Keys Total (21)	0.009 ± 0.004	1.7 ± 0.4	11	0.191 ± 0.062	2.0 ± 0.1	241
Spur & Groove Total (40)	**0.008 ± 0.003**	**1.9 ± 0.2**	**18**	**0.143 ± 0.036**	**2.0 ± 0.1**	**344**
Fore-reef (6-15 m)						
Upper Florida Keys NMS						
42 - South of BNP boundary	0 ± 0	0	0	0 ± 0	0	0
52 - Carysfort Reef SPA**	0 ± 0	0	0	0 ± 0	0	0
51 - Carysfort Reef SPA**	0 ± 0	0	0	0 ± 0	0	0
50 - SW of Carysfort Reef SPA	0 ± 0	0	0	0 ± 0	0	0
40 - SW of Carysfort Reef SPA	0 ± 0	0	0	0 ± 0	0	0
39 - North of Elbow Reef SPA	0 ± 0	0	0	0 ± 0	0	0
245 - Elbow Reef SPA**	0.017 ± 0.017	0.7	1	0 ± 0	0	0
46 - Elbow Reef SPA**	0 ± 0	0	0	0.033 ± 0.033	1.5 ± 0.3	2
38 - SW of Elbow Reef SPA	0 ± 0	0	0	0 ± 0	0	0
49 - South of Elbow Reef SPA	0 ± 0	0	0	0 ± 0	0	0
37 - Dixie Shoal	0 ± 0	0	0	0 ± 0	0	0
48 - Dixie Shoal	0 ± 0	0	0	0 ± 0	0	0
47 - SW of Molasses Reef SPA	0 ± 0	0	0	0 ± 0	0	0
Upper Florida Keys Total (13)	0.001 ± 0.001	0.7	1	0.003 ± 0.003	1.5	2
Middle Florida Keys NMS						
81 - Conch Reef SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
80 - Conch Reef SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
82 - Conch Reef RO**	0.017 ± 0.017	0.9	1	0.017 ± 0.017	2.9	1
279 - Conch Reef RO**	0 ± 0	0	0	0 ± 0	0 ± 0	0
84 - Davis Reef SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
83 - Davis Reef SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
79 - SW of Crocker Reef	0.017 ± 0.017	2.0	1	0.017 ± 0.017	1.8	1
78 - SW of Crocker Reef	0 ± 0	0	0	0 ± 0	0 ± 0	0
85 - Alligator Reef SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
68 - Alligator Reef SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
77 - SW of Alligator Reef SPA	0.017 ± 0.017	1.0	1	0.100 ± 0	2.4 ± 0.2	6
87 - Tennessee Reef RO**	0 ± 0	0	0	0 ± 0	0 ± 0	0
86 - Tennessee Reef RO**	0 ± 0	0	0	0.017 ± 0.017	2.0	1
76 - NE of Tennessee Light	0 ± 0	0	0	0.017 ± 0.017	2.5	1
75 - East of Coffins Patch SPA	0 ± 0	0	0	0.017 ± 0.017	1.5	1
293 - Sombrero Key SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0
96 - Sombrero Key SPA**	0 ± 0	0	0	0 ± 0	0 ± 0	0

Site number/site location	*Echinometra viridis*			*Eucidaris tribuloides*		
	No./m^2	TD (cm)	N	No./m^2	TD (cm)	N
73 - West of Sombrero Key SPA	0 ± 0	0 ± 0	0	0.017 ± 0.017	1.8	1
71 - South of Moser Channel	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
72 - South of Moser Channel	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
70 - South of Moser Channel	0 ± 0	0 ± 0	0	0.017 ± 0.017	1.6	1
90 - South of Moser Channel	0.017 ± 0.017	0.9	1	0 ± 0	0 ± 0	0
Middle Florida Keys Total (22)	0.003 ± 0.001	1.2 ± 0.3	4	0.010 ± 0.005	2.1 ± 0.2	**13**
Lower Florida Keys NMS						
136 - South of Bahia Honda Key	0 ± 0	0 ± 0	0	0.017 ± 0.017	3.0	1
138 - South of Bahia Honda Key	0 ± 0	0 ± 0	0	0.033 ± 0.033	2.5 ± 0.2	2
137 - South of Bahia Honda Key	0 ± 0	0 ± 0	0	0.050 ± 0.032	2.7 ± 0.2	3
135 - West of Looe Key SPA	0 ± 0	0 ± 0	0	0.017 ± 0.017	4.0	1
134 - West of Pelican Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
139 - Eastern Sambo RO**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
336 - Eastern Sambo RO**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
141 - Western Sambo ER**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
140 - Western Sambo ER**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
143 - West of Western Sambo	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
132 - East of E. Dry Rocks SPA	0.017 ± 0.017	3.0	1	0 ± 0	0 ± 0	0
346 - Rock Key SPA**	0 ± 0	0 ± 0	0	0.017 ± 0.017	4.0	1
149 - Rock Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
347 - Sand Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
150 - Sand Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
142 - SW of Sand Key SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Lower Florida Keys Total (16)	0.001 ± 0	3.0	1	0.008 ± 0.004	3.2 ± 0.3	8
Fore-reef Total (51)	**0.002 ± 0**	**1.4 ± 0.4**	**6**	**0.008 ± 0.002**	**2.4 ± 0.2**	**23**

Table 15. Mean ± 1 SE densities (no. individuals per m^2), test diameter (TD, cm), and numbers of individuals (N) sampled of the urchins *Lytechinus variegatus* and *Tripneustes ventricosus* in the Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m belt transects per site at 145 sites during June-August 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are no-take marine reserves.

Site number/site location	***Lytechinus variegatus***			***Tripneustes ventricosus***		
	No./m^2	TD (cm)	N	No./m^2	TD (cm)	N
Mid-channel patch reefs						
Upper Florida Keys NMS						
6 - Basin Hill Shoals	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
5 - Basin Hill Shoals	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
4 - Inshore of Grecian Rocks SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
3 - South of Cannon Patch Reef	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
2 - Mosquito Bank	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
1 - Inshore of Molasses Reef	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Upper Florida Keys Total (6)	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Middle Florida Keys NMS						
56 - Tavernier Rocks	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
55 - Tavernier Rocks	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
59 - Hen and Chickens SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
58 - Hen and Chickens SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
61 - Cheeca Rocks SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
60 - Cheeca Rocks SPA**	0.017 ± 0.017	7.1	1	0 ± 0	0 ± 0	0
57 - NE of Cheeca Rocks SPA	0.017 ± 0.017	6.7	1	0 ± 0	0 ± 0	0
54 - South of Duck Key	0.050 ± 0.017	5.9 ± 1.1	3	0 ± 0	0 ± 0	0
53 - South of Ohio Key	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Middle Florida Keys Total (9)	0.009 ± 0.006	6.6 ± 0.4	**5**	0 ± 0	0 ± 0	0
Lower Florida Keys NMS						
103 - North of Looe Key RO	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
102 - North of Maryland Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
101 - North of Maryland Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
100 - North of Eastern Sambo RO	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
105 - Western Sambo ER**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
104 - Western Sambo ER**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
99 - West of Western Sambo ER	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
98 - Middle Ground	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
97 - Middle Ground	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Lower Florida Keys Total (9)	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Mid-channel Patch Reef Total (24)	**0.003 ± 0.002**	**6.6 ± 0.4**	**5**	**0 ± 0**	**0 ± 0**	**0**
Offshore patch reefs						
Upper Florida Keys NMS						
12 - South of BNP boundary	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
41 - North of Carysfort Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
11 - North of Carysfort Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
14 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
13 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
10 - North of Dry Rocks SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
9 - SW of Grecian Rocks SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
8 - Inshore of French Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
7 - Inshore of Pickles Reef	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Upper Florida Keys Total (9)	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Middle Florida Keys NMS						
65 - North of Davis Reef SPA	0 ± 0	0 ± 0	0	0.017 ± 0.017	5.1	1
64 - North of Davis Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0

Site number/site location	*Lytechinus variegatus*			*Tripneustes ventricosus*		
	No./m^2	TD (cm)	N	No./m^2	TD (cm)	N
63 - North of Davis Reef SPA	0.017 ± 0.017	4.0	1	0 ± 0	0 ± 0	0
62 - North of Davis Reef SPA	0 ± 0	0 ± 0	0	0.017 ± 0.017	8.0	1
89 - Coffins Patch SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
88 - Coffins Patch SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Middle Florida Keys Total (6)	0.003 ± 0.003	4.0	1	0.006 ± 0.004	6.6 ± 1.5	2
Lower Florida Keys NMS						
109 - East of Looe Key RO	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
110 - Looe Key Research Only**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
111 - Looe Key Research Only**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
107 - North of Pelican Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
112 - Western Sambo ER**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
113 - Western Sambo ER**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
106 - NE of E. Dry Rocks SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
133 - NE of E. Dry Rocks SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Lower Florida Keys Total (8)	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Offshore Patch Reef Total (23)	**0.001 ± 0.001**	**4.0**	**1**	**0.001 ± 0.001**	**6.6 ± 1.5**	**2**
Inner line reef tract spur & groove						
Upper Florida Keys NMS						
32 - Turtle Rocks	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
31 - Inshore of Elbow Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
30 - North Dry Rocks	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
34 - Dry Rocks SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
33 - Dry Rocks SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
36 - Grecian Rocks SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
35 - Grecian Rocks SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Upper Florida Keys Total (7)	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Inner Line Spur & Groove Total (7)	**0 ± 0**	**0 ± 0**	**0**	**0 ± 0**	**0 ± 0**	**0**
High-relief spur & groove						
Upper Florida Keys NMS						
23 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
22 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
21 - Maitland grounding site	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
24 - Elbow Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
223 - Elbow Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
19 - North of French Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
25 - French Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
26 - French Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
20 - Sand Island	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
18 - Sand Island	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
28 - Molasses Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
27 - Molasses Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
17 - Pickles Reef	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
16 - Pickles Reef	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
15 - Pickles Reef	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
Middle Florida Keys NMS						
67 - Delta Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
66 - Delta Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
69 - Sombrero Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
266 - Sombrero Key SPA**	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
Lower Florida Keys NMS						

Site number/site location	*Lytechinus variegatus*			*Tripneustes ventricosus*		
	No./m^2	TD (cm)	N	No./m^2	TD (cm)	N
124 - Looe Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
123 - Looe Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
120 - American Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
122 - American Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
119 - Maryland Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
121 - Maryland Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
118 - Pelican Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
117 - Pelican Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
116 - No Name Reef	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
322 - Eastern Sambo RO**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
125 - Eastern Sambo RO**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
127 - Western Sambo ER**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
126 - Western Sambo ER**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
115 - East of E. Dry Rocks SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
129 - Eastern Dry Rocks SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
128 - Eastern Dry Rocks**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
327 - Rock Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
130 - Rock Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
131 - Sand Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
328 - Sand Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
114 - Western Dry Rocks	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Lower Florida Keys Total (21)	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
High-relief Spur & Groove Total (40)	**0 ± 0**	**0 ± 0**	**0**	**0 ± 0**	**0 ± 0**	**0**
Fore-reef (6-15 m)						
Upper Florida Keys NMS						
42 - South of BNP boundary	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
52 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
51 - Carysfort Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
50 - SW of Carysfort Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
40 - SW of Carysfort Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
39 - North of Elbow Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
245 - Elbow Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
46 - Elbow Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
38 - SW of Elbow Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
49 - South of Elbow Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
37 - Dixie Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
48 - Dixie Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
47 - SW of Molasses 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
Middle Florida Keys NMS						
81 - Conch Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
80 - Conch Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
82 - Conch Reef RO**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
279 - Conch Reef RO**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
84 - Davis Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
83 - Davis Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
79 - SW of Crocker Reef	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
78 - SW of Crocker Reef	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
85 - Alligator Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
68 - Alligator Reef SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
77 - SW of Alligator Reef SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
87 - Tennessee Reef RO**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
86 - Tennessee Reef RO**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
76 - NE of Tennessee Light	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
75 - East of Coffins Patch SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
293 - Sombrero Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
96 - Sombrero Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0

Site number/site location	*Lytechinus variegatus*			*Tripneustes ventricosus*		
	No./m^2	TD (cm)	N	No./m^2	TD (cm)	N
73 - West of Sombrero Key SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
71 - South of Moser Channel	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
72 - South of Moser Channel	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
70 - South of Moser Channel	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
90 - South of Moser Channel	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Middle Florida Keys Total (22)	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Lower Florida Keys NMS						
136 - South of Bahia Honda Key	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
138 - South of Bahia Honda Key	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
137 - South of Bahia Honda Key	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
135 - West of Looe Key SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
134 - West of Pelican Shoal	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
139 - Eastern Sambo RO**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
336 - Eastern Sambo RO**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
141 - Western Sambo ER**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
140 - Western Sambo ER**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
143 - West of Western Sambo	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
132 - East of E. Dry Rocks SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
346 - Rock Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
149 - Rock Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
347 - Sand Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
150 - Sand Key SPA**	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
142 - SW of Sand Key SPA	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Lower Florida Keys Total (16)	0 ± 0	0 ± 0	0	0 ± 0	0 ± 0	0
Fore-reef Total (51)	**0 ± 0**	**0 ± 0**	**0**	**0 ± 0**	**0 ± 0**	**0**

Table 16. Number of individuals (N), mean, standard error (SE), and range in sea urchin test diameter by species and habitat type in the Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m belt transects per site at 145 sites during June-September 2008.

Habitat type (no. sites)	Transect depth (m)	N	Mean test size (cm)	SE	Min. test size (cm)	Max. test size (cm)
Diadema antillarum						
Mid-channel patch reef (24)	1.5-10.1 m	37	4.4	0.4	0.8	8.0
Offshore patch reef (23)	1.8-11.6 m	69	5.4	0.3	0.8	10.7
Inner line reef tract spur & groove (7)	2.4-6.4 m	3	4.7	1.5	2.0	7.2
High-relief spur and groove (40)	1.2-9.1 m	44	4.7	0.4	0.6	9.0
Deeper fore-reef (6-15 m) (51)	7.0-16.5 m	28	3.0	0.4	0.9	8.0
All habitats combined (145 sites)	1.2-16.5 m	181	4.7	0.2	0.6	10.7
Echinometra lucunter						
Mid-channel patch reef (24)	1.5-10.1 m	23	1.4	0.2	0.5	5.0
Offshore patch reef (23)	1.8-11.6 m	3	2.0	1.0	0.9	4.0
Inner line reef tract spur & groove (7)	2.4-6.4 m	2	1.7	0.7	1.0	2.4
High-relief spur and groove (40)	1.2-9.1 m	80	1.9	0.1	0.3	5.0
Deeper fore-reef (6-15 m) (51)	7.0-16.5 m	0				
All habitats combined (145 sites)	1.2-16.5 m	108	1.8	0.1	0.3	5.0
Echinometra viridis						
Mid-channel patch reef (24)	1.5-10.1 m	777	2.8	0.0	0.8	5.0
Offshore patch reef (23)	1.8-11.6 m	26	2.0	0.2	0.9	4.5
Inner line reef tract spur & groove (7)	2.4-6.4 m	3	2.0	0.3	1.4	2.5
High-relief spur and groove (40)	1.2-9.1 m	15	1.6	0.2	0.7	3.0
Deeper fore-reef (6-15 m) (51)	7.0-16.5 m	8	1.7	0.3	0.7	3.0
All habitats combined (145 sites)	1.2-16.5 m	829	2.8	0.0	0.7	5.0
Eucidaris tribuloides						
Mid-channel patch reef (24)	1.5-10.1 m	71	2.6	0.1	1.0	4.0
Offshore patch reef (23)	1.8-11.6 m	164	2.6	0.1	1.0	4.0
Inner line reef tract spur & groove (7)	2.4-6.4 m	20	2.1	0.1	1.1	3.5
High-relief spur and groove (40)	1.2-9.1 m	344	2.0	0.0	0.6	4.0
Deeper fore-reef (6-15 m) (51)	7.0-16.5 m	23	2.4	0.2	1.2	4.0
All habitats combined (145 sites)	1.2-16.5 m	622	2.2	0.0	0.6	4.0
Lytechinus variegatus						
Mid-channel patch reef (24)	1.5-10.1 m	5	6.3	0.7	4.0	7.8
Offshore patch reef (23)	1.8-11.6 m	1	4.0		4.0	4.0
Inner line reef tract spur & groove (7)	2.4-6.4 m					
High-relief spur and groove (40)	1.2-9.1 m					
Deeper fore-reef (6-15 m) (51)	7.0-16.5 m					
All habitats combined (145 sites)	1.2-16.5 m	6	5.9	0.7	4.0	7.8
Tripneustes ventricosus						
Mid-channel patch reef (24)	1.5-10.1 m	0				
Offshore patch reef (23)	1.8-11.6 m	2	6.6	1.5	5.1	8.0
Inner line reef tract spur & groove (7)	2.4-6.4 m	0				
High-relief spur and groove (40)	1.2-9.1 m	0				
Deeper fore-reef (6-15 m) (51)	7.0-16.5 m	0				
All habitats combined (145 sites)	1.2-16.5 m	2	6.6	1.5	5.1	8.0

VI. Anemone and corallimorpharian density

Background

Although there is considerable interest in the condition of tropical coral reefs, most historical and recent studies in the Caribbean, including the Florida Keys, have generally focused on either stony corals or fishes. This is not surprising, given that corals are the primary framework elements of many communities, while fishes, together with certain shellfish species (e.g. queen conch and spiny lobster) are generally the principal and most economically important targets of recreational and commercial fishers. In the Florida Keys, however, commercial marine-life fisheries and aquarium hobbyists remove an incredible diversity of invertebrates and fishes (Bohnsack et al. 1994). Available commercial landings data for the marine ornamental fishery (aquarium fishery) include both state and federal waters from West Palm Beach to Key West, organized by 16 areas (FWCC 2001). 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 within the Key Largo National Marine Sanctuary established in 1975. The Looe Key area has been protected since 1981, and area closures exist in Everglades National Park, the Dry Tortugas, Biscayne National Park, and Fish and Wildlife Service management areas. Four major biological categories are targeted: fishes (39 nominal groups), invertebrates (18 nominal groups), plants, and sand and live rock. 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).

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 2008, we continued to add to a spatial and temporal framework for describing the habitat distribution and abundance patterns of selected actinians (O. Actiniaria) and corallimorpharians (O. Corallimorpharia) in the Florida Keys in relation to habitat, regional, and management factors. 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 no density estimates we are aware of that consider multiple sites and benthic habitat types in the Florida Keys. Many of these species, most notably certain anemones, 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 provide an 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 for the 2008 surveys 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 carried out in the study area during 1999-2001 and 2005, as well as in the Tortugas region during 2000, 2006, and 2008. Six anemone species were recorded (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, the sun anemone *Stichodactyla* (=*Stoichactis*) *helianthus* in the Family Stichodactylidae, *Heteractis lucida*, and *Lebrunia danae*. Three corallimorpharians were found: *Discosoma* (=*Paradiscosoma*) *carlgreni* and *D.* (=*Rhodactis*) *sanctithomae* in the Family Actinodiscidae and *Ricordea florida* in the Family Corallimorpharidae. Corallimorpharians, sometimes called false corals, differ from anemones in the arrangement of the tentacles, and may be solitary, but are typically found in clusters.

2008 Survey Results

Six anemone species were recorded from the 145 survey sites in 2008 (Figure 59) and a total of 530 individuals were enumerated from surveys of 8,700 m^2 of benthic habitat. Tables 14-16 provide site-level densities for the six species. The anemones found were represented by: *Bartholomea annulata* (306 individuals, 57.7% of the total), *Condylactis gigantea* (21 individuals, 4.0%), *Epicystes crucifera* (35 individuals, 6.6%), *Heteractis lucida* (4 individuals, 0.8%), *Lebrunia danae* (155 individuals, 29.3%), and *Stichodactyla helianthus* (9 individuals 1.7%). The six species exhibited markedly different habitat and regional distribution patterns in the Florida Keys. *B. annulata* was the most abundant and wide-ranging anemone, similar to earlier surveys conducted by our program in 1999-2001. Mean habitat-level densities for this species were relatively similar among the five habitats, ranging from 0.027 ± 0.004 per m^2 on high-relief spur and groove to 0.048 ± 0.005 per m^2 on the deeper fore-reef. The greatest site-level density was 0.133 individuals per m^2 (8 individuals from four 15-m x 1-m transects) recorded from a low-relief spur and groove site on the deeper fore-reef. On mid-channel patch reefs, densities tended to be greater in

the upper and lower Keys, especially in reference sites (Figure 60). No discernible pattern in density among regions or between no-fishing zones and reference areas was apparent for other habitats (Figures 61-63).

Similar to surveys in 1999-2001 and 2005, densities of *Condylactis gigantea* were relatively low in 2008 (Table 14). In contrast to *B. annulata*, most *C. gigantea* were restricted to mid-channel and offshore patch reefs, as well as inner line reef sites. Densities on mid-channel patch reefs were greater in the upper Keys compared to other regions, while densities on offshore patch reefs were greater in the middle Keys. Distribution patterns of *Epicystes crucifera* were similar to *C. gigantea*, but with greater habitat specificity on mid-channel patch reefs, especially in the lower Keys (Table 14). Individuals were particularly abundant (up to 0.32 per m^2) in the Western Sambo Ecological Reserve. Only four individuals of the knobby anemone (*Heteractis lucida*) were encountered, all of which were found on mid-channel and offshore patch reefs (Table 15). In contrast, the sun anemone (*Stichodactyla helianthus*) was only found in high-relief spur and groove, specifically at one site (Maryland Shoal) in the lower Keys. *Lebrunia danae*, the second most abundant anemone surveyed during 2008, was most abundant on mid-channel patch reefs and offshore patch reefs. In contrast to some of the other species, *L. danae* exhibited a clear regional pattern in density, with the greatest densities in the lower Keys for four of the five habitats sampled (Table 15).

A total of 2,063 corallimorpharians representing three species were sampled during 2008 (Figure 64): *Discosoma carlgreni* (22 individuals, 1.1%), *D. sanctithomae* (459 individuals, 22.3%), and *Ricordea florida* (1,582 individuals, 76.7%). Table 16 provides site-level densities for the three corallimorpharians and Figures 65-68 illustrate variations in abundance by region and management zone for *R. florida* in four of the five habitats. Of the 22 *D. carlgreni* encountered, all were found on mid-channel patch reefs, and 77% were found in the lower Keys. Patch reef sites within the Western Sambo Ecological Reserve yielded the highest site-level densities recorded during 2008. Similar to its congener, *D. sanctithomae* was most abundant on mid-channel patch reefs, especially in the lower Keys region, and only a few individuals were found on offshore patch reefs and the deeper fore-reef, but these were limited as well to the lower Keys (Table 16). Site-level densities were as high as 3.4 individuals per m^2.

The most abundant corallimorpharian surveyed during 2008 was *Ricordea florida*. Like *D. sanctithomae*, the greatest densities of *R. florida* were found on mid-channel and offshore patch reefs, especially in the lower Keys (Figures 65-66), while offshore habitats yielded substantially lower densities (Figures 67-68). Site-level densities were as high as 4.6 individuals per m^2. On the 24 patch reefs sites, the two highest

site-level densities were recorded within the Western Sambo Ecological Reserve (Table 16). A similar pattern was found on offshore patch reefs, where two out of the 23 sites sampled with the greatest densities were within the Looe Key Research Only Area.

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), quantitative estimates of density in the wider Caribbean 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), we are not aware of any quantitative data on densities and habitat distributions of actinians and corallimorpharians in the Florida Keys. Levy et al. (1996) reviewed Florida Keys invertebrate inventories up to 1995 and found only three publications that discussed abundance and habitat distribution (e.g. Voss and Voss 1955; Voss et al. 1969).

Our surveys in the Florida Keys indicated that, with the exception of some corallimorpharians on mid-channel and offshore patch reefs, mean density estimates were low (usually < 1 individual per 100 m^2) at the spatial scales investigated and habitat types investigated for the six anemones and three corallimorpharians sampled. Four of the six actinians and two of the three corallimorpharians were extremely rare and/or exhibited very limited habitat distributions. The three more commonly encountered species exhibited different density and distribution patterns. *B. annulata* was generally rare but similarly abundant among the habitat strata, while *L. danae* was more common on patch reefs, especially in the lower Keys. The most abundant corallimorpharian, *R. florida*, was significantly more abundant on mid-channel and offshore patch reefs, especially in the lower Keys and particularly within no-take zones.

Conclusions from the 2008 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 intensive fishing in the Florida Keys, and the documented spatial patterns may signify under-sampling, habitat utilization, differential exploitation, or perhaps all of these factors. Few significant actinian and corallimorpharian density differences were detected between the no-fishing

zones and reference areas sampled. In general, however, densities for most actinians and corallimorpharians were either similar or lower in no-fishing zones compared to reference sites. The ability to detect density differences between the no-fishing zones and reference areas presumes that: 1) fishing pressure for these organisms is concentrated in the habitat types surveyed, 2) fishing pressure is detectable at the scale of sampling, and 3) fishing pressure is the predominant factor affecting density and distribution. Because spatially explicit fishing effort for the marine aquarium trade is not available, it is difficult to ascertain where organisms are being harvested. 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. It is possible that overlooked soft-sediment and nearshore hard-bottom habitats contain greater densities of these organisms, perhaps due to differences in wave energy, competition for space, or other unexplored hypotheses. However, 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).

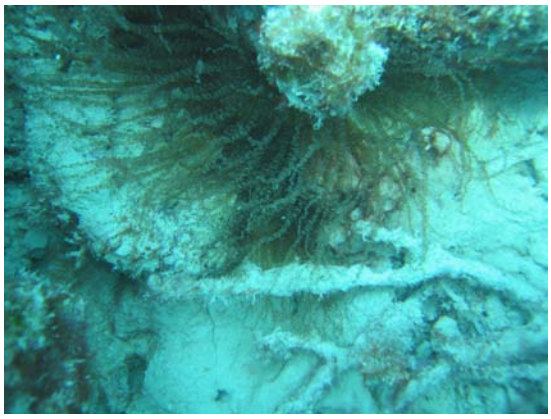
Although spatially explicit (e.g. at the scale of individual reefs) landings and fishing effort data are not available for Florida Keys anemones and corallimorpharians, the possibility that the observed density patterns are influenced by fishing should not be dismissed. For example, anecdotal observations, 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). The daily quota for fishes and invertebrates is 20 organisms per person per day, with no more than five angelfishes (Pomacanthidae) and no more than six gorgonian (Octocorallia) colonies, with live landing and live well requirements. In addition to a prohibition on collection in 23 of the no-take zones within the FKNMS, 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), and the Florida Bay area within Everglades National Park. With a saltwater products license, marine life fishery endorsement, and restricted species endorsement issued by the State of Florida, a limit of 400 *Condylactis gigantea* per vessel per day is currently permitted (FWCC 2000). Recreational regulations allow for a daily quota of 20 individuals of "unregulated" species per day (fished, possessed or landed), but data on recreational landings and effort are not available (NOAA 1996).

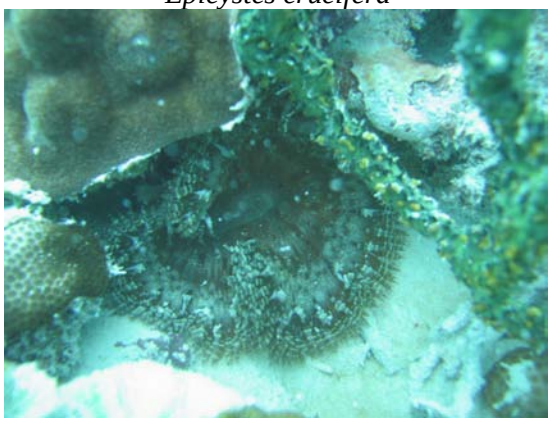
Management of exploited species requires essential information on fishing effort, population trends, and life history parameters. Density estimates for anemones and corallimorpharians provide one baseline from which to measure the effects of protection within no-fishing zones. Because density data for shallow-water actinians and corallimorpharians were not available prior to our surveys, these initial samples were a first attempt at exploring spatial variability relative to sampling effort (e.g. number of transects per site, number of sites per stratum). 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 59. Anemones (Cnidaria, Anthozoa) surveyed for density and habitat distribution in the Florida Keys during 2008.

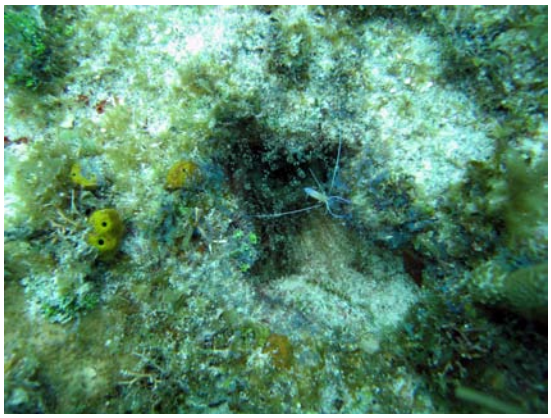
Bartholomea annulata



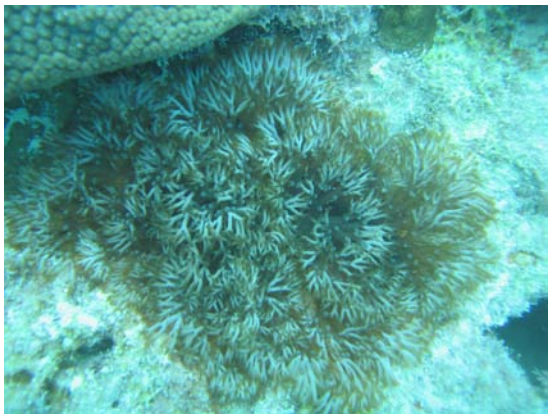
Epicystes crucifera



Bartholomea annulata



Lebrunia danae



Condylactis gigantea

Stichodactyla helianthus

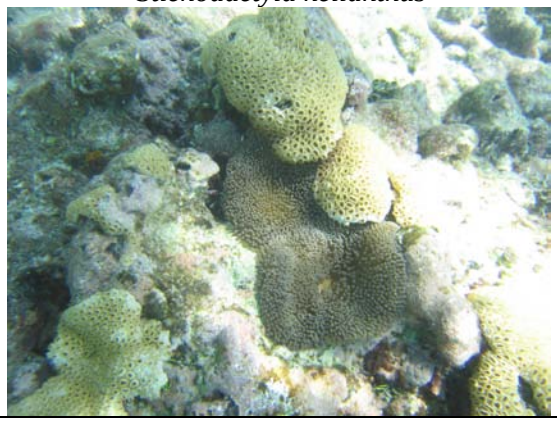


Figure 60. Mean (+ 1 SE) densities (no. per m^2) of the corkscrew anemone (*Bartholomea annulata*) on mid-channel patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

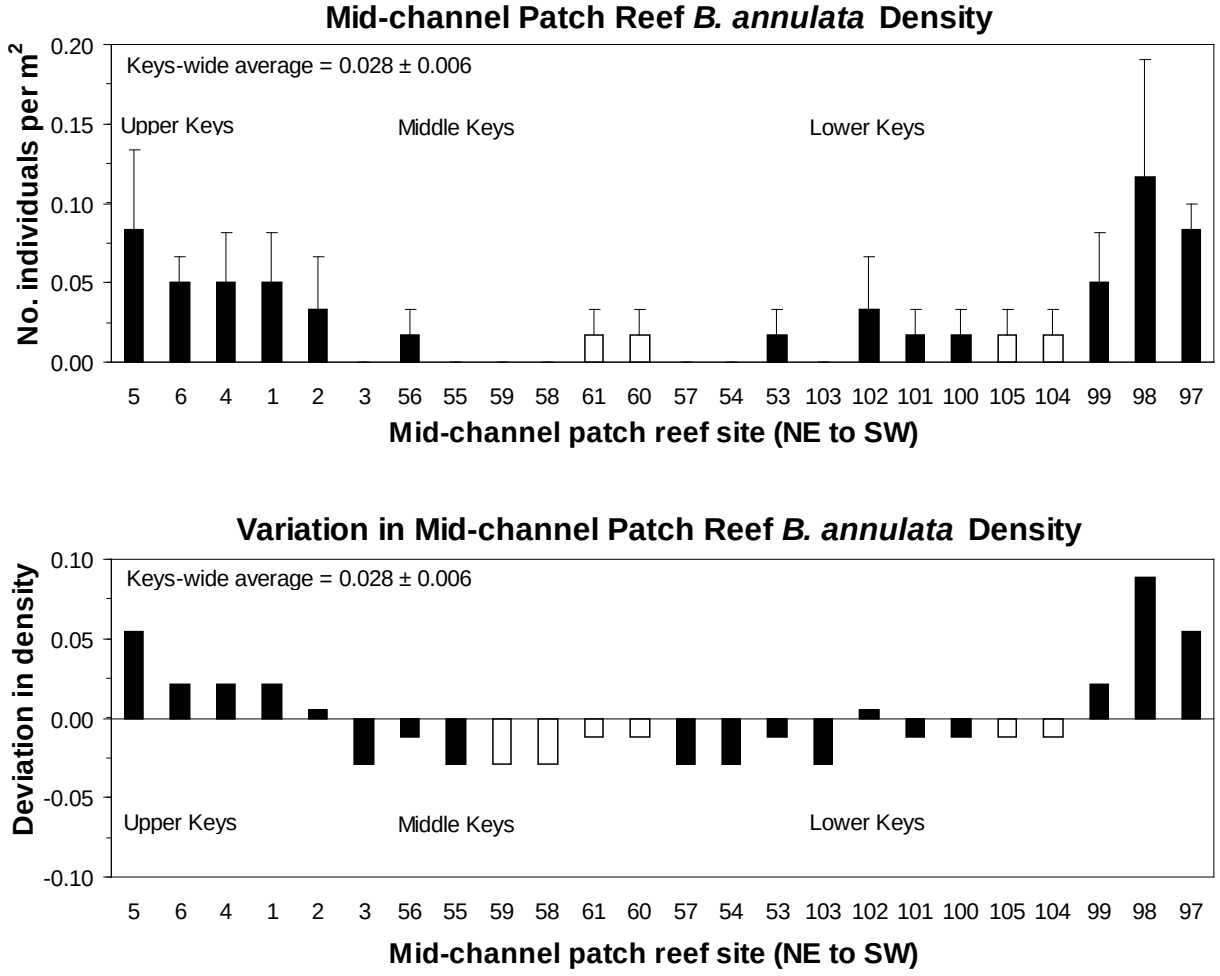


Figure 61. Mean (+ 1 SE) densities (no. per m^2) of the corkscrew anemone (*Bartholomea annulata*) on offshore patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

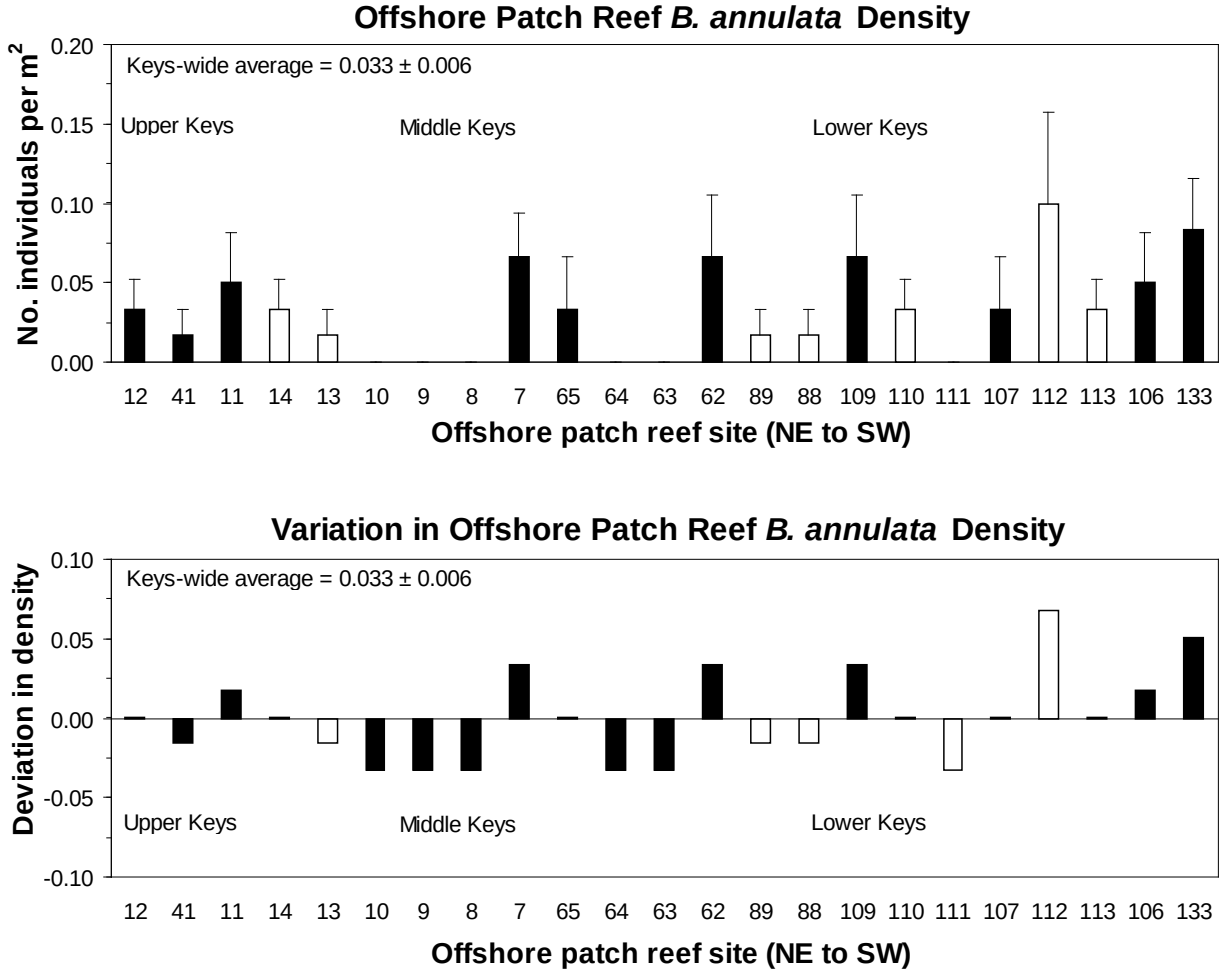


Figure 62. Mean (+ 1 SE) densities (no. per m^2) of the corkscrew anemone (*Bartholomea annulata*) on shallow (< 6 m), high-relief spur and groove reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

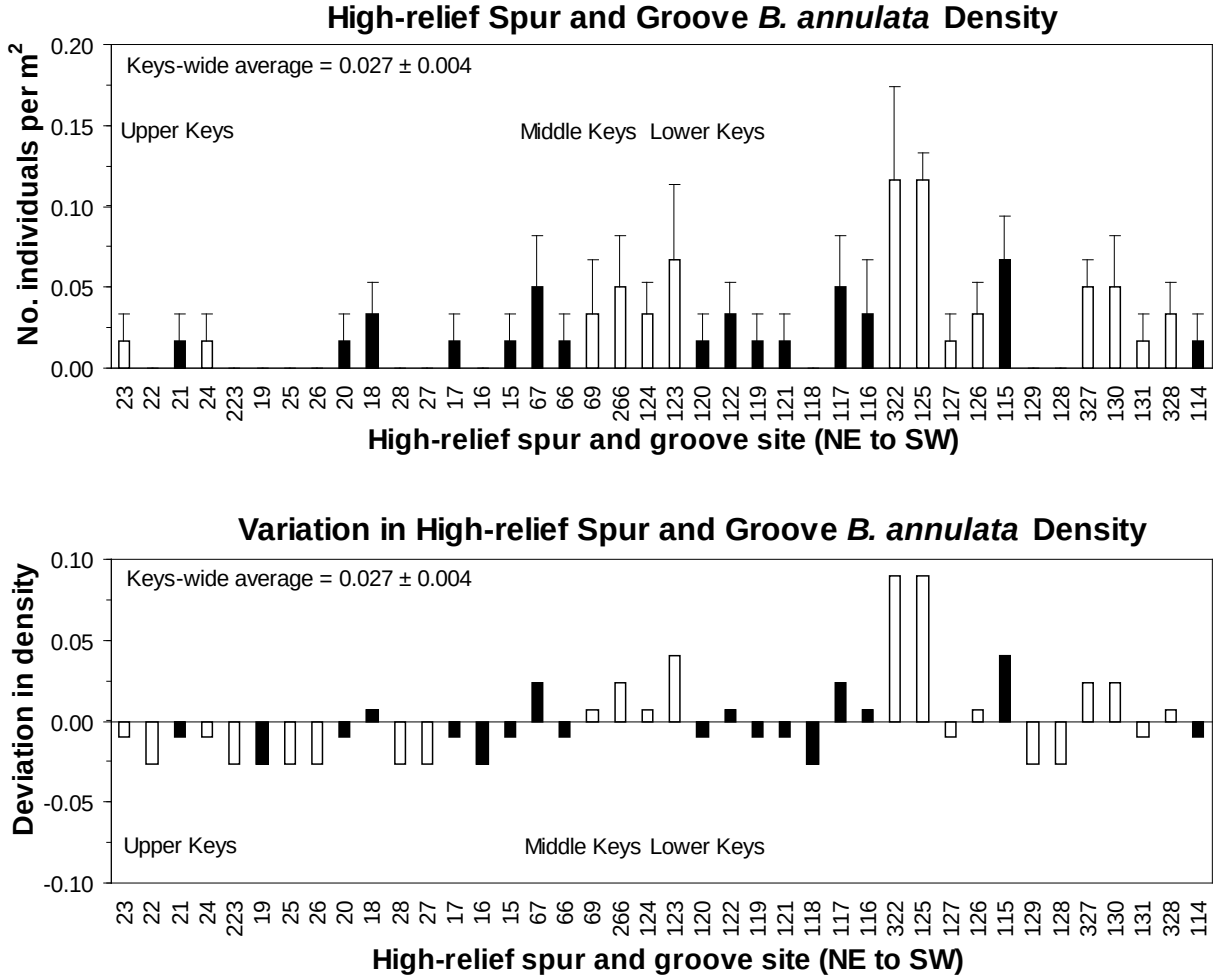


Figure 63. Mean (+ 1 SE) densities (no. per m^2) of the corkscrew anemone (*Bartholomea annulata*) on deeper (6-15 m) fore-reef sites (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

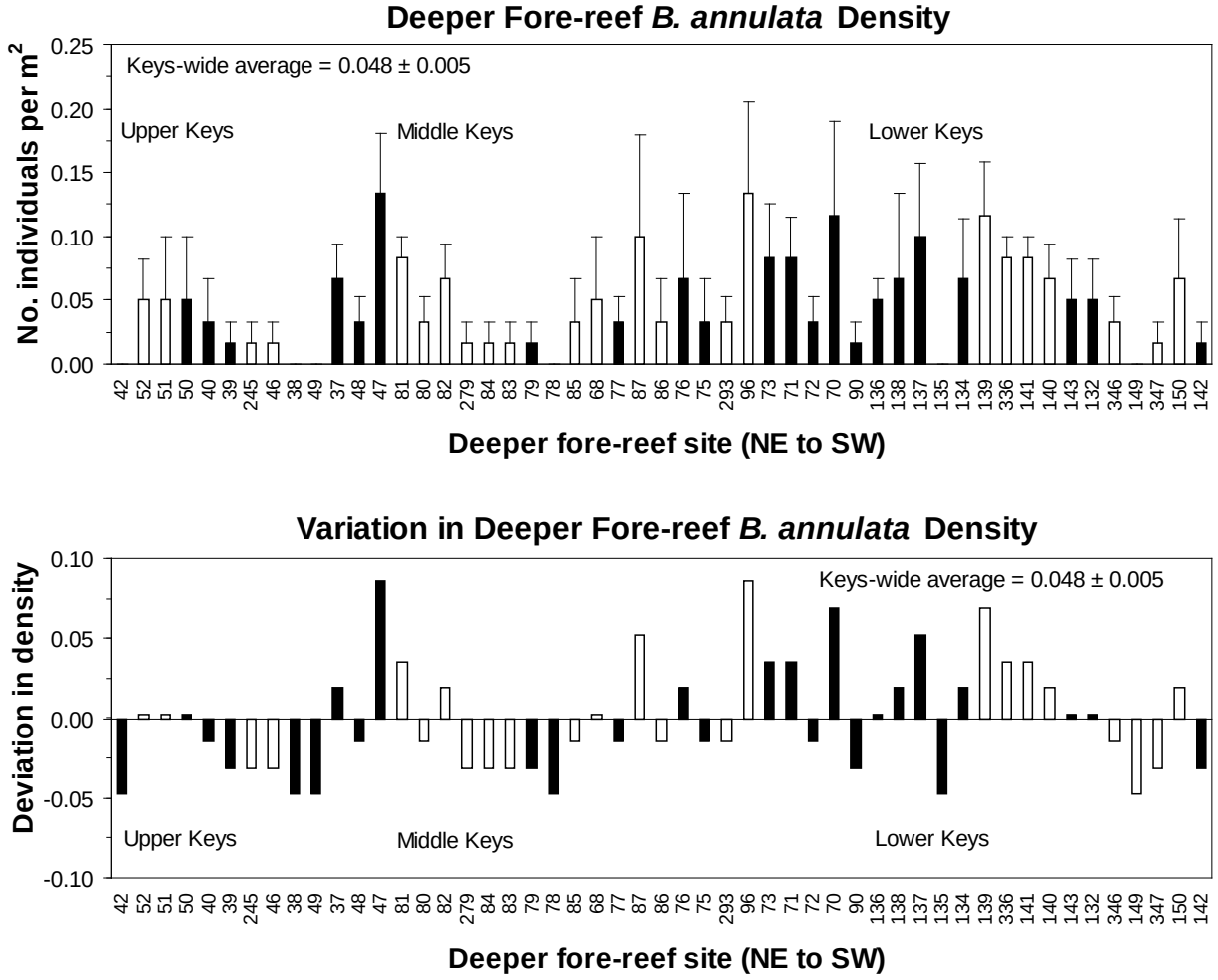
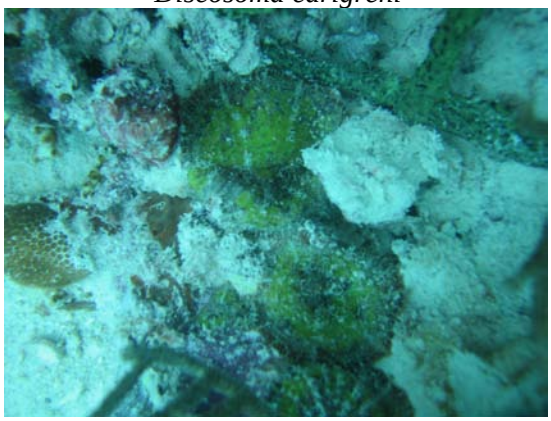


Figure 64. Corallimorpharians (Cnidaria, Anthozoa, Corallimorpharia) surveyed for density and habitat distribution in the Florida Keys during 2008.

Discosoma carlgreni



Ricordea florida

D. sanctithomae

R. florida

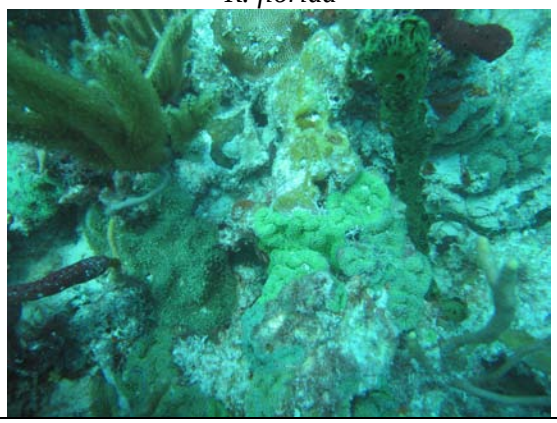


Figure 65. Mean (+ 1 SE) densities (no. per m^2) of the Florida corallimorph (*Ricordea florida*) on mid-channel patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

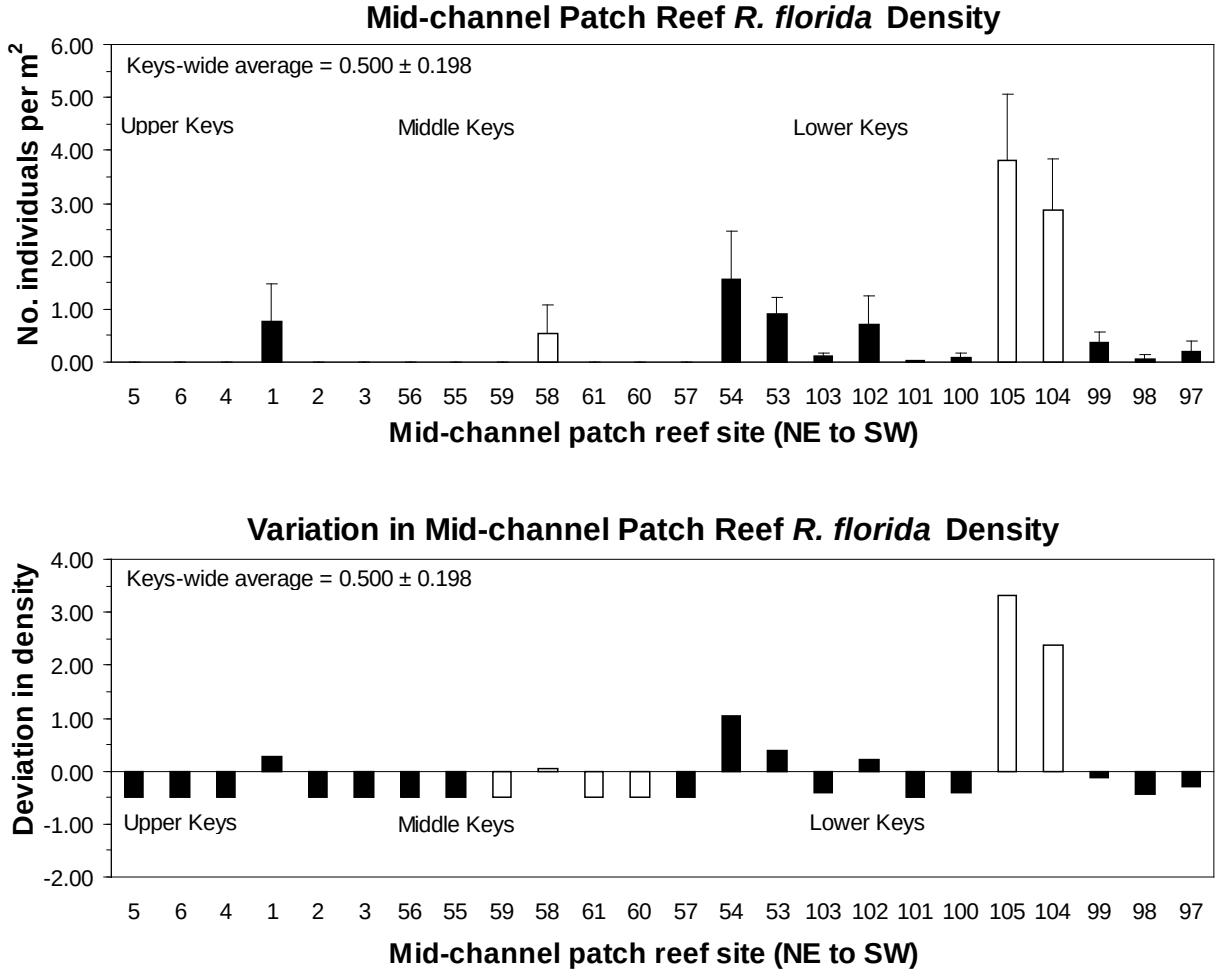


Figure 66. Mean (+ 1 SE) densities (no. per m^2) of the Florida corallimorph (*Ricordea florida*) on offshore patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

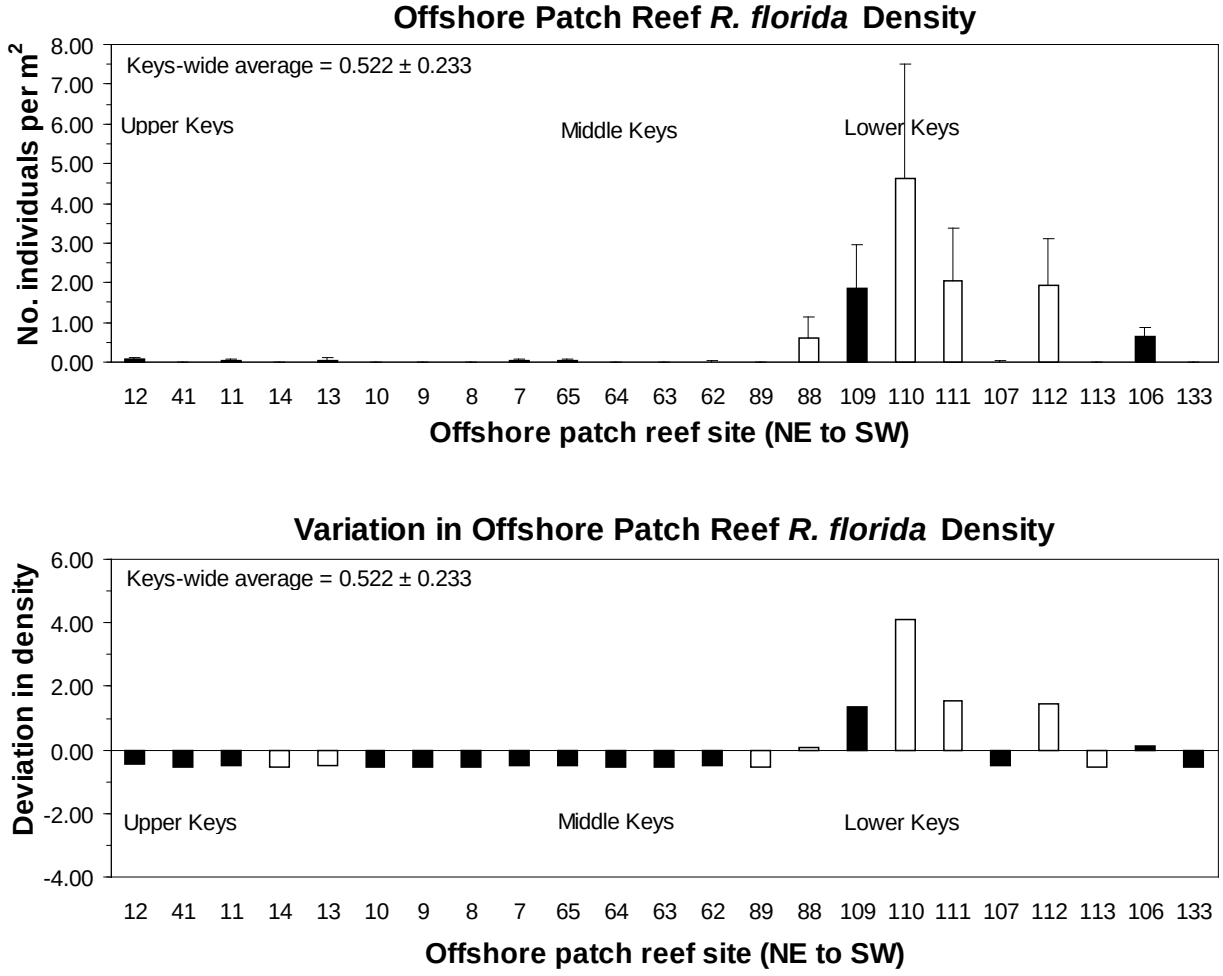


Figure 67. Mean (+ 1 SE) densities (no. per m^2) of the Florida corallimorph (*Ricordea florida*) on shallow (< 6 m), high-relief spur and groove reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

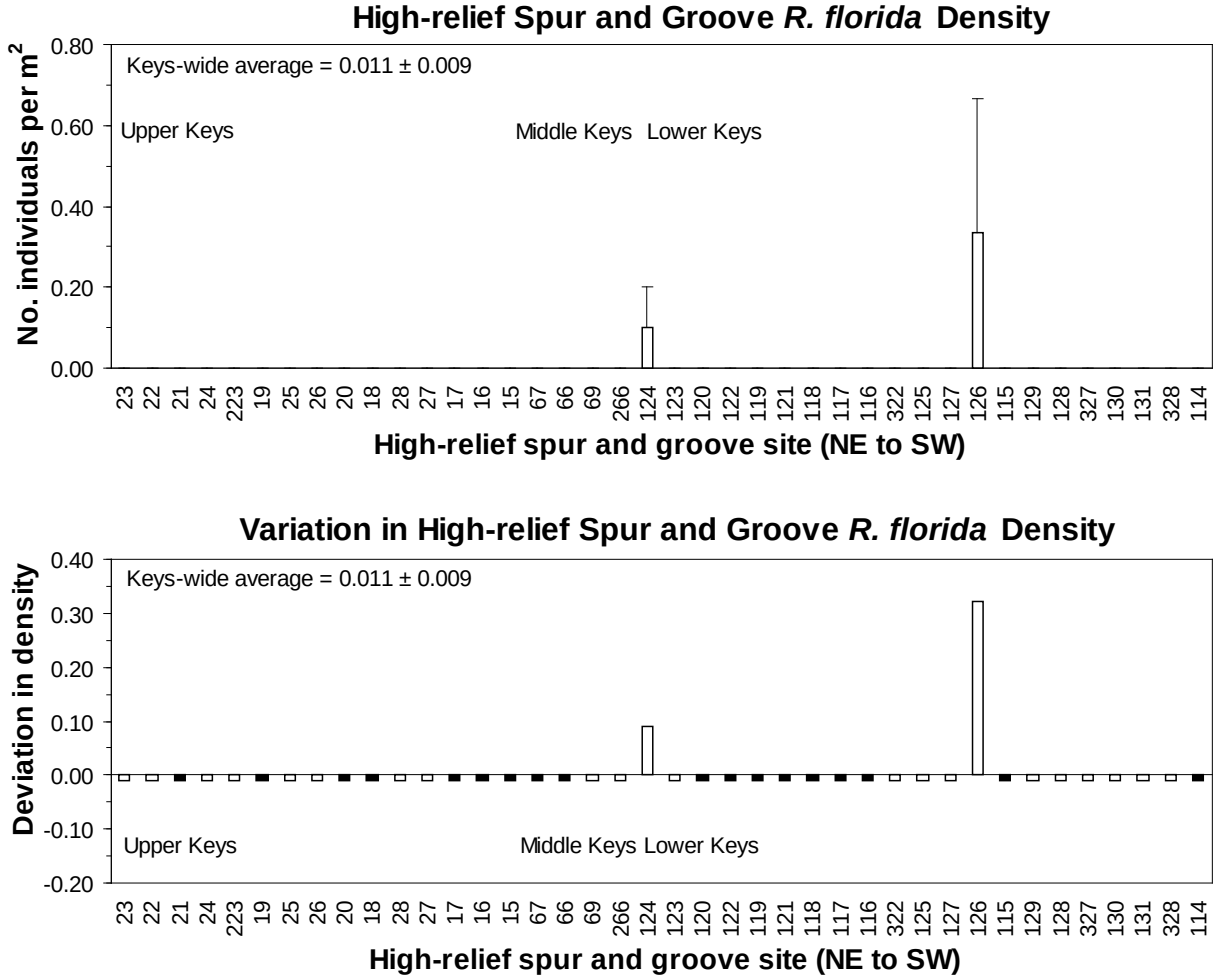


Figure 68. Mean (+ 1 SE) densities (no. per m^2) of the Florida corallimorph (*Ricordea florida*) on deeper (6-15 m) fore-reef sites (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

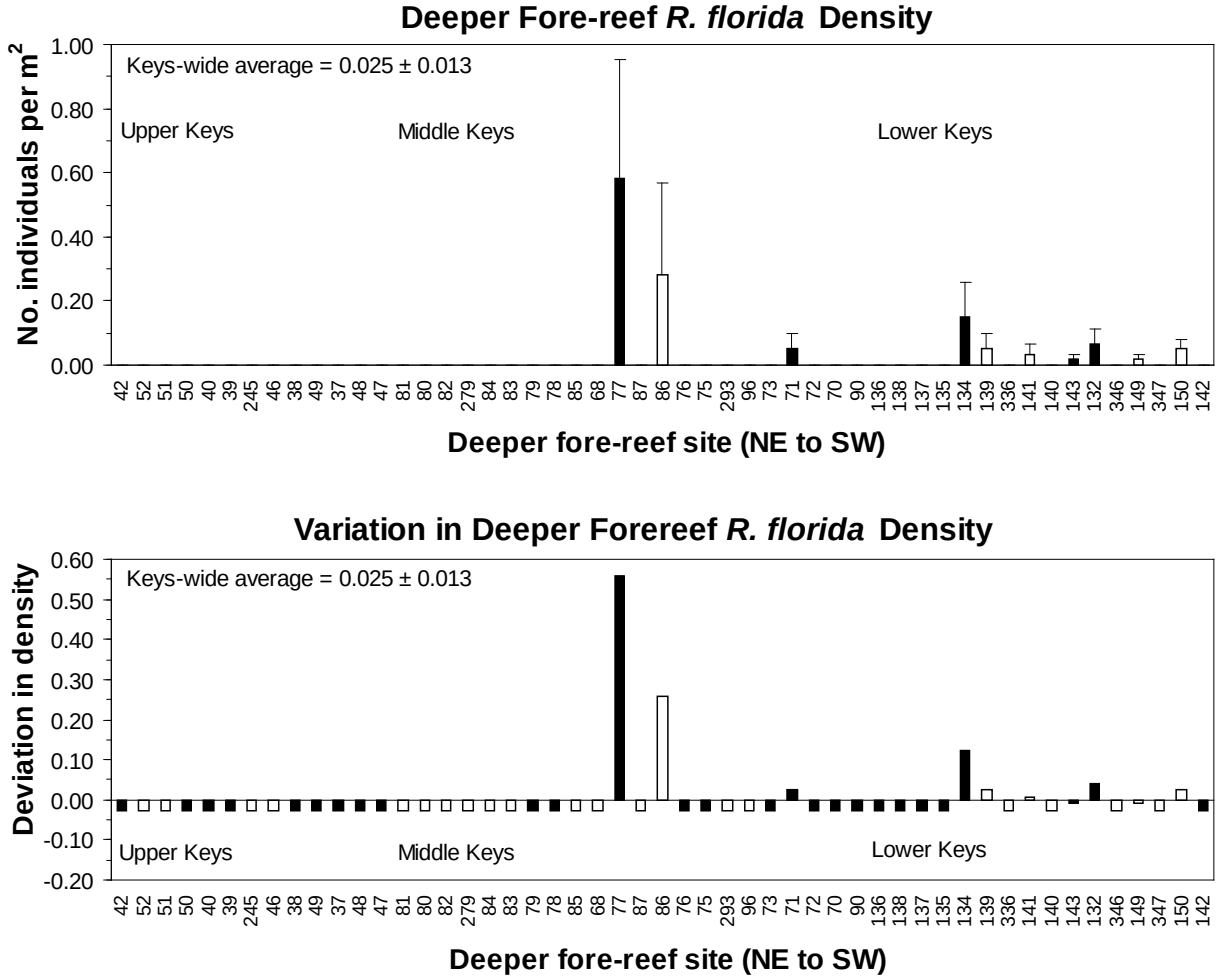


Table 17. Number of individuals (N) and mean ± 1 SE densities (no. of individuals per m^2) for the anemones *Bartholomea annulata*, *Condylactis gigantea*, and *Epicystes crucifera* in the Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m belt transects per site at 145 sites during June-August 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are no-take marine reserves.

Site number/site location	***Bartholomea annulata***		***Condylactis gigantea***		***Epicystes crucifera***	
	N	No. per m^2	N	No. per m^2	N	No. per m^2
Mid-channel patch reefs						
Upper Florida Keys NMS						
6 - Basin Hill Shoals	3	0.050 ± 0.017	4	0.067 ± 0.027	0	0 ± 0
5 - Basin Hill Shoals	5	0.083 ± 0.050	1	0.017 ± 0.017	0	0 ± 0
4 - Inshore of Grecian Rocks	3	0.050 ± 0.032	0	0 ± 0	0	0 ± 0
3 - South of Cannon Patch Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
2 - Mosquito Bank	2	0.033 ± 0.033	0	0 ± 0	0	0 ± 0
1 - Inshore of Molasses Reef	3	0.050 ± 0.032	0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (6)	16	0.044 ± 0.011	5	0.014 ± 0.011	0	0 ± 0
Middle Florida Keys NMS						
56 - Tavernier Rocks	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
55 - Tavernier Rocks	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
59 - Hen and Chickens SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
58 - Hen and Chickens SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
61 - Cheeca Rocks SPA**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
60 - Cheeca Rocks SPA**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
57 - NE of Cheeca Rocks SPA	0	0 ± 0	0	0 ± 0	1	0.017 ± 0.017
54 - South of Duck Key	0	0 ± 0	0	0 ± 0	0	0 ± 0
53 - South of Ohio Key	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (9)	4	0.007 ± 0.003	1	0.002 ± 0.002	1	0.002 ± 0.002
Lower Florida Keys NMS						
103 - North of Looe Key RO	0	0 ± 0	0	0 ± 0	1	0.017 ± 0.017
102 - North of Maryland Shoal	2	0.033 ± 0.033	0	0 ± 0	0	0 ± 0
101 - North of Maryland Shoal	1	0.017 ± 0.017	0	0 ± 0	1	0.017 ± 0.017
100 - North of Eastern Sambo	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
105 - Western Sambo ER**	1	0.017 ± 0.017	0	0 ± 0	19	0.317 ± 0.110
104 - Western Sambo ER**	1	0.017 ± 0.017	0	0 ± 0	1	0.017 ± 0.017
99 - West of Western Sambo	3	0.050 ± 0.032	0	0 ± 0	0	0 ± 0
98 - Middle Ground	7	0.117 ± 0.074	0	0 ± 0	0	0 ± 0
97 - Middle Ground	5	0.083 ± 0.017	2	0.033 ± 0.019	4	0.067 ± 0.027
Lower Florida Keys Total (9)	21	0.039 ± 0.013	2	0.004 ± 0.004	26	0.048 ± 0.034
Mid-channel Patch Reef Total (24)	**41**	**0.028 ± 0.006**	**8**	**0.006 ± 0.003**	**27**	**0.019 ± 0.013**
Offshore patch reefs						
Upper Florida Keys NMS						
12 - South of BNP boundary	2	0.033 ± 0.019	1	0.017 ± 0.017	0	0 ± 0
41 - North of Carysfort Reef SPA	1	0.017 ± 0.017	1	0.017 ± 0.017	0	0 ± 0
11 - North of Carysfort Reef SPA	3	0.050 ± 0.032	0	0 ± 0	0	0 ± 0
14 - Carysfort Reef SPA**	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
13 - Carysfort Reef SPA**	1	0.017 ± 0.017	1	0.017 ± 0.017	0	0 ± 0
10 - North of Dry Rocks SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
9 - SW of Grecian Rocks SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
8 - Inshore of French Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
7 - Inshore of Pickles Reef	4	0.067 ± 0.027	1	0.017 ± 0.017	0	0 ± 0
Upper Florida Keys Total (9)	13	0.024 ± 0.008	4	0.007 ± 0.003	0	0 ± 0
Middle Florida Keys NMS						
65 - North of Davis Reef SPA	2	0.033 ± 0.033	3	0.050 ± 0.017	0	0 ± 0
64 - North of Davis Reef SPA	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0

Site number/site location	*Bartholomea annulata*		*Condylactis gigantea*		*Epicystes crucifera*	
	N	No. per m^2	N	No. per m^2	N	No. per m^2
63 - North of Davis Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
62 - North of Davis Reef SPA	4	0.067 ± 0.038	2	0.033 ± 0.019	0	0 ± 0
89 - Coffins Patch SPA**	1	0.017 ± 0.017	1	0.017 ± 0.017	0	0 ± 0
88 - Coffins Patch SPA**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (6)	8	0.022 ± 0.010	7	0.019 ± 0.008	0	0 ± 0
Lower Florida Keys NMS						
109 - East of Looe Key RO	4	0.067 ± 0.038	0	0 ± 0	0	0 ± 0
110 - Looe Key Research Only**	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
111 - Looe Key Research Only**	0	0 ± 0	0	0 ± 0	1	0.017 ± 0.017
107 - North of Pelican Shoal	2	0.033 ± 0.033	0	0 ± 0	0	0 ± 0
112 - Western Sambo ER**	6	0.100 ± 0.058	1	0.017 ± 0.017	1	0.017 ± 0.017
113 - Western Sambo ER**	2	0.033 ± 0.019	1	0.017 ± 0.017	2	0.033 ± 0.033
106 - NE of E. Dry Rocks SPA	3	0.050 ± 0.032	0	0 ± 0	1	0.017 ± 0.017
133 - NE of E. Dry Rocks SPA	5	0.083 ± 0.032	0	0 ± 0	0	0 ± 0
Lower Florida Keys Total (8)	24	0.050 ± 0.011	2	0.004 ± 0.003	5	0.010 ± 0.004
Offshore Patch Reef Total (23)	**45**	**0.033 ± 0.006**	**13**	**0.009 ± 0.003**	**5**	**0.004 ± 0.002**
Inner line reef tract spur & groove						
Upper Florida Keys NMS						
32 - Turtle Rocks	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
31 - Inshore of Elbow Reef SPA	3	0.050 ± 0.032	0.017	0.017 ± 0.017	1	0.017 ± 0.017
30 - North Dry Rocks	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
34 - Dry Rocks SPA**	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
33 - Dry Rocks SPA**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
36 - Grecian Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
35 - Grecian Rocks SPA**	3	0.050 ± 0.032	0.017	0.017 ± 0.017	0	0 ± 0
Upper Florida Keys Total (7)	13	0.031 ± 0.007	0.005	0.005 ± 0.003	1	0.002 ± 0.002
Inner Line Reef Tract Total (7)	**13**	**0.031 ± 0.007**	**0.005**	**0.005 ± 0.003**	**1**	**0.002 ± 0.002**
High-relief spur & groove						
Upper Florida Keys NMS						
23 - Carysfort Reef SPA**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
22 - Carysfort Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
21 - Maitland grounding site	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
24 - Elbow Reef SPA**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
223 - Elbow Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
19 - North of French Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
25 - French Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
26 - French Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
20 - Sand Island	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
18 - Sand Island	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
28 - Molasses Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
27 - Molasses Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
17 - Pickles Reef	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
16 - Pickles Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
15 - Pickles Reef	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (15)	8	0.009 ± 0.003	0	0 ± 0	0	0 ± 0
Middle Florida Keys NMS						
67 - Delta Shoal	3	0.050 ± 0.032	0	0 ± 0	0	0 ± 0
66 - Delta Shoal	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
69 - Sombrero Key SPA**	2	0.033 ± 0.033	0	0 ± 0	0	0 ± 0
266 - Sombrero Key SPA**	3	0.050 ± 0.032	0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (4)	9	0.038 ± 0.008	0	0 ± 0	0	0 ± 0
Lower Florida Keys NMS						

Site number/site location	*Bartholomea annulata*		*Condylactis gigantea*		*Epicystes crucifera*	
	N	No. per m^2	N	No. per m^2	N	No. per m^2
124 - Looe Key SPA**	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
123 - Looe Key SPA**	4	0.067 ± 0.047	0	0 ± 0	0	0 ± 0
120 - American Shoal	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
122 - American Shoal	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
119 - Maryland Shoal	1	0.017 ± 0.017	0	0 ± 0	1	0.017 ± 0.017
121 - Maryland Shoal	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
118 - Pelican Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
117 - Pelican Shoal	3	0.050 ± 0.032	0	0 ± 0	0	0 ± 0
116 - No Name Reef	2	0.033 ± 0.033	0	0 ± 0	0	0 ± 0
322 - Eastern Sambo RO**	7	0.117 ± 0.057	0	0 ± 0	0	0 ± 0
125 - Eastern Sambo RO**	7	0.117 ± 0.017	0	0 ± 0	0	0 ± 0
127 - Western Sambo ER**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
126 - Western Sambo ER**	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
115 - East of E. Dry Rocks SPA	4	0.067 ± 0.027	0	0 ± 0	0	0 ± 0
129 - Eastern Dry Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
128 - Eastern Dry Rocks**	0	0 ± 0	0	0 ± 0	0	0 ± 0
327 - Rock Key SPA**	3	0.050 ± 0.017	0	0 ± 0	0	0 ± 0
130 - Rock Key SPA**	3	0.050 ± 0.032	0	0 ± 0	0	0 ± 0
131 - Sand Key SPA**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
328 - Sand Key SPA**	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
114 - Western Dry Rocks	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
Lower Florida Keys Total (21)	47	0.037 ± 0.007	0	0 ± 0	1	0.001 ± 0.001
Spur & Groove Total (40)	**64**	**0.027 ± 0.004**	**0**	**0 ± 0**	**0**	**0.0004 ± 0.0004**
Fore-reef (6-15 m)						
Upper Florida Keys NMS						
42 - South of BNP boundary	0	0 ± 0	0	0 ± 0	0	0 ± 0
52 - Carysfort Reef SPA**	3	0.050 ± 0.032	0	0 ± 0	0	0 ± 0
51 - Carysfort Reef SPA**	3	0.050 ± 0.050	0	0 ± 0	0	0 ± 0
50 - SW of Carysfort Reef SPA	3	0.050 ± 0.050	0	0 ± 0	0	0 ± 0
40 - SW of Carysfort Reef SPA	2	0.033 ± 0.033	0	0 ± 0	0	0 ± 0
39 - North of Elbow Reef SPA	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
245 - Elbow Reef SPA**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
46 - Elbow Reef SPA**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
38 - SW of Elbow Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
49 - South of Elbow Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
37 - Dixie Shoal	4	0.067 ± 0.027	0	0 ± 0	0	0 ± 0
48 - Dixie Shoal	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
47 - SW of Molasses Reef SPA	8	0.133 ± 0.047	0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (13)	28	0.036 ± 0.010	0	0 ± 0	0	0 ± 0
Middle Florida Keys NMS						
81 - Conch Reef SPA**	5	0.083 ± 0.017	0	0 ± 0	0	0 ± 0
80 - Conch Reef SPA**	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
82 - Conch Reef RO**	4	0.067 ± 0.027	0	0 ± 0	0	0 ± 0
279 - Conch Reef RO**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
84 - Davis Reef SPA**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
83 - Davis Reef SPA**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
79 - SW of Crocker Reef	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
78 - SW of Crocker Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
85 - Alligator Reef SPA**	2	0.033 ± 0.033	0	0 ± 0	0	0 ± 0
68 - Alligator Reef SPA**	3	0.050 ± 0.050	0	0 ± 0	0	0 ± 0
77 - SW of Alligator Reef SPA	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
87 - Tennessee Reef RO**	6	0.100 ± 0.079	0	0 ± 0	0	0 ± 0
86 - Tennessee Reef RO**	2	0.033 ± 0.033	0	0 ± 0	0	0 ± 0
76 - NE of Tennessee Light	4	0.067 ± 0.067	0	0 ± 0	0	0 ± 0
75 - East of Coffins Patch SPA	2	0.033 ± 0.033	0	0 ± 0	0	0 ± 0
293 - Sombrero Key SPA**	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
96 - Sombrero Key SPA**	8	0.133 ± 0.072	0	0 ± 0	0	0 ± 0

Site number/site location	*Bartholomea annulata*		*Condylactis gigantea*		*Epicystes crucifera*	
	N	No. per m^2	N	No. per m^2	N	No. per m^2
73 - West of Sombrero Key SPA	5	0.083 ± 0.042	1	0.017 ± 0.017	0	0 ± 0
71 - South of Moser Channel	5	0.083 ± 0.032	0	0 ± 0	0	0 ± 0
72 - South of Moser Channel	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
70 - South of Moser Channel	7	0.117 ± 0.074	0	0 ± 0	0	0 ± 0
90 - South of Moser Channel	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (22)	66	0.050 ± 0.008	1	0.001 ± 0.001	0	0 ± 0
Lower Florida Keys NMS						
136 - South of Bahia Honda Key	3	0.050 ± 0.017	0	0 ± 0	0	0 ± 0
138 - South of Bahia Honda Key	4	0.067 ± 0.067	0	0 ± 0	0	0 ± 0
137 - South of Bahia Honda Key	6	0.100 ± 0.058	0	0 ± 0	0	0 ± 0
135 - West of Looe Key SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
134 - West of Pelican Shoal	4	0.067 ± 0.047	0	0 ± 0	0	0 ± 0
139 - Eastern Sambo RO**	7	0.117 ± 0.042	0	0 ± 0	0	0 ± 0
336 - Eastern Sambo RO**	5	0.083 ± 0.017	0	0 ± 0	0	0 ± 0
141 - Western Sambo ER**	5	0.083 ± 0.017	0	0 ± 0	0	0 ± 0
140 - Western Sambo ER**	4	0.067 ± 0.027	0	0 ± 0	0	0 ± 0
143 - West of Western Sambo	3	0.050 ± 0.032	0	0 ± 0	0	0 ± 0
132 - East of E. Dry Rocks SPA	3	0.050 ± 0.032	0	0 ± 0	0	0 ± 0
346 - Rock Key SPA**	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
149 - Rock Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
347 - Sand Key SPA**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
150 - Sand Key SPA**	4	0.067 ± 0.047	0	0 ± 0	0	0 ± 0
142 - SW of Sand Key SPA	1	0.017 ± 0.017	1	0.017 ± 0.017	0	0 ± 0
Lower Florida Keys Total (16)	52	0.054 ± 0.009	1	0.001 ± 0.001	1	0.001 ± 0.001
Fore-reef Total (51)	**146**	**0.048 ± 0.005**	**2**	**0.001 ± 0.000**	**0**	**0.0003 ± 0.0003**

Table 18. Number of individuals (N) and mean ± 1 SE densities (no. of individuals per m^2) for the anemones *Heteractis lucida*, *Lebrunia danae*, and *Stichodactyla helianthus* in the Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m belt transects per site at 145 sites during June-August 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are no-take marine reserves.

Site number/site location	***Heteractis lucida***		***Lebrunia danae***		***Stichodactyla helianthus***	
	N	No. per m^2	N	No. per m^2	N	No. per m^2
Mid-channel patch reefs						
Upper Florida Keys NMS						
6 - Basin Hill Shoals	0	0 ± 0	0	0 ± 0	0	0 ± 0
5 - Basin Hill Shoals	0	0 ± 0	0	0 ± 0	0	0 ± 0
4 - Inshore of Grecian Rocks	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
3 - South of Cannon Patch Reef	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
2 - Mosquito Bank	0	0 ± 0	0	0 ± 0	0	0 ± 0
1 - Inshore of Molasses Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (6)	0	0 ± 0	2	0.006 ± 0.004	0	0 ± 0
Middle Florida Keys NMS						
56 - Tavernier Rocks	0	0 ± 0	0	0 ± 0	0	0 ± 0
55 - Tavernier Rocks	0	0 ± 0	0	0 ± 0	0	0 ± 0
59 - Hen and Chickens SPA**	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
58 - Hen and Chickens SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
61 - Cheeca Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
60 - Cheeca Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
57 - NE of Cheeca Rocks SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
54 - South of Duck Key	0	0 ± 0	0	0 ± 0	0	0 ± 0
53 - South of Ohio Key	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
Middle Florida Keys Total (9)	0	0 ± 0	2	0.004 ± 0.002	0	0 ± 0
Lower Florida Keys NMS						
103 - North of Looe Key RO	0	0 ± 0	3	0.050 ± 0.032	0	0 ± 0
102 - North of Maryland Shoal	0	0 ± 0	11	0.183 ± 0.057	0	0 ± 0
101 - North of Maryland Shoal	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
100 - North of Eastern Sambo	0	0 ± 0	0	0 ± 0	0	0 ± 0
105 - Western Sambo ER**	1	0.017 ± 0.017	13	0.217 ± 0.042	0	0 ± 0
104 - Western Sambo ER**	1	0.017 ± 0.017	6	0.100 ± 0.058	0	0 ± 0
99 - West of Western Sambo	0	0 ± 0	2	0.033 ± 0.033	0	0 ± 0
98 - Middle Ground	0	0 ± 0	35	0.583 ± 0.210	0	0 ± 0
97 - Middle Ground	0	0 ± 0	16	0.267 ± 0.082	0	0 ± 0
Lower Florida Keys Total (9)	2	0.004 ± 0.002	87	0.161 ± 0.061	0	0 ± 0
Mid-channel Patch Reef Total (24)	**2**	**0.001 ± 0.001**	**91**	**0.063 ± 0.027**	**0**	**0 ± 0**
Offshore patch reefs						
Upper Florida Keys NMS						
12 - South of BNP boundary	0	0 ± 0	0	0 ± 0	0	0 ± 0
41 - North of Carysfort Reef SPA	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
11 - North of Carysfort Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
14 - Carysfort Reef SPA**	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
13 - Carysfort Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
10 - North of Dry Rocks SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
9 - SW of Grecian Rocks SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
8 - Inshore of French Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
7 - Inshore of Pickles Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (9)	1	0.002 ± 0.002	1	0.002 ± 0.002	0	0 ± 0
Middle Florida Keys NMS						
65 - North of Davis Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
64 - North of Davis Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0

Site number/site location	*Heteractis lucida*		*Lebrunia danae*		*Stichodactyla helianthus*	
	N	No. per m^2	N	No. per m^2	N	No. per m^2
63 - North of Davis Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
62 - North of Davis Reef SPA	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
89 - Coffins Patch SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
88 - Coffins Patch SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (6)	0	0 ± 0	1	0.003 ± 0.003	0	0 ± 0
Lower Florida Keys NMS						
109 - East of Looe Key RO	0	0 ± 0	2	0.033 ± 0.033	0	0 ± 0
110 - Looe Key Research Only**	0	0 ± 0	2	0.033 ± 0.033	0	0 ± 0
111 - Looe Key Research Only**	0	0 ± 0	0	0 ± 0	0	0 ± 0
107 - North of Pelican Shoal	0	0 ± 0	2	0.033 ± 0.033	0	0 ± 0
112 - Western Sambo ER**	0	0 ± 0	4	0.067 ± 0.027	0	0 ± 0
113 - Western Sambo ER**	0	0 ± 0	0	0 ± 0	0	0 ± 0
106 - NE of E. Dry Rocks SPA	0	0 ± 0	5	0.083 ± 0.032	0	0 ± 0
133 - NE of E. Dry Rocks SPA	1	0.017 ± 0.017	17	0.283 ± 0.092	0	0 ± 0
Lower Florida Keys Total (8)	1	0.002 ± 0.002	32	0.067 ± 0.033	0	0 ± 0
Offshore Patch Reef Total (23)	**2**	**0.001 ± 0.001**	**34**	**0.025 ± 0.013**	**0**	**0 ± 0**
Inner line reef tract spur & groove						
Upper Florida Keys NMS						
32 - Turtle Rocks	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
31 - Inshore of Elbow Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
30 - North Dry Rocks	0	0 ± 0	0	0 ± 0	0	0 ± 0
34 - Dry Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
33 - Dry Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
36 - Grecian Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
35 - Grecian Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (7)	0	0 ± 0	1	0.002 ± 0.002	0	0 ± 0
Inner Line Reef Tract Total (7)	**0**	**0 ± 0**	**1**	**0.002 ± 0.002**	**0**	**0 ± 0**
High-relief spur & groove						
Upper Florida Keys NMS						
23 - Carysfort Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
22 - Carysfort Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
21 - Maitland grounding site	0	0 ± 0	0	0 ± 0	0	0 ± 0
24 - Elbow Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
223 - Elbow Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
19 - North of French Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
25 - French Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
26 - French Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
20 - Sand Island	0	0 ± 0	0	0 ± 0	0	0 ± 0
18 - Sand Island	0	0 ± 0	0	0 ± 0	0	0 ± 0
28 - Molasses Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
27 - Molasses Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
17 - Pickles Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
16 - Pickles Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
15 - Pickles Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (15)	0	0 ± 0	0	0 ± 0	0	0 ± 0
Middle Florida Keys NMS						
67 - Delta Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
66 - Delta Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
69 - Sombrero Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
266 - Sombrero Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (4)	0	0 ± 0	0	0 ± 0	0	0 ± 0
Lower Florida Keys NMS						

Site number/site location	*Heteractis lucida*		*Lebrunia danae*		*Stichodactyla helianthus*	
	N	No. per m^2	N	No. per m^2	N	No. per m^2
124 - Looe Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
123 - Looe Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
120 - American Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
122 - American Shoal	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
119 - Maryland Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
121 - Maryland Shoal	0	0 ± 0	1	0.017 ± 0.017	9	0.150 ± 0.096
118 - Pelican Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
117 - Pelican Shoal	0	0 ± 0	3	0.050 ± 0.032	0	0 ± 0
116 - No Name Reef	0	0 ± 0	5	0.083 ± 0.032	0	0 ± 0
322 - Eastern Sambo RO**	0	0 ± 0	3	0.050 ± 0.032	0	0 ± 0
125 - Eastern Sambo RO**	0	0 ± 0	0	0 ± 0	0	0 ± 0
127 - Western Sambo ER**	0	0 ± 0	2	0.033 ± 0.019	0	0 ± 0
126 - Western Sambo ER**	0	0 ± 0	0	0 ± 0	0	0 ± 0
115 - East of E. Dry Rocks SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
129 - Eastern Dry Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
128 - Eastern Dry Rocks**	0	0 ± 0	0	0 ± 0	0	0 ± 0
327 - Rock Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
130 - Rock Key SPA**	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
131 - Sand Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
328 - Sand Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
114 - Western Dry Rocks	0	0 ± 0	0	0 ± 0	0	0 ± 0
Lower Florida Keys Total (21)	0	0 ± 0	16	0.013 ± 0.005	9	0.007 ± 0.007
Spur & Groove Total (40)	**0**	**0 ± 0**	**16**	**0.007 ± 0.003**	**9**	**0.004 ± 0.004**
Fore-reef (6-15 m)						
Upper Florida Keys NMS						
42 - South of BNP boundary	0	0 ± 0	0	0 ± 0	0	0 ± 0
52 - Carysfort Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
51 - Carysfort Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
50 - SW of Carysfort Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
40 - SW of Carysfort Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
39 - North of Elbow Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
245 - Elbow Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
46 - Elbow Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
38 - SW of Elbow Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
49 - South of Elbow Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
37 - Dixie Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
48 - Dixie Shoal	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
47 - SW of Molasses Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (13)	0	0 ± 0	1	0.001 ± 0.001	0	0 ± 0
Middle Florida Keys NMS						
81 - Conch Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
80 - Conch Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
82 - Conch Reef RO**	0	0 ± 0	0	0 ± 0	0	0 ± 0
279 - Conch Reef RO**	0	0 ± 0	0	0 ± 0	0	0 ± 0
84 - Davis Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
83 - Davis Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
79 - SW of Crocker Reef	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
78 - SW of Crocker Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
85 - Alligator Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
68 - Alligator Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
77 - SW of Alligator Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
87 - Tennessee Reef RO**	0	0 ± 0	0	0 ± 0	0	0 ± 0
86 - Tennessee Reef RO**	0	0 ± 0	0	0 ± 0	0	0 ± 0
76 - NE of Tennessee Light	0	0 ± 0	0	0 ± 0	0	0 ± 0
75 - East of Coffins Patch SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
293 - Sombrero Key SPA**	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
96 - Sombrero Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0

Site number/site location	*Heteractis lucida*		*Lebrunia danae*		*Stichodactyla helianthus*	
	N	No. per m^2	N	No. per m^2	N	No. per m^2
73 - West of Sombrero Key SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
71 - South of Moser Channel	0	0 ± 0	0	0 ± 0	0	0 ± 0
72 - South of Moser Channel	0	0 ± 0	0	0 ± 0	0	0 ± 0
70 - South of Moser Channel	0	0 ± 0	0	0 ± 0	0	0 ± 0
90 - South of Moser Channel	0	0 ± 0	0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (22)	0	0 ± 0	2	0.002 ± 0.001	0	0 ± 0
Lower Florida Keys NMS						
136 - South of Bahia Honda Key	0	0 ± 0	0	0 ± 0	0	0 ± 0
138 - South of Bahia Honda Key	0	0 ± 0	0	0 ± 0	0	0 ± 0
137 - South of Bahia Honda Key	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
135 - West of Looe Key SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
134 - West of Pelican Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
139 - Eastern Sambo RO**	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
336 - Eastern Sambo RO**	0	0 ± 0	0	0 ± 0	0	0 ± 0
141 - Western Sambo ER**	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
140 - Western Sambo ER**	0	0 ± 0	2	0.033 ± 0.019	0	0 ± 0
143 - West of Western Sambo	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
132 - East of E. Dry Rocks SPA	0	0 ± 0	3	0.050 ± 0.032	0	0 ± 0
346 - Rock Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
149 - Rock Key SPA**	0	0 ± 0	1	0.017 ± 0.017	0	0 ± 0
347 - Sand Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
150 - Sand Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
142 - SW of Sand Key SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
Lower Florida Keys Total (16)	0	0 ± 0	10	0.010 ± 0.004	0	0 ± 0
Fore-reef Total (51)	**0**	**0 ± 0**	**13**	**0.004 ± 0.001**	**0**	**0 ± 0**

Table 19. Number of individuals (N) and mean ± 1 SE densities (no. of individuals per m^2) for the corallimorpharians *Discosoma carlgreni*, *D. sanctithomae*, and *Ricordea florida* in the Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 1-m belt transects per site at 145 sites during June-August 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are no-take marine reserves.

Site number/site location	***Discosoma carlgreni***		***D. sanctithomae***		***Ricordea florida***	
	N	No. per m^2	N	No. per m^2	N	No. per m^2
Mid-channel patch reefs						
Upper Florida Keys NMS						
6 - Basin Hill Shoals	0	0 ± 0	0	0 ± 0	0	0 ± 0
5 - Basin Hill Shoals	0	0 ± 0	0	0 ± 0	0	0 ± 0
4 - Inshore of Grecian Rocks	0	0 ± 0	0	0 ± 0	0	0 ± 0
3 - South of Cannon Patch Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
2 - Mosquito Bank	0	0 ± 0	0	0 ± 0	0	0 ± 0
1 - Inshore of Molasses Reef	0	0 ± 0	0	0 ± 0	46	0.767 ± 0.723
Upper Florida Keys Total (6)	0	0 ± 0	0	0 ± 0	46	0.128 ± 0.128
Middle Florida Keys NMS						
56 - Tavernier Rocks	0	0 ± 0	0	0 ± 0	0	0 ± 0
55 - Tavernier Rocks	0	0 ± 0	0	0 ± 0	0	0 ± 0
59 - Hen and Chickens SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
58 - Hen and Chickens SPA**	0	0 ± 0	0	0 ± 0	32	0.533 ± 0.533
61 - Cheeca Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
60 - Cheeca Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
57 - NE of Cheeca Rocks SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
54 - South of Duck Key	0	0 ± 0	0	0 ± 0	93	1.550 ± 0.922
53 - South of Ohio Key	0	0 ± 0	0	0 ± 0	54	0.900 ± 0.333
Middle Florida Keys Total (9)	0	0 ± 0	0	0 ± 0	179	0.331 ± 0.187
Lower Florida Keys NMS						
103 - North of Looe Key RO	0	0 ± 0	0	0 ± 0	6	0.100 ± 0.064
102 - North of Maryland Shoal	3	0.050 ± 0.032	204	3.400 ± 2.006	43	0.717 ± 0.530
101 - North of Maryland Shoal	0	0 ± 0	0	0 ± 0	1	0.017 ± 0.017
100 - North of Eastern Sambo	0	0 ± 0	0	0 ± 0	5	0.083 ± 0.083
105 - Western Sambo ER**	12	0.200 ± 0.200	142	2.367 ± 0.847	229	3.817 ± 1.250
104 - Western Sambo ER**	1	0.017 ± 0.017	33	0.550 ± 0.183	173	2.883 ± 0.969
99 - West of Western Sambo	0	0 ± 0	0	0 ± 0	22	0.367 ± 0.212
98 - Middle Ground	1	0.017 ± 0.017	53	0.883 ± 0.817	4	0.067 ± 0.067
97 - Middle Ground	0	0 ± 0	21	0.350 ± 0.223	12	0.200 ± 0.200
Lower Florida Keys Total (9)	17	0.031 ± 0.022	453	0.839 ± 0.409	495	0.917 ± 0.472
Mid-channel Patch Reef Total (24)	**22**	**0.015 ± 0.009**	**453**	**0.315 ± 0.170**	**720**	**0.500 ± 0.198**
Offshore patch reefs						
Upper Florida Keys NMS						
12 - South of BNP boundary	0	0 ± 0	0	0 ± 0	4	0.067 ± 0.047
41 - North of Carysfort Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
11 - North of Carysfort Reef SPA	0	0 ± 0	0	0 ± 0	2	0.033 ± 0.033
14 - Carysfort Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
13 - Carysfort Reef SPA**	0	0 ± 0	0	0 ± 0	3	0.050 ± 0.050
10 - North of Dry Rocks SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
9 - SW of Grecian Rocks SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
8 - Inshore of French Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
7 - Inshore of Pickles Reef	0	0 ± 0	0	0 ± 0	2	0.033 ± 0.033
Upper Florida Keys Total (9)	0	0 ± 0	0	0 ± 0	11	0.020 ± 0.009
Middle Florida Keys NMS						
65 - North of Davis Reef SPA	0	0 ± 0	0	0 ± 0	2	0.033 ± 0.033
64 - North of Davis Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0

Site number/site location	*Discosoma carlgreni*		*D. sanctithomae*		*Ricordea florida*	
	N	No. per m^2	N	No. per m^2	N	No. per m^2
63 - North of Davis Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
62 - North of Davis Reef SPA	0	0 ± 0	0	0 ± 0	1	0.017 ± 0.017
89 - Coffins Patch SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
88 - Coffins Patch SPA**	0	0 ± 0	0	0 ± 0	37	0.617 ± 0.529
Middle Florida Keys Total (6)	0	0 ± 0	0	0 ± 0	40	0.111 ± 0.101
Lower Florida Keys NMS						
109 - East of Looe Key RO	0	0 ± 0	0	0 ± 0	112	1.867 ± 1.090
110 - Looe Key Research Only**	0	0 ± 0	0	0 ± 0	278	4.633 ± 2.888
111 - Looe Key Research Only**	0	0 ± 0	0	0 ± 0	123	2.050 ± 1.320
107 - North of Pelican Shoal	0	0 ± 0	0	0 ± 0	1	0.017 ± 0.017
112 - Western Sambo ER**	0	0 ± 0	4	0.067 ± 0.047	117	1.950 ± 1.144
113 - Western Sambo ER**	0	0 ± 0	0	0 ± 0	0	0 ± 0
106 - NE of E. Dry Rocks SPA	0	0 ± 0	0	0 ± 0	38	0.633 ± 0.232
133 - NE of E. Dry Rocks SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
Lower Florida Keys Total (8)	0	0 ± 0	4	0.008 ± 0.008	669	1.394 ± 0.564
Offshore Patch Reef Total (23)	**0**	**0 ± 0**	**4**	**0.003 ± 0.003**	**720**	**0.522 ± 0.233**
Inner line reef tract spur & groove						
Upper Florida Keys NMS						
32 - Turtle Rocks	0	0 ± 0	0	0 ± 0	0	0 ± 0
31 - Inshore of Elbow Reef SPA	0	0 ± 0	0	0 ± 0	38	0.633 ± 0.140
30 - North Dry Rocks	0	0 ± 0	0	0 ± 0	0	0 ± 0
34 - Dry Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
33 - Dry Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
36 - Grecian Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
35 - Grecian Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (7)	0	0 ± 0	0	0 ± 0	38	0.190 ± 0.090
Inner Line Reef Tract Total (7)	**0**	**0 ± 0**	**0**	**0 ± 0**	**38**	**0.190 ± 0.090**
High-relief spur & groove						
Upper Florida Keys NMS						
23 - Carysfort Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
22 - Carysfort Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
21 - Maitland grounding site	0	0 ± 0	0	0 ± 0	0	0 ± 0
24 - Elbow Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
223 - Elbow Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
19 - North of French Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
25 - French Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
26 - French Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
20 - Sand Island	0	0 ± 0	0	0 ± 0	0	0 ± 0
18 - Sand Island	0	0 ± 0	0	0 ± 0	0	0 ± 0
28 - Molasses Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
27 - Molasses Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
17 - Pickles Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
16 - Pickles Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
15 - Pickles Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (15)	0	0 ± 0	0	0 ± 0	0	0 ± 0
Middle Florida Keys NMS						
67 - Delta Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
66 - Delta Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
69 - Sombrero Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
266 - Sombrero Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (4)	0	0 ± 0	0	0 ± 0	0	0 ± 0
Lower Florida Keys NMS						

Site number/site location	*Discosoma carlgreni*		*D. sanctithomae*		*Ricordea florida*	
	N	No. per m^2	N	No. per m^2	N	No. per m^2
124 - Looe Key SPA**	0	0 ± 0	0	0 ± 0	6	0.100 ± 0.100
123 - Looe Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
120 - American Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
122 - American Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
119 - Maryland Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
121 - Maryland Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
118 - Pelican Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
117 - Pelican Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
116 - No Name Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
322 - Eastern Sambo RO**	0	0 ± 0	0	0 ± 0	0	0 ± 0
125 - Eastern Sambo RO**	0	0 ± 0	0	0 ± 0	0	0 ± 0
127 - Western Sambo ER**	0	0 ± 0	0	0 ± 0	0	0 ± 0
126 - Western Sambo ER**	0	0 ± 0	0	0 ± 0	20	0.333 ± 0.333
115 - East of E. Dry Rocks SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
129 - Eastern Dry Rocks SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
128 - Eastern Dry Rocks**	0	0 ± 0	0	0 ± 0	0	0 ± 0
327 - Rock Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
130 - Rock Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
131 - Sand Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
328 - Sand Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
114 - Western Dry Rocks	0	0 ± 0	0	0 ± 0	0	0 ± 0
Lower Florida Keys Total (21)	0	0 ± 0	0	0 ± 0	26	0.021 ± 0.016
Spur & Groove Total (40)	**0**	**0 ± 0**	**0**	**0 ± 0**	**26**	**0.011 ± 0.009**
Fore-reef (6-15 m)						
Upper Florida Keys NMS						
42 - South of BNP boundary	0	0 ± 0	0	0 ± 0	0	0 ± 0
52 - Carysfort Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
51 - Carysfort Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
50 - SW of Carysfort Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
40 - SW of Carysfort Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
39 - North of Elbow Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
245 - Elbow Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
46 - Elbow Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
38 - SW of Elbow Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
49 - South of Elbow Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
37 - Dixie Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
48 - Dixie Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
47 - SW of Molasses Reef SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
Upper Florida Keys Total (13)	0	0 ± 0	0	0 ± 0	0	0 ± 0
Middle Florida Keys NMS						
81 - Conch Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
80 - Conch Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
82 - Conch Reef RO**	0	0 ± 0	0	0 ± 0	0	0 ± 0
279 - Conch Reef RO**	0	0 ± 0	0	0 ± 0	0	0 ± 0
84 - Davis Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
83 - Davis Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
79 - SW of Crocker Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
78 - SW of Crocker Reef	0	0 ± 0	0	0 ± 0	0	0 ± 0
85 - Alligator Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
68 - Alligator Reef SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
77 - SW of Alligator Reef SPA	0	0 ± 0	0	0 ± 0	35	0.583 ± 0.369
87 - Tennessee Reef RO**	0	0 ± 0	0	0 ± 0	0	0 ± 0
86 - Tennessee Reef RO**	0	0 ± 0	0	0 ± 0	17	0.283 ± 0.283
76 - NE of Tennessee Light	0	0 ± 0	0	0 ± 0	0	0 ± 0
75 - East of Coffins Patch SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
293 - Sombrero Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
96 - Sombrero Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0

Site number/site location	*Discosoma carlgreni*		*D. sanctithomae*		*Ricordea florida*	
	N	No. per m^2	N	No. per m^2	N	No. per m^2
73 - West of Sombrero Key SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
71 - South of Moser Channel	0	0 ± 0	0	0 ± 0	3	0.050 ± 0.050
72 - South of Moser Channel	0	0 ± 0	0	0 ± 0	0	0 ± 0
70 - South of Moser Channel	0	0 ± 0	0	0 ± 0	0	0 ± 0
90 - South of Moser Channel	0	0 ± 0	0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (22)	0	0 ± 0	0	0 ± 0	55	0.042 ± 0.029
Lower Florida Keys NMS						
136 - South of Bahia Honda Key	0	0 ± 0	0	0 ± 0	0	0 ± 0
138 - South of Bahia Honda Key	0	0 ± 0	0	0 ± 0	0	0 ± 0
137 - South of Bahia Honda Key	0	0 ± 0	0	0 ± 0	0	0 ± 0
135 - West of Looe Key SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
134 - West of Pelican Shoal	0	0 ± 0	1	0.017 ± 0.017	9	0.150 ± 0.110
139 - Eastern Sambo RO**	0	0 ± 0	1	0.017 ± 0.017	3	0.050 ± 0.050
336 - Eastern Sambo RO**	0	0 ± 0	0	0 ± 0	0	0 ± 0
141 - Western Sambo ER**	0	0 ± 0	0	0 ± 0	2	0.033 ± 0.033
140 - Western Sambo ER**	0	0 ± 0	0	0 ± 0	0	0 ± 0
143 - West of Western Sambo	0	0 ± 0	0	0 ± 0	1	0.017 ± 0.017
132 - East of E. Dry Rocks SPA	0	0 ± 0	0	0 ± 0	4	0.067 ± 0.047
346 - Rock Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
149 - Rock Key SPA**	0	0 ± 0	0	0 ± 0	1	0.017 ± 0.017
347 - Sand Key SPA**	0	0 ± 0	0	0 ± 0	0	0 ± 0
150 - Sand Key SPA**	0	0 ± 0	0	0 ± 0	3	0.050 ± 0.032
142 - SW of Sand Key SPA	0	0 ± 0	0	0 ± 0	0	0 ± 0
Lower Florida Keys Total (16)	0	0 ± 0	2	0.002 ± 0.001	23	0.024 ± 0.010
Fore-reef Total (51)	**0**	**0 ± 0**	**2**	**0.001 ± 0.000**	**78**	**0.025 ± 0.013**

VII. Marine debris distribution

Background

Fishing constitutes one of the most significant threats to marine biodiversity and ecosystem function, documented by a growing 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 species population structure, 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 such as 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 and 2001 (Chiappone et al. 2002c, 2004, 2005). These initial surveys included an assessment of 45 sites in the lower Keys from inshore to offshore during 2000, followed by sampling of 63 platform margin sites Keys-wide in 2001. These initial efforts addressed several questions pertaining to marine debris and its impacts to organisms and habitats in the study area. 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 the 2008 sampling to document the different 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 study

area. Our hope is that this information will help Federal and state resource managers to identify areas in dire need of debris removal. These data also demonstrate the ubiquitous and damaging characteristics of marine debris, particularly derelict fishing gear, even within "protected" no-fishing zones.

2008 Survey Results

At all 145 Florida Keys sites sampled during 2008, four belt transects 15-m x 4-m in dimension were used to quantify the type, length (where applicable), weight, and impacts of marine debris to benthic coral reef organisms. Figures 69 and 70 illustrate examples of marine debris, especially derelict trap fishing gear, encountered during 2008. From surveys of 34,800 m^2 of hard-bottom and coral reef habitat, a total of 686 marine debris items were encountered along belt transects, representing 59 different items or combinations of items (Table 20). Of these 59 different items, at least 15 (25.4%) were clearly hook-and-line angling gear, 11 (18.6%) were lost lobster/crab trap gear, and the remaining 33 items (55.9%) were designated as "other". Other marine debris included a range of metal, cloth, ceramic, and plastic items. Of the 686 total debris items counted and retrieved, 363 (53%) were hook-and-line gear (monofilament, wire leaders, hooks, lead sinkers, etc.), followed by 241 trap debris items (35%), and other debris (82 items, 12.0%). For hook-and-line gear, a total of 477.6 m of debris was measured and retrieved from the bottom, mostly represented by monofilament line and wire leader (Table 20). For trap debris, 944.3 m of rope, either free (not attached to something) or attached to wooden slats and/or metal gratings, was measured and retrieved. The 686 debris items recorded during the 2008 surveys caused abrasion damage to 448 different coral reef benthic organisms, represented by *Millepora* and scleractinian corals, gorgonians, sponges, and the colonial zoanthid *Palythoa* (Table 21). Lost hook-and-line gear caused impacts to 194 different organisms (43.3%). Trap debris, while representing 35% of all debris encountered, resulted in documented damage to 225 different benthic organisms (50.2%). This indicates that when trap debris was encountered, its effects on the benthic community were proportionally larger than for hook-and-line and other debris types.

The paragraphs below highlight four aspects of the two dominant debris types, lost hook-and-line fishing gear and lobster/crab trap gear, found in the Florida Keys study area: 1) the total number of debris items and mean densities of debris by site, habitat, regional sector, and management zone; 2) the total length of debris recovered at various spatial scales; 3) the average length of each debris incidence; and 4) the biological impacts caused by the debris to benthic coral reef organisms.

Lost Hook-and-line Gear

Hook-and-line gear was the most frequently category of marine debris in 2008 in terms of the number of sites and number of items encountered. Figures 71-76 illustrate the spatial distribution of lost hook-and-line fishing gear density (no. items per 60 m^2) throughout the Florida Keys study area. The distribution of hook-and-line debris indicates that it is ubiquitous throughout the study area in the habitat types sampled. Site-level mean (± 1 SE) densities of hook-and-line debris were as high as 8.50 items per 60 m^2 (Table 22). Hook-and-line debris was recovered from 86 out of the 145 sites (59.3%) and all five habitats: mid-channel patch reefs (16 sites, 66.7%), offshore patch reefs, (11 sites, 52.4%), inner line reef tract (4 sites, 57.1%), high-relief spur and groove (27 sites, 67.5%), and the deeper fore reef (28 sites, 54.9%). Differences in mean hook-and-line gear densities (no. items per 60 m^2) among habitats were evident, with mid-channel patch reefs (1.35 ± 0.49) and high-relief spur and groove (0.66 ± 0.15) yielding the greatest densities, while inner line reef tract sites had the lowest (0.18 ± 0.07) (Table 22). Figures 77-80 provide comparisons of lost hook-and-line gear densities among regions and management zones by habitat type. No-take zones and reference areas were roughly similar in terms of lost hook-and-line gear densities for several of the habitat types in particular regional sectors, and in several instances, hook-and-line gear densities were, in fact, greater within no-take zones (Table 22). Particularly noteworthy is the relatively high densities of hook-and-line debris documented at Hen and Chickens SPA, Cheeca Rocks SPA, Sombrero Key SPA, Conch Reef RO, and Alligator Reef SPA. On mid-channel patch reefs in the middle Keys, hook-and-line gear density was 1.25 greater within no-take zones (2.50 ± 1.32 items per 60 m^2) compared to reference areas (2.00 ± 1.32). On lower Keys offshore patch reefs, upper Keys inner line reef tract, and middle Keys high-relief spur and groove, hook-and-line gear densities between no-take zones and reference areas were roughly similar. On the deeper fore-reef, combined hook-and-line gear density was 2.7 times greater on middle Keys no-take zones (0.90 ± 0.41) compared to reference areas (0.33 ± 0.11).

Figure 81 illustrates the length distribution of lost hook-and-line gear recovered for all sites combined. Of the 347 hook-and-line gear items measured, nearly 86% were less than 2.0 m in length. The average (± 1 SE) length of all items recovered was 1.4 ± 0.1 m, ranging from 0.08 m to 19 m. Figures 82-87 illustrate the spatial distribution of lost hook-and-line gear length (total length recovered per site) throughout the Florida Keys study area. The length of hook-and-line gear recovered per site varied substantially among the five habitat types. Mid-channel patch reefs (6.2 ± 2.4 m per site), high-relief spur and groove (3.3 ± 0.9 m), and the deeper fore-reef (3.0 ± 0.8 m) yielded the greatest average total length of hook-and-line debris. Figure 88-91 compare lost hook-and-line gear length among regions and management zones by habitat type. Mid-channel patch reef no-take zones (9.8 ± 5.9 m per site) and reference areas (9.3 ± 5.6) were similar in the middle Keys, due to the substantial amount of hook-and-line gear recovered from Hen

and Chickens SPA and Cheeca Rocks SPA. No hook-and-line gear was recovered from mid-channel patch reefs in the Western Sambo Ecological Reserve in the lower Keys, but substantial amounts of gear (6.6 ± 6.4 m per site) was recovered from reference sites, especially north of Looe Key RO. On offshore patch reefs, less total hook-and-line gear was recovered from no-take zones compared to reference areas, except in the middle Keys, where gear length recovered per site was substantially greater (4.1 ± 4.1 m) in Coffins Patch SPA compared to reference sites (0.2 ± 0.2 m). On inner line reef tract, no-take zones and reference areas yielded similar lengths of hook-and-line gear. On high-relief spur and groove reefs, reference areas consistently yielded greater total lengths of gear. However, substantial lengths of hook-and-line debris was recovered from upper Keys (2.0 ± 0.9 m per site) and middle Keys (3.2 ± 2.4 m per site) no-take zones, especially Elbow Reef SPA, French Reef SPA, Molasses Reef SPA, and Sombrero Key SPA. On the deeper fore-reef, reference areas yielded greater total lengths of hook-and-line gear per site in two regions, while no-take zones in the middle Keys (3.4 ± 1.4 m per site) yielded more than reference areas (2.4 ± 0.9 m per site). This latter result reflected the substantial total lengths of hook-and-line gear recovered from Conch Reef RO, Alligator Reef SPA, and Tennessee Reef RO.

The 15 categories of lost hook-and-line fishing gear accounted for 363 out of the 686 incidences of marine debris encountered during 2008 (Table 20). The 363 hook-and-line debris items representing 47.8 m of debris caused abrasion damage to 194 different coral reef organisms among five major categories. Gorgonians (104 colonies impacted), followed by sponges (41 impacts), were the most frequently damaged by lost hook-and-line fishing gear (Table 21). This is not surprising, given the upright morphologies of these two taxonomic groups and their abundances in the habitats sampled. Both gorgonians and sponges were particularly susceptible to entanglement and abrasion damage from monofilament line and wire leaders.

Relative to the area sampled in each habitat, regional sector, and management zone, initial estimates can be derived for the Florida Keys sampling domain (northern Key Largo to SW of Key West) for hook-and-line gear, using gear density and total length of debris retrieved per site, as well as information on the spatial extent of habitats (see Smith et al. in press). For the Florida Keys sampling domain, the targeted habitats were divided by regional sector and management zone and estimates of the total area of each stratum was obtained based upon existing habitat and bathymetry maps (Table 1). Within each targeted 200-m x 200-m cell or block, four belt transects 15-m x 4-m in dimension (totaling 240 m^2 in area) were sampled, thus representing 0.6% of the total cell area. For each site, there are data on the number of debris items, the mean density of debris items, and total length of debris recovered (Table 22). Even if we do not scale up the transect data (60 m^2 x 4 per site) to the area of a block (40,000 m^2), and assume that all of the

debris in a 200-m x 200-m block only occurred within our transect boundaries, then a very conservative estimate of the total number of hook-and-line gear items and the total length can be obtained. These estimates only apply to the five habitat types that were actually sampled during 2008 and are as follows:

- Mid-channel patch reefs: 10,628 debris items with a total length of 83.8 km (~52.0 miles),
- Offshore patch reefs: 1,142 debris items with a total length of 97.5 km (~60.6 miles),
- Inner line reef tract: 463 debris items with a total length of 0.5 km (~0.32 miles),
- High-relief spur and groove: 101 debris items with a total length of 0.5 km (~0.30 miles),
- Deeper fore reef (6-15 m): 6,203 items with a total length of 14.7 km (~9.1 miles), and
- Total for the five habitats: ~18,503 hook-and-line debris items with a total length of 196.5 km (~122 miles). This is equivalent to stretching a single piece of monofilament line or wire leader from Key West to Florida City.

If the results were scaled up to assume the debris found within the 240 m^2 area comprised by the four transects is similarly distributed throughout the 40,00m^2 cell, then the estimated line or leader could stretch back and forth between the two cities 170 times.

It is important to note that these estimates are affected by the accuracy of the existing habitat and bathymetry maps for the Florida Keys, as well as the density and gear length estimates derived for each site. In addition, the values assume hook-and-line fishing effort, which affects the amount of hook-and-line gear lost, is evenly distributed throughout the study area, which is probably not the case. Nevertheless, these initial estimates illustrate the potential amount of lost hook-and-line fishing gear that may be present in the Florida Keys, not including Biscayne National Park, the Marquesas Keys, or the Dry Tortugas.

Lost Lobster/Crab Trap Debris

Next to hook-and-line gear, lobster/crab trap debris was the next most frequent category of marine debris in 2008 in terms of the number of sites where it was encountered and number of items retrieved (Table 20). Figures 92-97 illustrate the spatial distribution of trap debris density (no. items per 60 m^2) throughout the Florida Keys study area, consisting of rope, wooden slats, cement slabs, plastic pot openings, and metal mesh trap grating, not including intact, but unbuoyed, traps on the bottom. The distribution of trap debris indicates that it is ubiquitous throughout the study area in all of the habitats sampled. Site-level mean (± 1 SE) densities of trap debris were as high as 3.75 items per 60 m^2 (Table 23). Trap debris was recovered from 85 out of the 145 sites (58.6%) and all five habitats as follows: mid-channel patch reefs

(17 sites, 70.8%), offshore patch reefs, (21 sites, 91.3%), inner line reef tract (5 sites, 71.4%), high-relief spur and groove (14 sites, 35%), and the deeper fore reef (28 sites, 54.9%). Differences in trap gear mean densities (no. items per 60 m^2) among habitats were evident, with the three more inshore habitats, specifically mid-channel patch reefs (0.65 ± 0.17), offshore patch reefs (0.62 ± 0.11), and inner line reef tract (0.57 ± 0.21), yielding greater densities than offshore spur and groove (0.15 ± 0.04) and the deeper fore-reef (0.40 ± 0.10) (Table 23). Figures 98-101 provide comparisons of trap debris among regions and management zones by habitat type. Similar to lost hook-and-line fishing debris, no-take zones and reference areas were roughly similar in terms of trap debris for several of the habitat types in particular regional sectors, and in several instances, trap debris were greater within no-take zones (Table 23). Particularly noteworthy are the relatively high densities of trap debris documented at Grecian Rocks SPA, Hen and Chickens SPA, Tennessee Reef RO, Coffins Patch SPA, and Looe Key RO. On mid-channel patch reefs in both the middle and lower Keys, trap gear densities were lower in reference areas, although substantial densities of trap gear and total lengths of rope were recovered from some of the no-take zones (Table 23). On middle Keys offshore patch reefs, greater trap gear density (1.13 ± 0.88 items per 60 m^2) and average trap rope length per site (8.6 ± 8.6 m) were recorded from Coffins Patch SPA compared to reference areas (0.56 ± 0.28 per 60 m^2, 5.9 ± 2.5 m per site). On lower Keys offshore patch reefs, similar densities of trap debris were found between no-take zones (0.56 ± 0.28) and reference areas (0.56 ± 0.16), although substantially greater trap rope was recovered per site (43.0 ± 20.9 m) from reference areas. Even so, an average of 13.5 ± 7.9 m of trap rope was recovered from no-take zones, all of which was found in the Looe Key RO.

Figure 102 illustrates the length distribution of lost trap rope debris recovered for all sites combined. Of the 81 incidences of trap rope, ~21% were less than 5.0 m in length, while 53% of the rope items were between 5 m and 15 m in length. The average (± 1 SE) length of all trap rope debris recovered was 11.7 ± 1.0 m. Figures 103-108 illustrate the spatial distribution of trap rope length (total length recovered per site) throughout the Florida Keys study area. The length of trap rope recovered per site varied substantially among the five habitat types. Mid-channel patch reefs (13.8 ± 3.5 m per site) and offshore patch reefs (14.6 ± 4.6 m per site) yielded the greatest average length of rope per site, roughly four times or greater than for the remaining three habitats. Figure 109-112 illustrate comparisons of lost hook-and-line gear length among regions and management zones by habitat type. Reference mid-channel and offshore patch reefs were particularly noteworthy for the total length of trap recovered from many sites (Table 23). However, significant amounts (10+ m total length) of trap rope were recovered from several no-take zones, including Hen and Chickens SPA, Cheeca Rocks SPA, Coffins Patch SPA, Looe Key RO, and Tennessee Reef RO.

The 11 different types or combinations of trap debris accounted for 241 out of the 686 incidences of marine debris encountered during 2008 (Table 20). Trap debris resulted in 225 impacts to benthic coral reef organisms, so in comparison to hook-and-line gear, which was more frequently encountered, trap debris caused more damage. Similar to hook-and-line debris, lobster trap debris caused the most amount of abrasion damage to gorgonians (Table 21). In contrast, however, scleractinian corals were the second most frequently damaged group of organisms, followed by sponges. Trap rope in particular was the most damaging of the trap debris types encountered.

Relative to the area sampled in each habitat, regional sector, and management zone, initial estimates can be derived for the Florida Keys sampling domain (northern Key Largo to SW of Key West) for trap debris, using gear density and total length of trap rope retrieved per site, as well as information on the spatial extent of habitats (see Smith et al. in press). Even if we do not scale up the transect data (60 m^2 x 4 per site) to the area of a block (40,000 m^2), and assume that all of the debris in a 200-m x 200-m area only occurred within our transect boundaries, then a very conservative estimate of the total number of trap debris items and the total trap rope present can be obtained. These estimates only apply to the five habitat types that were actually sampled during 2008 and are as follows:

- Mid-channel patch reefs: 4,870 debris items with a total trap rope length of 31.4 km (~19.5 miles),
- Offshore patch reefs: 2,466 debris items with a total length of 16.0 km (~9.9 miles),
- Inner line reef tract: 157 debris items with a total trap rope length of 0.1 km (~0.06 miles),
- High-relief spur and groove: 119 debris items with a total trap rope length of 0.7 km (~0.44 miles),
- Deeper fore reef (6-15 m): 6,203 debris items with a total trap rope length of 14.7 km (~9.1 miles), and
- Total for the five habitats: ~16,512 debris items with a total trap rope length of 61.5 km (~38.2 miles).

The total trap rope length for the five habitats is equivalent to stretching a single piece of trap rope from Marathon to Tavernier.

It is important to note that these estimates are affected by the accuracy of the existing habitat and bathymetry maps for the Florida Keys, as well as the density and trap rope length estimates derived for

each site. In addition, the values assume that lobster/crab trapping effort, which affects the amount of gear lost, is evenly distributed throughout the study area, which is probably not the case. Nevertheless, these initial estimates illustrate the potential amount of lost trap gear that may be present in the Florida Keys, not including Biscayne National Park, the Marquesas Keys, or the Dry Tortugas. Given that trap fishing has been going on for decades, and the fact that upwards of 450,000 traps are deployed every single year, with perhaps a 20-25% trap loss rate, it is not surprising that this amount of gear could accumulate in the study area.

Other Marine Debris

Besides hook-and-line and trap gear fishing debris, an assortment of marine debris classified as "other" was documented and recovered during 2008. A total of 33 other debris types that were not included in hook-and-line and trap debris categories were found, and included a range of paper, plastic, ceramic, and metal objects (Table 20). The 82 incidences of other debris caused abrasion damage to 29 different benthic coral reef organisms, of which gorgonians were the most frequently damaged (Table 21). In contrast to the two major types of fishing gear debris, other marine debris was found in relatively low amounts and somewhat randomly distributed among sites (Table 24).

Total Marine Debris

Figures 113-118 illustrate the spatial distribution of all marine debris encountered in the Florida Keys during 2008. As total debris largely reflects lost fishing gear, the spatial distribution of total marine is similar to lost hook-and-line and trap debris. Table 24 lists the total marine debris densities by site. What are noteworthy are the widespread occurrence of debris among the different habitats sampled and the relatively high densities of debris encountered in many of the Sanctuary no-take zones (Figures 119-122). For most of the habitats, the total marine debris encountered was proportional to the sampling effort allocated to no-take zones and corresponding reference areas. Unfortunately, one would expect significantly lower marine debris densities in the no-take zones, especially for debris that is derelict fishing gear. On mid-channel patch reefs, no-take zones represented 25% of the total sampling effort, yet 27.6% of debris items and 10.3% of the total debris wet weight were found in the no-take zones. On offshore patch reefs, 34.8% of the sampling effort in this habitat was allocated to no-take zones, while 35.9% of the total debris and 29.0% of the total weight was recovered from the zones. On inner line reef tract, more debris than expected was recovered in the no-take zones, both in terms of the number of items (69.2%) and debris wet weight (73.9%), relative to the sampling effort (57.1%) allocated to no-fishing zones in this habitat. For both high-relief spur and groove and the deeper fore-reef, less debris than expected was found in the no-take zones, assuming that debris incidence was proportional to the sampling

effort. Overall, no-take zones represented 44.1% of the total sampling effort in 2008, yet 36.3% of the total debris items and ~30% of the total debris wet was recovered from the 22 no-take zones visited.

In addition to density and debris length estimates, all debris encountered during 2008 was recovered from the bottom and weighed. Table 25 provides site-level data for marine debris wet weight and Figures 123-128 illustrate the spatial distribution of debris weight recovered throughout the study area. A total of 443.098 kg of debris (~975 lbs.) was recovered from the 145 sampling locations. Total debris wet recovered per site reflects not the only the amount of debris, but also the debris type. Not surprisingly, those sites yielding the greatest densities and amounts of trap debris also yielded the largest debris weights, reflecting cement used to weight traps, as well as trap rope. Mid-channel (73.121 kg among 24 sites) and offshore patch reefs (122.864 kg among 23 sites), as well as the deeper fore reef (160.798 kg among 51 sites), yielded the greatest habitat-level weights of 3.047 ± 0.848, 5.342 ± 1.829, and 3.153 ± 0.735 kg of total debris per site, respectively (Figures 129-132). In a similar fashion to lost fishing gear, estimates of total weight of marine debris in the study area can be calculated by using site-level estimates (per 240 m^2) of debris weight and the number of available sites (200-m x 200-m blocks or cells) in a particular habitat. These estimates suggest that there may be as much as the following total marine debris by habitat in the study area:

- Mid-channel patch reefs: 7,052 kg (~7.76 tons),
- Offshore patch reefs: 5,990 kg (~6.59 tons),
- Inner line reef tract: 146 kg (~0.16 tons),
- High-relief spur and groove: 359 kg (~0.40 tons),
- Deeper fore reef (6-15 m): 15,079 kg (~16.59 tons), and
- Total for the five habitats: 28,627 kg (~31.49 tons).

These estimates illustrate the potential amount of total marine debris that may be present in the Florida Keys, not including Biscayne National Park, the Marquesas Keys, or the Dry Tortugas.

Discussion

Methods of fishing that cause habitat modification or damage to benthic organisms represent potentially 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 (T. Matthews et al. at FWRI) indicate the potential for extensive movement of deployed gear, especially during storms. Relative to surveys completed by our program in 2000 and 2001, the results from 2008 indicated the continued persistence of marine debris, especially lost fishing gear, throughout the Florida Keys.

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 observed several instances where hook-and-line and trap gear, especially monofilament and trap rope, were 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. Results from this study suggest that overall estimates of biological impact from marine debris may be considerable, and such impacts are among a suite of factors that affect the structure and condition of Florida Keys reefs. In particular, lost trap rope, while lower in density than lost hook-and-line gear, causes a disproportionate amount of damage to benthic invertebrates. As visitation and fishing pressure increase in this area, it can be expected that the extent of marine debris and the impacts to organisms will also increase.

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. We initially assumed that, independent of habitat type, the mean density of debris, especially fishing gear, would be lower in no-fishing zones “protected” since 1997 compared to reference areas. However, marine debris

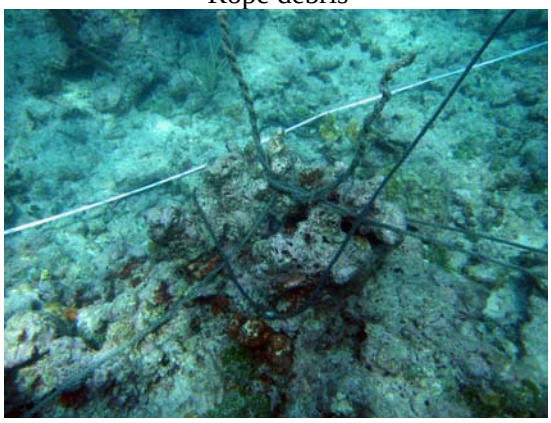
occurrence, most of which was derelict fishing gear in terms of the number of items and total weight, was more or less proportional to the sampling effort. This is similar to results obtained in 2000 (Chiappone et al. 2002c) and 2001 (Chiappone et al. 2004) in the study area. In other words, we did not find substantially less debris in the no-take zones compared to reference areas open to fishing, and, in fact, several of the no-take zones yielded greater densities and amounts (length, weight) of debris, particularly derelict fishing gear, compared to adjacent reference areas. There are several possible explanations for these patterns. First, non-compliance may have occurred in some of the no-fishing zones sampled. It was not uncommon to find "fresh" hook-and-line gear in the no-take zones. Second, the no-take zones may attract fishers to fish illegally or to fish close to the zone boundaries, otherwise known as "fishing the line". For example, substantial amounts of hook-and-line gear were found within the Research Only Area at Conch Reef, which has four yellow zone buoys, as well as several buoys in the interior marking the location of NOAA's Aquarius undersea habitat. Third, it is possible that storms distribute debris from areas where it is initially lost preferentially to the no-take zones. For example, while lobster traps are most commonly deployed in seagrass beds, with some deployed on the periphery of patch reefs, wave action from storms could have transport trap components elsewhere. It is quite likely that tropical storms during 2008 resulted in the destruction and transport of numerous lobster traps. For example, six complete lobster pots, together with buoys, were inside the Tennessee Reef RO for several weeks, but perhaps were set outside of the no-take zone initially.

Figure 69. Examples of plastic and trap rope debris documented in the Florida Keys during 2008.

Plastic debris

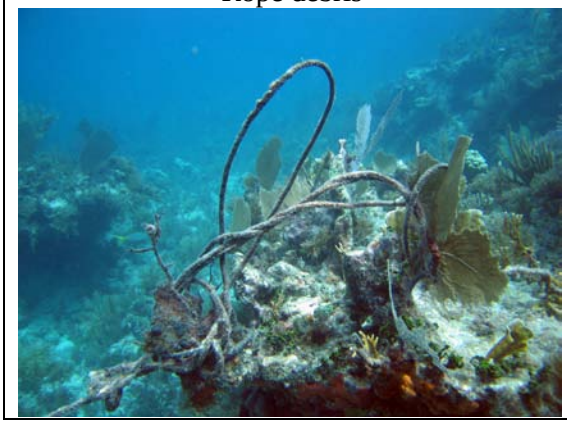
Rope debris

Rope debris



Rope debris

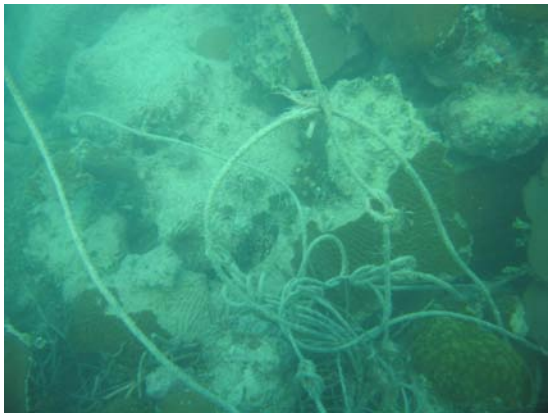
Rope debris



Rope debris

Figure 70. Examples of lobster/crab trap rope and derelict traps documented in the Florida Keys during 2008.

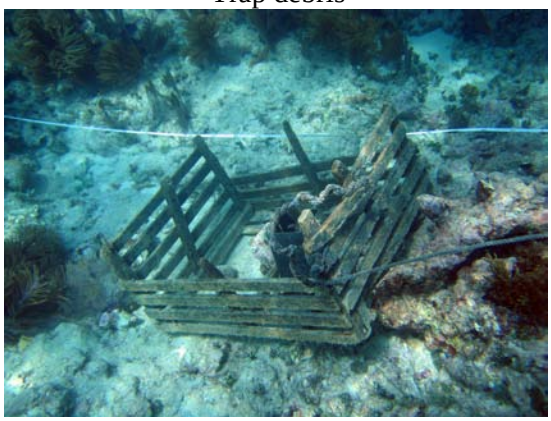
Plastic debris



Rope debris

Rope debris

Trap debris



Rope debris

Trap debris

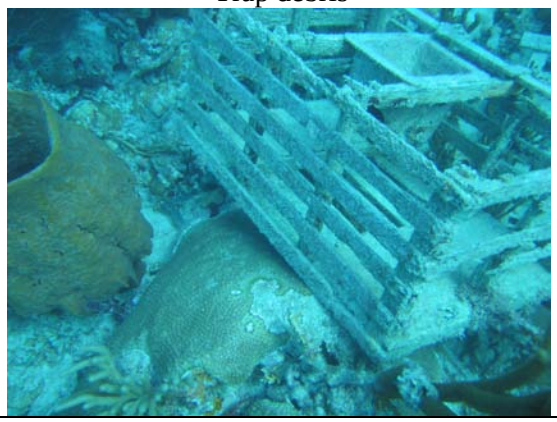


Figure 71. Densities (no. items per 60 m^2) of hook-and-line fishing gear in the upper Florida Keys (top) and from the southern BNP boundary to Carysfort Reef (bottom) during June-September 2008.

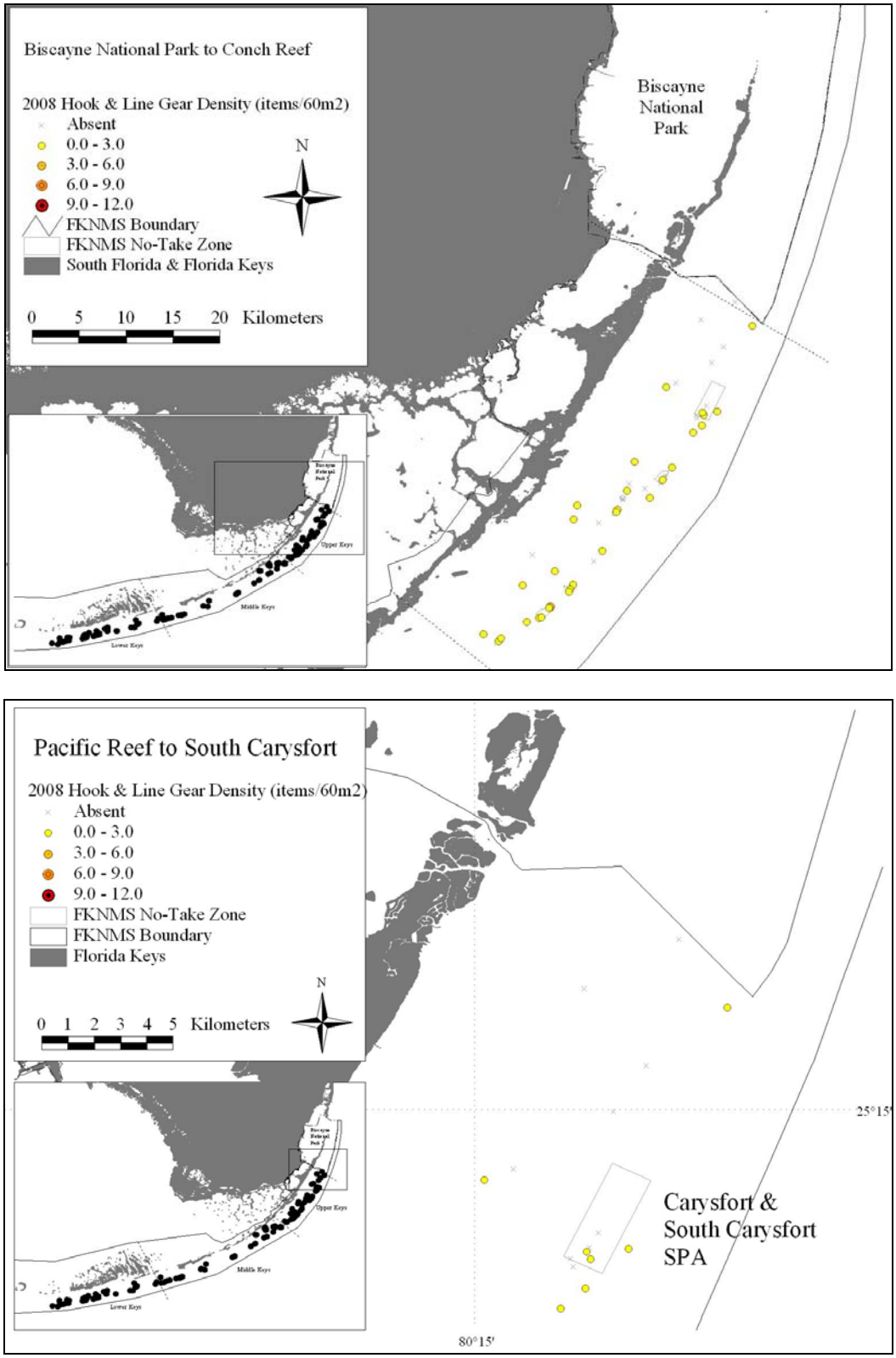


Figure 72. Densities (no. items per 60 m^2) of hook-and-line fishing gear in the upper Florida Keys from Elbow Reef to Pickles Reef (top) and in the middle Florida Keys (bottom) during June-September 2008.

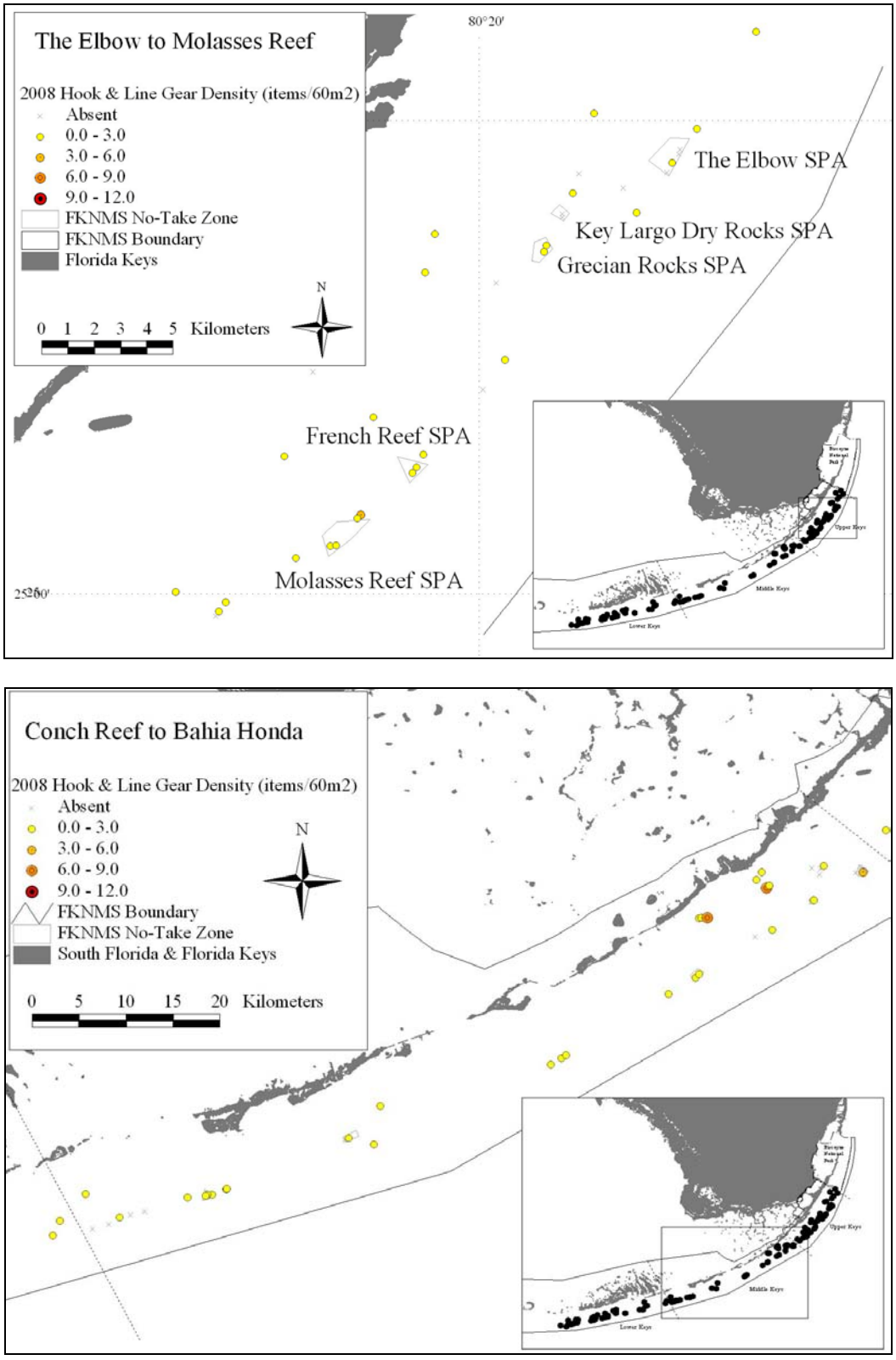


Figure 73. Densities (no. items per 60 m^2) of hook-and-line fishing gear in the middle Florida Keys from Conch Reef to Alligator Reef (top) and from Tennessee Reef to Coffins Patch (bottom) during June-September 2008.

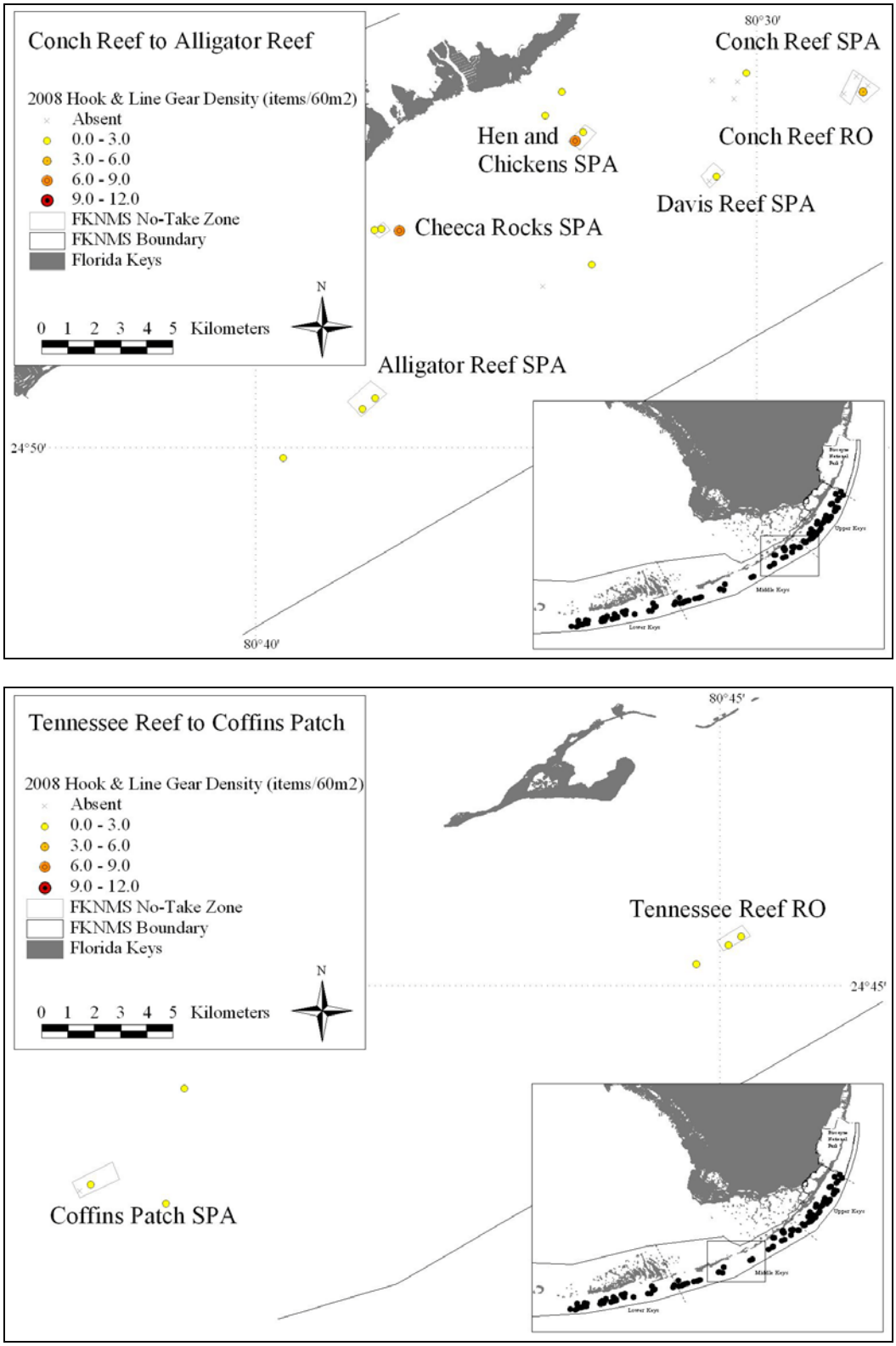


Figure 74. Densities (no. items per 60 m^2) of hook-and-line fishing gear in the middle Florida Keys from Sombrero Reef to Bahia Honda (top) and in the lower Florida Keys (bottom) during June-September 2008.

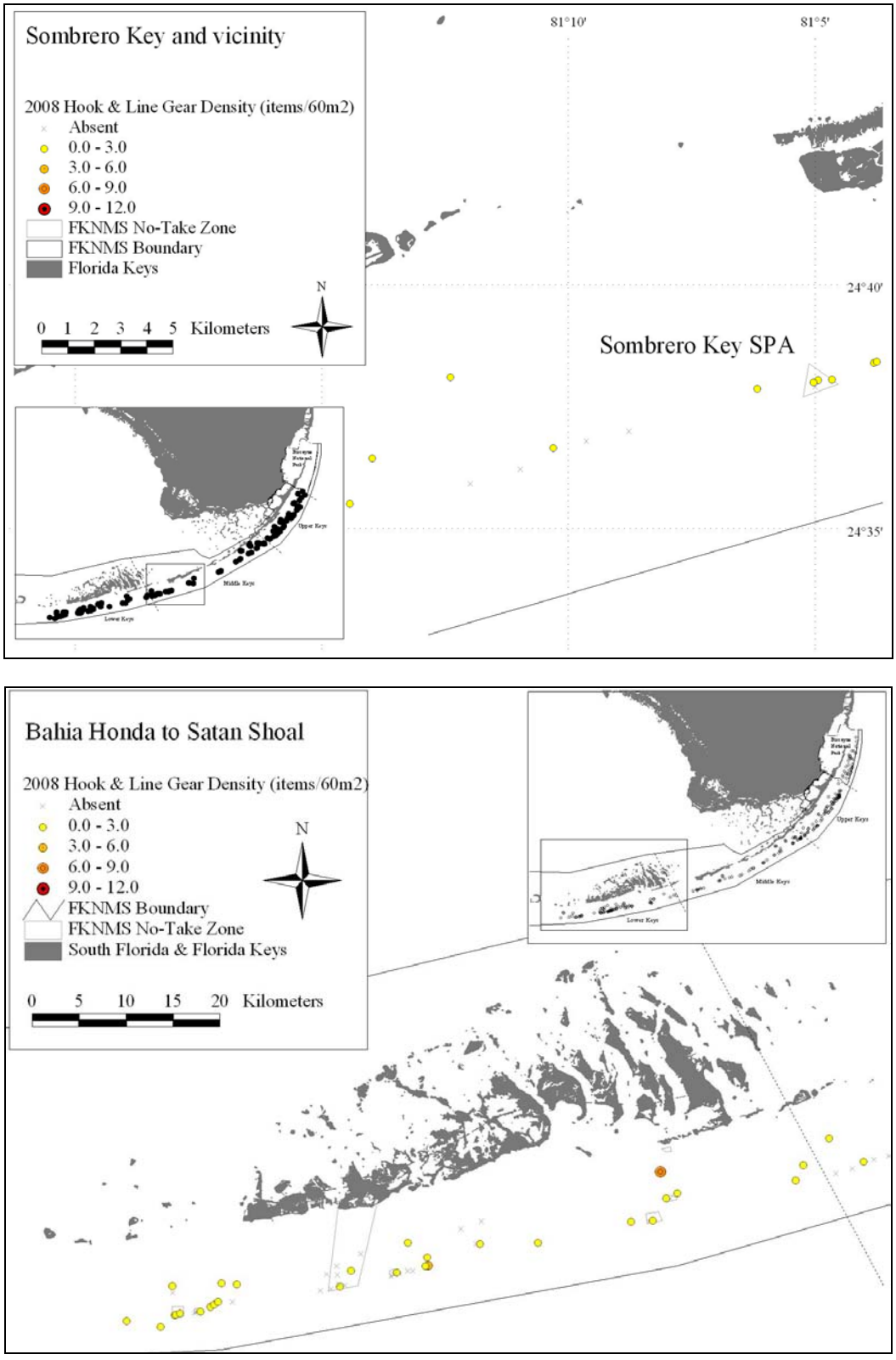


Figure 75. Densities (no. items per 60 m^2) of hook-and-line fishing gear in the lower Florida Keys from Bahia Honda to Looe Key (top) and from American Shoal to Western Sambo (bottom) during June-September 2008.

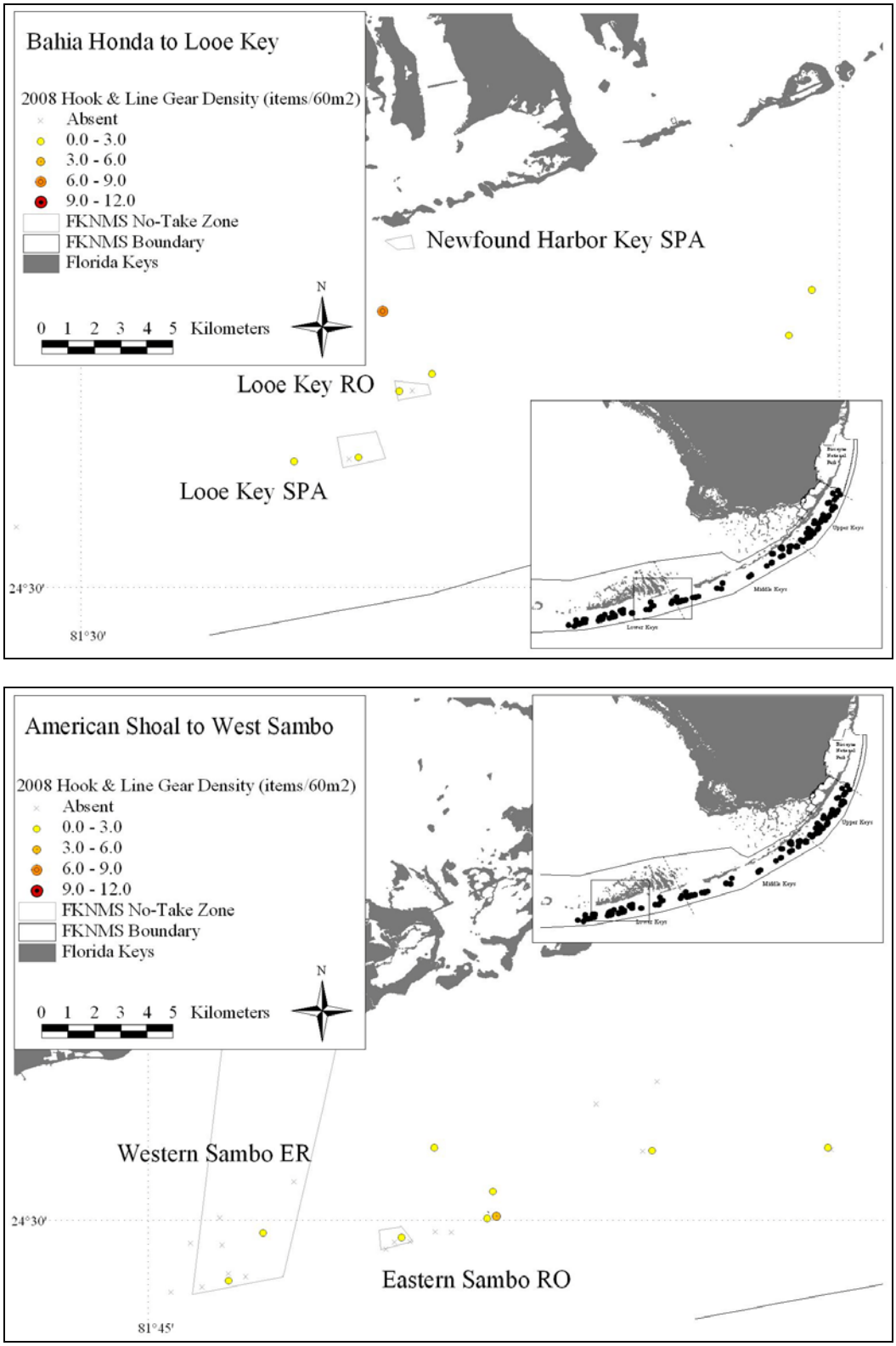


Figure 76. Densities (no. items per 60 m^2) of hook-and-line fishing gear in the lower Florida Keys from Eastern Dry Rocks to Sand Key during June-September 2008.

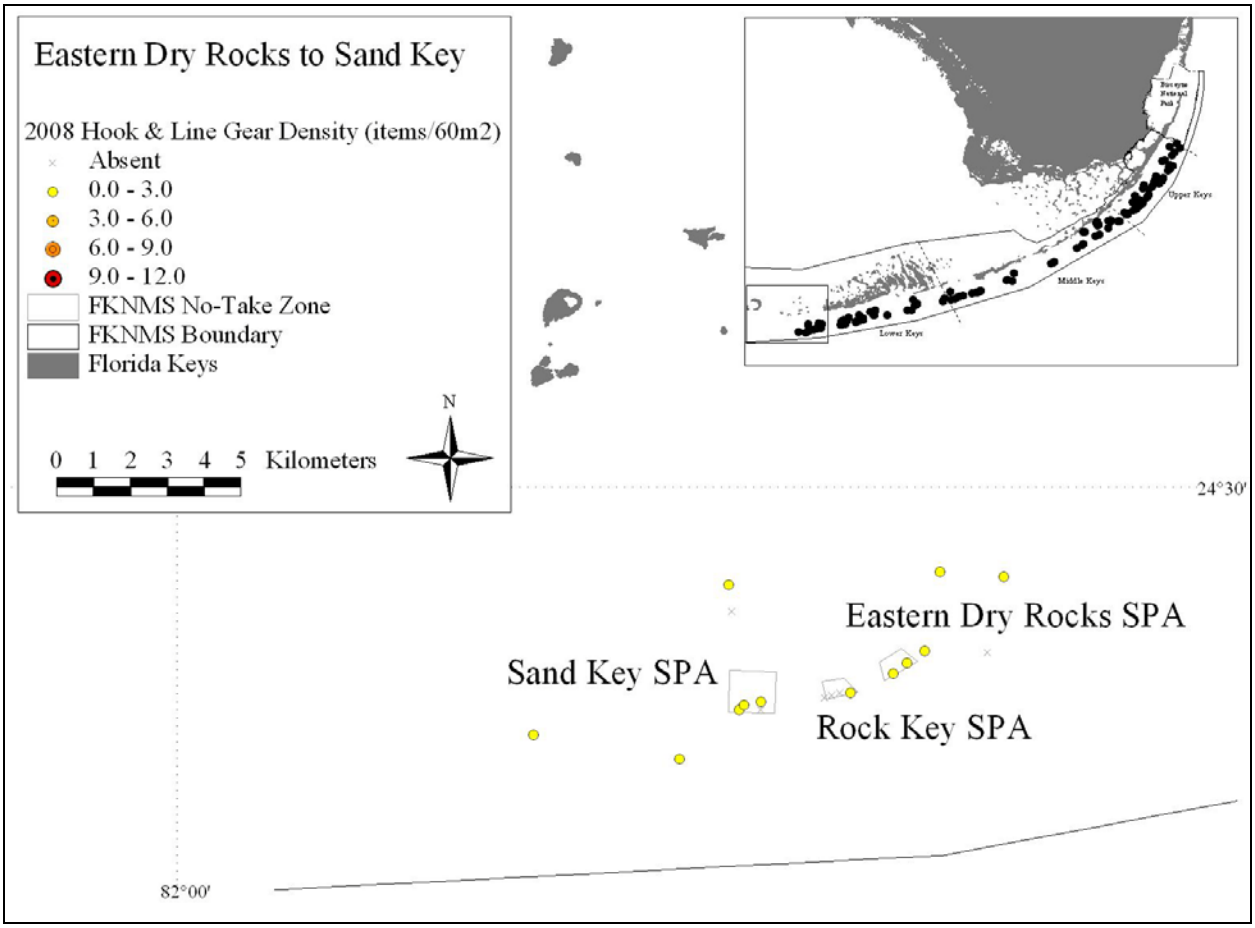


Figure 77. Mean (+ 1 SE) densities (no. items per 60 m^2) of hook-and-line fishing gear on mid-channel patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

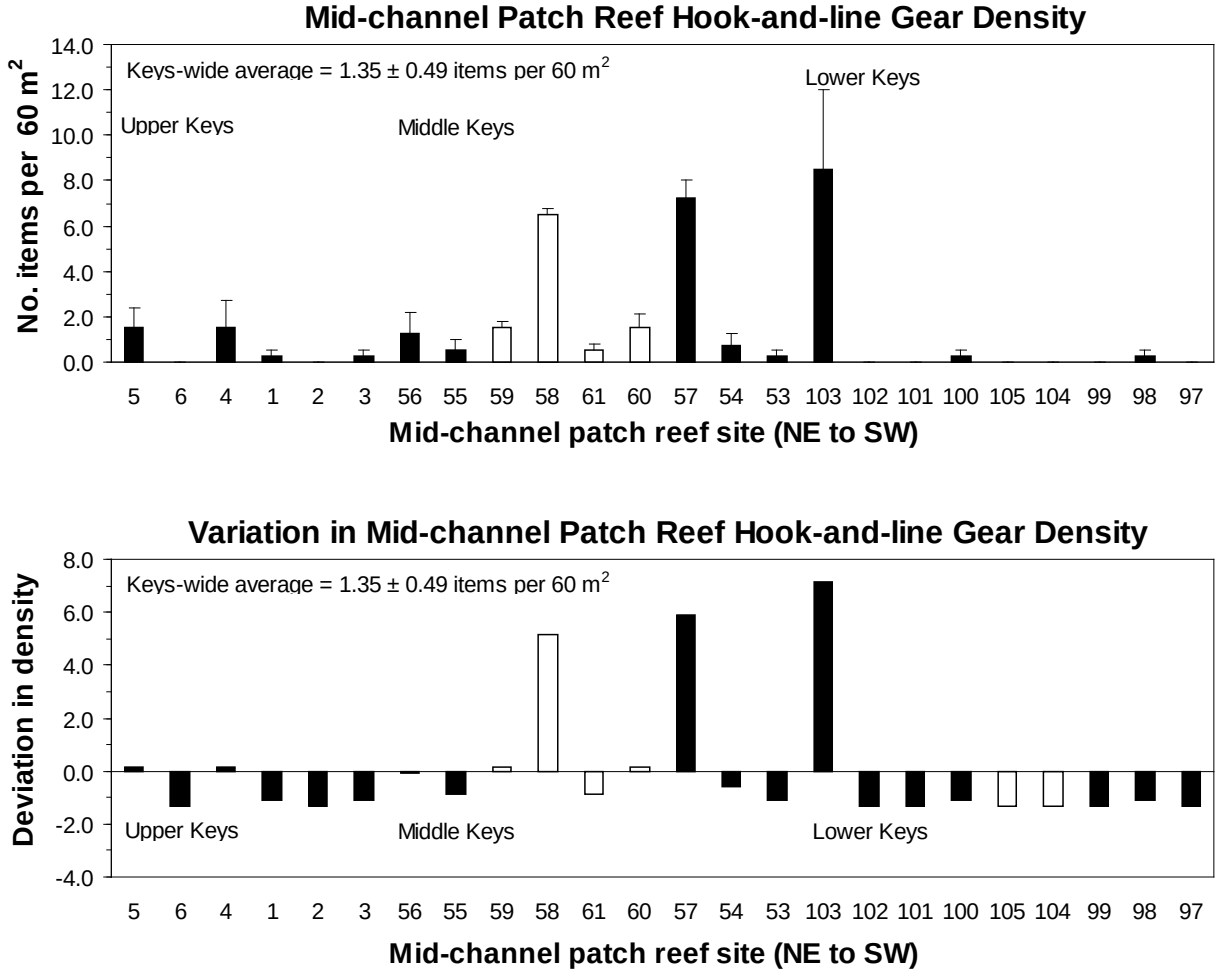


Figure 78. Mean (+ 1 SE) densities (no. items per 60 m^2) of hook-and-line fishing gear on offshore patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

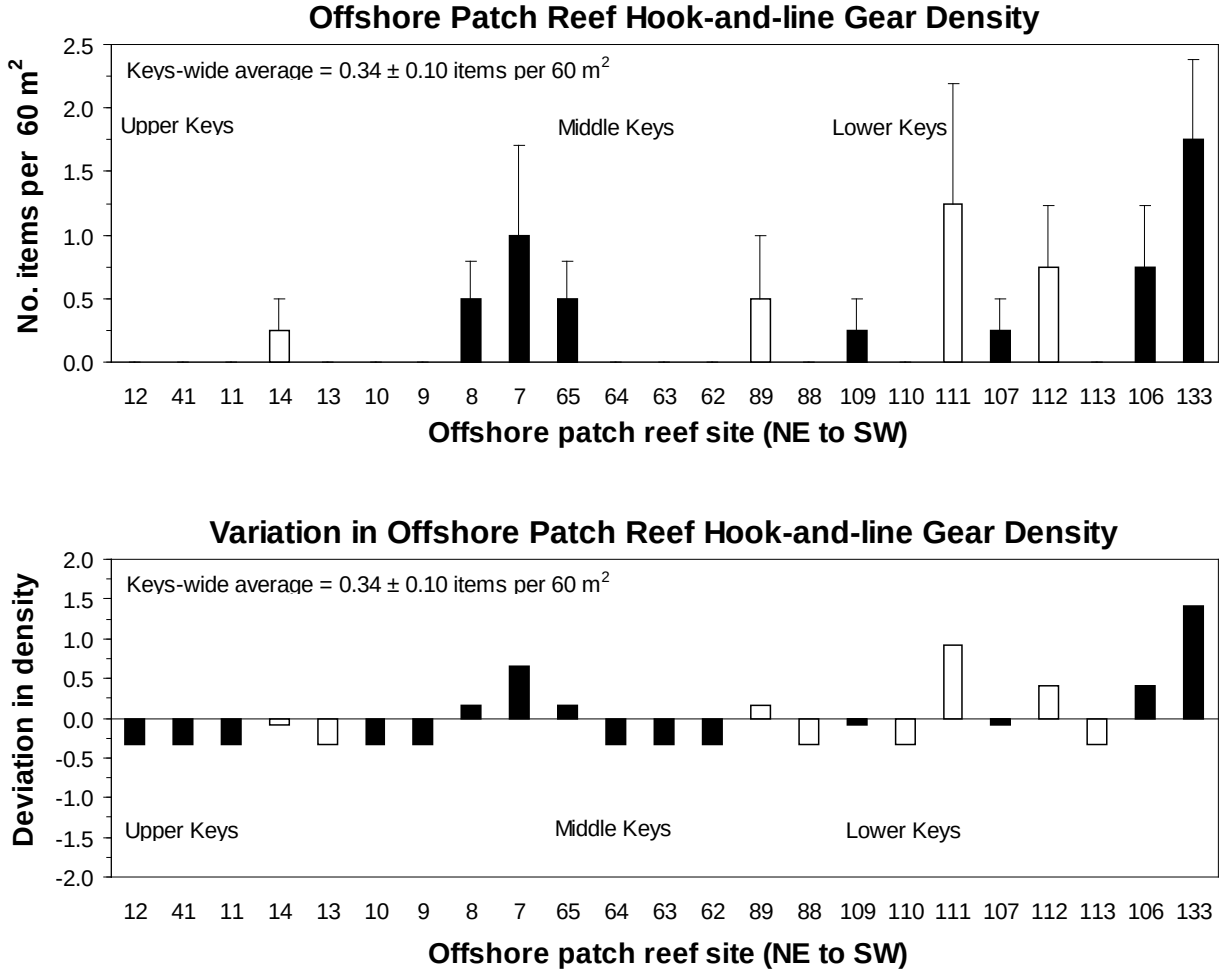


Figure 79. Mean (+ 1 SE) densities (no. items per 60 m^2) of hook-and-line fishing gear on shallow (< 6 m), high-relief spur and groove reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

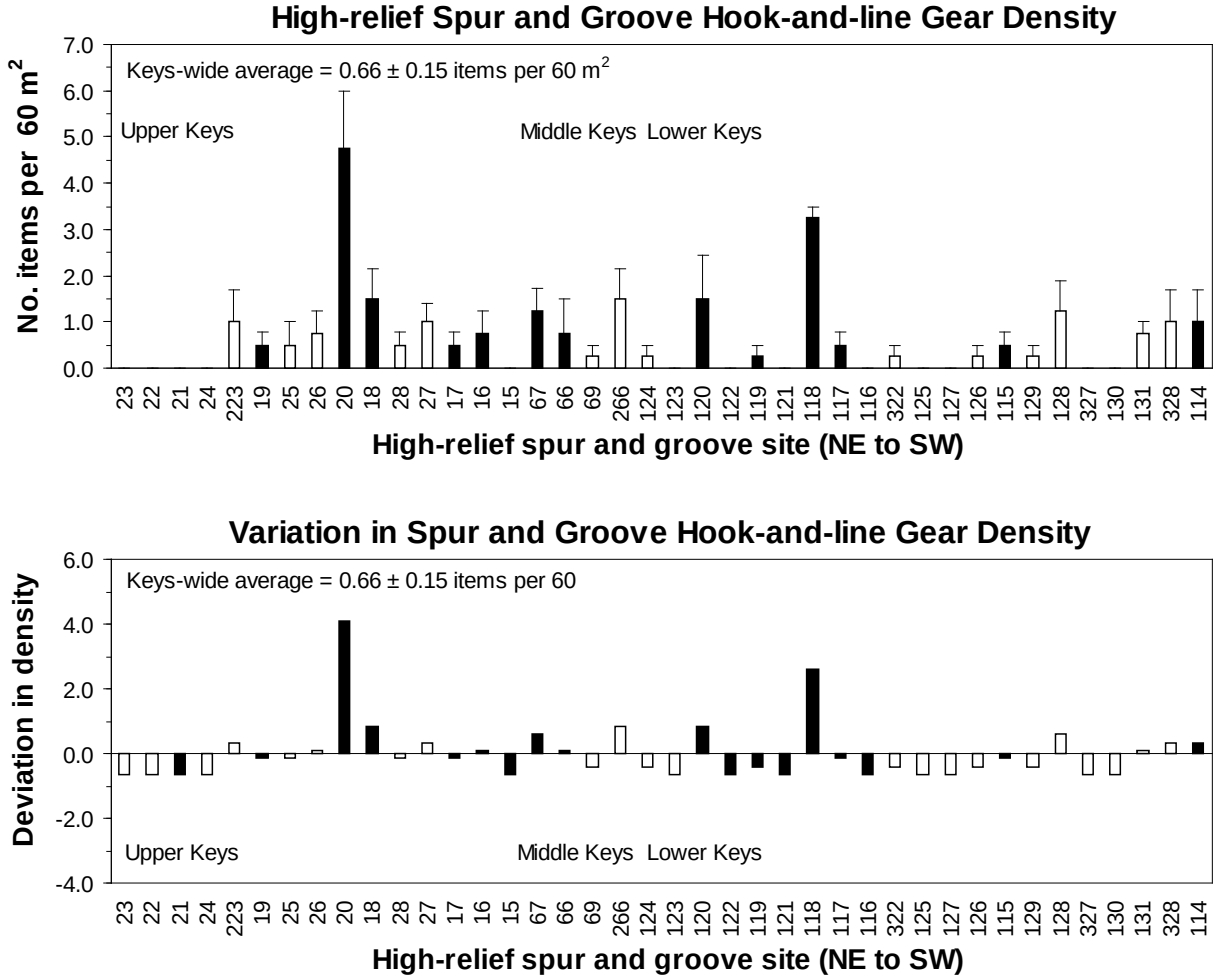


Figure 80. Mean (+ 1 SE) densities (no. items per 60 m^2) of hook-and-line fishing gear on deeper (6-15 m) fore-reef sites (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

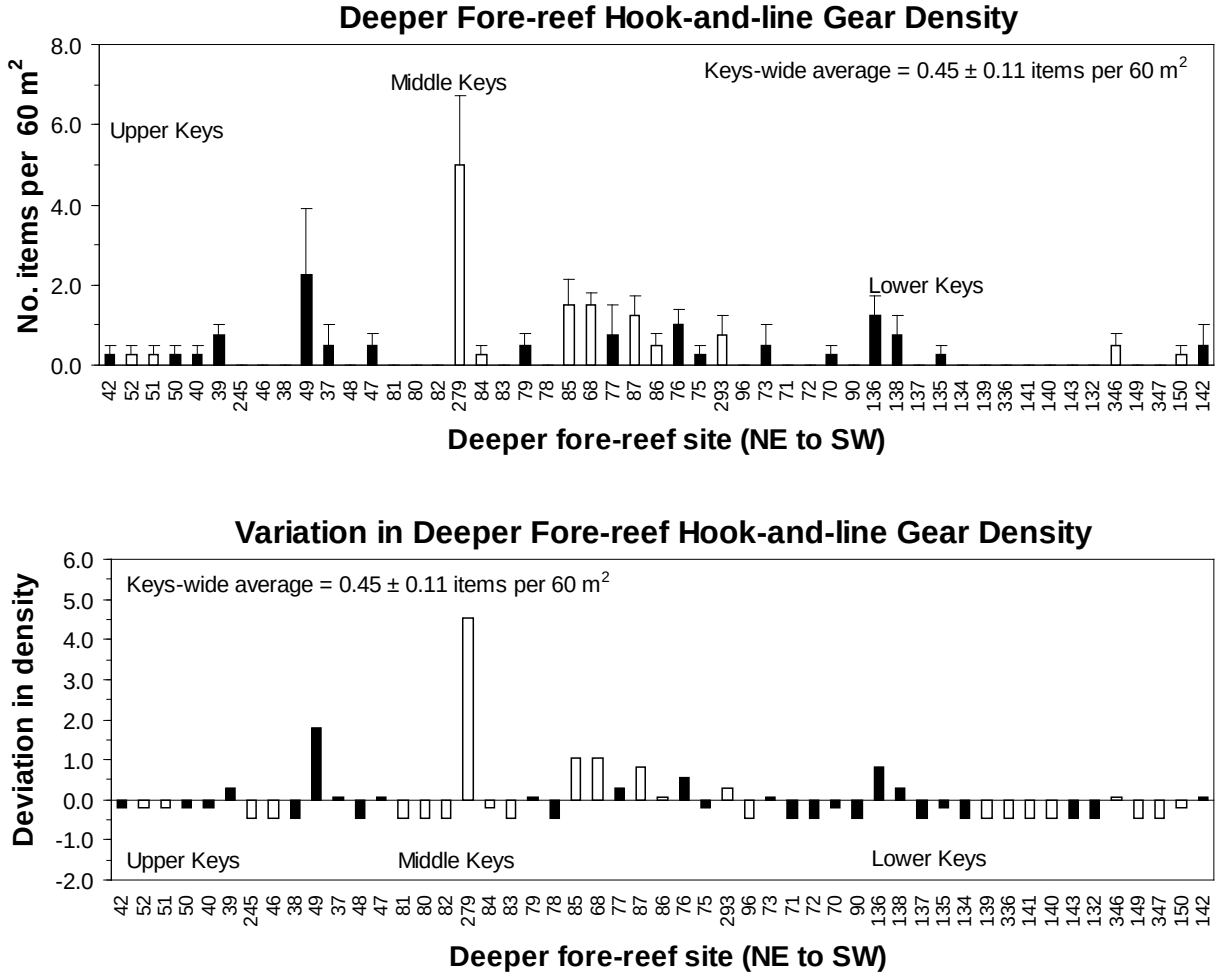


Figure 81. Length distribution (m) of derelict hook-and-line fishing gear retrieved from surveys of 145 sites in the Florida Keys National Marine Sanctuary during June-September 2008.

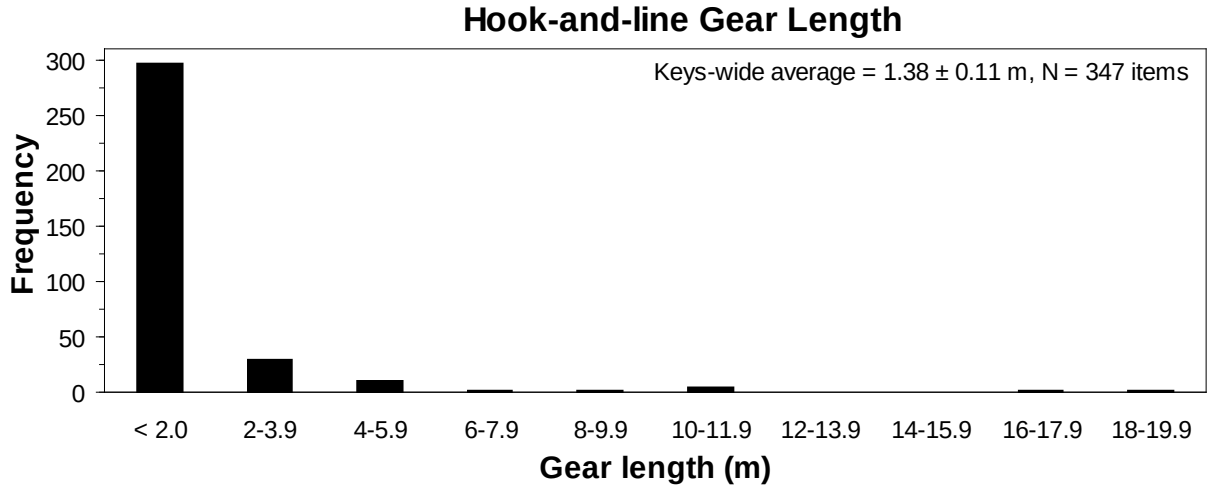


Figure 82. Total length (m) of derelict hook-and-line fishing gear retrieved from 240-m^2 search areas per site in the upper Florida Keys (top) and from the southern BNP boundary to Carysfort Reef (bottom) during June-September 2008.

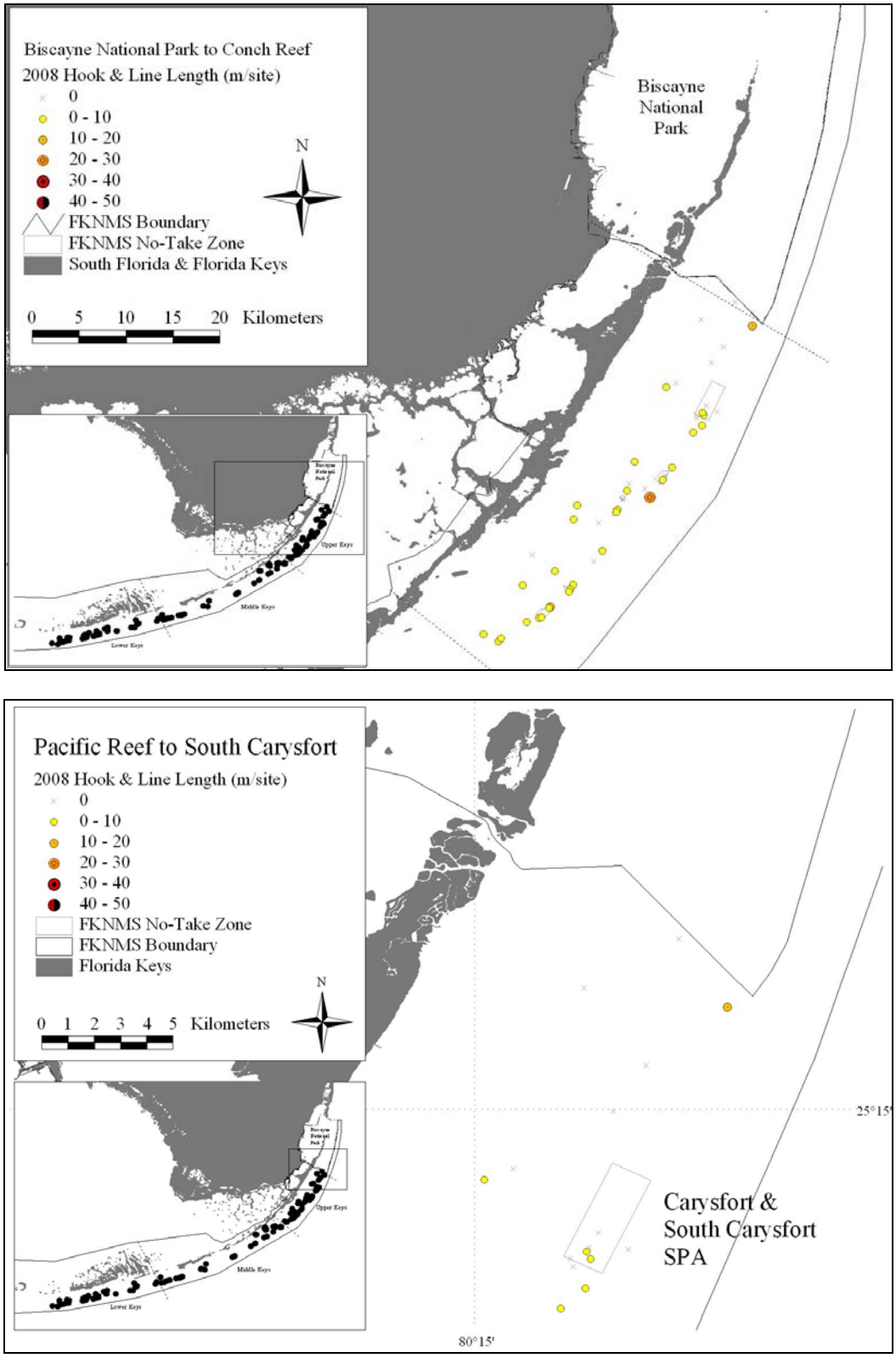
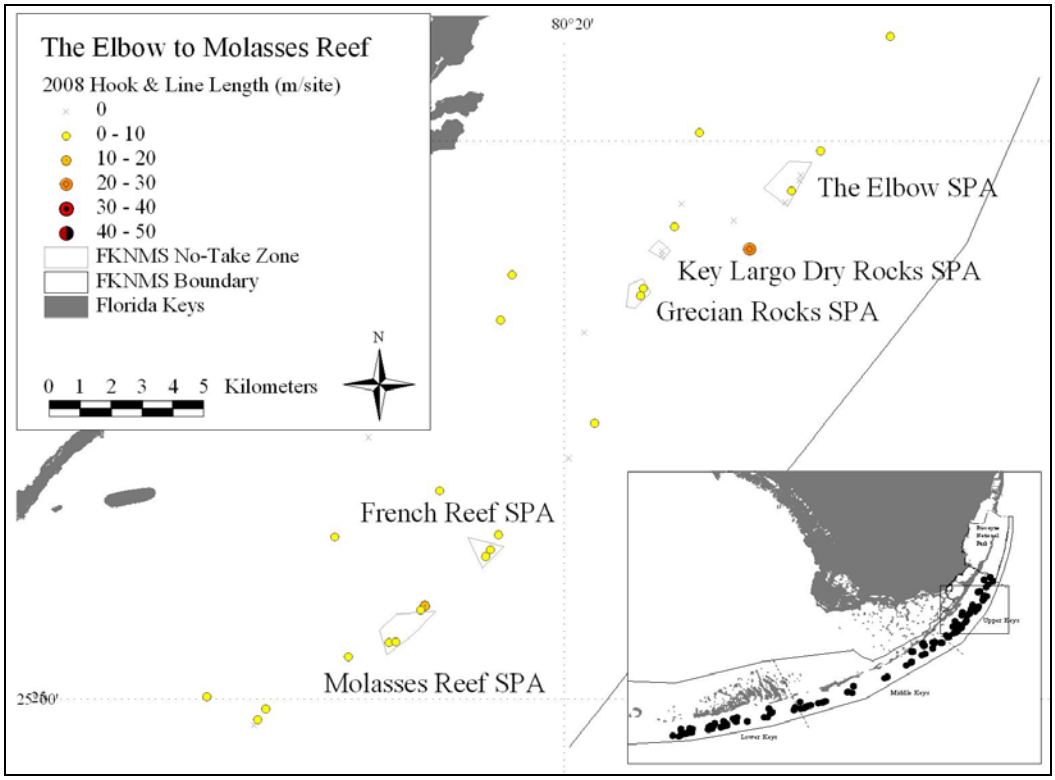


Figure 83. Total length (m) of derelict hook-and-line fishing gear retrieved from 240-m^2 search areas per site in the upper Florida Keys from Elbow Reef to Pickles Reef (top) and in the middle Florida Keys (bottom) during June-September 2008.



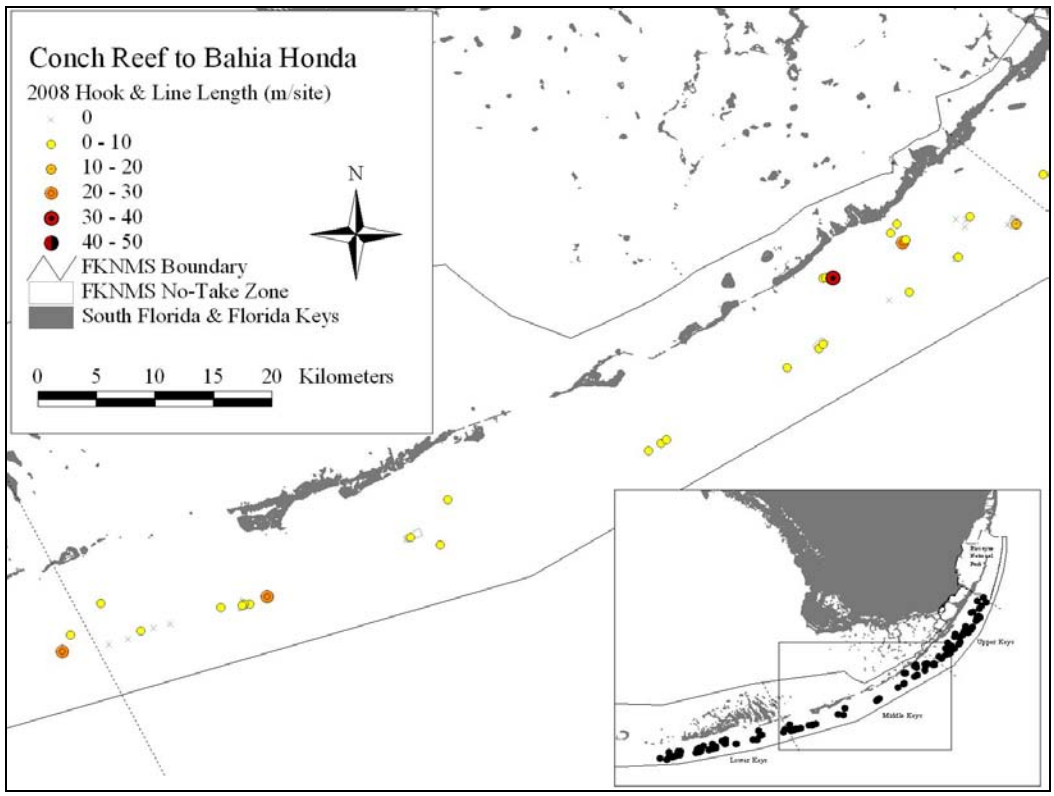
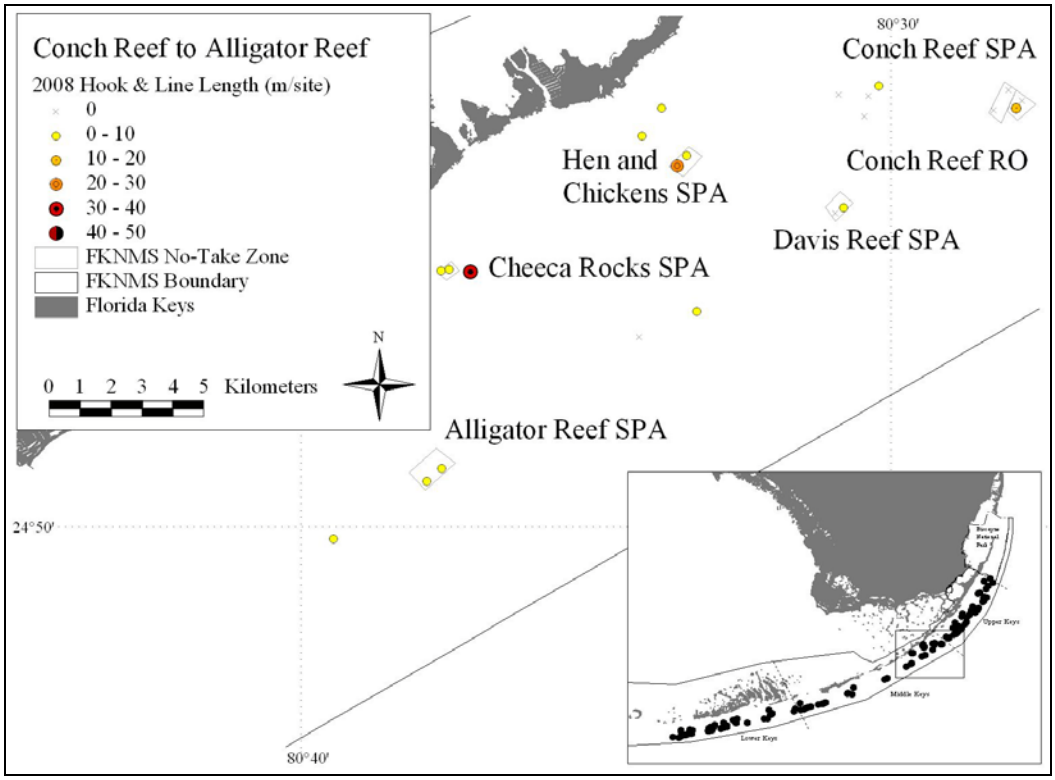


Figure 84. Total length (m) of derelict hook-and-line fishing gear retrieved from 240-m^2 search areas per site in the middle Florida Keys from Conch Reef to Alligator Reef (top) and from Tennessee Reef to Coffins Patch (bottom) during June-September 2008.



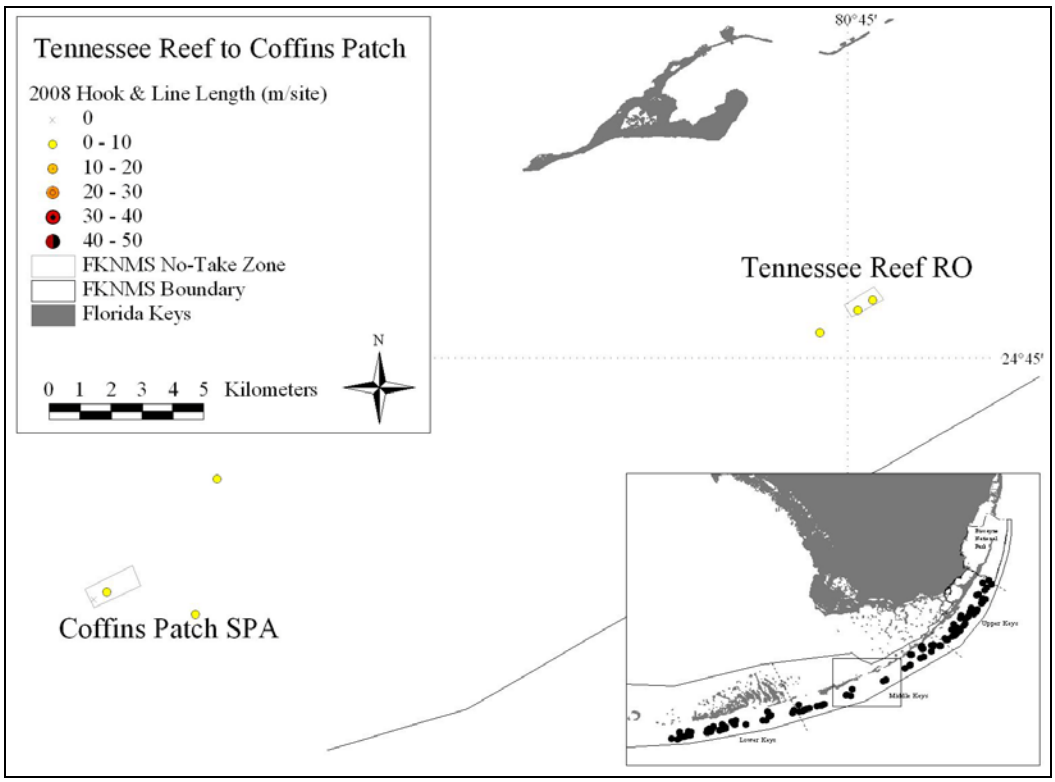


Figure 85. Total length (m) of derelict hook-and-line fishing gear retrieved from 240-m^2 search areas per site in the middle Florida Keys from Sombrero Reef to Bahia Honda (top) and in the lower Florida Keys (bottom) during June-September 2008.

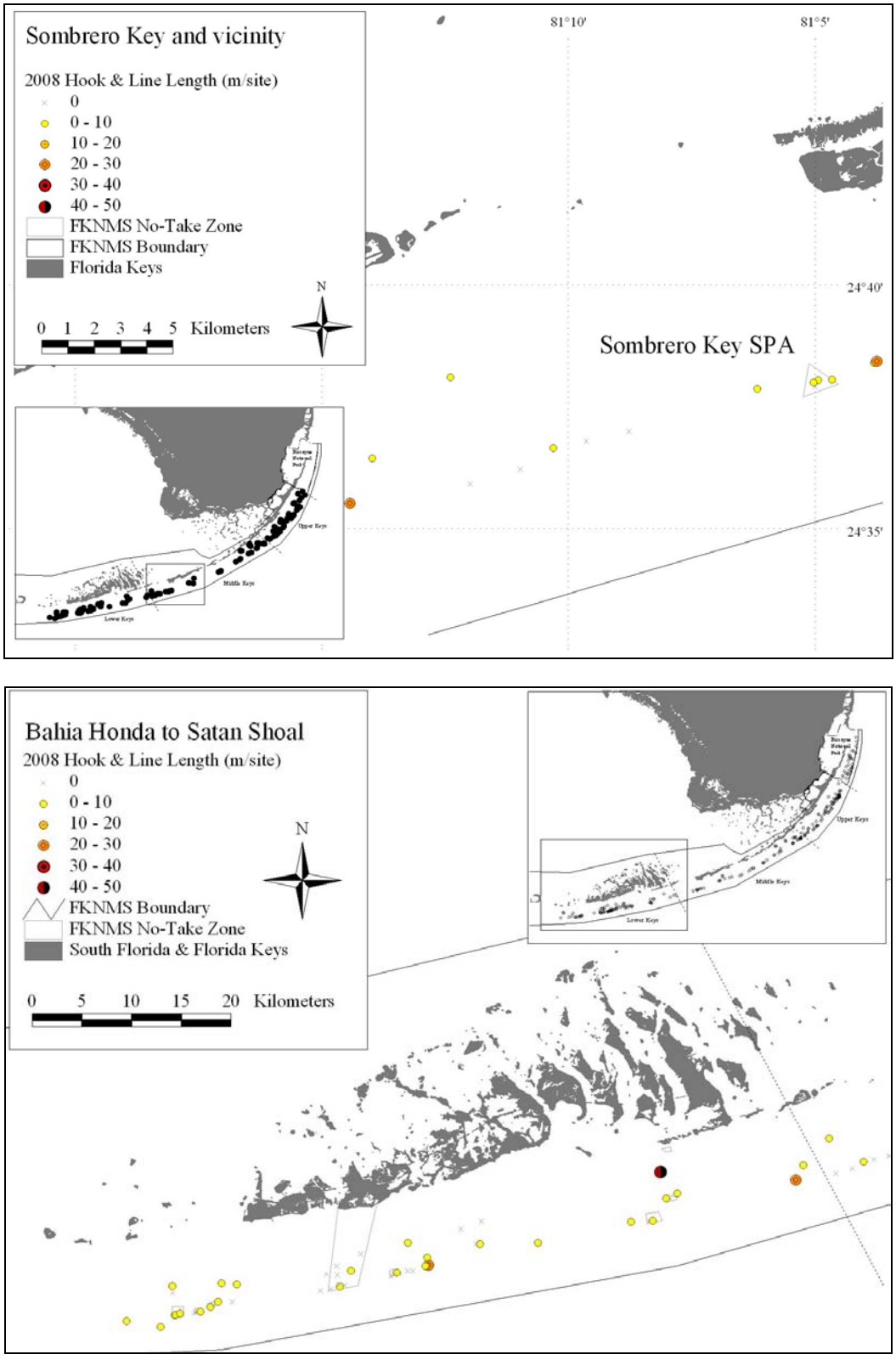


Figure 86. Total length (m) of derelict hook-and-line fishing gear retrieved from 240-m^2 search areas per site in the lower Florida Keys from Bahia Honda to Looe Key (top) and from American Shoal to Western Sambo (bottom) during June-September 2008.

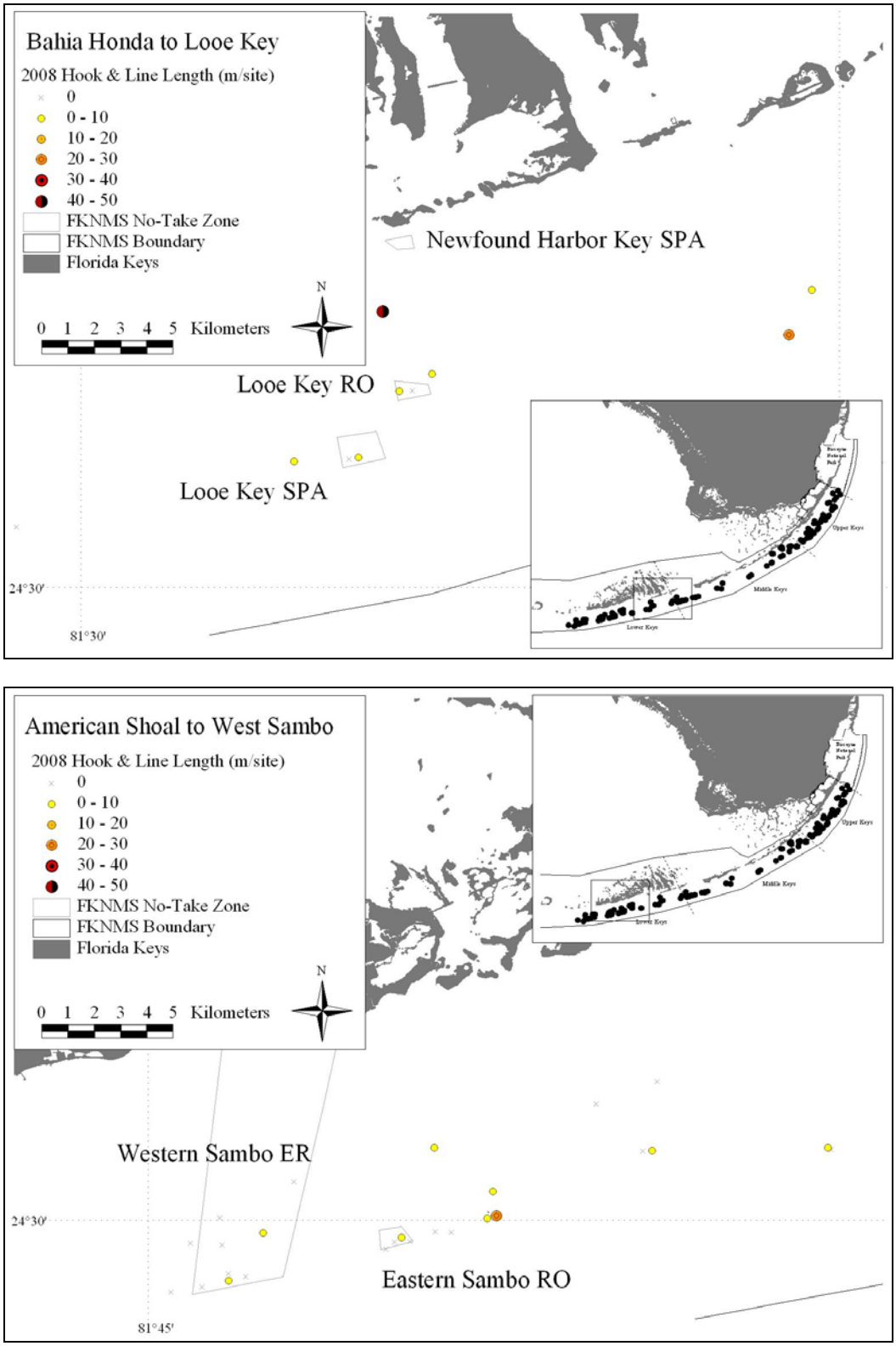


Figure 87. Total length (m) of derelict hook-and-line fishing gear retrieved from 240-m^2 search areas per site in the lower Florida Keys from Eastern Dry Rocks to Sand Key during June-September 2008.

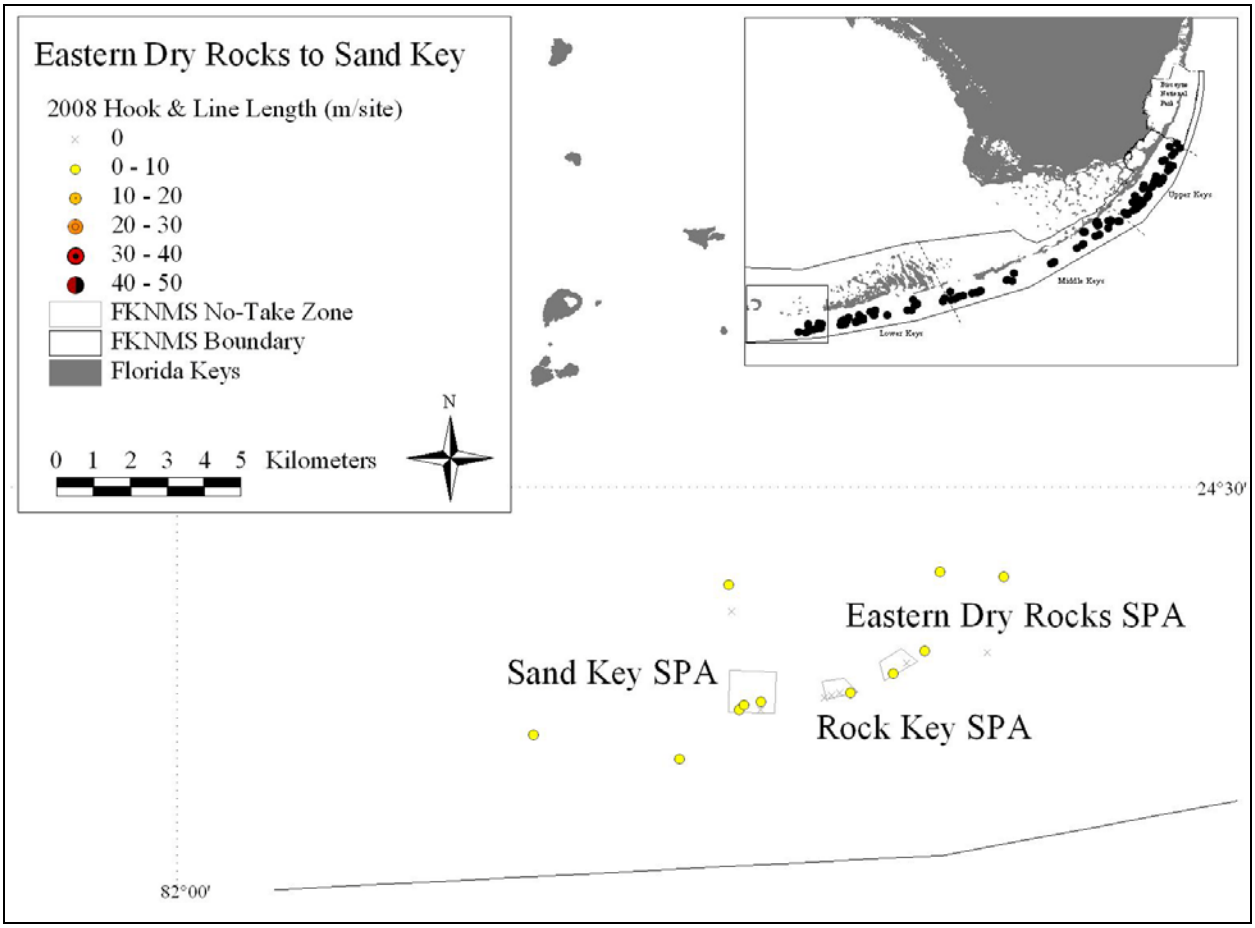


Figure 88. Total length (m) of hook-and-line fishing gear retrieved from 240-m^2 search areas per site on mid-channel patch reefs (top) and variations in total gear length retrieved relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

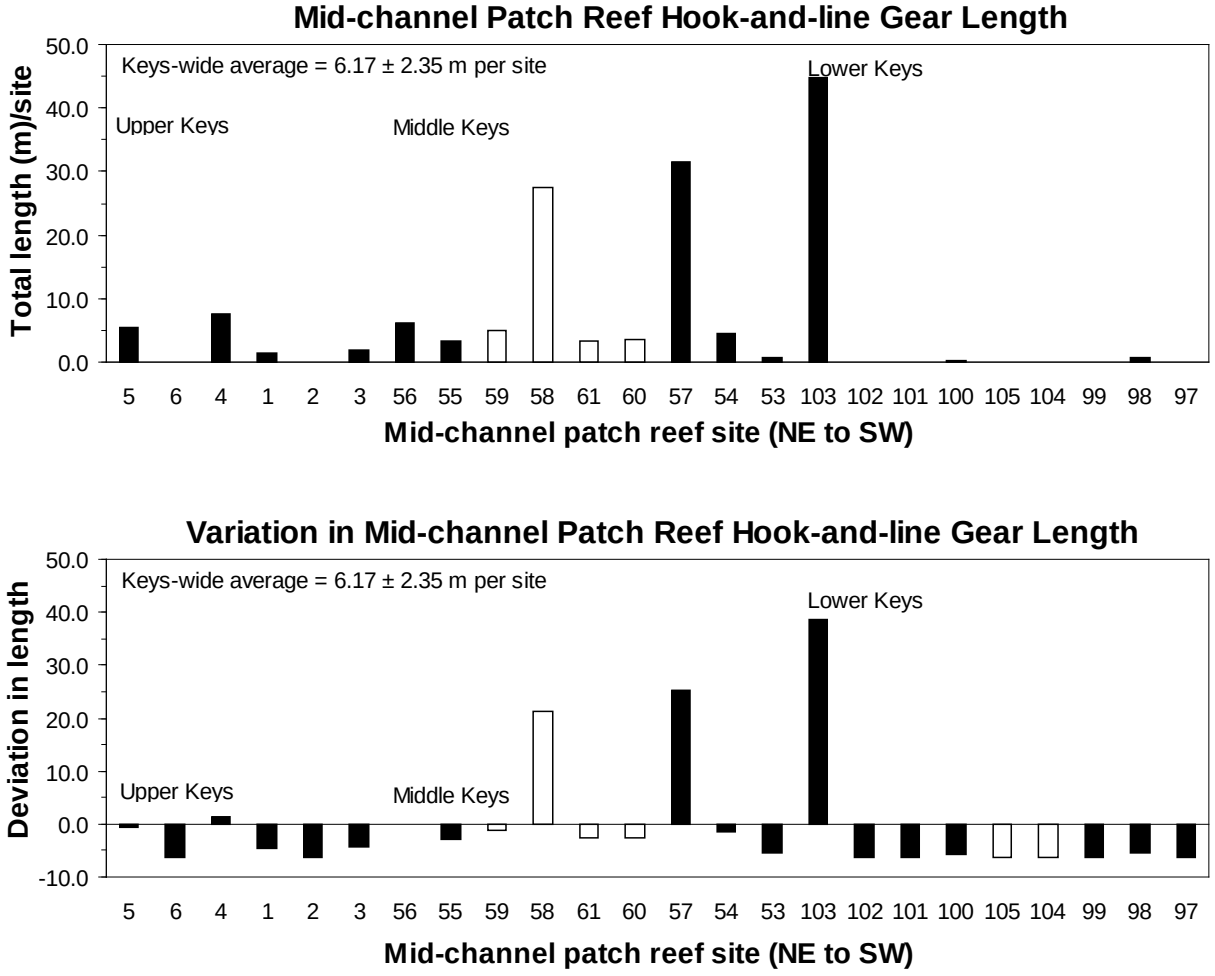


Figure 89. Total length (m) of hook-and-line fishing gear retrieved from 240-m^2 search areas per site on offshore patch reefs (top) and variations in total gear length retrieved relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

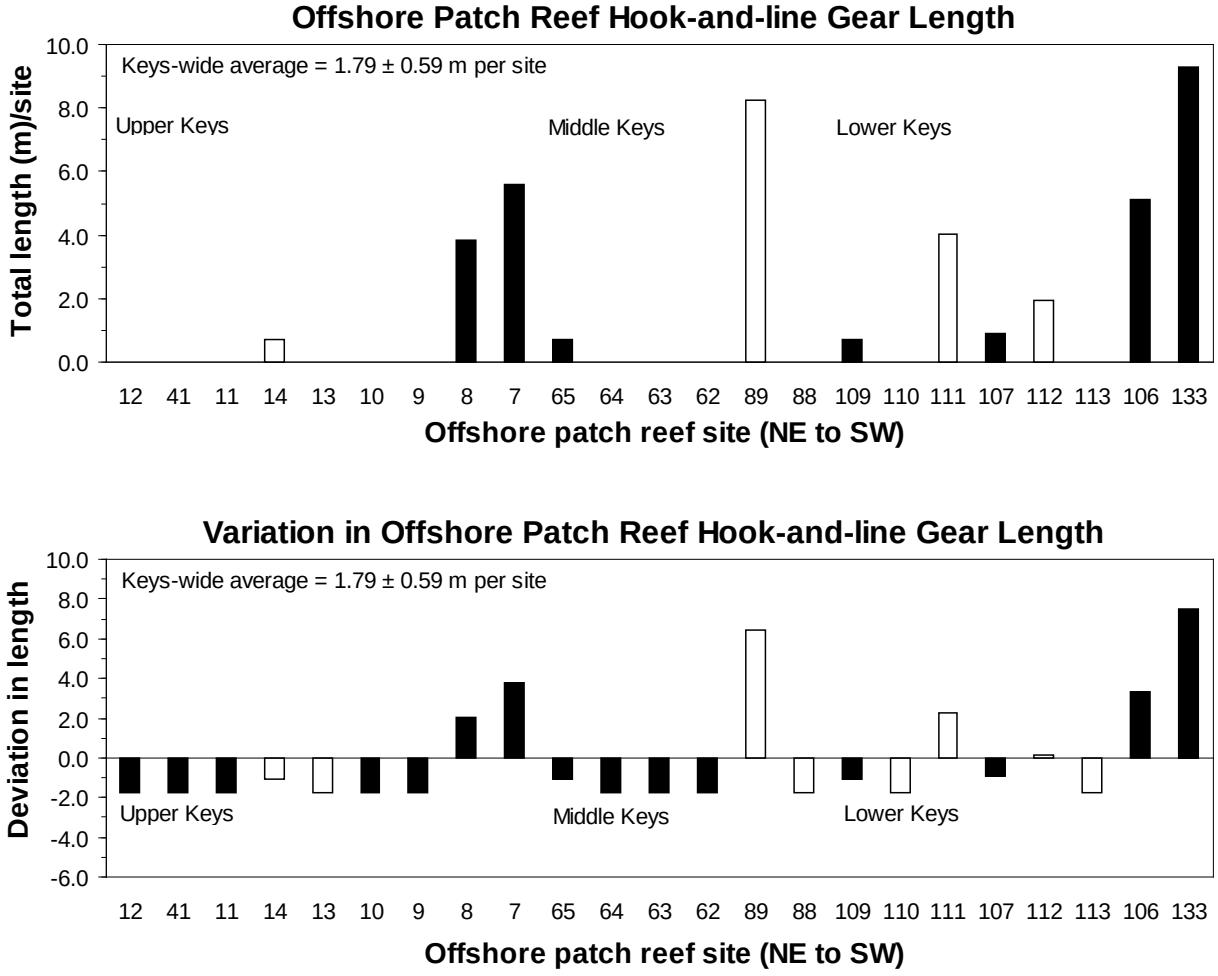


Figure 90. Total length (m) of hook-and-line fishing gear retrieved from 240-m^2 search areas per site on shallow (< 6 m), high-relief spur and groove reefs (top) and variations in total gear length retrieved relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

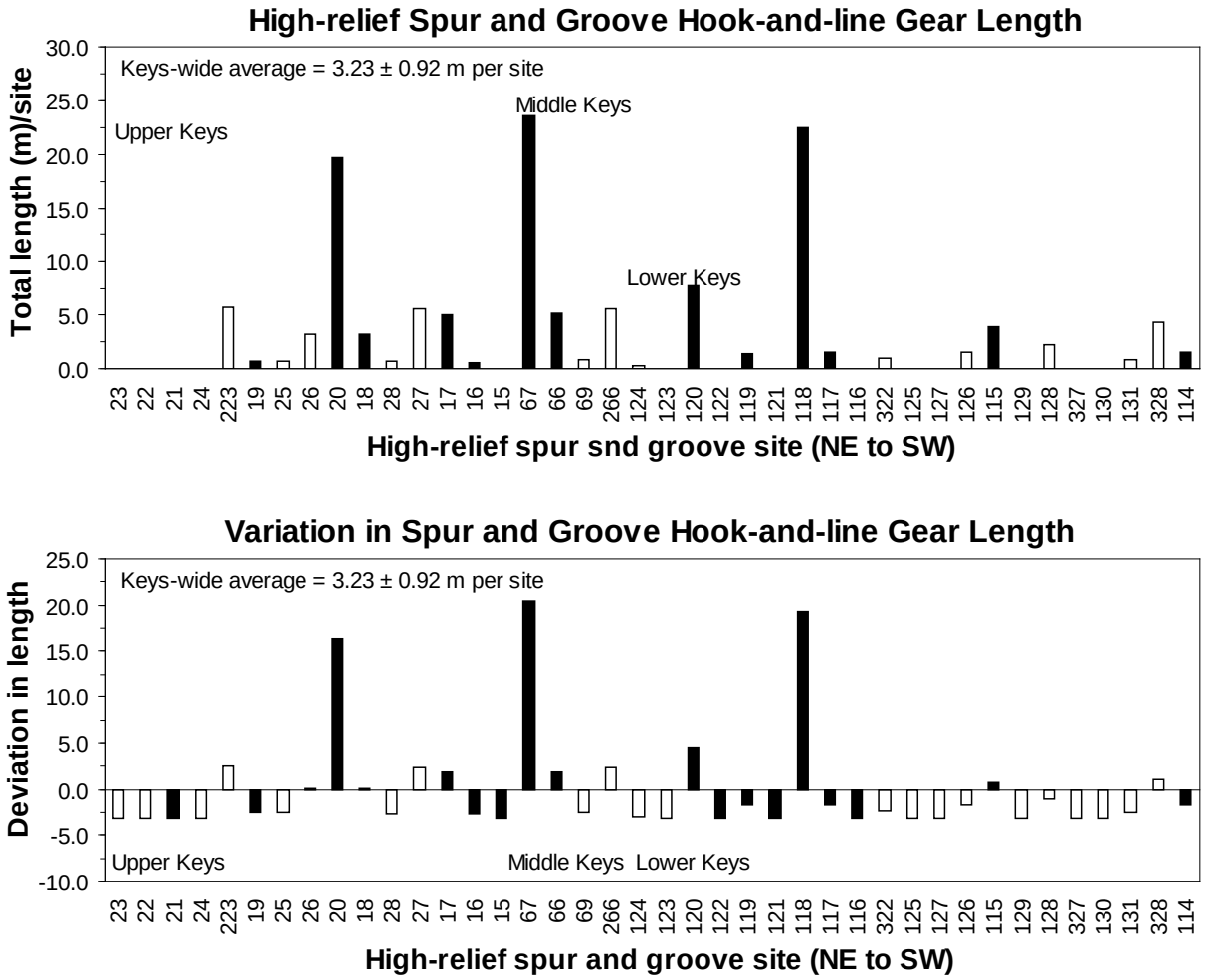


Figure 91. Total length (m) of hook-and-line fishing gear retrieved from 240-m^2 search areas per site on deeper (6-15 m) fore-reef sites (top) and variations in total gear length retrieved relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

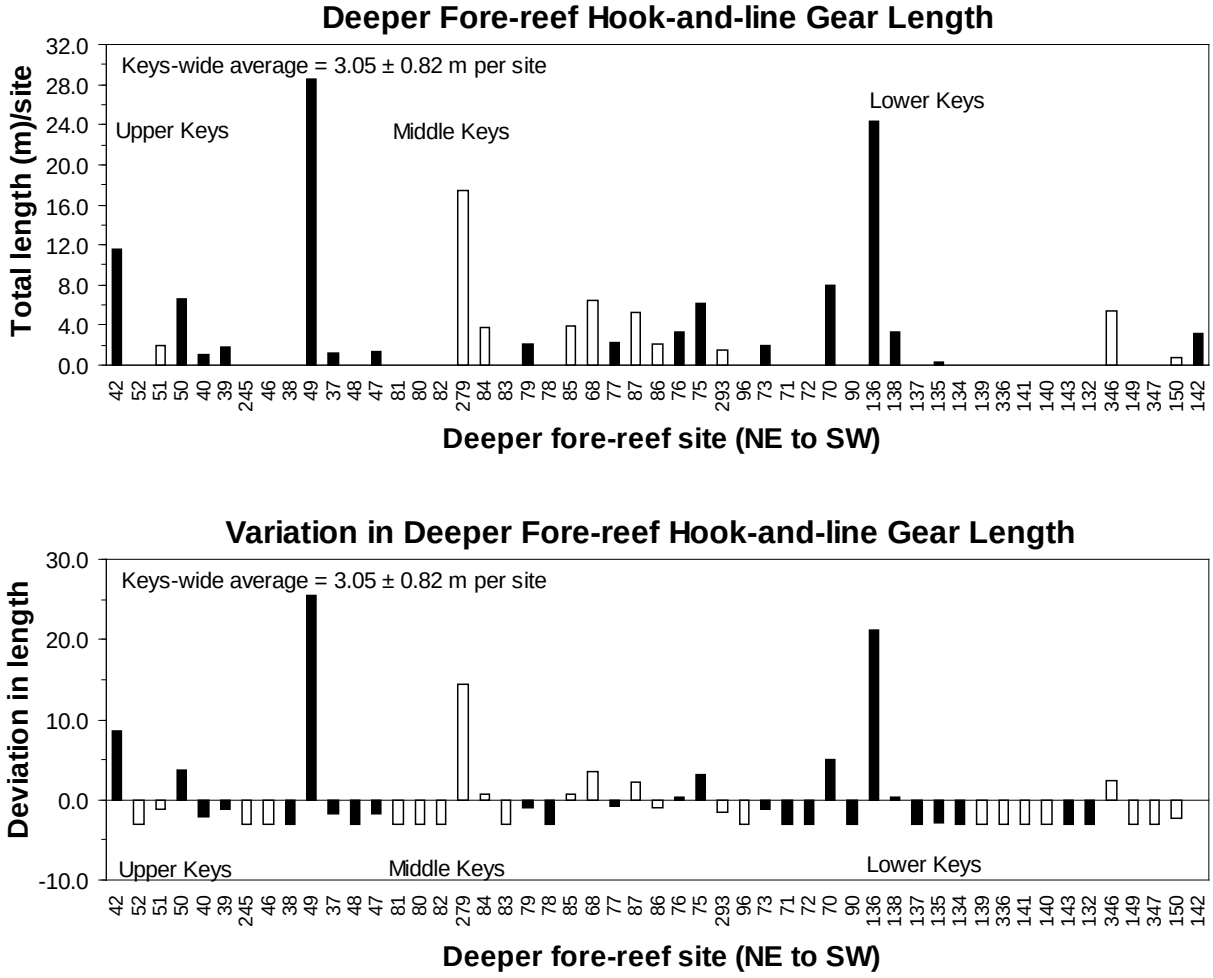


Figure 92. Densities (no. items per 60 m^2) of lobster/crab trap fishing gear in the upper Florida Keys (top) and from the southern BNP boundary to Carysfort Reef (bottom) during June-September 2008.

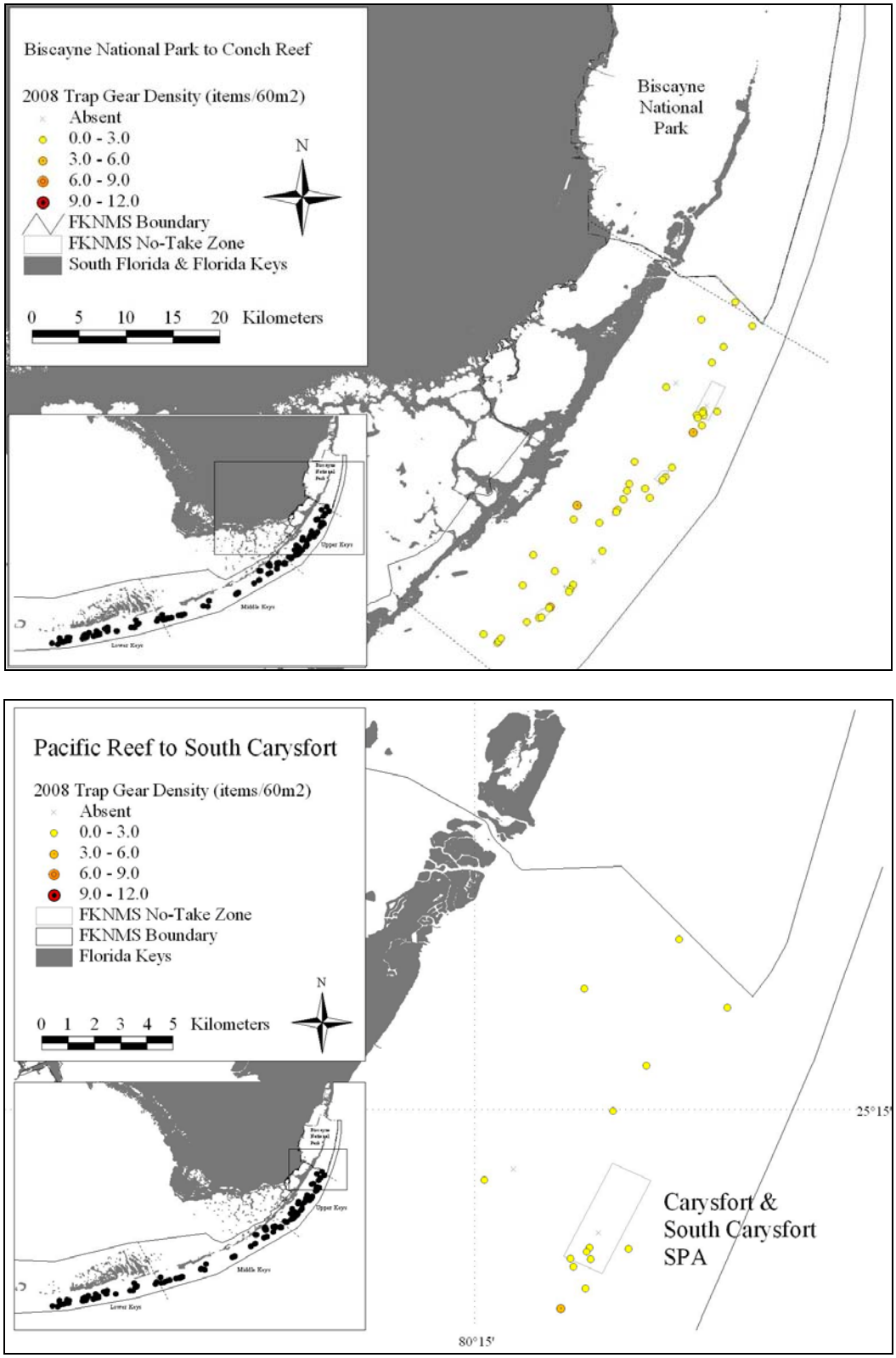


Figure 93. Densities (no. items per 60 m^2) of lobster/crab trap fishing gear in the upper Florida Keys from Elbow Reef to Pickles Reef (top) and in the middle Florida Keys (bottom) during June-September 2008.

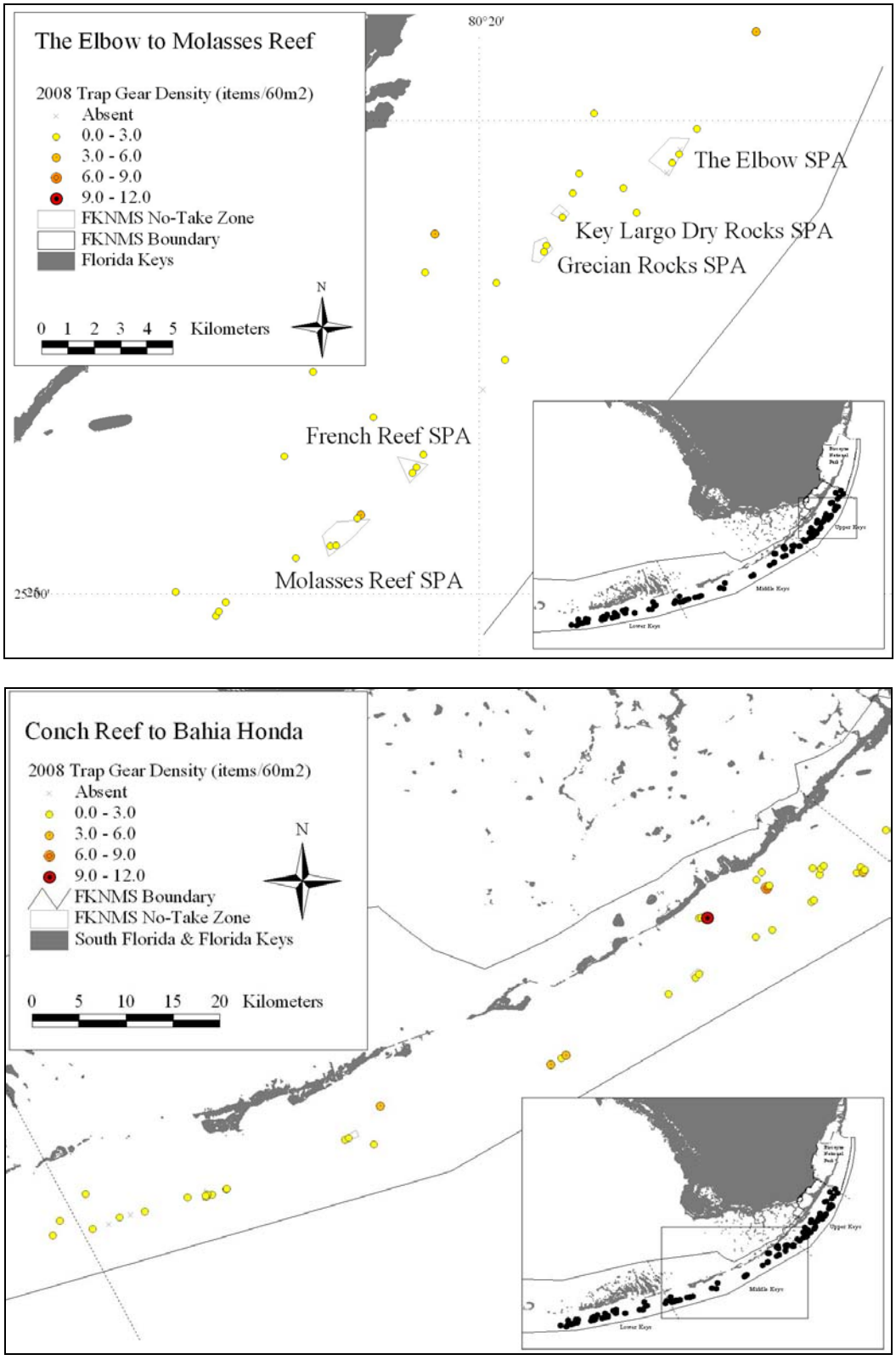
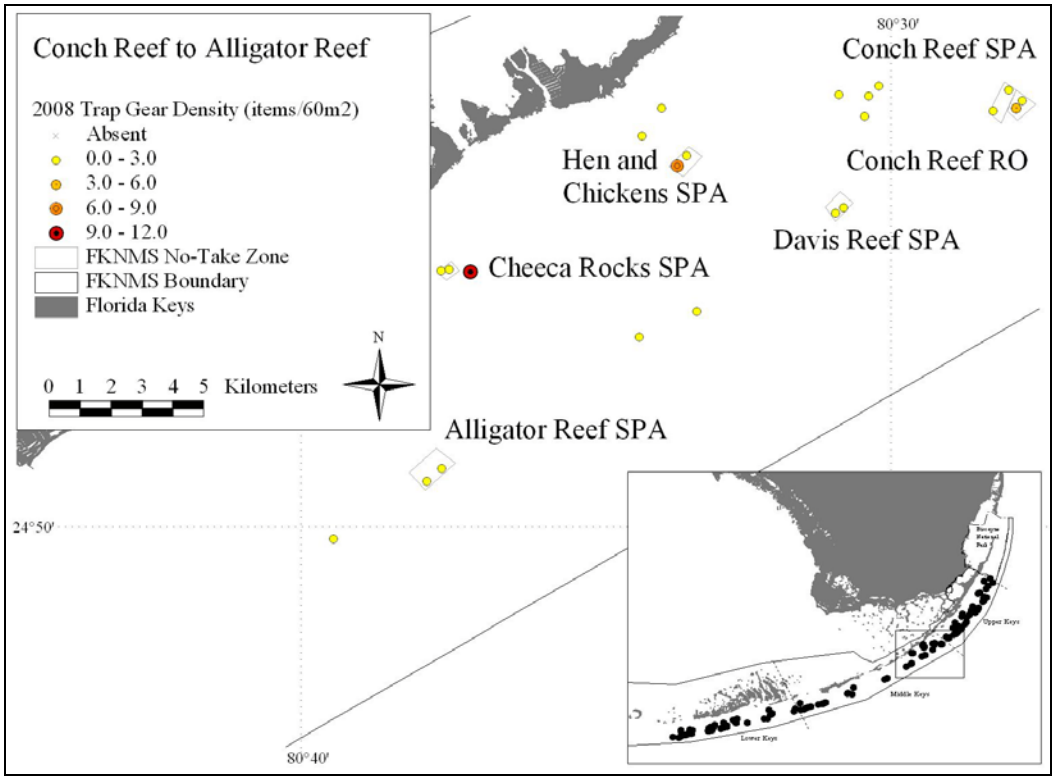


Figure 94. Densities (no. items per 60 m^2) of lobster/crab trap fishing gear in the middle Florida Keys from Conch Reef to Alligator Reef (top) and from Tennessee Reef to Coffins Patch (bottom) during June-September 2008.



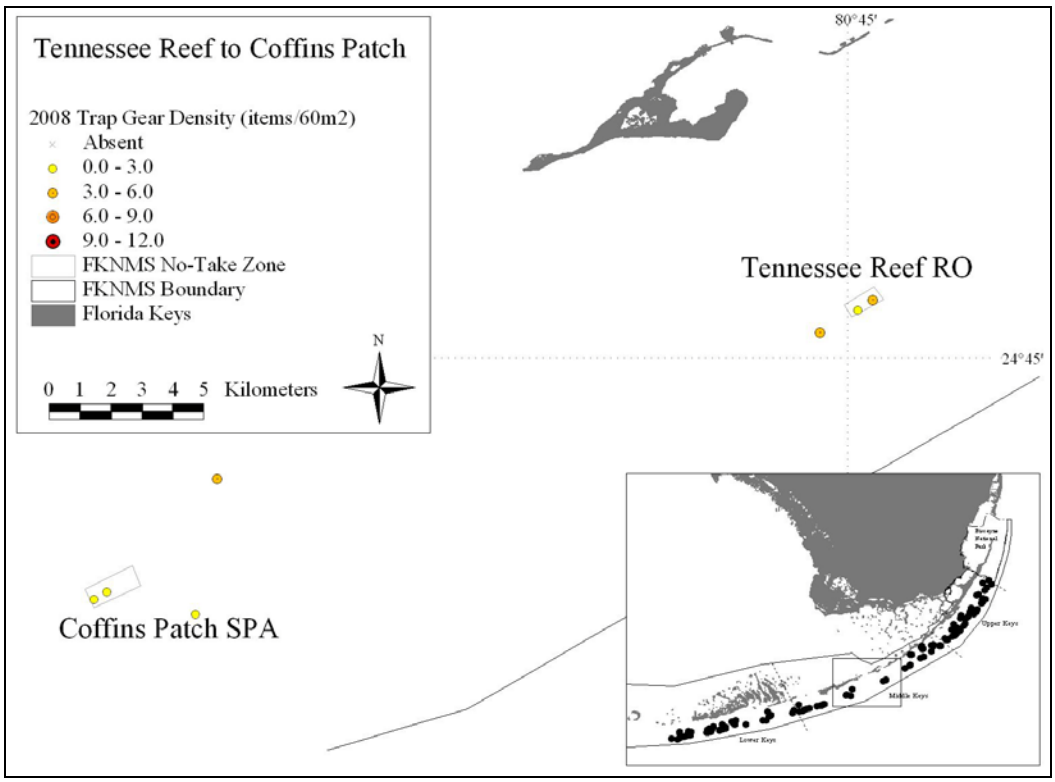


Figure 95. Densities (no. items per 60 m^2) of lobster/crab trap fishing gear in the middle Florida Keys from Sombrero Reef to Bahia Honda (top) and in the lower Florida Keys (bottom) during June-September 2008.

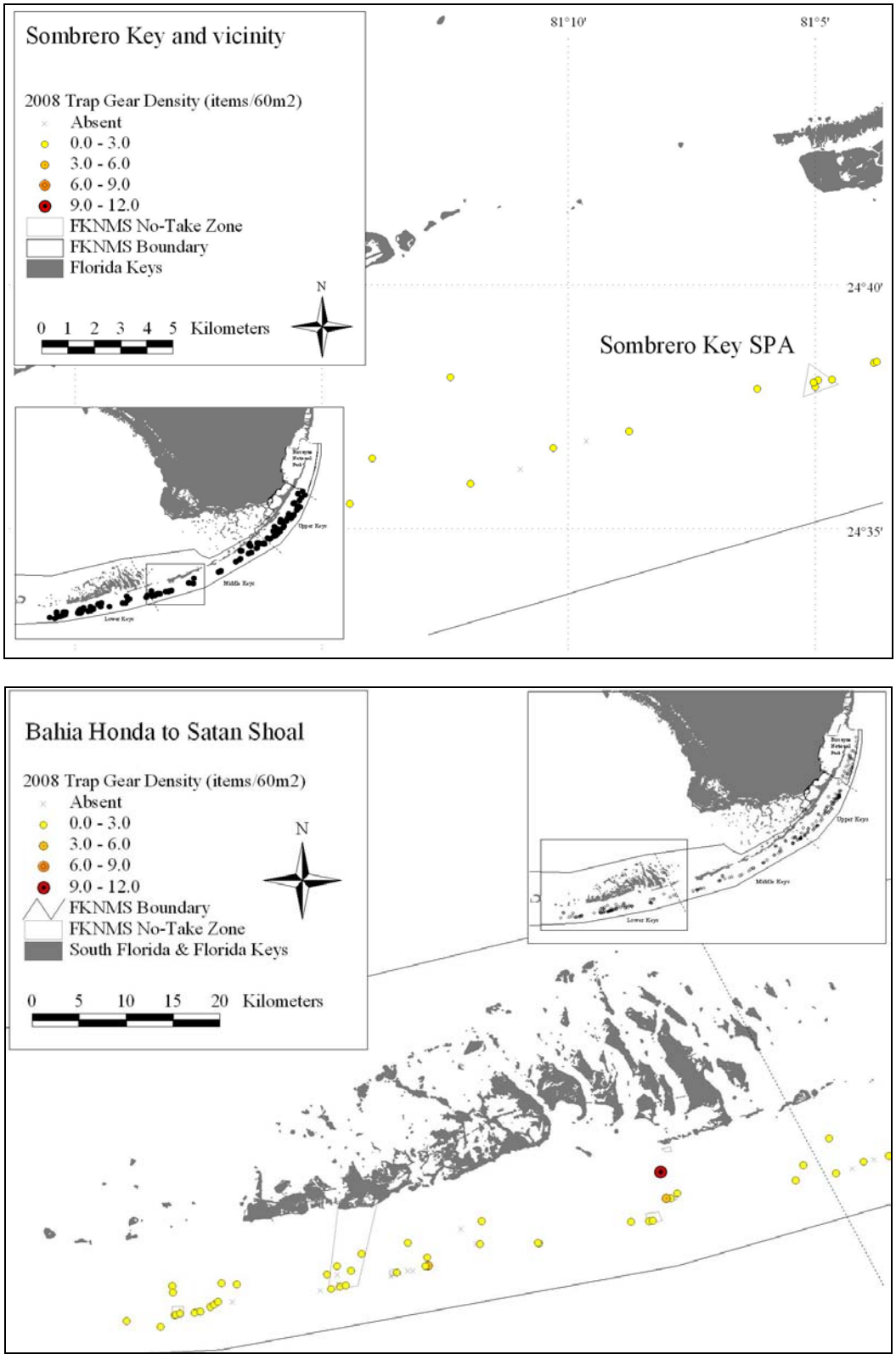


Figure 96. Densities (no. items per 60 m^2) of lobster/crab trap fishing gear in the lower Florida Keys from Bahia Honda to Looe Key (top) and from American Shoal to Western Sambo (bottom) during June-September 2008.

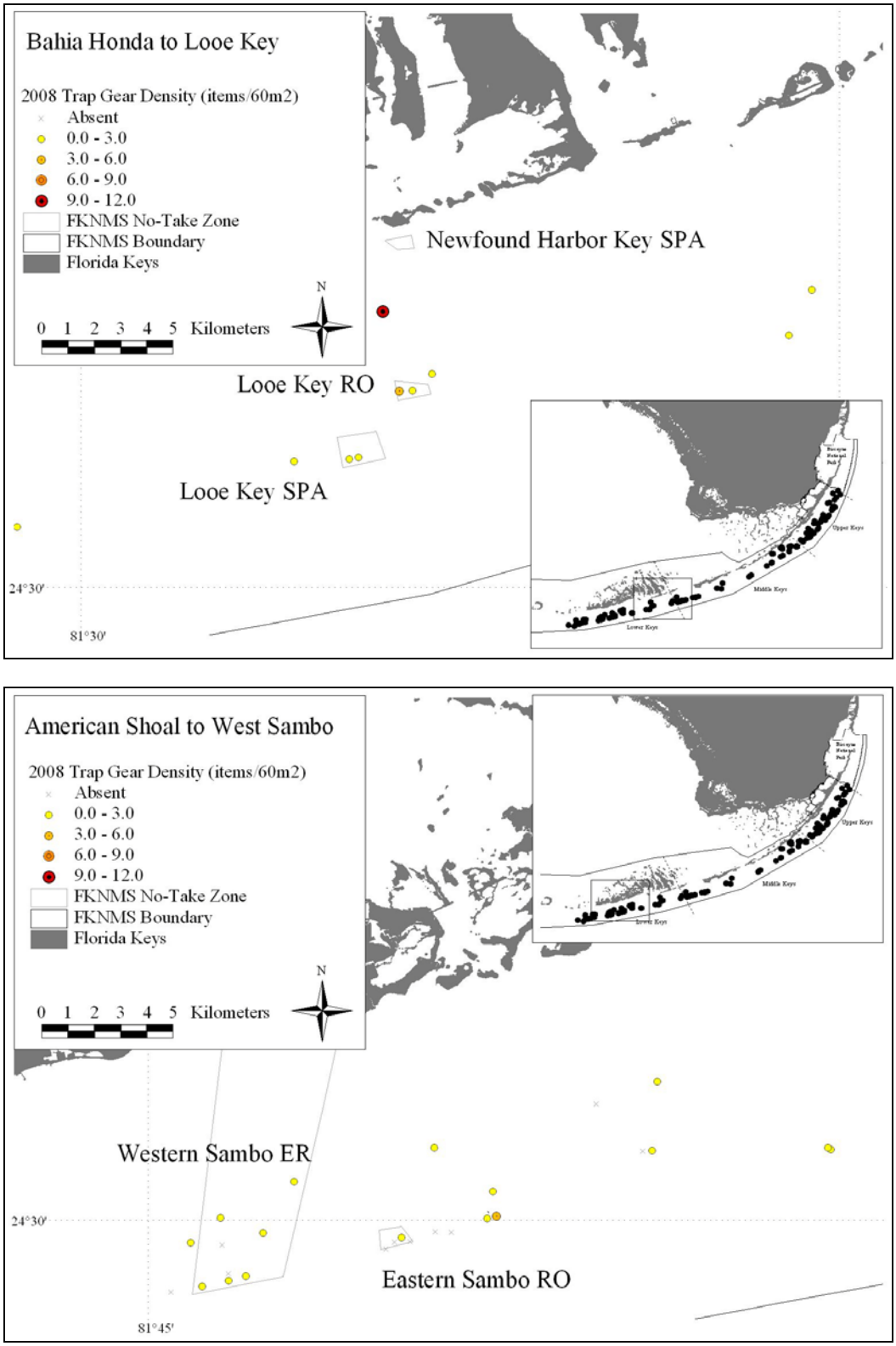


Figure 97. Densities (no. items per 60 m^2) of lobster/crab trap fishing gear in the lower Florida Keys from Eastern Dry Rocks to Sand Key during June-September 2008.

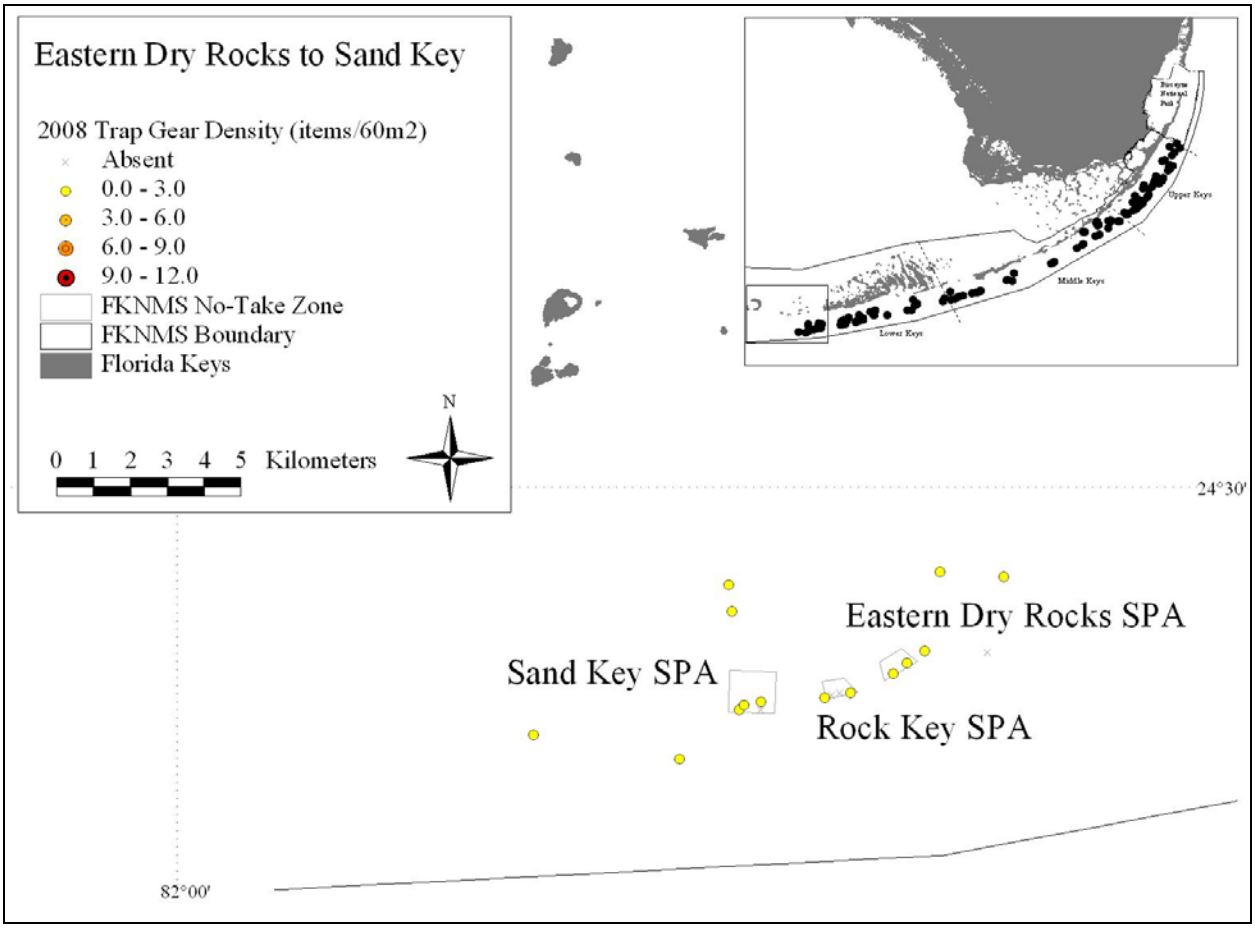


Figure 98. Mean (+ 1 SE) densities (no. items per 60 m^2) of lobster/crab trap fishing gear on mid-channel patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

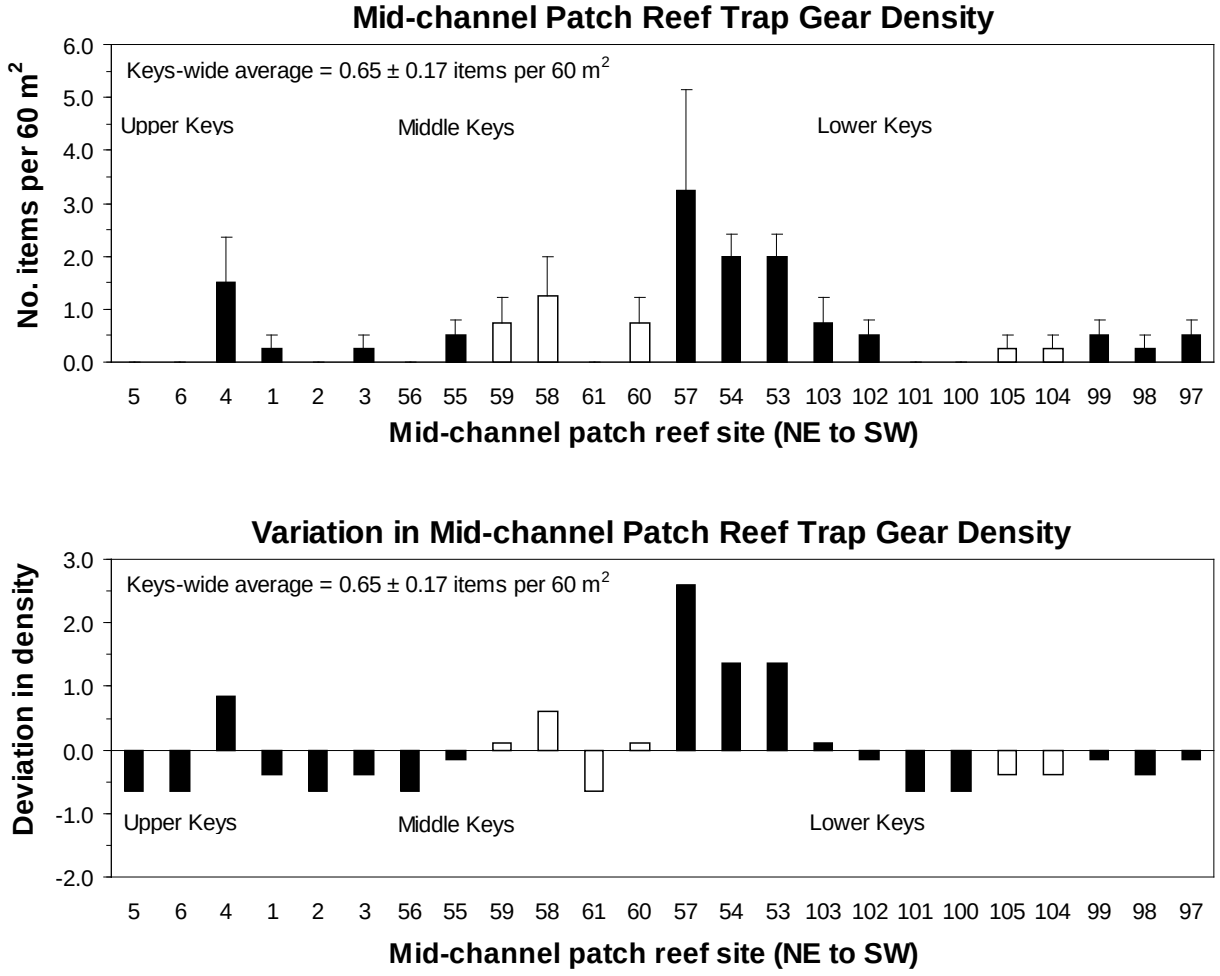


Figure 99. Mean (+ 1 SE) densities (no. items per 60 m^2) of lobster/crab trap fishing gear on offshore patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

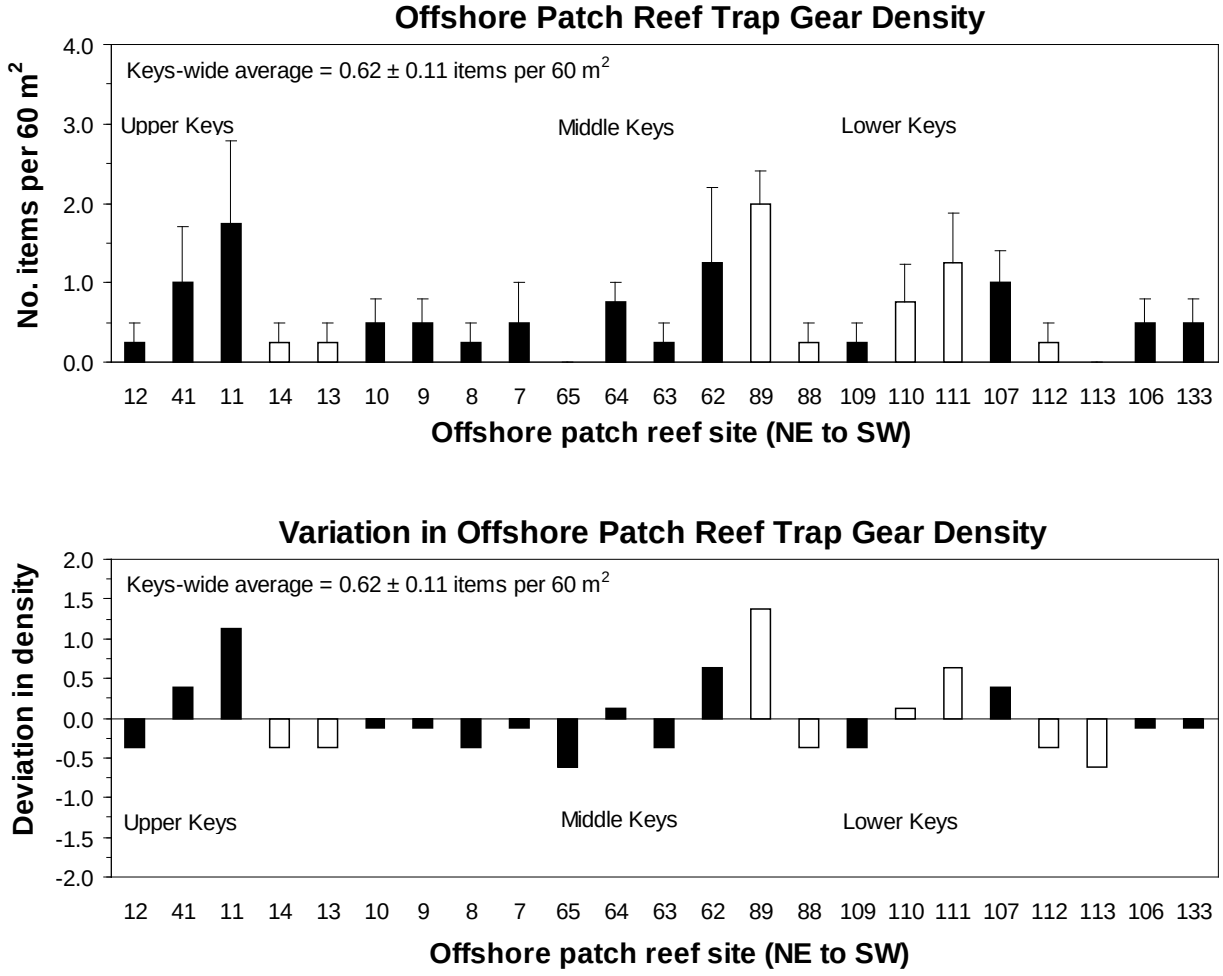


Figure 100. Mean (+ 1 SE) densities (no. items per 60 m^2) of lobster/crab trap fishing gear on shallow (< 6 m), high-relief spur and groove reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

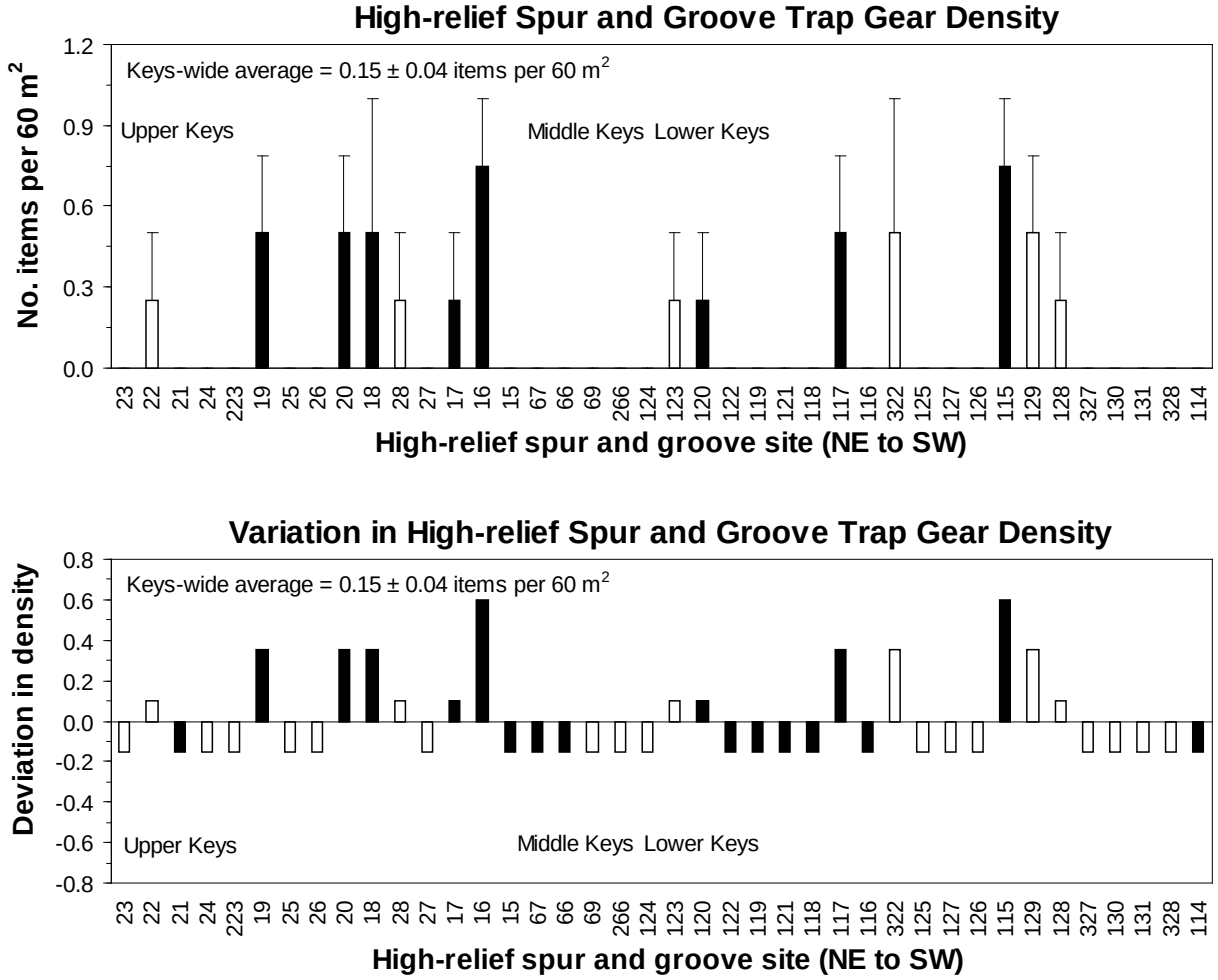


Figure 101. Mean (+ 1 SE) densities (no. items per 60 m^2) of lobster/crab trap fishing gear on deeper (6-15 m) fore-reef sites (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

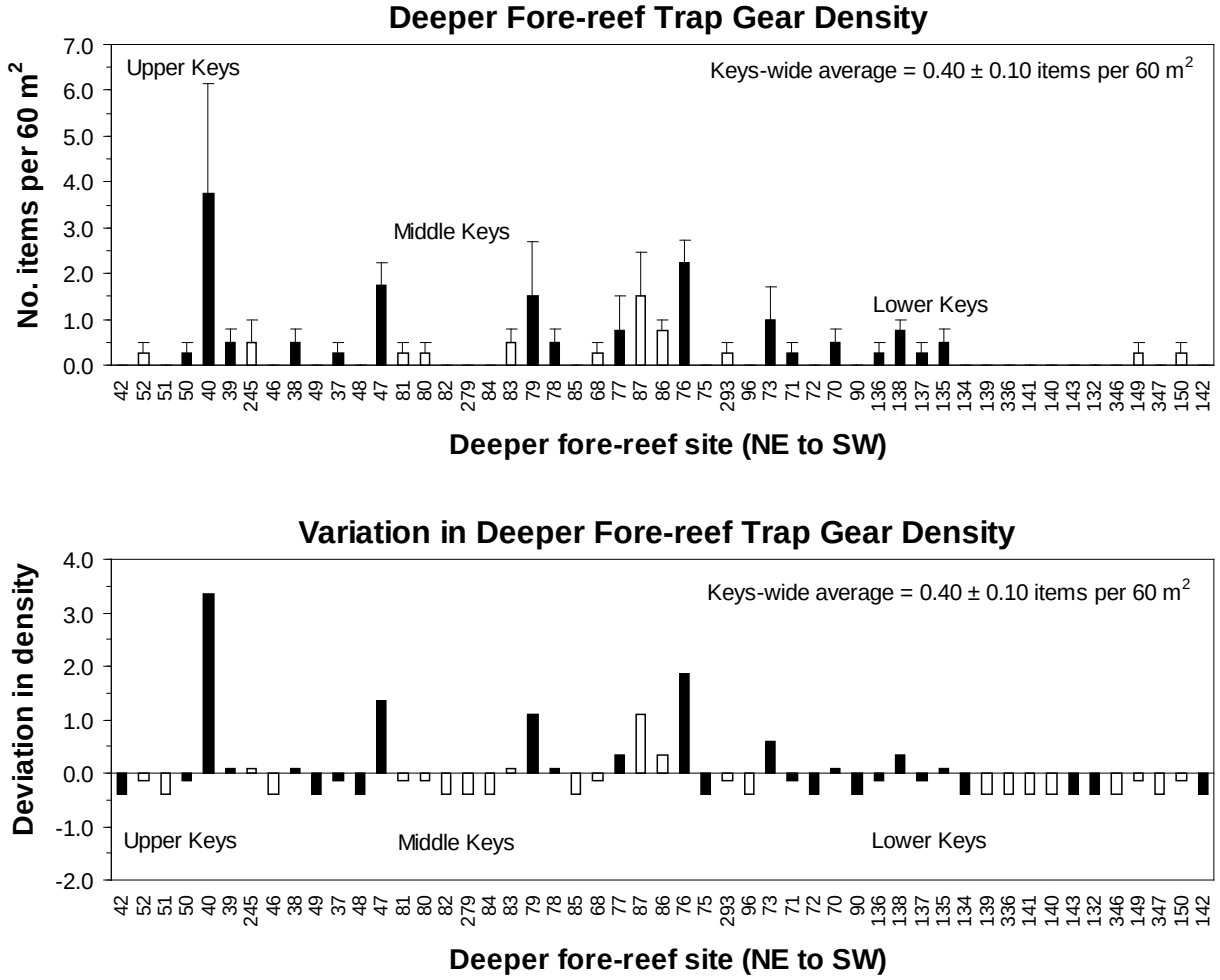


Figure 102. Length distribution (m) of derelict lobster/crab trap rope retrieved from surveys of 145 sites in the Florida Keys National Marine Sanctuary during June-September 2008.

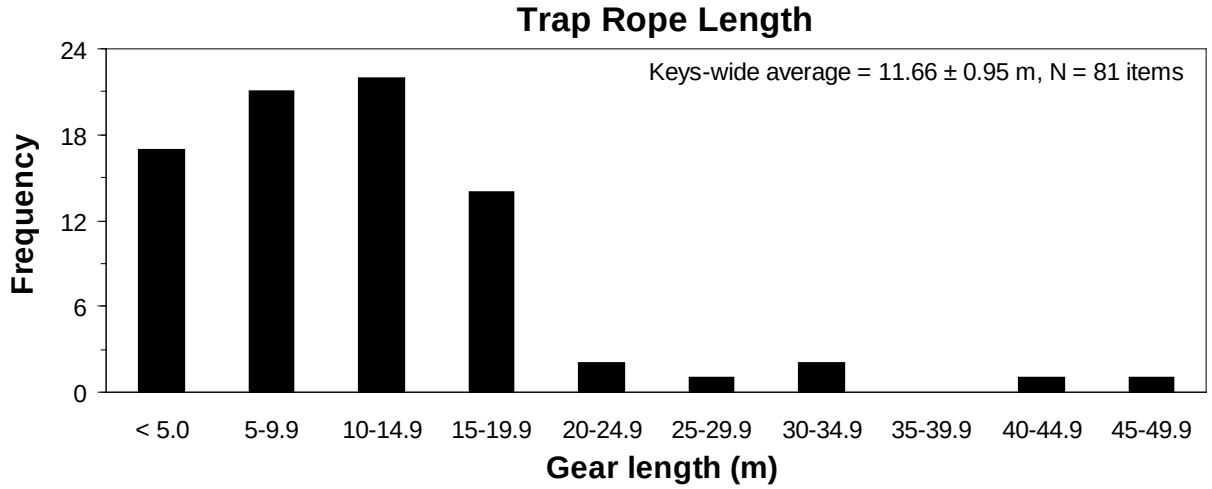


Figure 103. Total length (m) of derelict lobster/crab trap rope retrieved from 240-m^2 search areas per site in the upper Florida Keys (top) and from the southern BNP boundary to Carysfort (bottom) during June-September 2008.

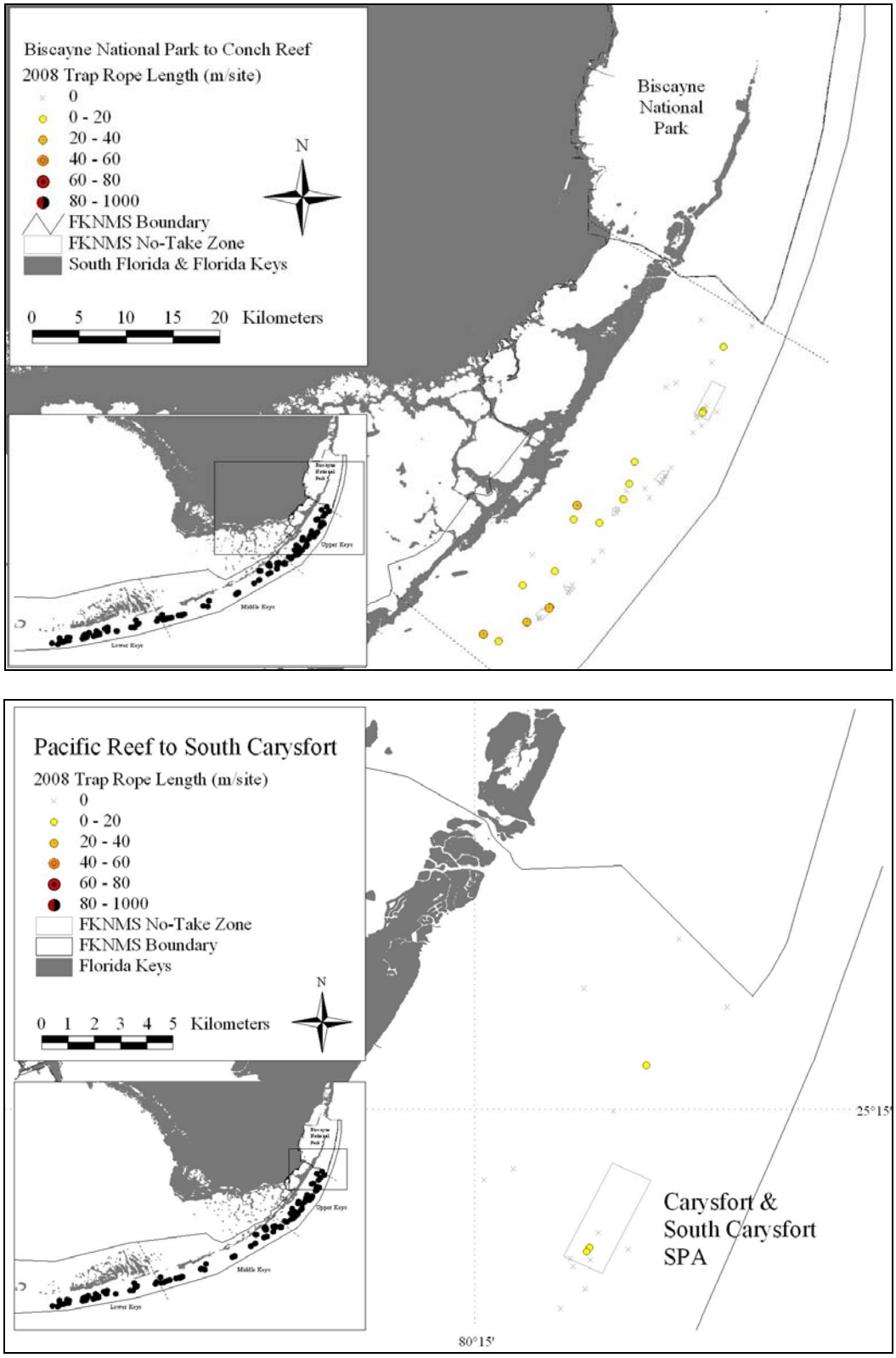


Figure 104. Total length (m) of derelict lobster/crab trap rope retrieved from 240-m^2 search areas per site in the upper Florida Keys from Elbow Reef to Pickles Reef (top) and in the middle Florida Keys (bottom) during June-September 2008.

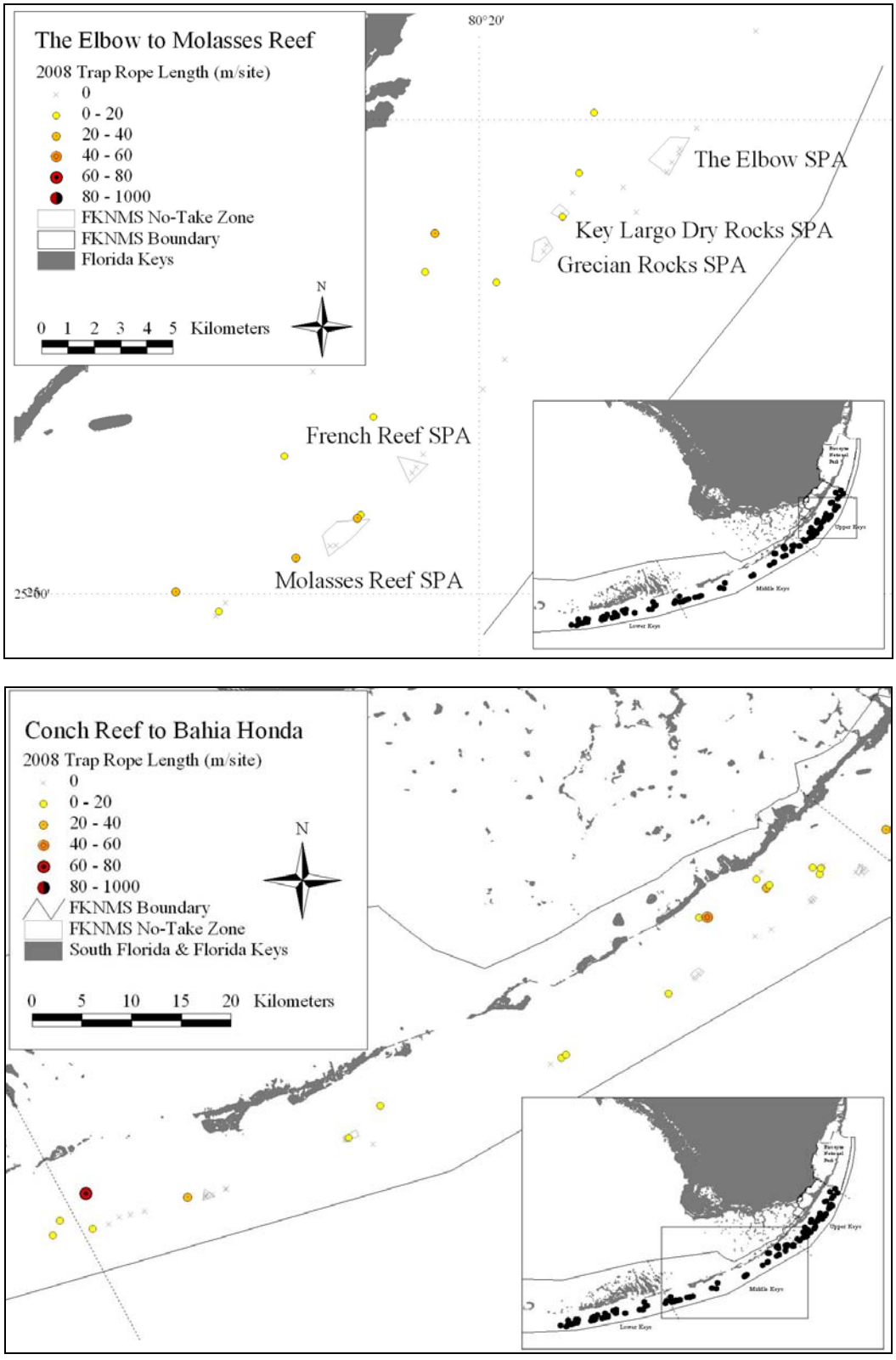
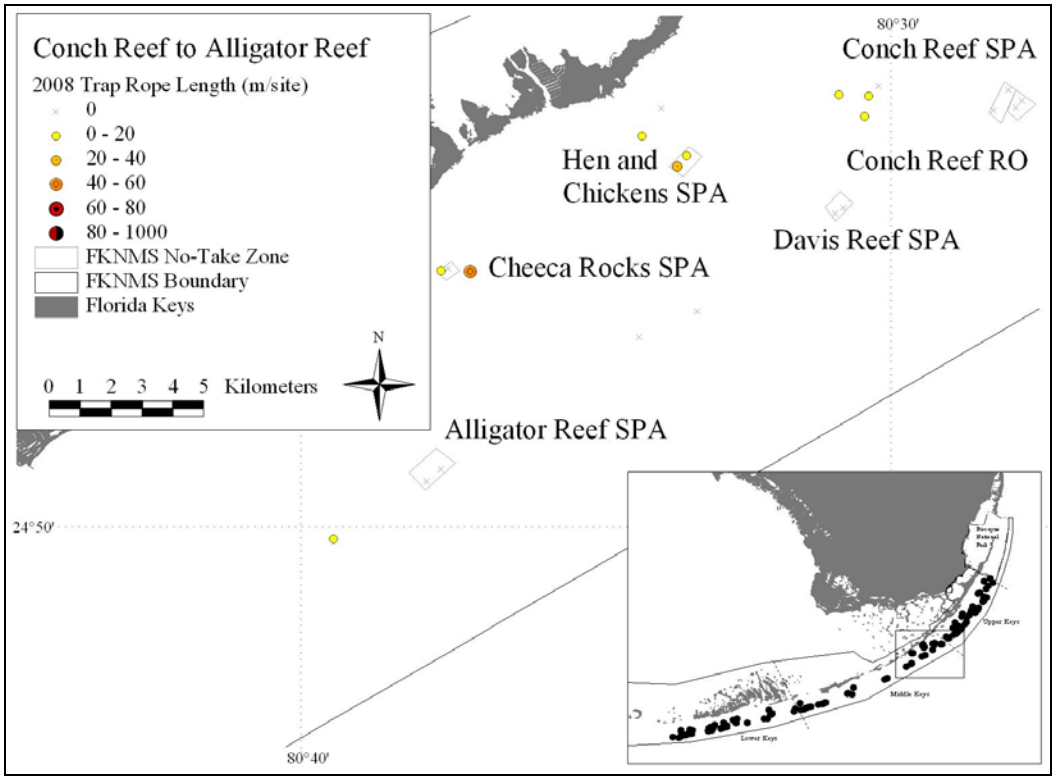


Figure 105. Total length (m) of derelict lobster/crab trap rope retrieved from 240-m^2 search areas per site in the middle Florida Keys from Conch Reef to Alligator Reef (top) and from Tennessee Reef to Coffins Patch (bottom) during June-September 2008.



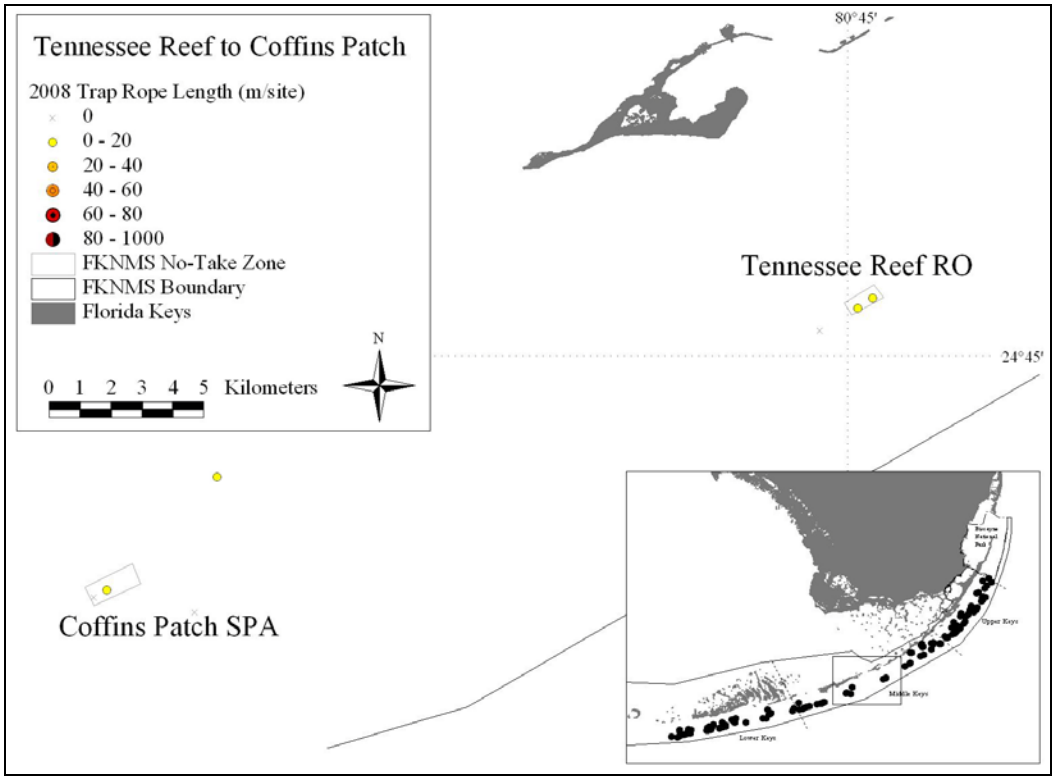


Figure 106. Total length (m) of derelict lobster/crab trap rope retrieved from 240-m^2 search areas per site in the middle Florida Keys from Sombrero Reef to Bahia Honda (top) and in the lower Florida Keys (bottom) during June-September 2008.

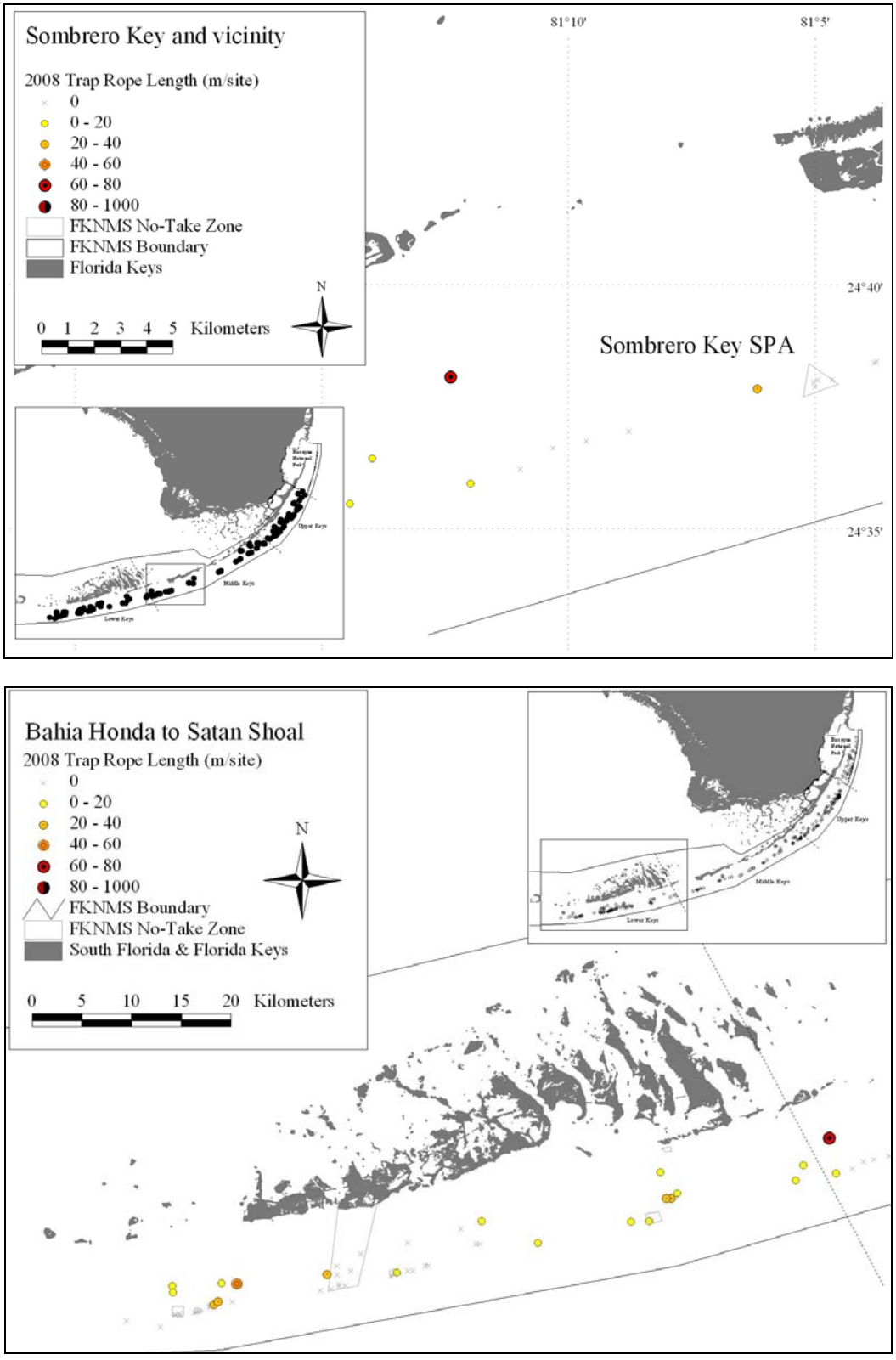


Figure 107. Total length (m) of derelict lobster/crab trap rope retrieved from 240-m^2 search areas per site in the lower Florida Keys from Bahia Honda to Looe Key (top) and from American Shoal to Western Sambo (bottom) during June-September 2008.

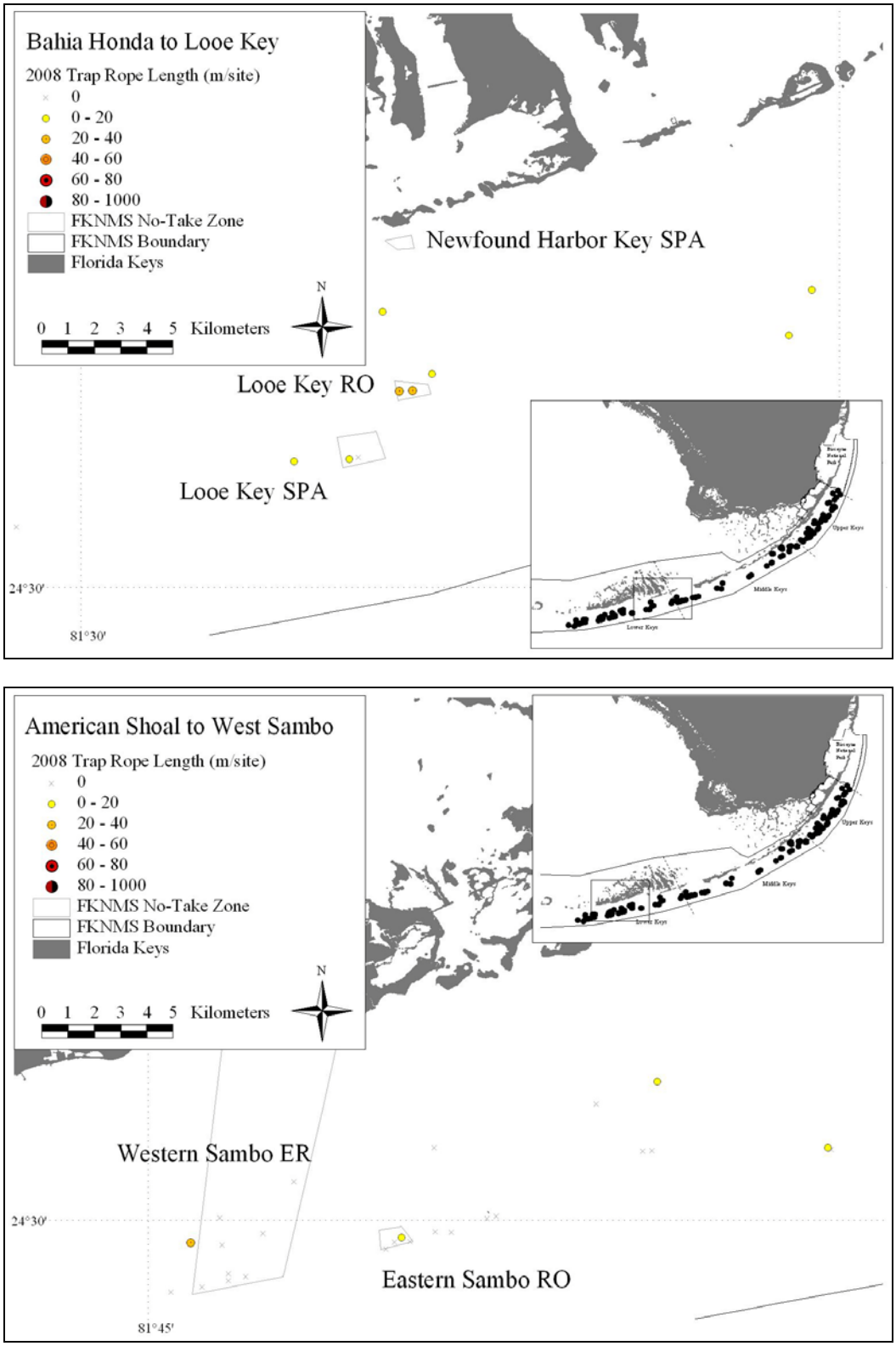


Figure 108. Total length (m) of derelict lobster/crab trap rope retrieved from 240-m^2 search areas per site in the lower Florida Keys from Eastern Dry Rocks to Sand Key during June-September 2008.

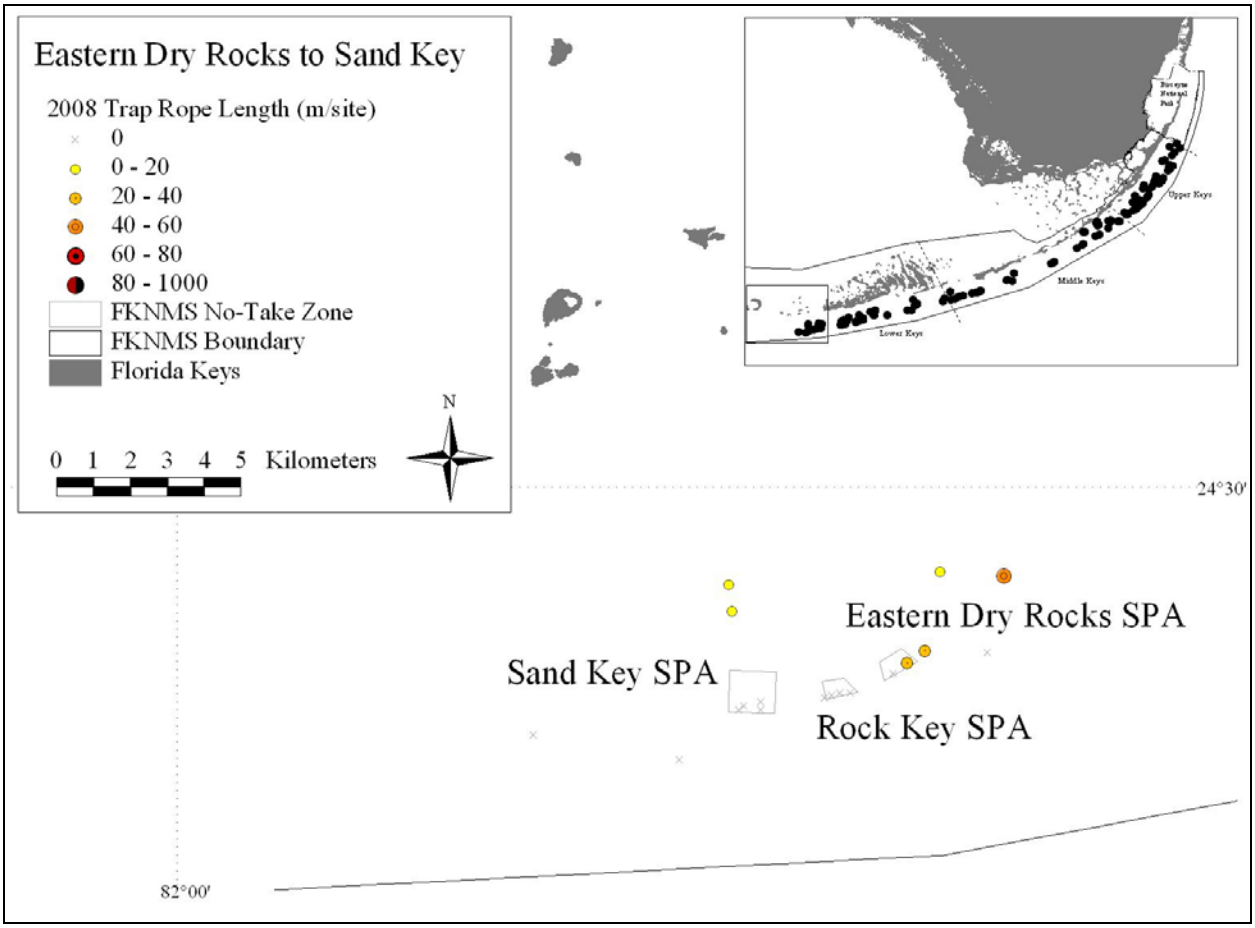


Figure 109. Total length (m) of lobster/crab trap rope retrieved from 240-m^2 search areas per site on mid-channel patch reefs (top) and variations in total gear length retrieved relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

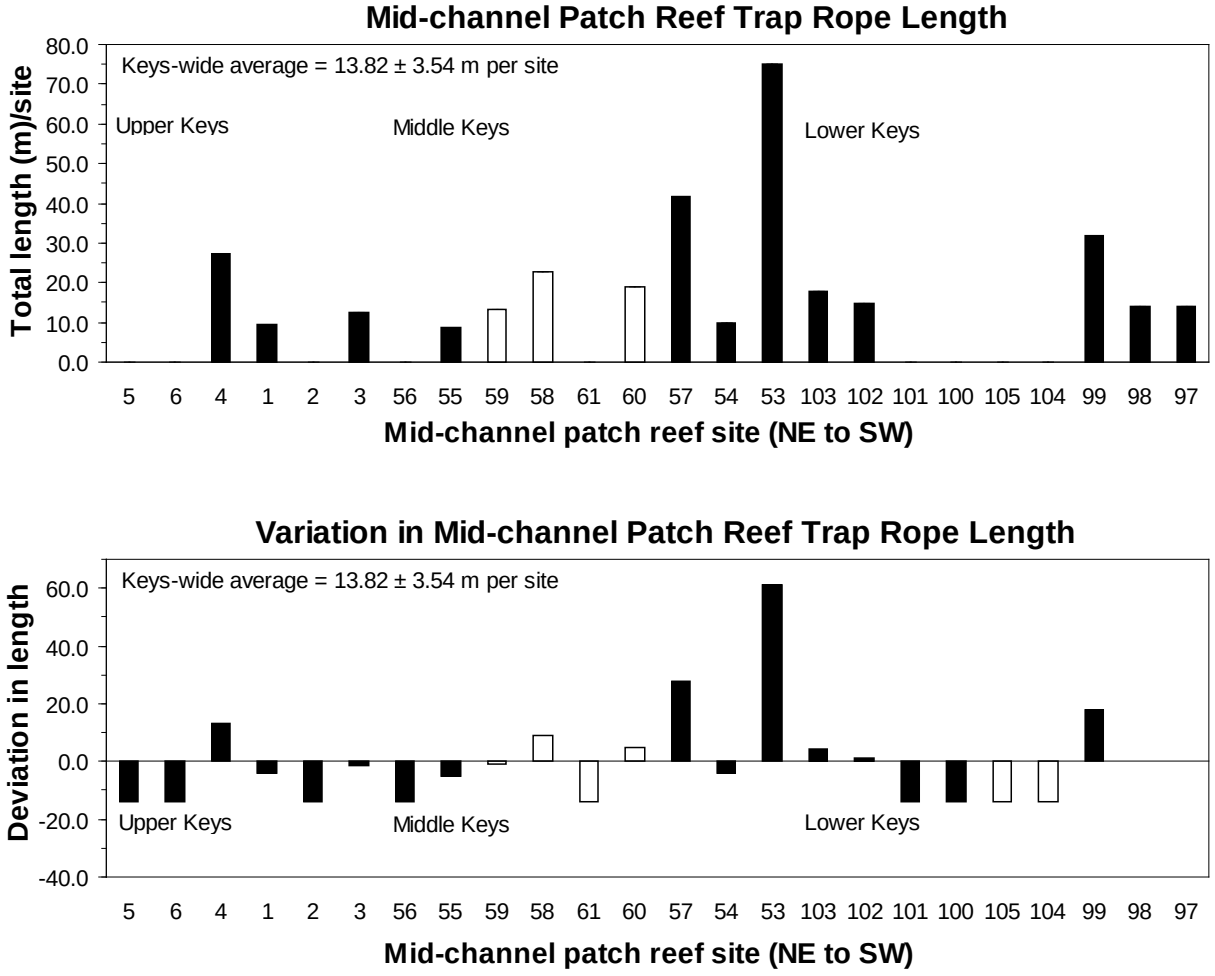


Figure 110. Total length (m) of lobster/crab trap rope retrieved from 240-m^2 search areas per site on offshore patch reefs (top) and variations in total gear length retrieved relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

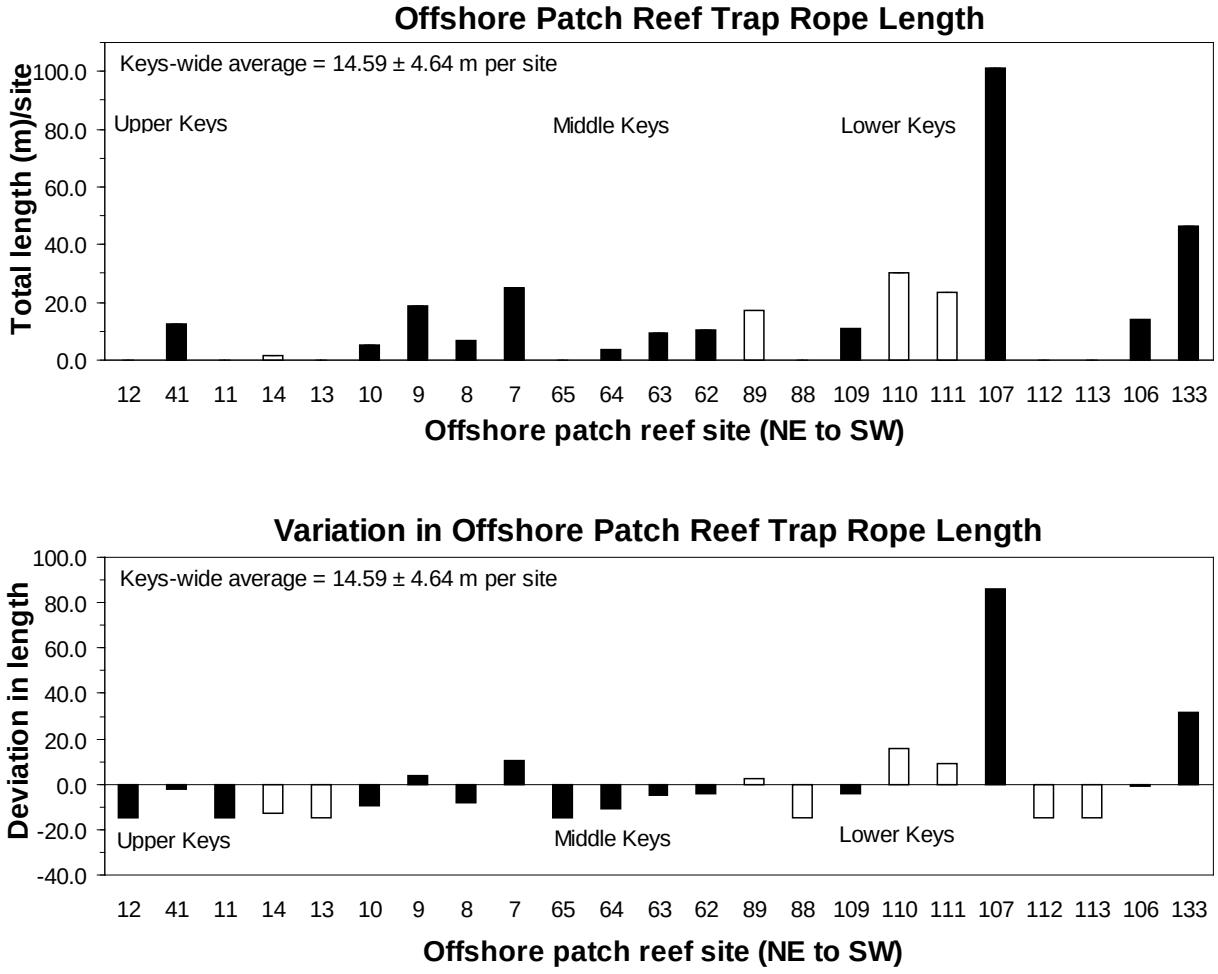


Figure 111. Total length (m) of lobster/crab trap rope retrieved from 240-m^2 search areas per site on shallow (< 6 m), high-relief spur and groove reefs (top) and variations in total gear length retrieved relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

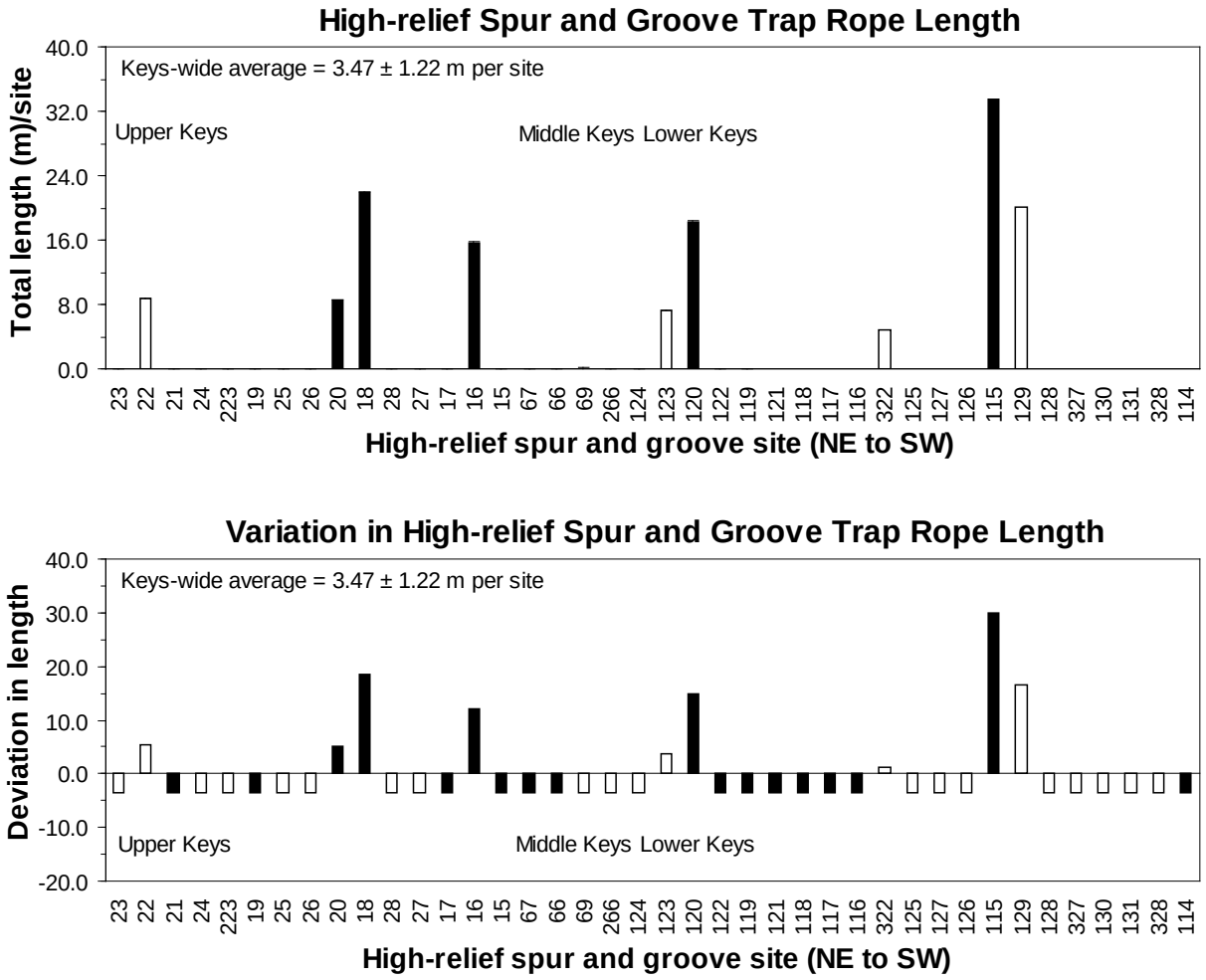


Figure 112. Total length (m) of lobster/crab trap rope retrieved from 240-m^2 search areas per site on deeper (6-15 m) fore-reef sites (top) and variations in total gear length retrieved relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

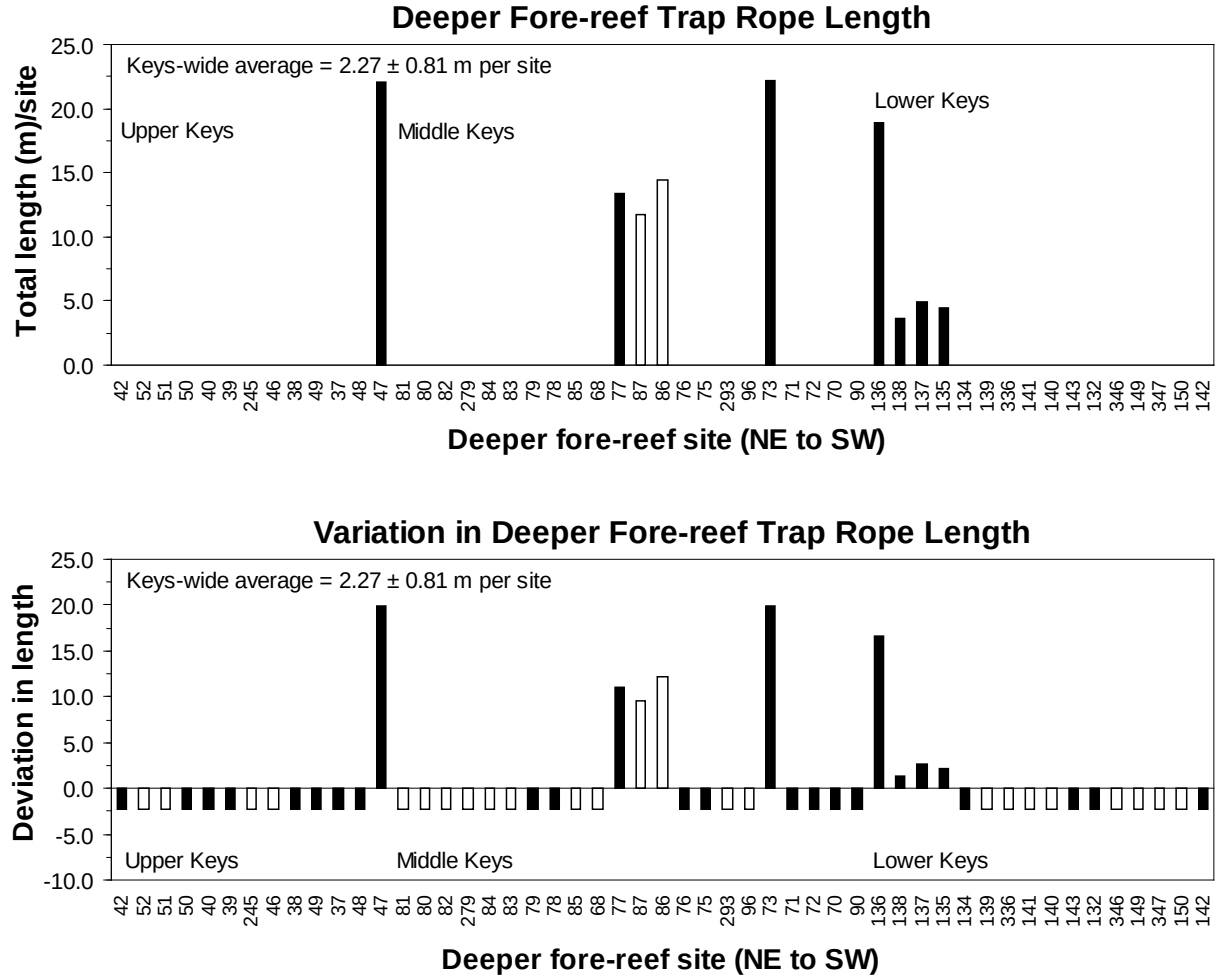


Figure 113. Total marine debris densities (no. items per 60 m^2) in the upper Florida Keys (top) and from the southern BNP boundary to Carysfort Reef (bottom) during June-September 2008.

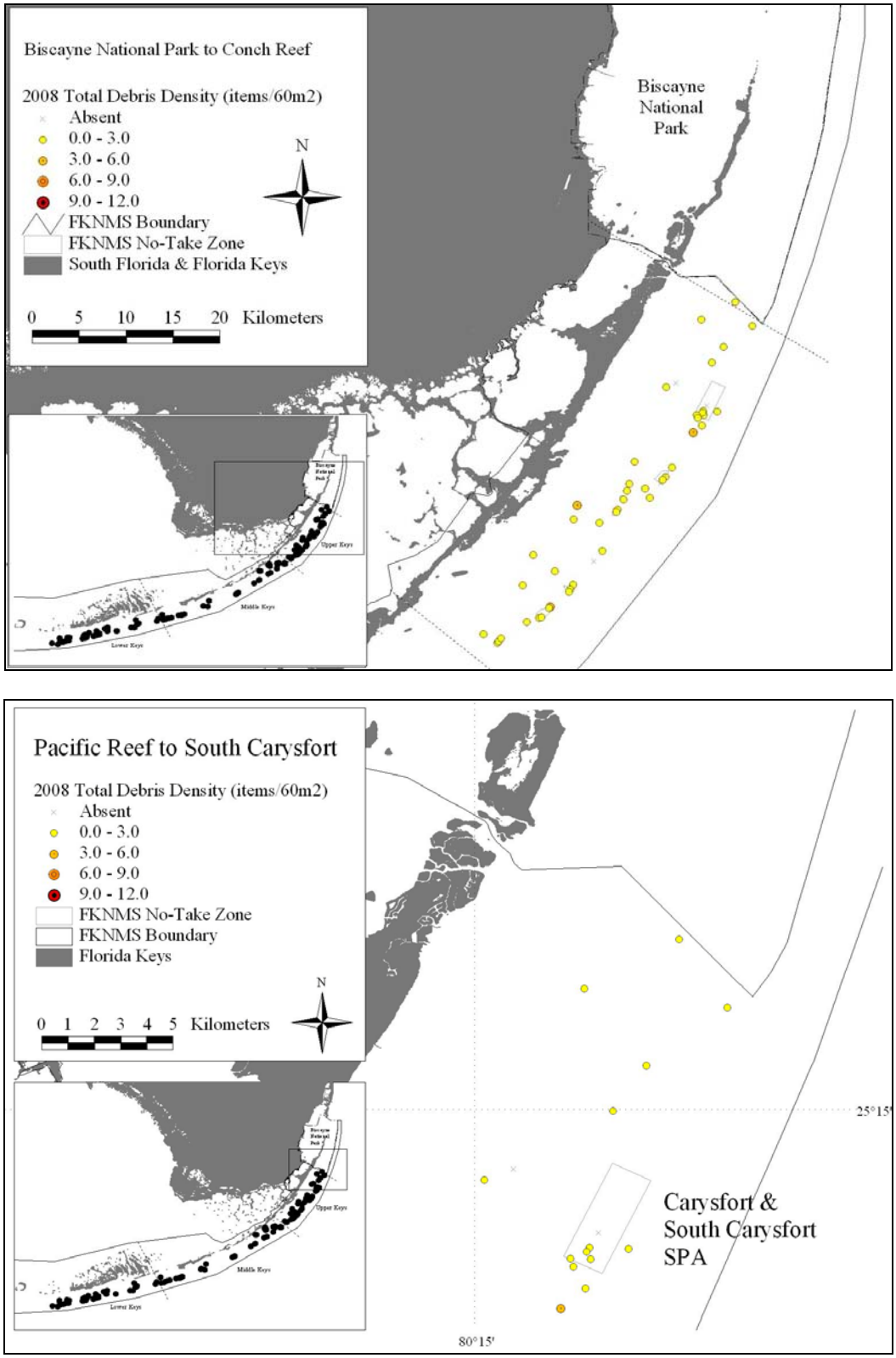


Figure 114. Total marine debris densities (no. items per 60 m^2) in the upper Florida Keys from Elbow Reef to Pickles Reef (top) and in the middle Florida Keys (bottom) during June-September 2008.

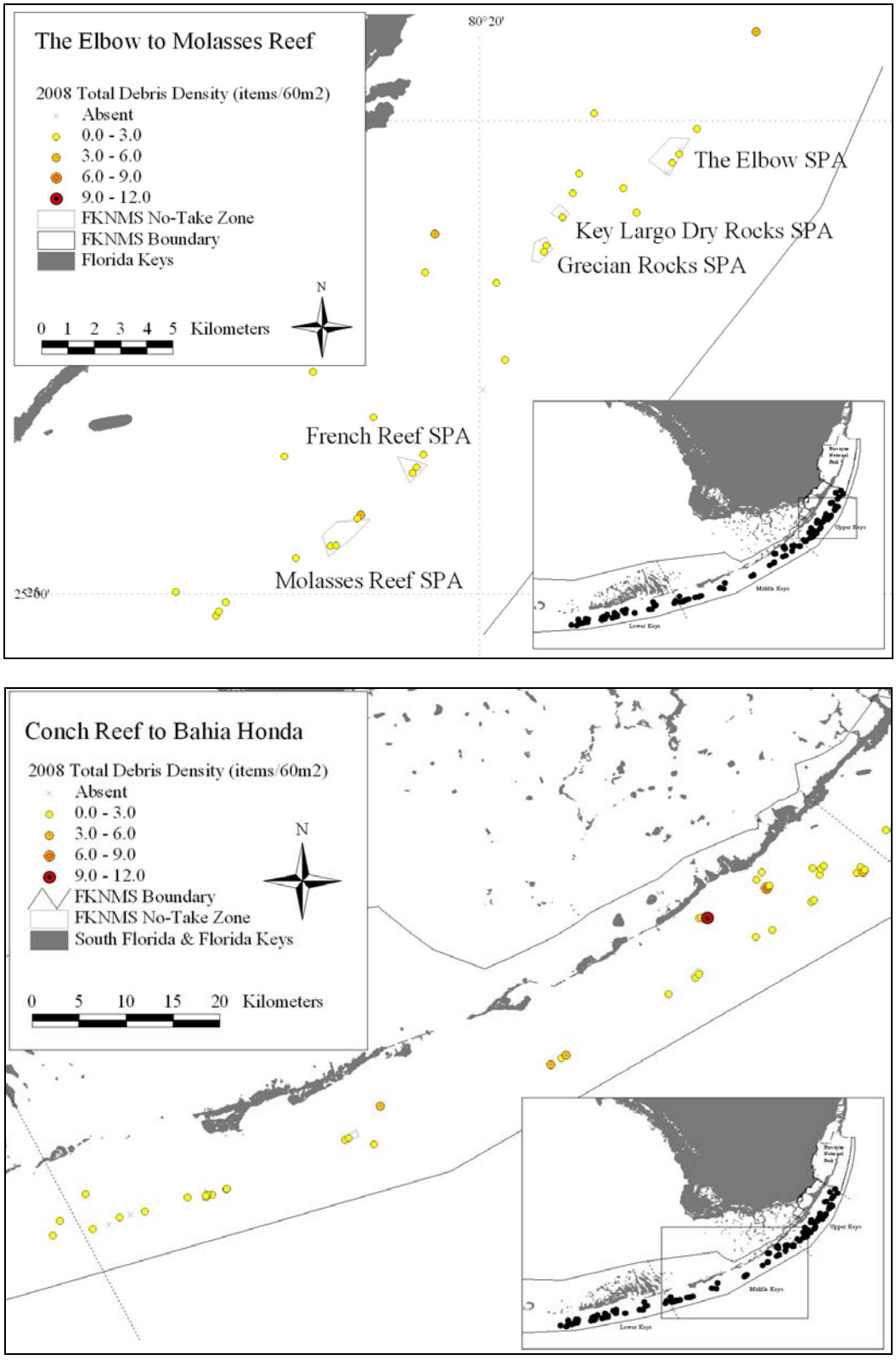


Figure 115. Total marine debris densities (no. items per 60 m^2) in the middle Florida Keys from Conch Reef to Alligator Reef (top) and from Tennessee Reef to Coffins Patch (bottom) during June-September 2008.

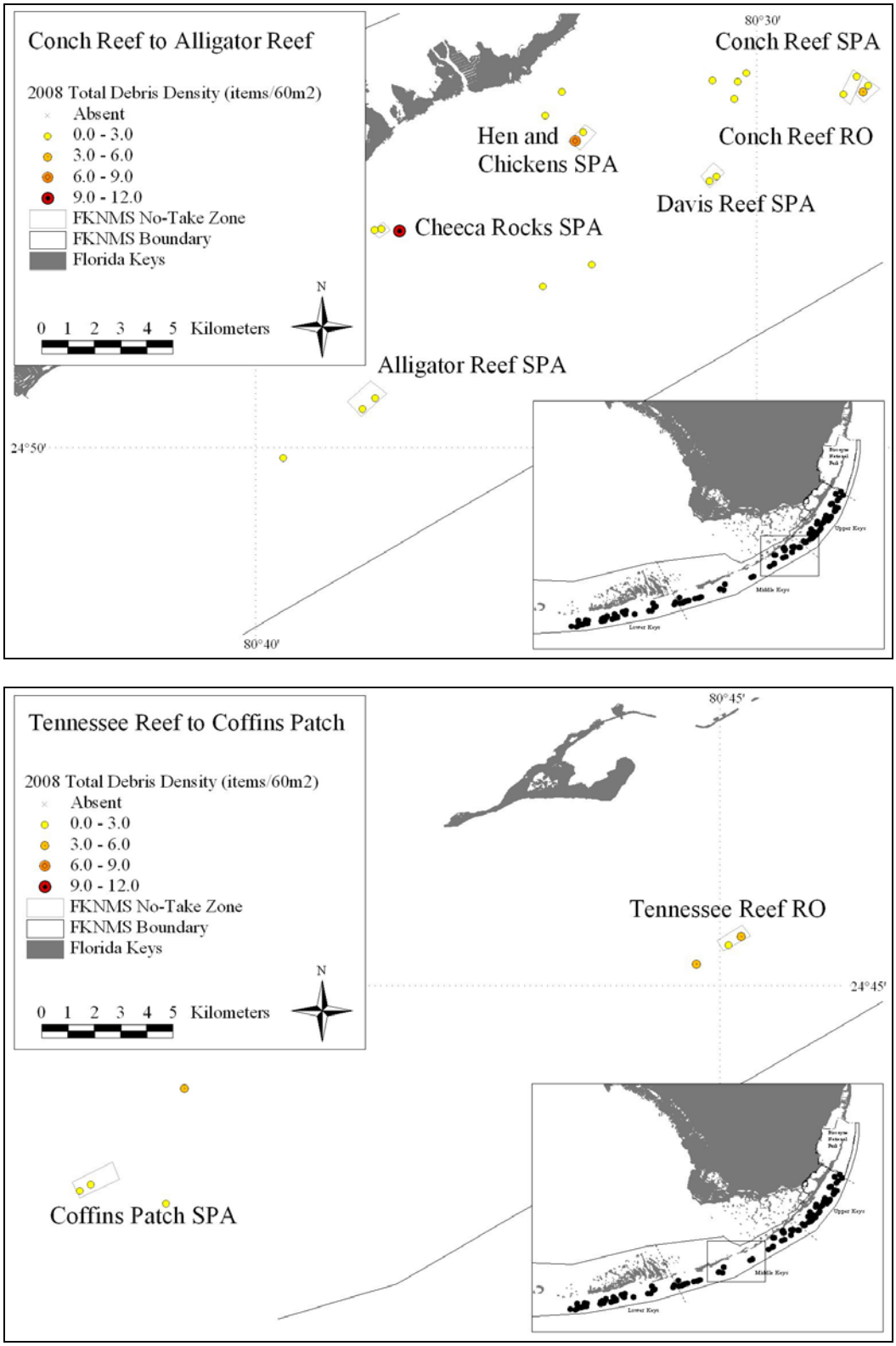


Figure 116. Total marine debris densities (no. items per 60 m^2) in the middle Florida Keys from Sombrero Reef to Bahia Honda (top) and in the lower Florida Keys (bottom) during June-September 2008.

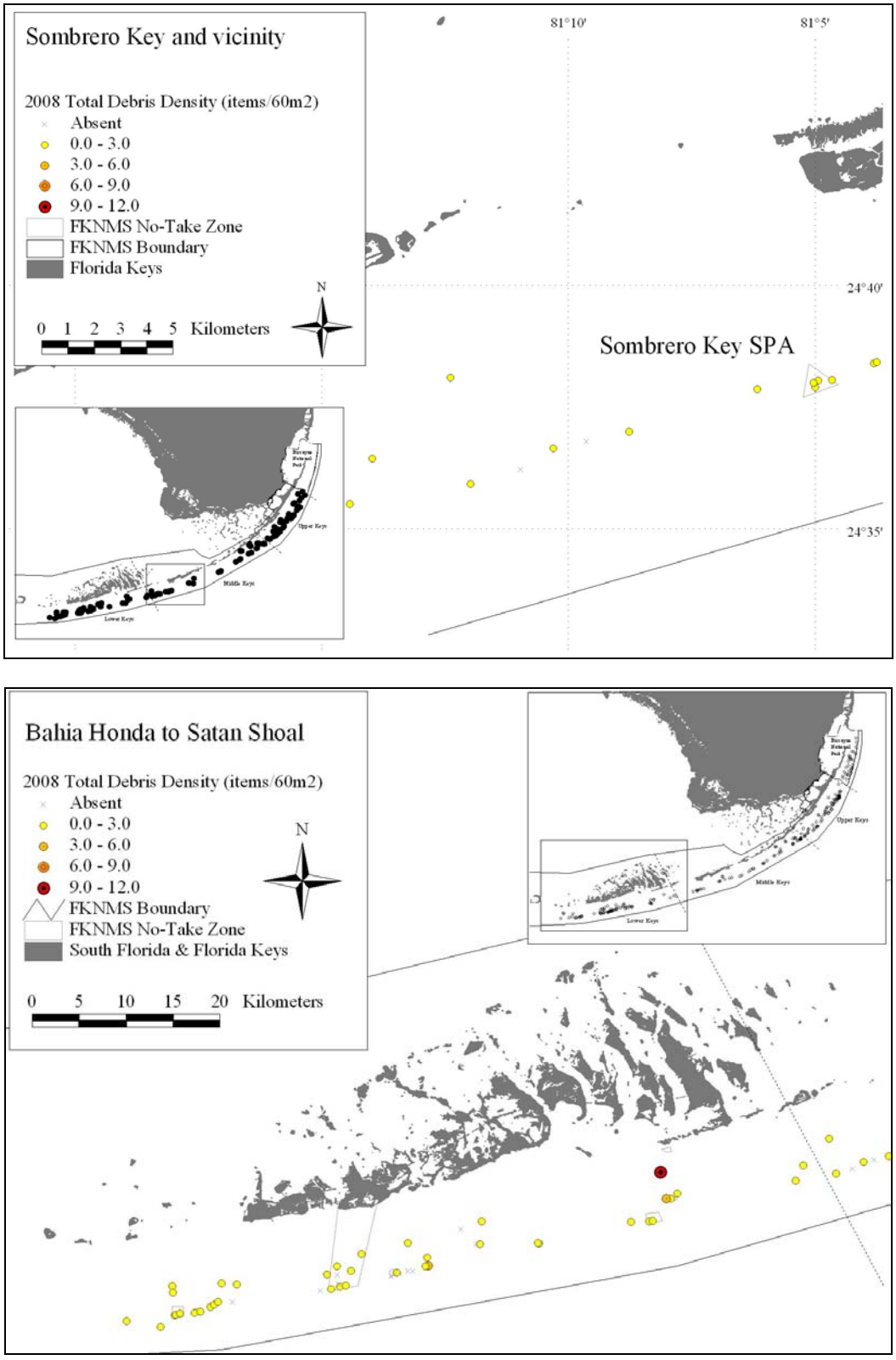


Figure 117. Total marine debris densities (no. items per 60 m^2) in the lower Florida Keys from Bahia Honda to Looe Key (top) and from American Shoal to Western Sambo (bottom) during June-September 2008.

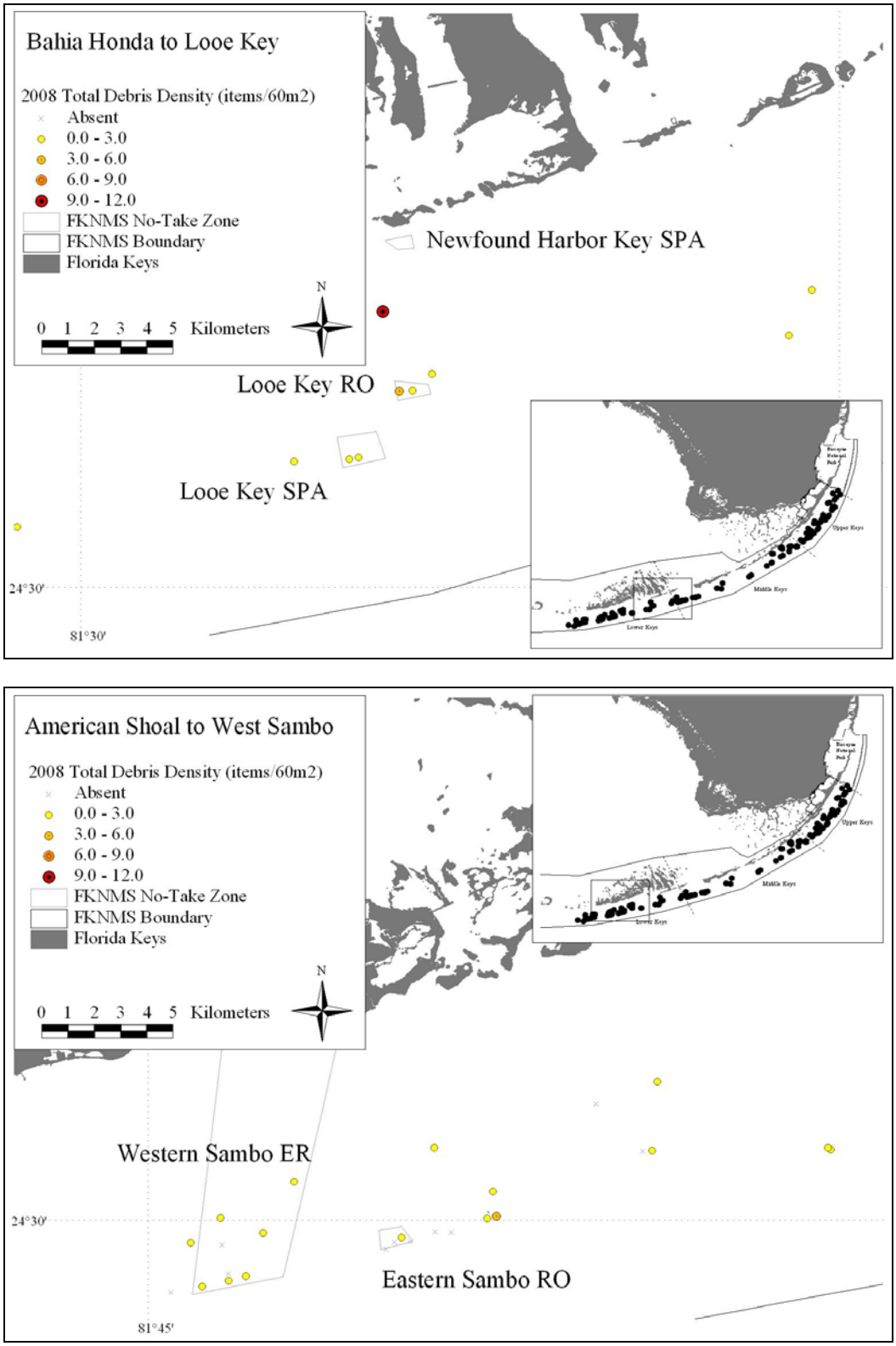


Figure 118. Total marine debris densities (no. items per 60 m^2) in the lower Florida Keys from Eastern Dry Rocks to Sand Key during June-September 2008.

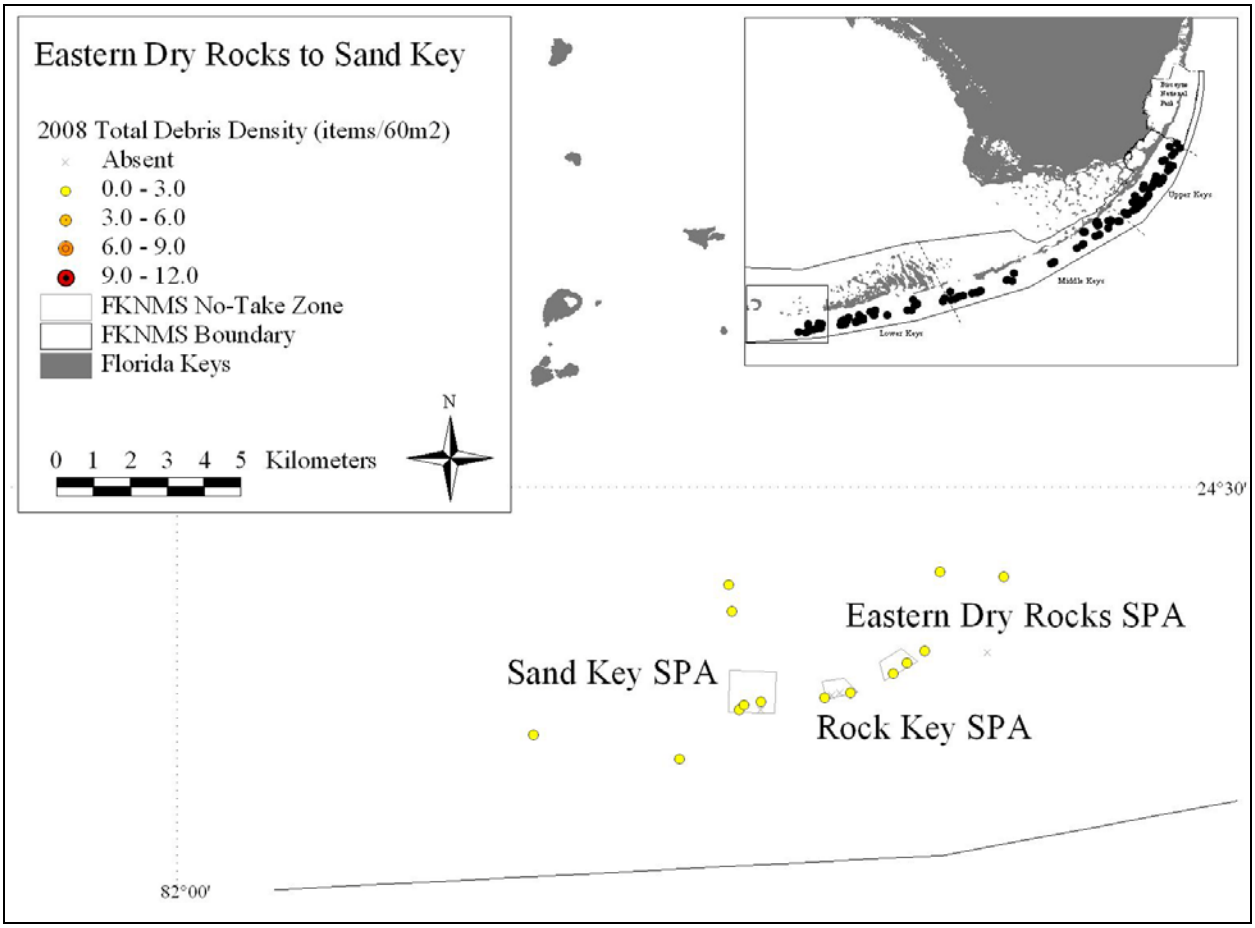


Figure 119. Mean (+ 1 SE) densities (no. items per 60 m^2) of total marine debris on mid-channel patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

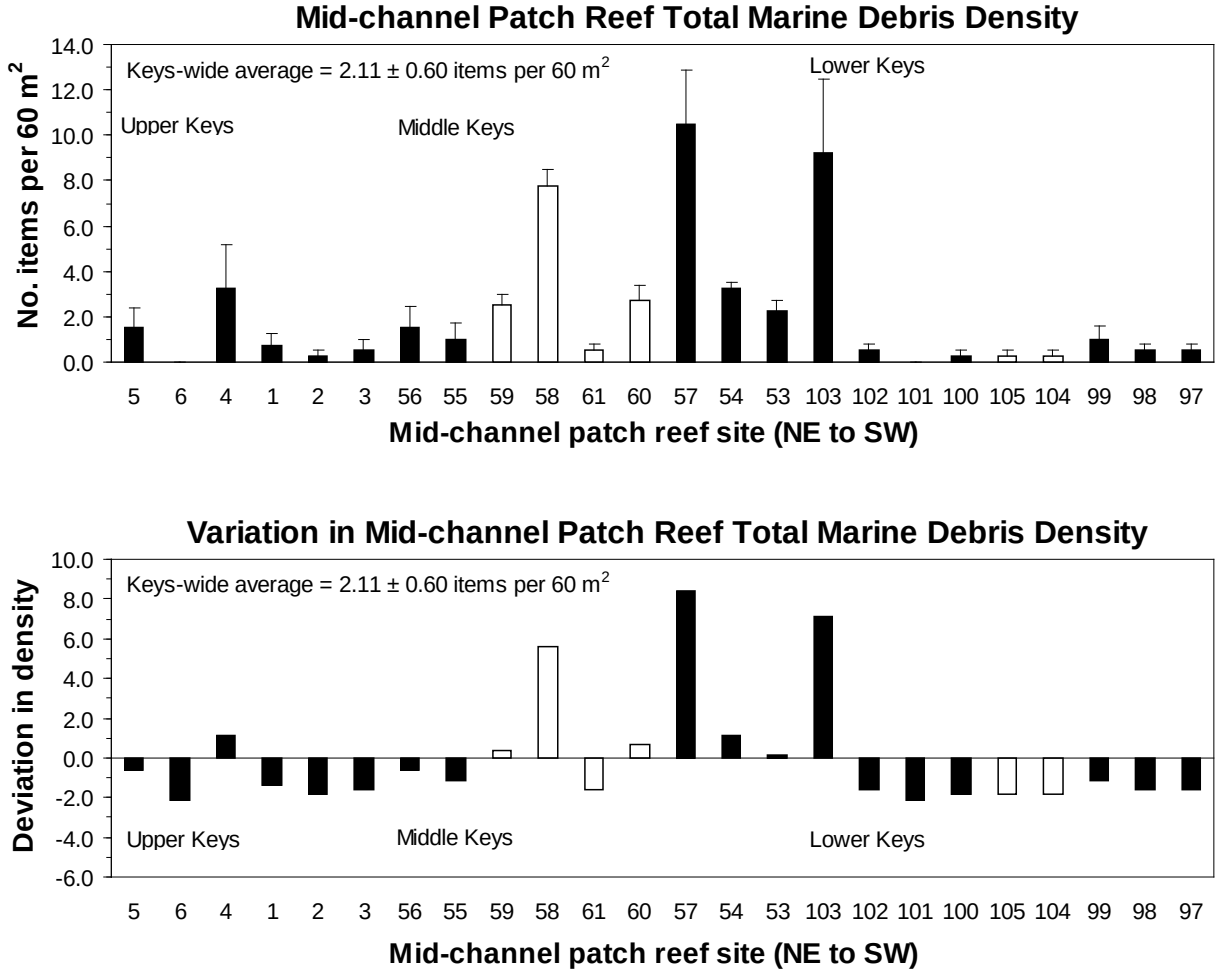


Figure 120. Mean (+ 1 SE) densities (no. items per 60 m^2) of total marine debris on offshore patch reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

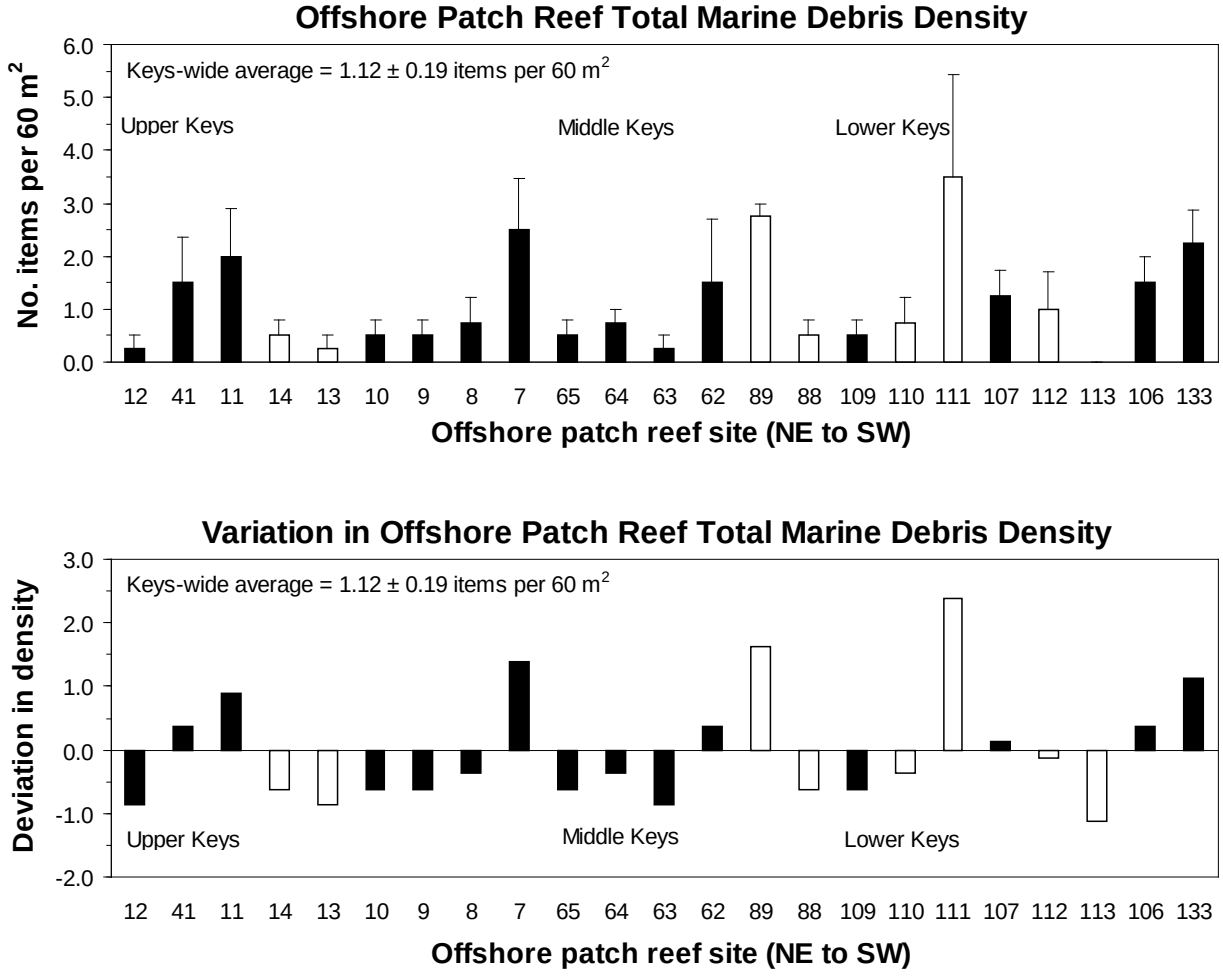


Figure 121. Mean (+ 1 SE) densities (no. items per 60 m^2) of total marine debris on shallow (< 6 m), high-relief spur and groove reefs (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

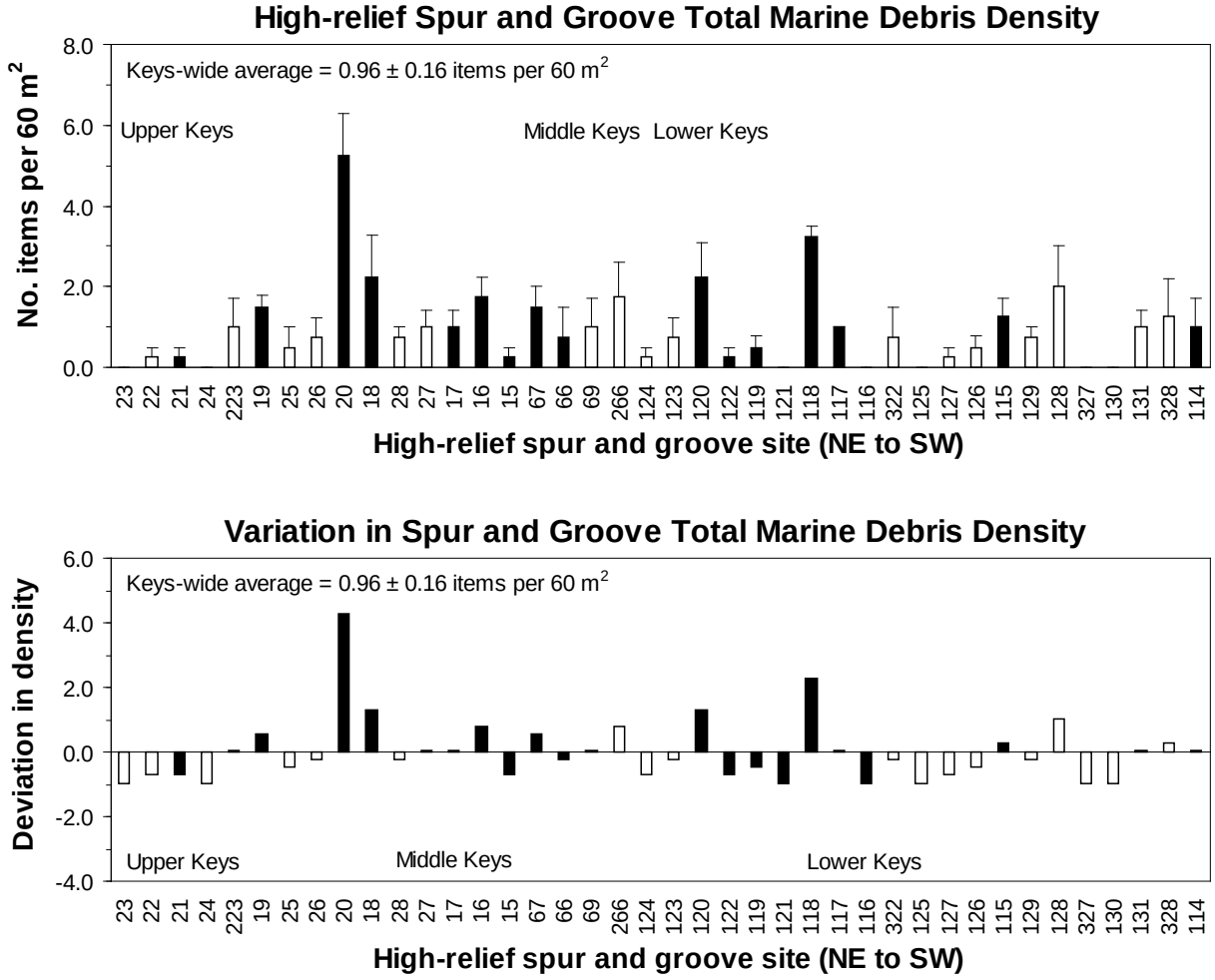


Figure 122. Mean (+ 1 SE) densities (no. items per 60 m^2) of total marine debris on deeper (6-15 m) fore-reef sites (top) and variations in site-level densities relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

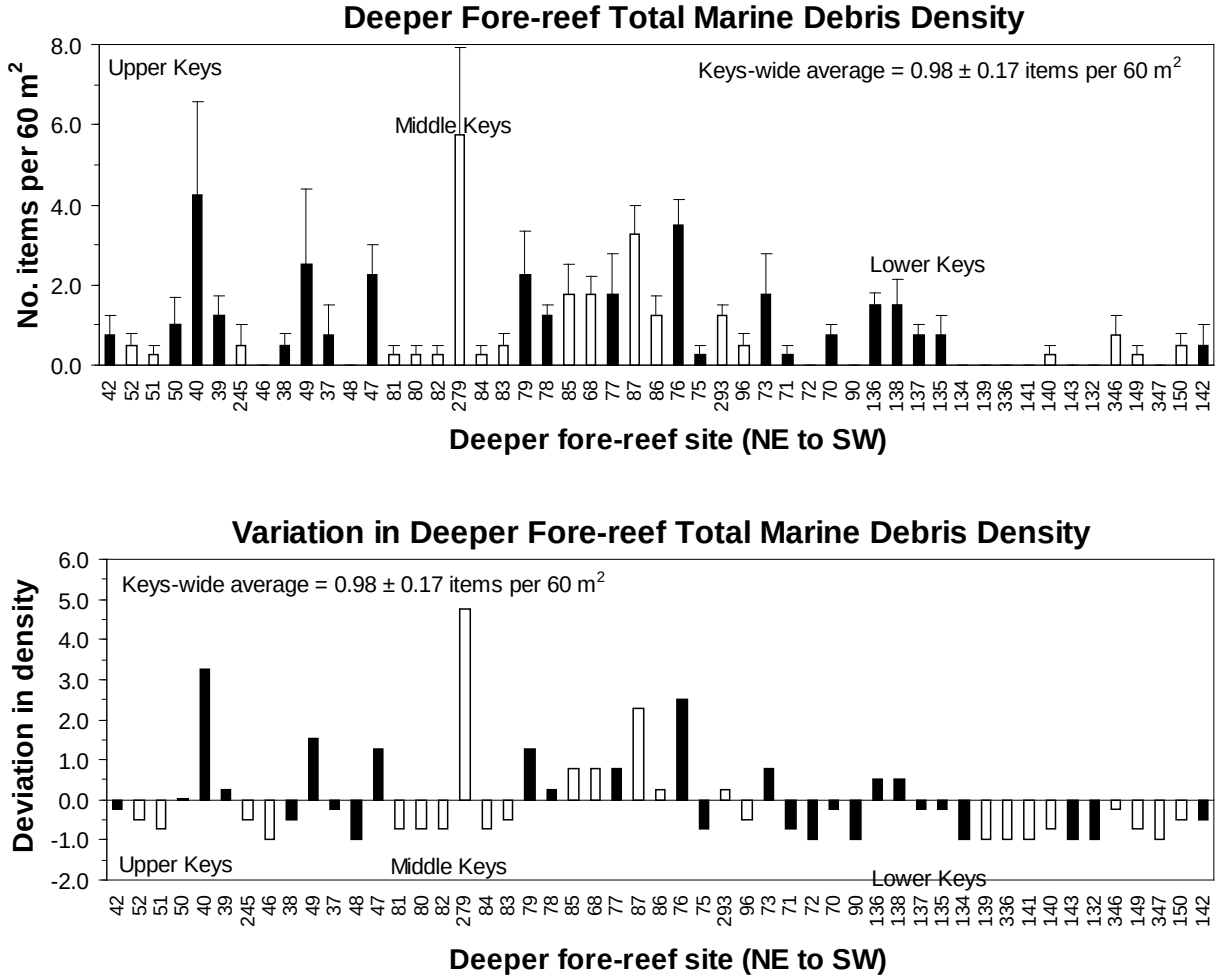


Figure 123. Total marine debris wet weight (kg retrieved per 240 m^2) in the upper Florida Keys (top) and from the southern BNP boundary to Carysfort Reef (bottom) during June-September 2008.

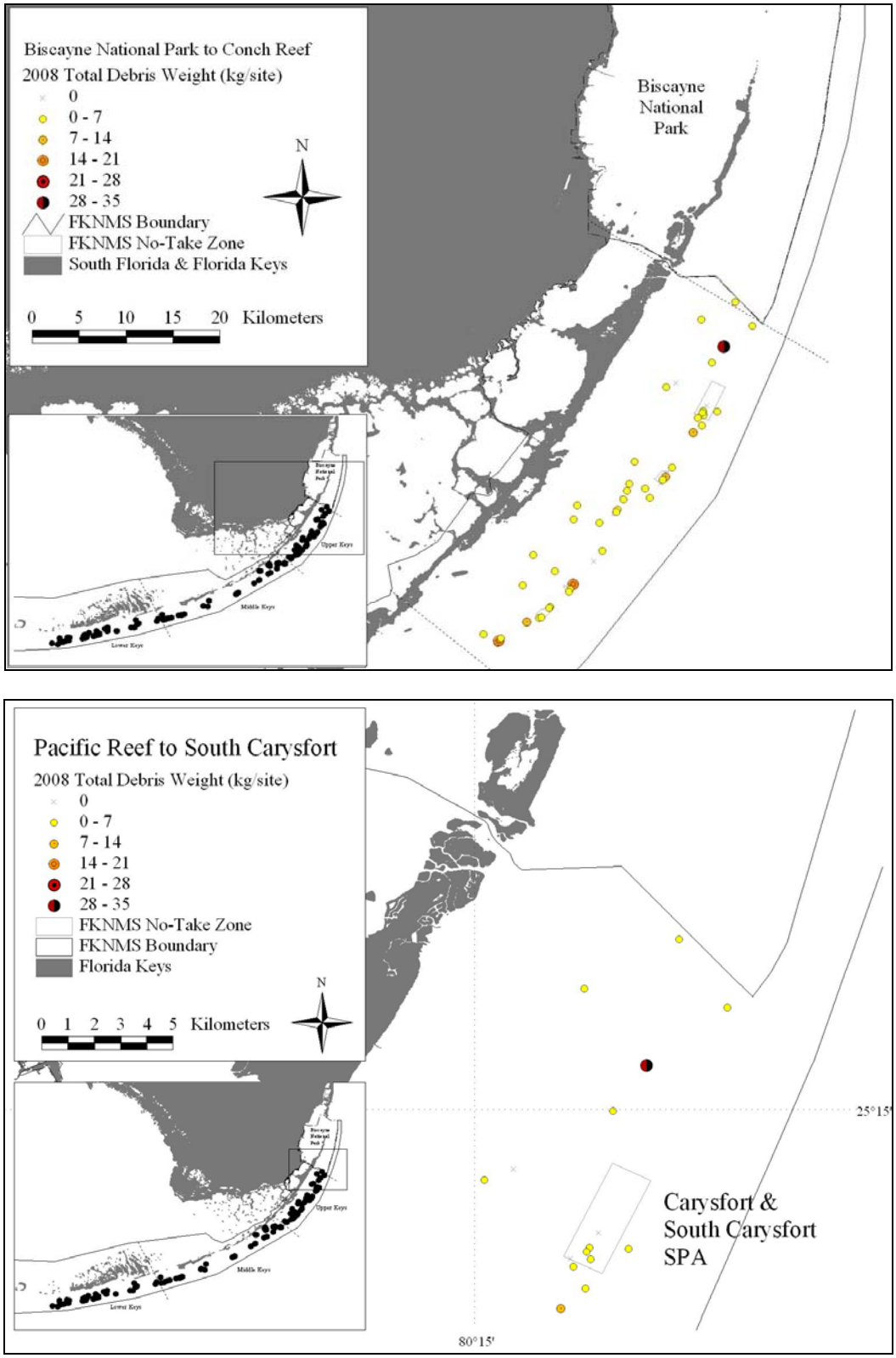


Figure 124. Total marine debris wet weight (kg retrieved per 240 m^2) in the upper Florida Keys from Elbow Reef to Pickles Reef (top) and in the middle Florida Keys (bottom) during June-September 2008.

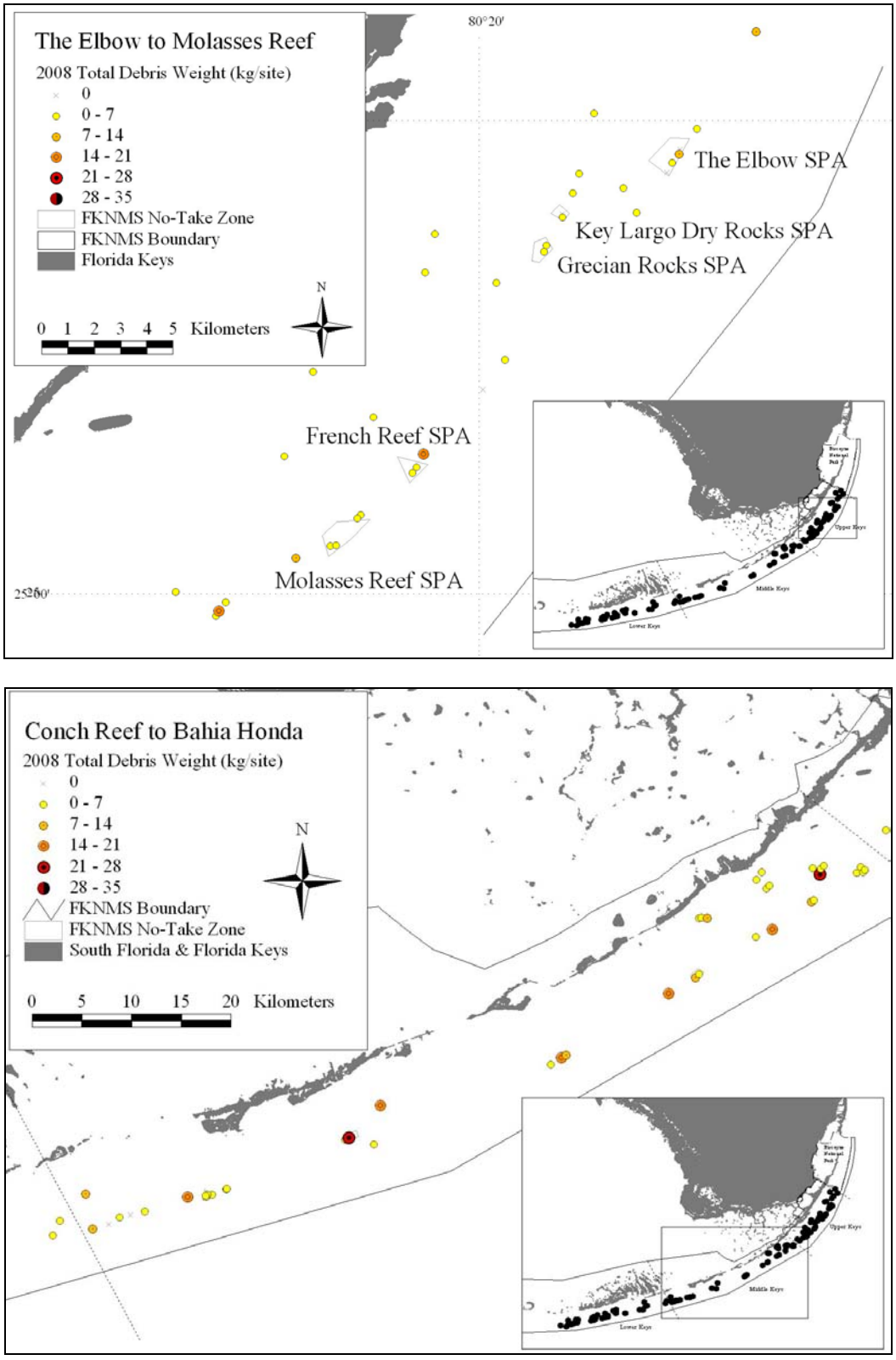
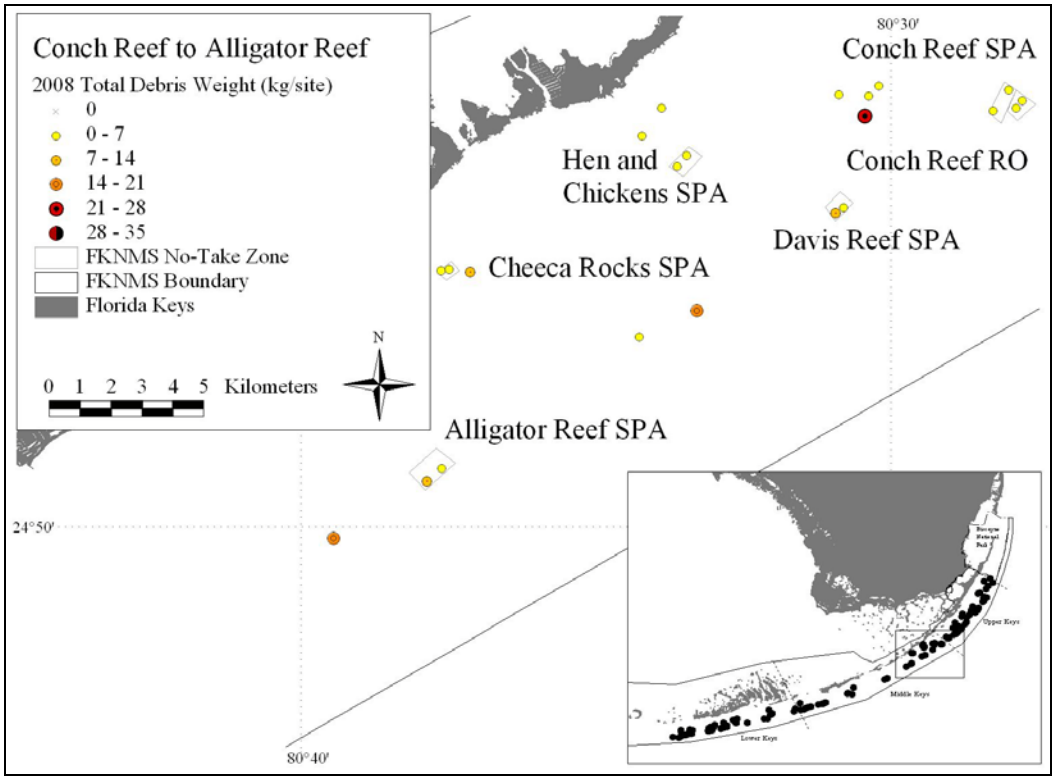


Figure 125. Total marine debris wet weight (kg retrieved per 240 m^2) in the middle Florida Keys from Conch Reef to Alligator Reef (top) and from Tennessee Reef to Coffins Patch (bottom) during June-September 2008.



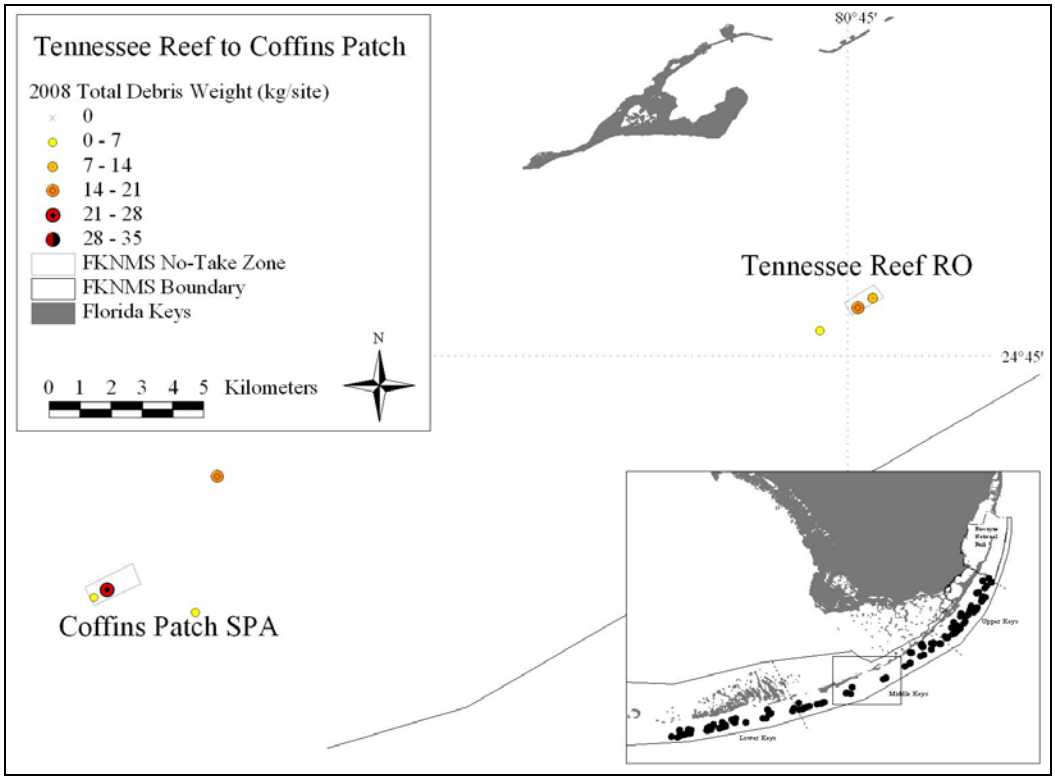


Figure 126. Total marine debris wet weight (kg retrieved per 240 m^2) in the middle Florida Keys from Sombrero Reef to Bahia Honda (top) and in the lower Florida Keys (bottom) during June-September 2008.

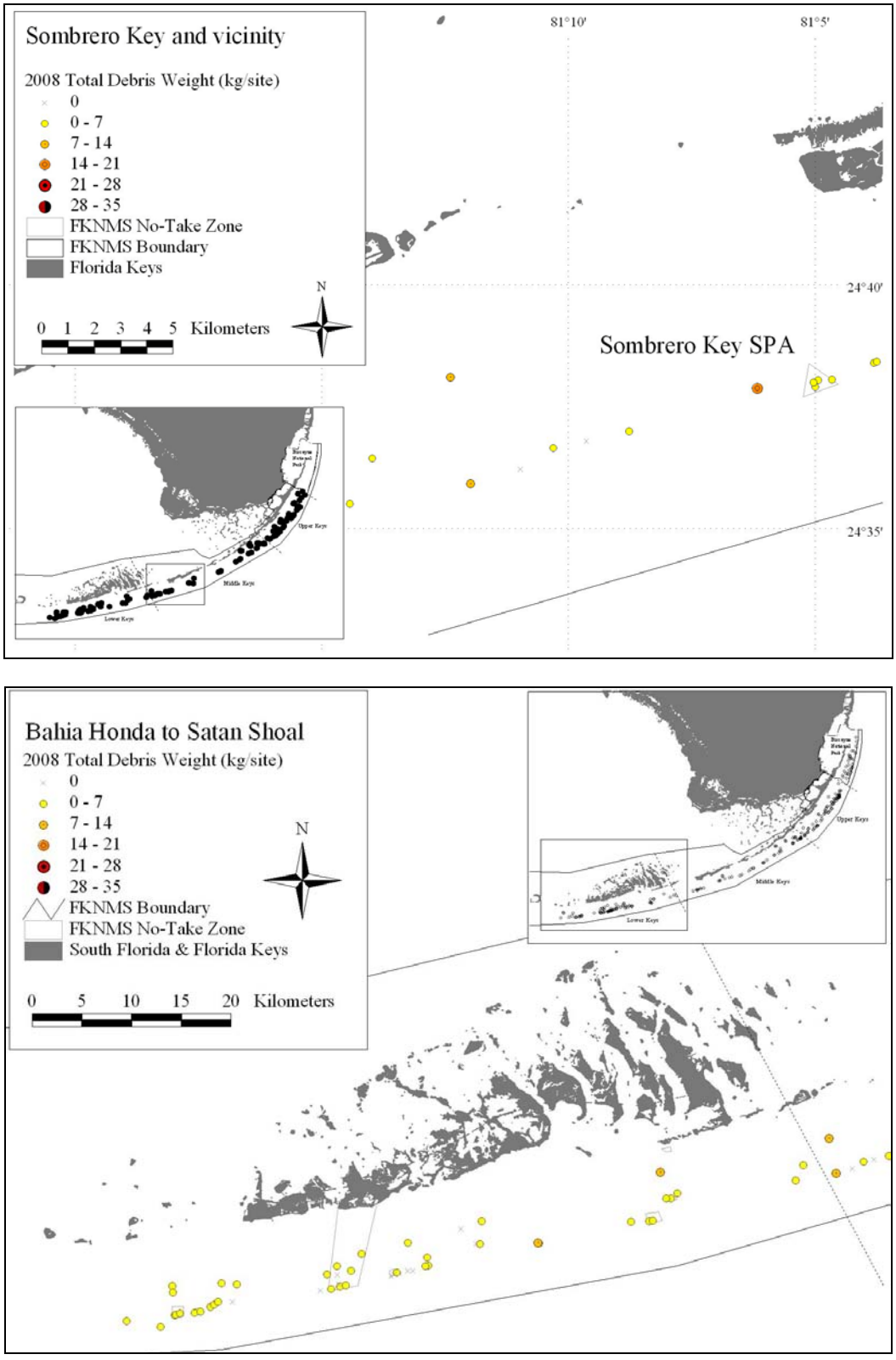


Figure 127. Total marine debris wet weight (kg retrieved per 240 m^2) in the lower Florida Keys from Bahia Honda to Looe Key (top) and from American Shoal to Western Sambo (bottom) during June-September 2008.

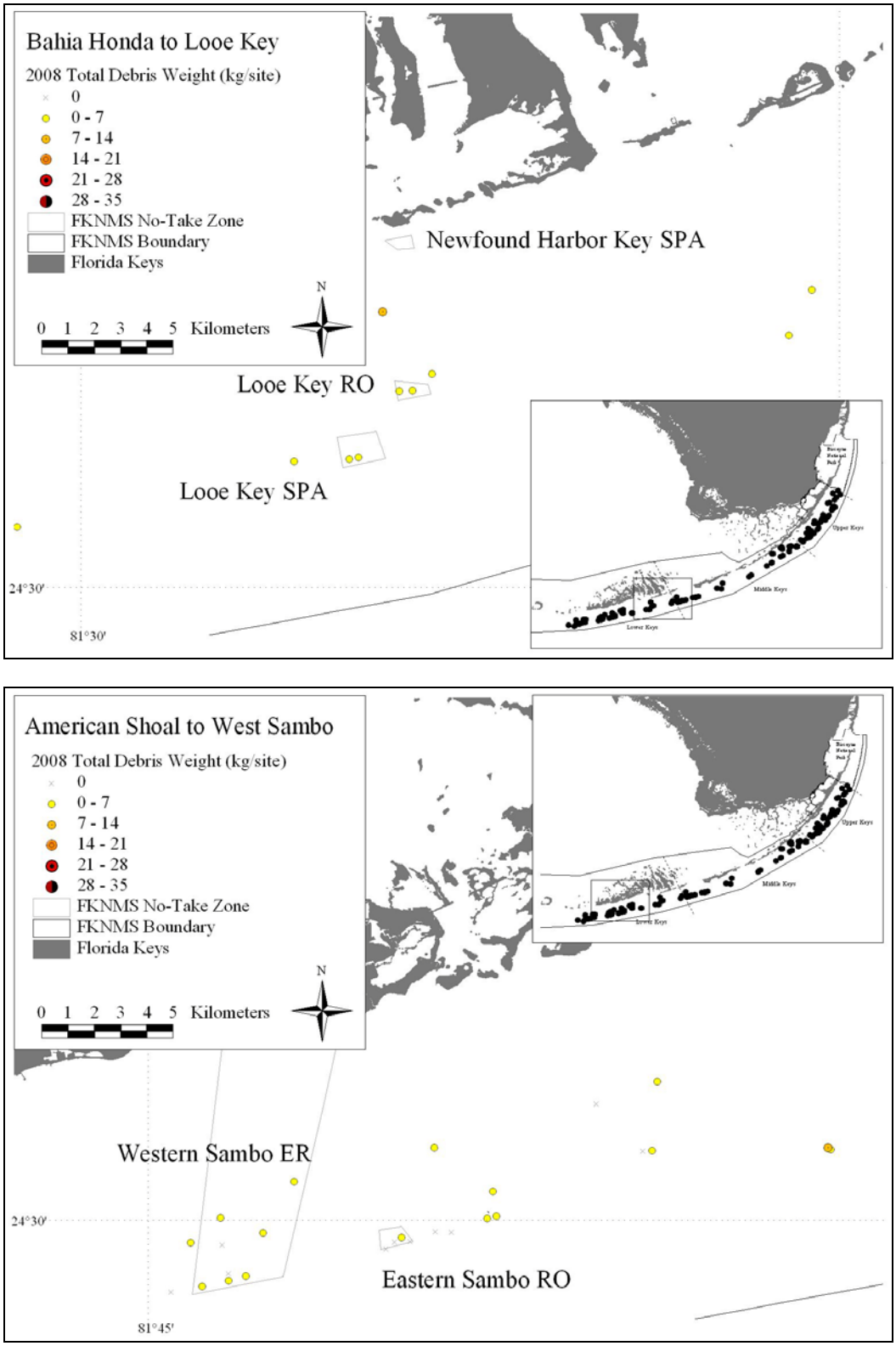


Figure 128. Total marine debris wet weight (kg retrieved per 240 m^2) in the lower Florida Keys from Eastern Dry Rocks to Sand Key during June-September 2008.

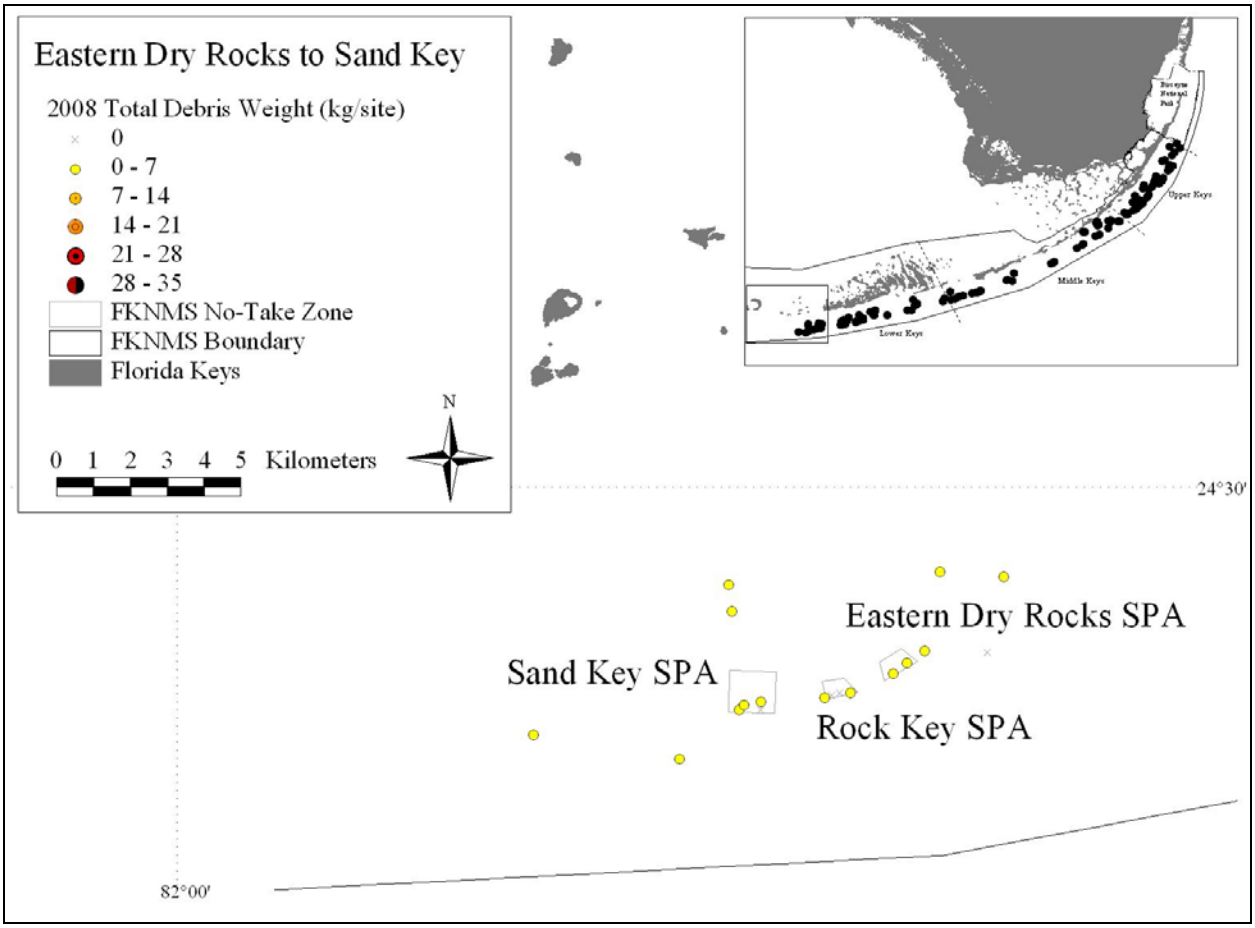


Figure 129. Total marine debris wet weight (kg retrieved per 240 m^2) on mid-channel patch reefs (top) and variations in site-level values relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

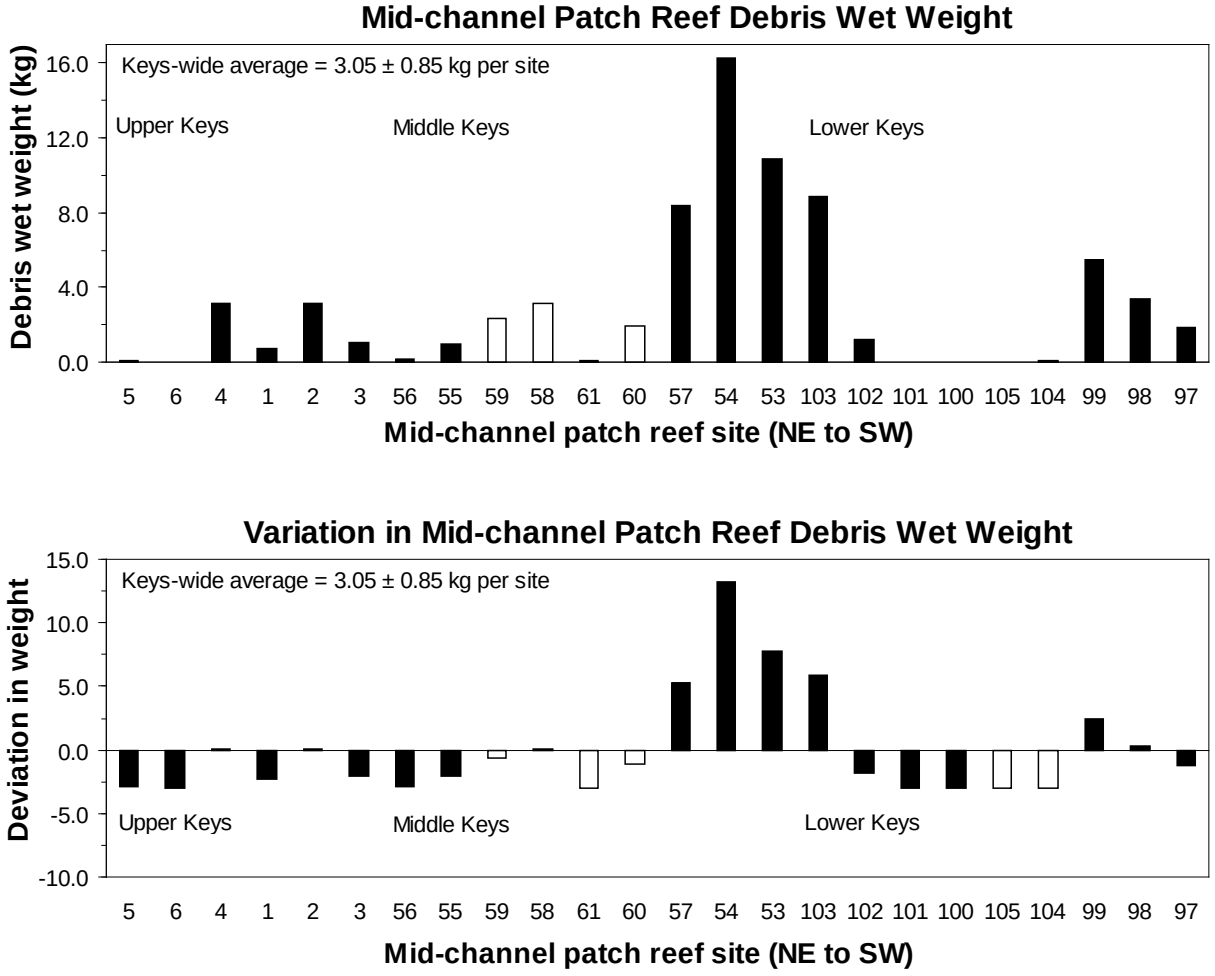


Figure 130. Total marine debris wet weight (kg retrieved per 240 m^2) on offshore patch reefs (top) and variations in site-level values relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

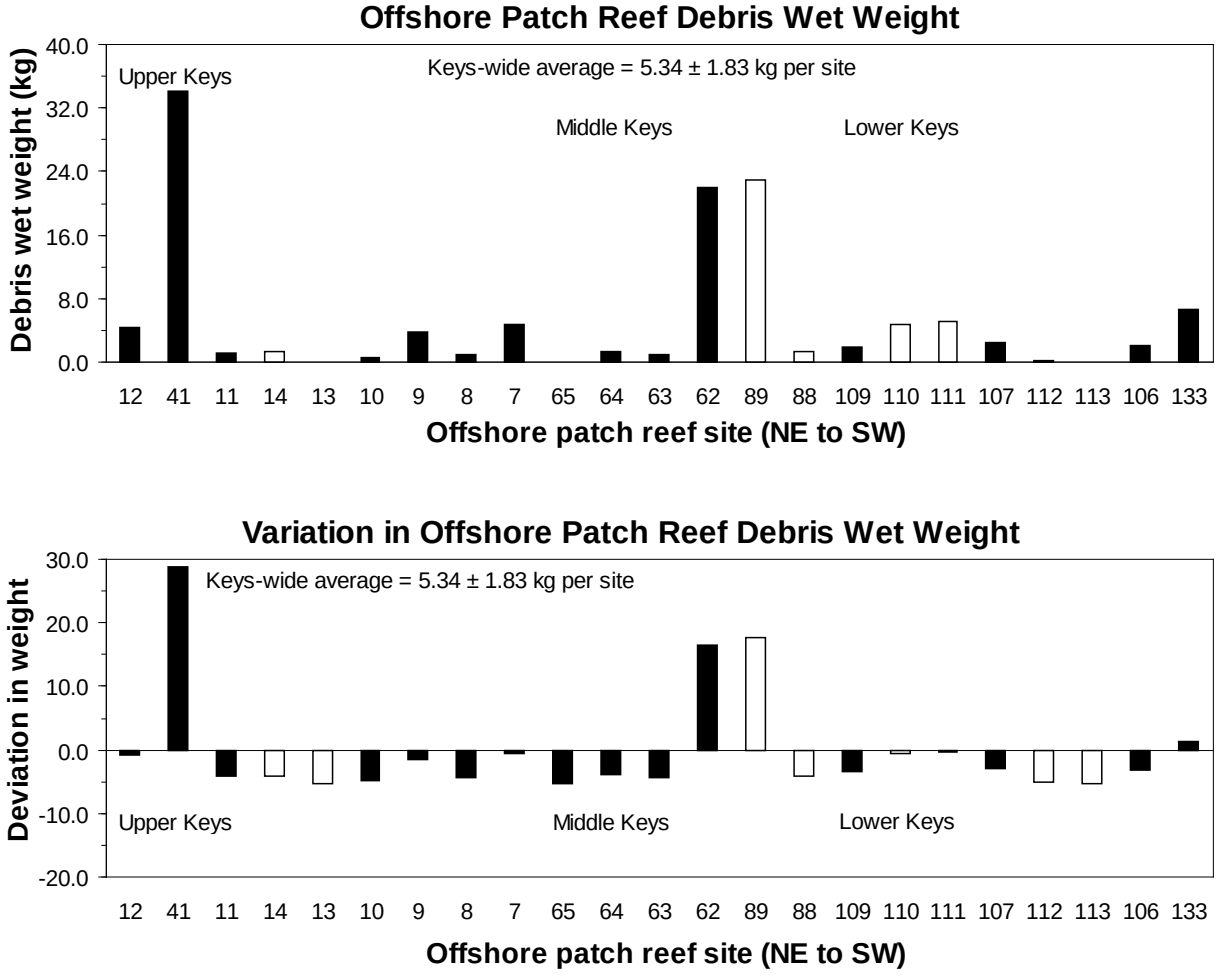


Figure 131. Total marine debris wet weight (kg retrieved per 240 m^2) on shallow (< 6 m), high-relief spur and groove reefs (top) and variations in site-level values relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

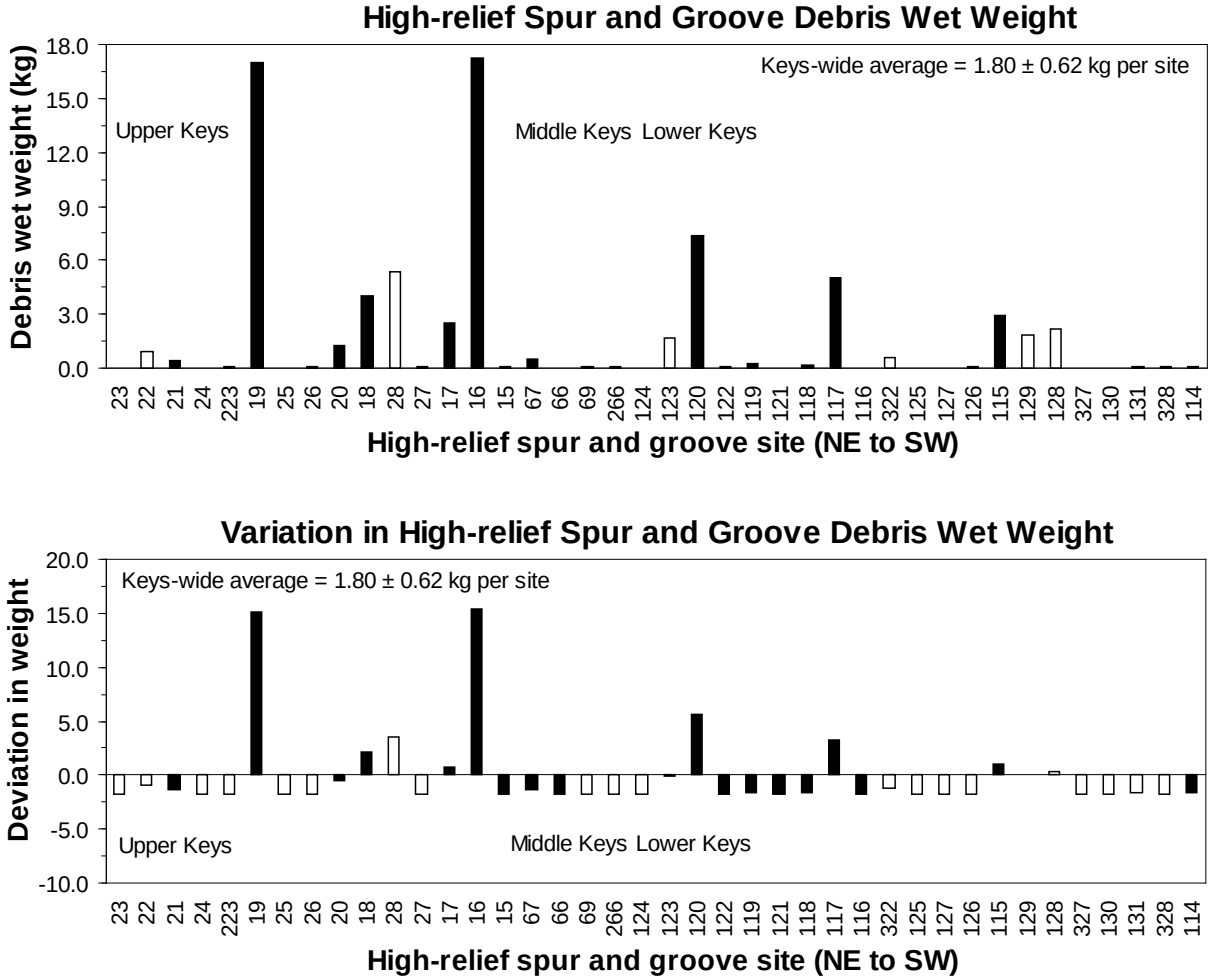


Figure 132. Total marine debris wet weight (kg retrieved per 240 m^2) on deeper (6-15 m) fore-reef sites (top) and variations in site-level values relative to the Keys-wide average (bottom). Open bars = FKNMS no-take zones; filled bars = reference areas.

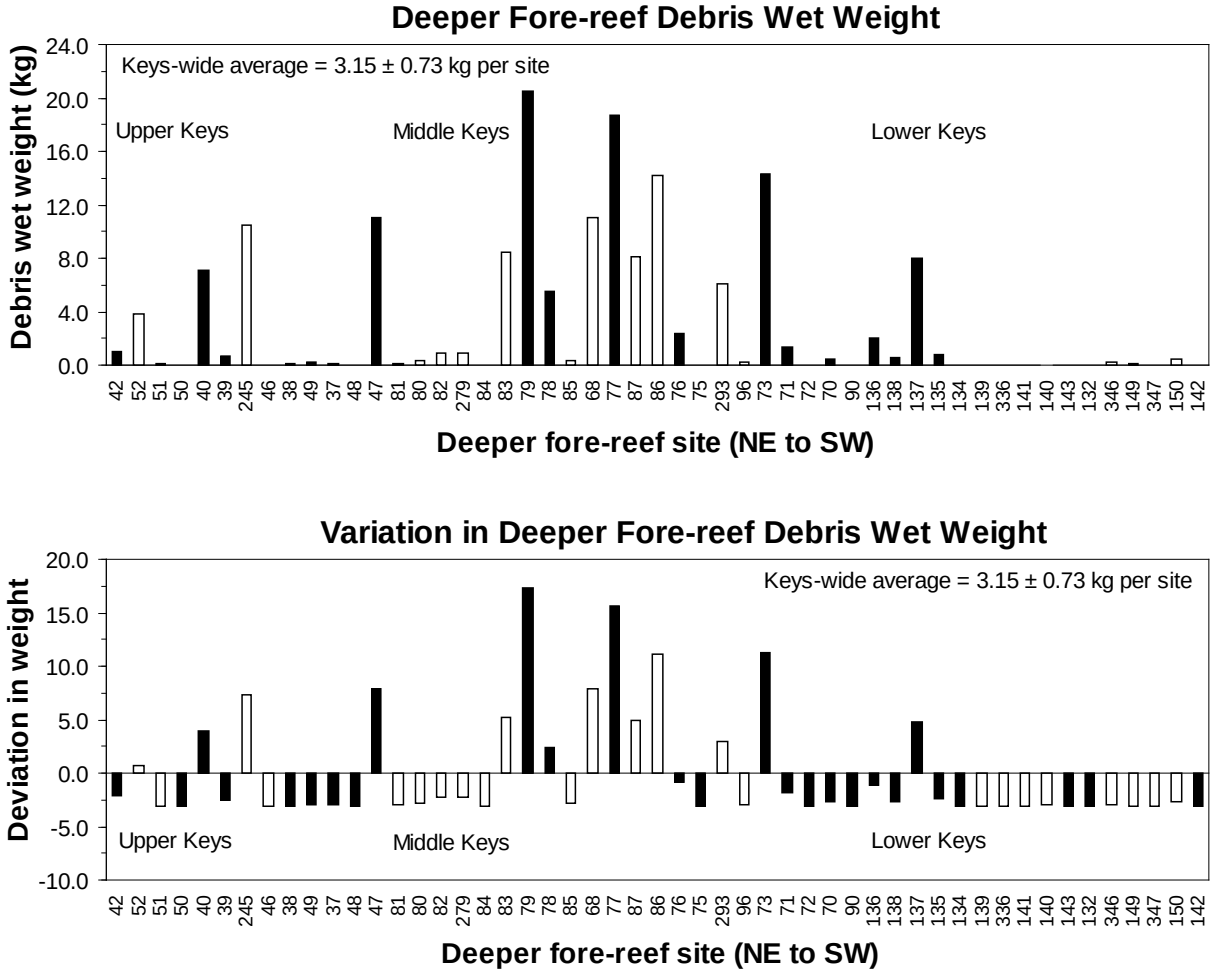


Table 20. Frequency and total length of marine debris in the Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 4-m belt transects per site at 145 sites during June-August 2008.

Debris type	Frequency	Length (m)
Hook-and-line gear		
Fishing rod	2	3.0
Lead sinker	14	0.0
Lure	1	0.0
Monofilament	145	248.4
Monofilament + hook	36	63.4
Monofilament + leader	13	14.1
Monofilament + lure	2	3.8
Monofilament + sinker	17	16.4
Monofilament + swivel	1	1.0
Wire cable	4	29.2
Wire leader	104	74.8
Wire leader + hook	12	13.8
Wire leader + hook + sinker	1	0.7
Wire leader + lure	3	2.5
Wire leader + sinker	8	6.5
Total hook-and-line gear	**363**	**477.6**
Lobster/crab trap gear		
Cement block	40	0.0
Cement block + grating	1	0.0
Metal trap grating	7	0.0
Plastic pot opening	3	0.0
Rope	75	845.5
Rope + grating	2	24.4
Rope + trap	2	46.1
Rope + wood	3	28.3
Wood	106	0.0
Wood + cement	1	0.0
Wood + pot opening	1	0.0
Total trap gear	**241**	**944.3**
Other debris		
Aluminum can	2	0
Anchor line + block	1	0
Anchor line + rope	1	8.2
Bolt	1	0
Bottle cap	1	0
Brick	2	0.4
Cable tie	2	0
Cardboard	1	0
Ceramic plate	1	0
Cloth	1	0
Coins	10	0
Computer cable	1	1.6
Cord/thin rope	3	5.2
Filet knife	1	0
Garden hose	1	0
Glass bottle	17	0
Hex nut	1	0
Mesh bag	1	0
Mesh rope	2	1.1
Metal bracket/other metal	4	2.5
Nylon cord	1	4.3
Plastic bag	7	0
Plastic band	3	7.7
Plastic bottle	1	0
Plastic cord	2	3.4
Plastic cup	2	0
Plastic jug	2	0
Ree-bar stake	1	0
Rope/string	5	12.6
Sardine can	1	0
Spear gun handle	1	0.5
Spear gun shaft	1	0
Spear gun tubing	1	0.7
Total other debris	**82**	**48.3**
Total debris	**686**	**1,470.2**

Table 21. Impacts to coral reef benthic organisms from marine debris in the Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 4-m belt transects per site at 145 sites during June-August 2008. Values represent the number of organisms with abrasions and/or partial mortality caused by various types of marine debris.

Debris type	***Millepora***	**Scleractinia**	**Gorgonians**	**Sponges**	***Palythoa***	**Total**
Hook-and-line gear						
Fishing rod	0	1	0	0	0	1
Lead sinker	0	0	0	0	0	0
Lure	0	0	0	0	0	0
Monofilament	18	7	73	26	0	124
Monofilament + hook	1	2	10	9	3	25
Monofilament + leader	0	0	2	2	0	4
Monofilament + lure	0	2	0	0	0	2
Monofilament + sinker	0	3	3	0	0	6
Monofilament + swivel	0	0	0	0	0	0
Wire cable	0	0	2	1	0	3
Wire leader	2	7	12	4	0	25
Wire leader + hook	0	0	2	0	0	2
Wire leader + hook + sinker	0	0	0	1	0	1
Wire leader + lure	0	0	0	0	0	0
Wire leader + sinker	0	0	0	1	0	1
Total hook-and-line gear	**21**	**22**	**104**	**44**	**3**	**194**
Lobster/crab trap gear						
Cement block	0	0	1	0	0	1
Cement block + grating	0	0	0	0	0	0
Metal trap grating	0	0	0	0	0	0
Plastic pot opening	0	0	0	0	0	0
Rope	10	39	140	18	4	211
Rope + grating	1	0	1	0	0	2
Rope + trap	0	0	1	0	0	1
Rope + wood	0	0	1	0	0	1
Wood	0	4	4	1	0	9
Wood + cement	0	0	0	0	0	0
Wood + pot opening	0	0	0	0	0	0
Total trap gear	**11**	**43**	**148**	**19**	**4**	**225**
Other debris						
Aluminum can	0	0	0	0	0	0
Anchor line + block	0	0	0	0	0	0
Anchor line + rope	0	0	2	1	0	3
Bolt	0	0	0	0	0	0
Bottle cap	0	0	0	0	0	0
Brick	0	0	0	0	0	0
Cable tie	0	0	0	0	0	0
Cardboard	0	0	0	0	0	0
Ceramic plate	0	0	0	0	0	0
Cloth	0	0	0	0	0	0
Coins	0	0	0	0	0	0
Computer cable	0	0	2	0	0	2
Cord/thin rope	1	0	0	0	0	1
Filet knife	0	0	0	0	0	0
Garden hose	0	0	0	0	0	0
Glass bottle	0	0	0	0	0	0
Hex nut	0	0	0	0	0	0
Mesh bag	0	0	0	0	0	0
Mesh rope	0	1	3	0	0	4
Metal bracket/other metal	0	0	1	0	0	1
Nylon cord	0	2	1	0	0	3
Plastic bag	2	1	0	0	0	3

Debris type	*Millepora*	Scleractinia	Gorgonians	Sponges	*Palythoa*	Total
Plastic band	0	1	1	0	0	2
Plastic bottle	0	0	0	0	0	0
Plastic cord	0	0	3	0	0	3
Plastic cup	0	0	0	0	0	0
Plastic jug	0	0	0	0	0	0
Ree-bar stake	0	0	0	0	0	0
Rope/string	1	1	4	0	1	7
Sardine can	0	0	0	0	0	0
Spear gun handle	0	0	0	0	0	0
Spear gun shaft	0	0	0	0	0	0
Spear gun tubing	0	0	0	0	0	0
Total other debris	**4**	**6**	**17**	**1**	**1**	**29**
All marine debris	**36**	**71**	**269**	**64**	**8**	**448**

Table 22. Number of items, mean ± 1 SE no. items per 60 m^2, total length (m), and mean ± 1 SE length per item for derelict hook-and-line gear in the Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 4-m belt transects per site at 145 sites during June-August 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are no-take marine reserves.

Site number/site location	Hook-and-line density		Hook-and-line gear length (m)		
	N	No. items/m^2	N	Total length	Mean length
Mid-channel patch reefs					
Upper Florida Keys NMS					
6 - Basin Hill Shoals	0	0 ± 0			
5 - Basin Hill Shoals	6	1.50 ± 0.87	6	4	92 ± 4
4 - Inshore of Grecian Rocks	6	1.50 ± 1.19	6	23	125 ± 23
3 - South of Cannon Patch Reef	1	0.25 ± 0.25	1		193
2 - Mosquito Bank	0	0 ± 0			
1 - Inshore of Molasses Reef	1	0.25 ± 0.25	1		151
Upper Florida Keys Total (6)	14	0.58 ± 0.29	14	21	140 ± 21
Middle Florida Keys NMS					
56 - Tavernier Rocks	5	1.25 ± 0.95	5	608	122 ± 24
55 - Tavernier Rocks	2	0.50 ± 0.50	2	340	170 ± 100
59 - Hen and Chickens SPA**	6	1.50 ± 0.29	6	488	81 ± 11
58 - Hen and Chickens SPA**	26	6.50 ± 0.29	26	2,746	106 ± 12
61 - Cheeca Rocks SPA**	2	0.50 ± 0.29	2	343	172 ± 139
60 - Cheeca Rocks SPA**	6	1.50 ± 0.65	6	356	59 ± 21
57 - NE of Cheeca Rocks SPA	29	7.25 ± 0.75	29	3,145	108 ± 14
54 - South of Duck Key	3	0.75 ± 0.48	3	458	153 ± 101
53 - South of Ohio Key	1	0.25 ± 0.25	1	80	80
Middle Florida Keys Total (9)	80	2.22 ± 0.89	80	8,564	117 ± 14
Lower Florida Keys NMS					
103 - North of Looe Key RO	34	8.50 ± 3.52	34	4,488	132 ± 20
102 - North of Maryland Shoal	0	0 ± 0			
101 - North of Maryland Shoal	0	0 ± 0			
100 - North of Eastern Sambo	1	0.25 ± 0.25	1	30	30
105 - Western Sambo ER**	0	0 ± 0			
104 - Western Sambo ER**	0	0 ± 0			
99 - West of Western Sambo	0	0 ± 0			
98 - Middle Ground	1	0.25 ± 0.25	1	81	81
97 - Middle Ground	0	0 ± 0			
Lower Florida Keys Total (9)	36	1.00 ± 0.94	36	4,599	81 ± 29
Mid-channel Patch Reef Total (24)	**130**	**1.35 ± 0.49**	**130**	**14,807**	**116 ± 11**
Offshore patch reefs					
Upper Florida Keys NMS					
12 - South of BNP boundary	0	0 ± 0			
41 - North of Carysfort Reef SPA	0	0 ± 0			
11 - North of Carysfort Reef SPA	0	0 ± 0			
14 - Carysfort Reef SPA**	1	0.25 ± 0.25	1	73	73
13 - Carysfort Reef SPA**	0	0 ± 0			
10 - North of Dry Rocks SPA	0	0 ± 0			
9 - SW of Grecian Rocks SPA	0	0 ± 0			
8 - Inshore of French Reef SPA	2	0.50 ± 0.29	2	385	193 ± 143
7 - Inshore of Pickles Reef	4	1.00 ± 0.71	4	558	140 ± 26
Upper Florida Keys Total (9)	7	0.19 ± 0.12	7	1,016	135 ± 35
Middle Florida Keys NMS					
65 - North of Davis Reef SPA	2	0.50 ± 0.29	2	72	36 ± 11
64 - North of Davis Reef SPA	0	0 ± 0			

Site number/site location	Hook-and-line density		Hook-and-line gear length (m)		
	N	No. items/m^2	N	Total length	Mean length
63 - North of Davis Reef SPA	0	0 ± 0			
62 - North of Davis Reef SPA	0	0 ± 0			
89 - Coffins Patch SPA**	2	0.50 ± 0.50	2	826	413 ± 158
88 - Coffins Patch SPA**	0	0 ± 0			
Middle Florida Keys Total (6)	4	0.17 ± 0.11	4	898	225 ± 189
Lower Florida Keys NMS					
109 - East of Looe Key RO	1	0.25 ± 0.25	1	73	73
110 - Looe Key Research Only**	0	0 ± 0			
111 - Looe Key Research Only**	5	1.25 ± 0.95	5	402	80 ± 28
107 - North of Pelican Shoal	1	0.25 ± 0.25	1	90	90
112 - Western Sambo ER**	3	0.75 ± 0.48	3	195	65 ± 15
113 - Western Sambo ER**	0	0 ± 0			
106 - NE of E. Dry Rocks SPA	3	0.75 ± 0.48	3	514	171 ± 129
133 - NE of E. Dry Rocks SPA	7	1.75 ± 0.63	7	927	132 ± 19
Lower Florida Keys Total (8)	20	0.63 ± 0.22	20	2,201	102 ± 17
Offshore Patch Reef Total (23)	**31**	**0.34 ± 0.10**	**31**	**4,115**	**133 ± 32**
Inner line reef tract spur & groove					
Upper Florida Keys NMS					
32 - Turtle Rocks	0	0 ± 0			
31 - Inshore of Elbow Reef SPA	1	0.25 ± 0.25	1	90	900
30 - North Dry Rocks	1	0.25 ± 0.25	1	40	40
34 - Dry Rocks SPA**	0	0 ± 0			
33 - Dry Rocks SPA**	0	0 ± 0			
36 - Grecian Rocks SPA**	1	0.25 ± 0.25	1	65	65
35 - Grecian Rocks SPA**	2	0.50 ± 0.50	2	171	86 ± 20
Upper Florida Keys Total (7)	5	0.18 ± 0.07	5	366	70 ± 11
Inner Line Reef Tract Total (7)	**5**	**0.18 ± 0.07**	**5**	**366**	**70 ± 11**
High-relief spur & groove					
Upper Florida Keys NMS					
23 - Carysfort Reef SPA**	0	0 ± 0			
22 - Carysfort Reef SPA**	0	0 ± 0			
21 - Maitland grounding site	0	0 ± 0			
24 - Elbow Reef SPA**	0	0 ± 0			
223 - Elbow Reef SPA**	4	1.00 ± 0.71	3	577	192 ± 144
19 - North of French Reef SPA	2	0.50 ± 0.29	2	71	36 ± 10
25 - French Reef SPA**	2	0.50 ± 0.50	2	66	33 ± 7
26 - French Reef SPA**	3	0.75 ± 0.48	2	326	163 ± 108
20 - Sand Island	19	4.75 ± 1.25	14	1,968	141 ± 78
18 - Sand Island	6	1.50 ± 0.65	6	325	54 ± 15
28 - Molasses Reef SPA**	2	0.50 ± 0.29	2	64	32 ± 8
27 - Molasses Reef SPA**	4	1.00 ± 0.41	4	565	141 ± 96
17 - Pickles Reef	2	0.50 ± 0.29	2	504	252 ± 222
16 - Pickles Reef	3	0.75 ± 0.48	2	55	28 ± 3
15 - Pickles Reef	0	0 ± 0			
Upper Florida Keys Total (15)	47	0.78 ± 0.31	39	4,521	107 ± 26
Middle Florida Keys NMS					
67 - Delta Shoal	5	1.25 ± 0.48	5	2,361	472 ± 295
66 - Delta Shoal	3	0.75 ± 0.75	3	515	172 ± 70
69 - Sombrero Key SPA**	1	0.25 ± 0.25	1	80	80 ± 0
266 - Sombrero Key SPA**	6	1.50 ± 0.65	6	554	92 ± 12
Middle Florida Keys Total (4)	15	0.94 ± 0.28	15	3,510	204 ± 92
Lower Florida Keys NMS					

Site number/site location	Hook-and-line density		Hook-and-line gear length (m)		
	N	No. items/m^2	N	Total length	Mean length
124 - Looe Key SPA**	1	0.25 ± 0.25	1	30	30
123 - Looe Key SPA**	0	0 ± 0			
120 - American Shoal	6	1.50 ± 0.96	6	780	156 ± 92
122 - American Shoal	0	0 ± 0			
119 - Maryland Shoal	1	0.25 ± 0.25	1	146	146
121 - Maryland Shoal	0	0 ± 0			
118 - Pelican Shoal	13	3.25 ± 0.25	13	2,253	173 ± 73
117 - Pelican Shoal	2	0.50 ± 0.29	2	160	80 ± 27
116 - No Name Reef	0	0 ± 0			
322 - Eastern Sambo RO**	1	0.25 ± 0.25	1	95	95
125 - Eastern Sambo RO**	0	0 ± 0			
127 - Western Sambo ER**	0	0 ± 0			
126 - Western Sambo ER**	1	0.25 ± 0.25	1	150	150
115 - East of E. Dry Rocks SPA	2	0.50 ± 0.29	2	397	199 ± 182
129 - Eastern Dry Rocks SPA**	1	0.25 ± 0.25			
128 - Eastern Dry Rocks**	5	1.25 ± 0.63	2	226	113 ± 87
327 - Rock Key SPA**	0	0 ± 0			
130 - Rock Key SPA**	0	0 ± 0			
131 - Sand Key SPA**	3	0.75 ± 0.25	2	80	40 ± 15
328 - Sand Key SPA**	4	1.00 ± 0.71	4	430	108 ± 32
114 - Western Dry Rocks	4	1.00 ± 0.71	4	159	40 ± 12
Lower Florida Keys Total (21)	44	0.52 ± 0.17	39	4,906	111 ± 16
Spur & Groove Total (40)	**106**	**0.66 ± 0.15**	**93**	**12,937**	**124 ± 19**
Fore-reef (6-15 m)					
Upper Florida Keys NMS					
42 - South of BNP boundary	1	0.25 ± 0.25	1	1,161	1,161
52 - Carysfort Reef SPA**	1	0.25 ± 0.25			
51 - Carysfort Reef SPA**	1	0.25 ± 0.25	1	190	190
50 - SW of Carysfort Reef SPA	1	0.25 ± 0.25	1	668	668
40 - SW of Carysfort Reef SPA	1	0.25 ± 0.25	1	100	100
39 - North of Elbow Reef SPA	3	0.75 ± 0.25	3	183	61 ± 12
245 - Elbow Reef SPA**	0	0 ± 0			
46 - Elbow Reef SPA**	0	0 ± 0			
38 - SW of Elbow Reef SPA	0	0 ± 0			
49 - South of Elbow Reef SPA	9	2.25 ± 1.65	9	2,852	317 ± 137
37 - Dixie Shoal	2	0.50 ± 0.50	2	124	62 ± 2
48 - Dixie Shoal	0	0 ± 0			
47 - SW of Molasses Reef SPA	2	0.50 ± 0.29	2	133	67 ± 27
Upper Florida Keys Total (13)	21	0.40 ± 0.17	20	5,411	328 ± 140
Middle Florida Keys NMS					
81 - Conch Reef SPA**	0	0 ± 0			
80 - Conch Reef SPA**	0	0 ± 0			
82 - Conch Reef RO**	0	0 ± 0			
279 - Conch Reef RO**	20	5.00 ± 1.73	19	1,745	92 ± 22
84 - Davis Reef SPA**	1	0.25 ± 0.25	1	381	381
83 - Davis Reef SPA**	0	0 ± 0			
79 - SW of Crocker Reef	2	0.50 ± 0.29	2	205	103 ± 50
78 - SW of Crocker Reef	0	0 ± 0			
85 - Alligator Reef SPA**	6	1.50 ± 0.65	6	384	64 ± 38
68 - Alligator Reef SPA**	6	1.50 ± 0.29	6	653	109 ± 52
77 - SW of Alligator Reef SPA	3	0.75 ± 0.75	3	225	75 ± 46
87 - Tennessee Reef RO**	5	1.25 ± 0.48	5	521	104 ± 36
86 - Tennessee Reef RO**	2	0.50 ± 0.29	2	204	102 ± 48
76 - NE of Tennessee Light	4	1.00 ± 0.41	4	332	83 ± 28
75 - East of Coffins Patch SPA	1	0.25 ± 0.25	1	612	612
293 - Sombrero Key SPA**	3	0.75 ± 0.48	3	155	52 ± 12
96 - Sombrero Key SPA**	0	0 ± 0			

Site number/site location	Hook-and-line density		Hook-and-line gear length (m)		
	N	No. items/m^2	N	Total	Mean length
73 - West of Sombrero Key SPA	2	0.50 ± 0.50	2	195	98 ± 43
71 - South of Moser Channel	0	0 ± 0			
72 - South of Moser Channel	0	0 ± 0			
70 - South of Moser Channel	1	0.25 ± 0.25	1	800	800
90 - South of Moser Channel	0	0 ± 0			
Middle Florida Keys Total (22)	56	0.64 ± 0.23	55	6,412	206 ± 67
Lower Florida Keys NMS					
136 - South of Bahia Honda Key	5	1.25 ± 0.48	5	2,428	486 ± 461
138 - South of Bahia Honda Key	3	0.75 ± 0.48	3	331	110 ± 77
137 - South of Bahia Honda Key	0	0 ± 0			
135 - West of Looe Key SPA	1	0.25 ± 0.25	1	24	24
134 - West of Pelican Shoal	0	0 ± 0			
139 - Eastern Sambo RO**	0	0 ± 0			
336 - Eastern Sambo RO**	0	0 ± 0			
141 - Western Sambo ER**	0	0 ± 0			
140 - Western Sambo ER**	0	0 ± 0			
143 - West of Western Sambo	0	0 ± 0			
132 - East of E. Dry Rocks SPA	0	0 ± 0			
346 - Rock Key SPA**	2	0.50 ± 0.29	2	544	272 ± 210
149 - Rock Key SPA**	0	0 ± 0			
347 - Sand Key SPA**	0	0 ± 0			
150 - Sand Key SPA**	1	0.25 ± 0.25	1	72	72
142 - SW of Sand Key SPA	2	0.50 ± 0.50	2	309	155 ± 41
Lower Florida Keys Total (16)	14	0.22 ± 0.09	14	3,708	186 ± 69
Fore-reef Total (51)	**91**	**0.45 ± 0.11**	**89**	**15,531**	**238 ± 54**

Table 23. Number of items, mean ± 1 SE no. items per 60 m^2, total rope length (m), and mean ± 1 SE rope length for lost lobster/crab trap gear in the Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 4-m belt transects per site at 145 sites during June-August 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are no-take marine reserves.

Site number/site location	Trap gear density		Trap rope length (m)		
	N	No. items/m^2	N	Total length	Mean length
Mid-channel patch reefs					
Upper Florida Keys NMS					
6 - Basin Hill Shoals	0	0 ± 0			
5 - Basin Hill Shoals	0	0 ± 0			
4 - Inshore of Grecian Rocks	6	1.50 ± 0.87	3	2,718	906 ± 160
3 - South of Cannon Patch Reef	1	0.25 ± 0.25	1	1,266	1,266
2 - Mosquito Bank	0	0 ± 0			0 ± 0
1 - Inshore of Molasses Reef	1	0.25 ± 0.25	1	961	961
Upper Florida Keys Total (6)	8	0.33 ± 0.24	5	4,945	1,044 ± 112
Middle Florida Keys NMS					
56 - Tavernier Rocks	0	0 ± 0			
55 - Tavernier Rocks	2	0.50 ± 0.29	1	866	866
59 - Hen and Chickens SPA**	3	0.75 ± 0.48	2	1,310	655 ± 405
58 - Hen and Chickens SPA**	5	1.25 ± 0.75	2	2,267	1,134 ± 424
61 - Cheeca Rocks SPA**	0	0 ± 0			
60 - Cheeca Rocks SPA**	3	0.75 ± 0.48	1	1,880	1,880
57 - NE of Cheeca Rocks SPA	13	3.25 ± 1.89	4	4,172	1,043 ± 761
54 - South of Duck Key	8	2.00 ± 0.41	1	976	976
53 - South of Ohio Key	8	2.00 ± 0.41	6	7,502	1,250 ± 249
Middle Florida Keys Total (9)	42	1.17 ± 0.36	17	18,973	1,115 ± 147
Lower Florida Keys NMS					
103 - North of Looe Key RO	3	0.75 ± 0.48	3	1,791	597 ± 519
102 - North of Maryland Shoal	2	0.50 ± 0.29	1	1,480	1,480
101 - North of Maryland Shoal	0	0 ± 0			
100 - North of Eastern Sambo	0	0 ± 0			
105 - Western Sambo ER**	1	0.25 ± 0.25			
104 - Western Sambo ER**	1	0.25 ± 0.25			
99 - West of Western Sambo	2	0.50 ± 0.29	2	3,174	1,587 ± 73
98 - Middle Ground	1	0.25 ± 0.25	1	1,420	1,420
97 - Middle Ground	2	0.50 ± 0.29	2	1,391	696 ± 96
Lower Florida Keys Total (9)	12	0.33 ± 0.08	9	9,256	1,156 ± 210
Mid-channel Patch Reef Total (24)	**62**	**0.65 ± 0.17**	**31**	**33,174**	**1,114 ± 95**
Offshore patch reefs					
Upper Florida Keys NMS					
12 - South of BNP boundary	1	0.25 ± 0.25			
41 - North of Carysfort Reef SPA	4	1.00 ± 0.71	1	1,237	1,237
11 - North of Carysfort Reef SPA	7	1.75 ± 1.03			
14 - Carysfort Reef SPA**	1	0.25 ± 0.25	1	150	150
13 - Carysfort Reef SPA**	1	0.25 ± 0.25			
10 - North of Dry Rocks SPA	2	0.50 ± 0.29	1	498	498
9 - SW of Grecian Rocks SPA	2	0.50 ± 0.29	1	1,870	1,870
8 - Inshore of French Reef SPA	1	0.25 ± 0.25	1	663	663
7 - Inshore of Pickles Reef	2	0.50 ± 0.50	2	2,480	1,240 ± 1,010
Upper Florida Keys Total (9)	21	0.58 ± 0.17	7	6,898	943 ± 254
Middle Florida Keys NMS					
65 - North of Davis Reef SPA	0	0 ± 0			
64 - North of Davis Reef SPA	3	0.75 ± 0.25	1	366	366

Site number/site location	Trap gear density		Trap rope length (m)		
	N	No. items/m^2	N	Total length	Mean length
63 - North of Davis Reef SPA	1	0.25 ± 0.25	1	963	963
62 - North of Davis Reef SPA	5	1.25 ± 0.95	1	1,040	1,040
89 - Coffins Patch SPA**	8	2.00 ± 0.41	2	1,715	858 ± 623
88 - Coffins Patch SPA**	1	0.25 ± 0.25			
Middle Florida Keys Total (6)	18	0.75 ± 0.31	5	4,084	807 ± 152
Lower Florida Keys NMS					
109 - East of Looe Key RO	1	0.25 ± 0.25	1	1,070	1,070
110 - Looe Key Research Only**	3	0.75 ± 0.48	1	3,042	3,042
111 - Looe Key Research Only**	5	1.25 ± 0.63	4	2,340	585 ± 250
107 - North of Pelican Shoal	4	1.00 ± 0.41	3	10,092	3,364 ± 1,097
112 - Western Sambo ER**	1	0.25 ± 0.25			
113 - Western Sambo ER**	0	0 ± 0			
106 - NE of E. Dry Rocks SPA	2	0.50 ± 0.29	2	1,388	694 ± 656
133 - NE of E. Dry Rocks SPA	2	0.50 ± 0.29	2	4,635	2,318 ± 633
Lower Florida Keys Total (8)	18	0.56 ± 0.15	13	22,567	1,845 ± 499
Offshore Patch Reef Total (23)	**57**	**0.62 ± 0.11**	**25**	**33,549**	**1,247 ± 234**
Inner line reef tract spur & groove					
Upper Florida Keys NMS					
32 - Turtle Rocks	0	0 ± 0			
31 - Inshore of Elbow Reef SPA	3	0.75 ± 0.25	1	316	316 ± 0
30 - North Dry Rocks	1	0.25 ± 0.25			
34 - Dry Rocks SPA**	0	0 ± 0			
33 - Dry Rocks SPA**	4	1.00 ± 0.41	2	1,964	982 ± 106
36 - Grecian Rocks SPA**	6	1.50 ± 0.65			
35 - Grecian Rocks SPA**	2	0.50 ± 0.29			
Upper Florida Keys Total (7)	16	0.57 ± 0.21	3	2,280	649 ± 333
Inner Line Reef Tract Total (7)	**16**	**0.57 ± 0.21**	**3**	**2,280**	**649 ± 333**
High-relief spur & groove					
Upper Florida Keys NMS					
23 - Carysfort Reef SPA**	0	0 ± 0			
22 - Carysfort Reef SPA**	1	0.25 ± 0.25	1	879	879
21 - Maitland grounding site	0	0 ± 0			
24 - Elbow Reef SPA**	0	0 ± 0			
223 - Elbow Reef SPA**	0	0 ± 0			
19 - North of French Reef SPA	2	0.50 ± 0.29			
25 - French Reef SPA**	0	0 ± 0			
26 - French Reef SPA**	0	0 ± 0			
20 - Sand Island	2	0.50 ± 0.29	1	855	855
18 - Sand Island	2	0.50 ± 0.50	2	2,190	1,095 ± 5
28 - Molasses Reef SPA**	1	0.25 ± 0.25			
27 - Molasses Reef SPA**	0	0 ± 0			
17 - Pickles Reef	1	0.25 ± 0.25			
16 - Pickles Reef	3	0.75 ± 0.25	1	1,570	1,570
15 - Pickles Reef	0	0 ± 0			
Upper Florida Keys Total (15)	12	0.20 ± 0.07	5	5,494	1,100 ± 0
Middle Florida Keys NMS					
67 - Delta Shoal	0	0 ± 0			
66 - Delta Shoal	0	0 ± 0			
69 - Sombrero Key SPA**	0	0 ± 0			
266 - Sombrero Key SPA**	0	0 ± 0			
Middle Florida Keys Total (4)	0	0 ± 0			
Lower Florida Keys NMS					

Site number/site location	Trap gear density		Trap rope length (m)		
	N	No. items/m^2	N	Total length	Mean length
124 - Looe Key SPA**	0	0 ± 0			
123 - Looe Key SPA**	1	0.25 ± 0.25	1		720
120 - American Shoal	1	0.25 ± 0.25	1		1,8320
122 - American Shoal	0	0 ± 0			
119 - Maryland Shoal	0	0 ± 0			
121 - Maryland Shoal	0	0 ± 0			
118 - Pelican Shoal	0	0 ± 0			
117 - Pelican Shoal	2	0.50 ± 0.29			
116 - No Name Reef	0	0 ± 0			
322 - Eastern Sambo RO**	2	0.50 ± 0.50	1		480
125 - Eastern Sambo RO**	0	0 ± 0			
127 - Western Sambo ER**	0	0 ± 0			
126 - Western Sambo ER**	0	0 ± 0			
115 - East of E. Dry Rocks SPA	3	0.75 ± 0.25	3	103	1,118 ± 103
129 - Eastern Dry Rocks SPA**	2	0.50 ± 0.29	2	794	1,007 ± 794
128 - Eastern Dry Rocks**	1	0.25 ± 0.25			
327 - Rock Key SPA**	0	0 ± 0			
130 - Rock Key SPA**	0	0 ± 0			
131 - Sand Key SPA**	0	0 ± 0			
328 - Sand Key SPA**	0	0 ± 0			
114 - Western Dry Rocks	0	0 ± 0			
Lower Florida Keys Total (21)	12	0.14 ± 0.05	8	229	1,031 ± 229
Spur & Groove Total (40)	**24**	**0.15 ± 0.04**	**13**	**139**	**1,062 ± 139**
Fore-reef (6-15 m)					
Upper Florida Keys NMS					
42 - South of BNP boundary	0	0 ± 0			
52 - Carysfort Reef SPA**	1	0.25 ± 0.25			
51 - Carysfort Reef SPA**	0	0 ± 0			
50 - SW of Carysfort Reef SPA	1	0.25 ± 0.25			
40 - SW of Carysfort Reef SPA	15	3.75 ± 2.39			
39 - North of Elbow Reef SPA	2	0.50 ± 0.29			
245 - Elbow Reef SPA**	2	0.50 ± 0.50			
46 - Elbow Reef SPA**	0	0 ± 0			
38 - SW of Elbow Reef SPA	2	0.50 ± 0.29			
49 - South of Elbow Reef SPA	0	0 ± 0			
37 - Dixie Shoal	1	0.25 ± 0.25			
48 - Dixie Shoal	0	0 ± 0			
47 - SW of Molasses Reef SPA	7	1.75 ± 0.48	1	2,210	2,210
Upper Florida Keys Total (13)	31	0.60 ± 0.29	1	2,210	2,210
Middle Florida Keys NMS					
81 - Conch Reef SPA**	1	0.25 ± 0.25			
80 - Conch Reef SPA**	1	0.25 ± 0.25			
82 - Conch Reef RO**	0	0 ± 0			
279 - Conch Reef RO**	0	0 ± 0			
84 - Davis Reef SPA**	0	0 ± 0			
83 - Davis Reef SPA**	2	0.50 ± 0.29			
79 - SW of Crocker Reef	6	1.50 ± 1.19			
78 - SW of Crocker Reef	2	0.50 ± 0.29			
85 - Alligator Reef SPA**	0	0 ± 0			
68 - Alligator Reef SPA**	1	0.25 ± 0.25			
77 - SW of Alligator Reef SPA	3	0.75 ± 0.75	1	1,336	1,336
87 - Tennessee Reef RO**	6	1.50 ± 0.96	1	1,176	1,176
86 - Tennessee Reef RO**	3	0.75 ± 0.25	1	1,440	1,440
76 - NE of Tennessee Light	9	2.25 ± 0.48			
75 - East of Coffins Patch SPA	0	0 ± 0			
293 - Sombrero Key SPA**	1	0.25 ± 0.25			
96 - Sombrero Key SPA**	0	0 ± 0			

Site number/site location	Trap gear density		Trap rope length (m)		
	N	No. items/m^2	N	Total	Mean length
73 - West of Sombrero Key SPA	4	1.00 ± 0.71	2	2,215	1,108 ± 108
71 - South of Moser Channel	1	0.25 ± 0.25			
72 - South of Moser Channel	0	0 ± 0			
70 - South of Moser Channel	2	0.50 ± 0.29			
90 - South of Moser Channel	0	0 ± 0			
Middle Florida Keys Total (22)	42	0.48 ± 0.13	5	6,167	1,265 ± 75
Lower Florida Keys NMS					
136 - South of Bahia Honda Key	1	0.25 ± 0.25	1	1,895	1,896
138 - South of Bahia Honda Key	3	0.75 ± 0.25	1	360	360
137 - South of Bahia Honda Key	1	0.25 ± 0.25	1	490	490
135 - West of Looe Key SPA	2	0.50 ± 0.29	1	451	451
134 - West of Pelican Shoal	0	0 ± 0			
139 - Eastern Sambo RO**	0	0 ± 0			
336 - Eastern Sambo RO**	0	0 ± 0			
141 - Western Sambo ER**	0	0 ± 0			
140 - Western Sambo ER**	0	0 ± 0			
143 - West of Western Sambo	0	0 ± 0			
132 - East of E. Dry Rocks SPA	0	0 ± 0			
346 - Rock Key SPA**	0	0 ± 0			
149 - Rock Key SPA**	1	0.25 ± 0.25			
347 - Sand Key SPA**	0	0 ± 0			
150 - Sand Key SPA**	1	0.25 ± 0.25			
142 - SW of Sand Key SPA	0	0 ± 0			
Lower Florida Keys Total (16)	9	0.14 ± 0.06	4	3,196	799 ± 367
Fore-reef Total (51)	**82**	**0.40 ± 0.10**	**10**	**11,573**	**1,163 ± 216**

Table 24. Number of items (N) and mean ± 1 SE no. items per 60 m^2 for other marine debris (non-angling and non-trap) and total marine debris in the Florida Keys National Marine Sanctuary, as determined from surveys of four 15-m x 4-m belt transects per site at 145 sites during June-August 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are no-take marine reserves.

Site number/site location	Other marine debris		Total marine debris	
	N	No. items/m^2	N	No. items/m^2
Mid-channel patch reefs				
Upper Florida Keys NMS				
6 - Basin Hill Shoals	0	0 ± 0	0	0 ± 0
5 - Basin Hill Shoals	0	0 ± 0	6	1.50 ± 0.87
4 - Inshore of Grecian Rocks	1	0.25 ± 0.25	13	3.25 ± 1.93
3 - South of Cannon Patch Reef	0	0 ± 0	2	0.50 ± 0.50
2 - Mosquito Bank	1	0.25 ± 0.25	1	0.25 ± 0.25
1 - Inshore of Molasses Reef	1	0.25 ± 0.25	3	0.75 ± 0.48
Upper Florida Keys Total (6)	3	0.13 ± 0.06	25	1.04 ± 0.49
Middle Florida Keys NMS				
56 - Tavernier Rocks	1	0.25 ± 0.25	6	1.50 ± 0.96
55 - Tavernier Rocks	0	0 ± 0	4	1.00 ± 0.71
59 - Hen and Chickens SPA**	1	0.25 ± 0.25	10	2.50 ± 0.50
58 - Hen and Chickens SPA**	0	0 ± 0	31	7.75 ± 0.75
61 - Cheeca Rocks SPA**	0	0 ± 0	2	0.50 ± 0.29
60 - Cheeca Rocks SPA**	2	0.50 ± 0.29	11	2.75 ± 0.63
57 - NE of Cheeca Rocks SPA	0	0 ± 0	42	10.50 ± 2.40
54 - South of Duck Key	2	0.50 ± 0.50	13	3.25 ± 0.25
53 - South of Ohio Key	0	0 ± 0	9	2.25 ± 0.48
Middle Florida Keys Total (9)	6	0.17 ± 0.07	128	3.56 ± 1.11
Lower Florida Keys NMS				
103 - North of Looe Key RO	0	0 ± 0	37	9.25 ± 3.25
102 - North of Maryland Shoal	0	0 ± 0	2	0.50 ± 0.29
101 - North of Maryland Shoal	0	0 ± 0	0	0 ± 0
100 - North of Eastern Sambo	0	0 ± 0	1	0.25 ± 0.25
105 - Western Sambo ER**	0	0 ± 0	1	0.25 ± 0.25
104 - Western Sambo ER**	0	0 ± 0	1	0.25 ± 0.25
99 - West of Western Sambo	2	0.50 ± 0.29	4	1.00 ± 0.58
98 - Middle Ground	0	0 ± 0	2	0.50 ± 0.29
97 - Middle Ground	0	0 ± 0	2	0.50 ± 0.29
Lower Florida Keys Total (9)	2	0.06 ± 0.06	50	1.39 ± 0.99
Mid-channel Patch Reef Total (24)	**11**	**0.11 ± 0.04**	**203**	**2.11 ± 0.60**
Offshore patch reefs				
Upper Florida Keys NMS				
12 - South of BNP boundary	0	0 ± 0	1	0.25 ± 0.25
41 - North of Carysfort Reef SPA	2	0.50 ± 0.29	6	1.50 ± 0.87
11 - North of Carysfort Reef SPA	1	0.25 ± 0.25	8	2.00 ± 0.91
14 - Carysfort Reef SPA**	0	0 ± 0	2	0.50 ± 0.29
13 - Carysfort Reef SPA**	0	0 ± 0	1	0.25 ± 0.25
10 - North of Dry Rocks SPA	0	0 ± 0	2	0.50 ± 0.29
9 - SW of Grecian Rocks SPA	0	0 ± 0	2	0.50 ± 0.29
8 - Inshore of French Reef SPA	0	0 ± 0	3	0.75 ± 0.48
7 - Inshore of Pickles Reef	4	1.00 ± 0.41	10	2.50 ± 0.96
Upper Florida Keys Total (9)	7	0.19 ± 0.12	35	0.97 ± 0.27
Middle Florida Keys NMS				
65 - North of Davis Reef SPA	0	0 ± 0	2	0.50 ± 0.29
64 - North of Davis Reef SPA	0	0 ± 0	3	0.75 ± 0.25
63 - North of Davis Reef SPA	0	0 ± 0	1	0.25 ± 0.25

Site number/site location	Other marine debris		Total marine debris	
	N	No. items/m^2	N	No. items/m^2
62 - North of Davis Reef SPA	1	0.25 ± 0.25	6	1.50 ± 1.19
89 - Coffins Patch SPA**	1	0.25 ± 0.25	11	2.75 ± 0.25
88 - Coffins Patch SPA**	1	0.25 ± 0.25	2	0.50 ± 0.29
Middle Florida Keys Total (6)	3	0.13 ± 0.06	25	1.04 ± 0.38
Lower Florida Keys NMS				
109 - East of Looe Key RO	0	0 ± 0	2	0.50 ± 0.29
110 - Looe Key Research Only**	0	0 ± 0	3	0.75 ± 0.48
111 - Looe Key Research Only**	4	1.00 ± 0.58	14	3.50 ± 1.94
107 - North of Pelican Shoal	0	0 ± 0	5	1.25 ± 0.48
112 - Western Sambo ER**	0	0 ± 0	4	1.00 ± 0.71
113 - Western Sambo ER**	0	0 ± 0	0	0 ± 0
106 - NE of E. Dry Rocks SPA	1	0.25 ± 0.25	6	1.50 ± 0.50
133 - NE of E. Dry Rocks SPA	0	0 ± 0	9	2.25 ± 0.63
Lower Florida Keys Total (8)	5	0.16 ± 0.12	43	1.34 ± 0.39
Offshore Patch Reef Total (23)	**15**	**0.16 ± 0.06**	**103**	**1.12 ± 0.19**
Inner line reef tract spur & groove				
Upper Florida Keys NMS				
32 - Turtle Rocks	1	0.25 ± 0.25	1	0.25 ± 0.25
31 - Inshore of Elbow Reef SPA	0	0 ± 0	4	1.00 ± 0.41
30 - North Dry Rocks	1	0.25 ± 0.25	3	0.75 ± 0.48
34 - Dry Rocks SPA**	0	0 ± 0	0	0 ± 0
33 - Dry Rocks SPA**	1	0.25 ± 0.25	5	1.25 ± 0.48
36 - Grecian Rocks SPA**	2	0.50 ± 0.50	9	2.25 ± 0.25
35 - Grecian Rocks SPA**	0	0 ± 0	4	1.00 ± 0.71
Upper Florida Keys Total (7)	5	0.18 ± 0.07	26	0.93 ± 0.28
Inner Line Reef Tract Total (7)	**5**	**0.18 ± 0.07**	**26**	**0.93 ± 0.28**
High-relief spur & groove				
Upper Florida Keys NMS				
23 - Carysfort Reef SPA**	0	0 ± 0	0	0 ± 0
22 - Carysfort Reef SPA**	0	0 ± 0	1	0.25 ± 0.25
21 - Maitland grounding site	1	0.25 ± 0.25	1	0.25 ± 0.25
24 - Elbow Reef SPA**	0	0 ± 0	0	0 ± 0
223 - Elbow Reef SPA**	0	0 ± 0	4	1.00 ± 0.71
19 - North of French Reef SPA	2	0.50 ± 0.29	6	1.50 ± 0.29
25 - French Reef SPA**	0	0 ± 0	2	0.50 ± 0.50
26 - French Reef SPA**	0	0 ± 0	3	0.75 ± 0.48
20 - Sand Island	0	0 ± 0	21	5.25 ± 1.03
18 - Sand Island	1	0.25 ± 0.25	9	2.25 ± 1.03
28 - Molasses Reef SPA**	0	0 ± 0	3	0.75 ± 0.25
27 - Molasses Reef SPA**	0	0 ± 0	4	1.00 ± 0.41
17 - Pickles Reef	1	0.25 ± 0.25	4	1.00 ± 0.41
16 - Pickles Reef	1	0.25 ± 0.25	7	1.75 ± 0.48
15 - Pickles Reef	1	0.25 ± 0.25	1	0.25 ± 0.25
Upper Florida Keys Total (15)	7	0.12 ± 0.04	66	1.10 ± 0.34
Middle Florida Keys NMS				
67 - Delta Shoal	1	0.25 ± 0.25	6	1.50 ± 0.50
66 - Delta Shoal	0	0 ± 0	3	0.75 ± 0.75
69 - Sombrero Key SPA**	3	0.75 ± 0.48	4	1.00 ± 0.71
266 - Sombrero Key SPA**	1	0.25 ± 0.25	7	1.75 ± 0.85
Middle Florida Keys Total (4)	5	0.31 ± 0.16	20	1.25 ± 0.23
Lower Florida Keys NMS				
124 - Looe Key SPA**	0	0 ± 0	1	0.25 ± 0.25

Site number/site location	Other marine debris		Total marine debris	
	N	No. items/m^2	N	No. items/m^2
123 - Looe Key SPA**	2	0.50 ± 0.50	3	0.75 ± 0.48
120 - American Shoal	2	0.50 ± 0.29	9	2.25 ± 0.85
122 - American Shoal	1	0.25 ± 0.25	1	0.25 ± 0.25
119 - Maryland Shoal	1	0.25 ± 0.25	2	0.50 ± 0.29
121 - Maryland Shoal	0	0 ± 0	0	0 ± 0
118 - Pelican Shoal	0	0 ± 0	13	3.25 ± 0.25
117 - Pelican Shoal	0	0 ± 0	4	1.00 ± 0.00
116 - No Name Reef	0	0 ± 0	0	0 ± 0
322 - Eastern Sambo RO**	0	0 ± 0	3	0.75 ± 0.75
125 - Eastern Sambo RO**	0	0 ± 0	0	0 ± 0
127 - Western Sambo ER**	1	0.25 ± 0.25	1	0.25 ± 0.25
126 - Western Sambo ER**	1	0.25 ± 0.25	2	0.50 ± 0.29
115 - East of E. Dry Rocks SPA	0	0 ± 0	5	1.25 ± 0.48
129 - Eastern Dry Rocks SPA**	0	0 ± 0	3	0.75 ± 0.25
128 - Eastern Dry Rocks**	2	0.50 ± 0.50	8	2.00 ± 1.00
327 - Rock Key SPA**	0	0 ± 0	0	0 ± 0
130 - Rock Key SPA**	0	0 ± 0	0	0 ± 0
131 - Sand Key SPA**	1	0.25 ± 0.25	4	1.00 ± 0.41
328 - Sand Key SPA**	1	0.25 ± 0.25	5	1.25 ± 0.95
114 - Western Dry Rocks	0	0 ± 0	4	1.00 ± 0.71
Lower Florida Keys Total (21)	12	0.14 ± 0.04	68	0.81 ± 0.18
Spur & Groove Total (40)	**24**	**0.15 ± 0.03**	**154**	**0.96 ± 0.16**
Fore-reef (6-15 m)				
Upper Florida Keys NMS				
42 - South of BNP boundary	2	0.50 ± 0.50	3	0.75 ± 0.48
52 - Carysfort Reef SPA**	0	0 ± 0	2	0.50 ± 0.29
51 - Carysfort Reef SPA**	0	0 ± 0	1	0.25 ± 0.25
50 - SW of Carysfort Reef SPA	2	0.50 ± 0.50	4	1.00 ± 0.71
40 - SW of Carysfort Reef SPA	1	0.25 ± 0.25	17	4.25 ± 2.32
39 - North of Elbow Reef SPA	0	0 ± 0	5	1.25 ± 0.48
245 - Elbow Reef SPA**	0	0 ± 0	2	0.50 ± 0.50
46 - Elbow Reef SPA**	0	0 ± 0	0	0 ± 0
38 - SW of Elbow Reef SPA	0	0 ± 0	2	0.50 ± 0.29
49 - South of Elbow Reef SPA	1	0.25 ± 0.25	10	2.50 ± 1.89
37 - Dixie Shoal	0	0 ± 0	3	0.75 ± 0.75
48 - Dixie Shoal	0	0 ± 0	0	0 ± 0
47 - SW of Molasses Reef SPA	0	0 ± 0	9	2.25 ± 0.75
Upper Florida Keys Total (13)	6	0.12 ± 0.05	58	1.12 ± 0.34
Middle Florida Keys NMS				
81 - Conch Reef SPA**	0	0 ± 0	0.25	0.25 ± 0.25
80 - Conch Reef SPA**	0	0 ± 0	0.25	0.25 ± 0.25
82 - Conch Reef RO**	1	0.25 ± 0.25	0.25	0.25 ± 0.25
279 - Conch Reef RO**	3	0.75 ± 0.48	2.17	5.75 ± 2.17
84 - Davis Reef SPA**	0	0 ± 0	0.25	0.25 ± 0.25
83 - Davis Reef SPA**	0	0 ± 0	0.29	0.50 ± 0.29
79 - SW of Crocker Reef	1	0.25 ± 0.25	1.11	2.25 ± 1.11
78 - SW of Crocker Reef	3	0.75 ± 0.25	0.25	1.25 ± 0.25
85 - Alligator Reef SPA**	1	0.25 ± 0.25	0.75	1.75 ± 0.75
68 - Alligator Reef SPA**	0	0 ± 0	0.48	1.75 ± 0.48
77 - SW of Alligator Reef SPA	1	0.25 ± 0.25	1.03	1.75 ± 1.03
87 - Tennessee Reef RO**	2	0.50 ± 0.50	0.75	3.25 ± 0.75
86 - Tennessee Reef RO**	0	0 ± 0	0.48	1.25 ± 0.48
76 - NE of Tennessee Light	1	0.25 ± 0.25	0.65	3.50 ± 0.65
75 - East of Coffins Patch SPA	0	0 ± 0	0.25	0.25 ± 0.25
293 - Sombrero Key SPA**	1	0.25 ± 0.25	0.25	1.25 ± 0.25
96 - Sombrero Key SPA**	2	0.50 ± 0.29	0.29	0.50 ± 0.29
73 - West of Sombrero Key SPA	1	0.25 ± 0.25	1.03	1.75 ± 1.03
71 - South of Moser Channel	0	0 ± 0	0.25	0.25 ± 0.25

Site number/site location	Other marine debris		Total marine debris	
	N	No. items/m^2	N	No. items/m^2
72 - South of Moser Channel	0	0 ± 0	0	0 ± 0
70 - South of Moser Channel	0	0 ± 0	0.25	0.75 ± 0.25
90 - South of Moser Channel	0	0 ± 0	0	0 ± 0
Middle Florida Keys Total (22)	17	0.19 ± 0.05	0.30	1.31 ± 0.30
Lower Florida Keys NMS				
136 - South of Bahia Honda Key	0	0 ± 0	6	1.50 ± 0.29
138 - South of Bahia Honda Key	0	0 ± 0	6	1.50 ± 0.65
137 - South of Bahia Honda Key	2	0.50 ± 0.29	3	0.75 ± 0.25
135 - West of Looe Key SPA	0	0 ± 0	3	0.75 ± 0.48
134 - West of Pelican Shoal	0	0 ± 0	0	0 ± 0
139 - Eastern Sambo RO**	0	0 ± 0	0	0 ± 0
336 - Eastern Sambo RO**	0	0 ± 0	0	0 ± 0
141 - Western Sambo ER**	0	0 ± 0	0	0 ± 0
140 - Western Sambo ER**	1	0.25 ± 0.25	1	0.25 ± 0.25
143 - West of Western Sambo	0	0 ± 0	0	0 ± 0
132 - East of E. Dry Rocks SPA	0	0 ± 0	0	0 ± 0
346 - Rock Key SPA**	1	0.25 ± 0.25	3	0.75 ± 0.48
149 - Rock Key SPA**	0	0 ± 0	1	0.25 ± 0.25
347 - Sand Key SPA**	0	0 ± 0	0	0 ± 0
150 - Sand Key SPA**	0	0 ± 0	2	0.50 ± 0.29
142 - SW of Sand Key SPA	0	0 ± 0	2	0.50 ± 0.50
Lower Florida Keys Total (16)	4	0.06 ± 0.04	27	0.42 ± 0.13
Fore-reef Total (51)	**27**	**0.13 ± 0.03**	**200**	**0.98 ± 0.17**

Table 25. Total marine debris weight wet per site (240 m^2) and mean ± 1 SE wet weight (kg) per 60 m^2 recovered from surveys of four 15-m x 4-m belt transects per site at 145 sites in the Florida Keys National Marine Sanctuary during June-August 2008. Sites are arranged by habitat from northeast to southwest and asterisked locations (**) are no-take marine reserves.

Site number/site location	No. items	Total wet weight (kg)	Mean wet weight (kg)	SE
Mid-channel patch reefs				
Upper Florida Keys NMS				
6 - Basin Hill Shoals	0	0	0	0
5 - Basin Hill Shoals	6	0.113	0.028	0.012
4 - Inshore of Grecian Rocks	13	3.150	0.788	0.375
3 - South of Cannon Patch Reef	2	1.022	0.255	0.255
2 - Mosquito Bank	1	3.121	0.780	0.780
1 - Inshore of Molasses Reef	3	0.738	0.184	0.166
Upper Florida Keys Total (6)	25	8.144	0.339	0.146
Middle Florida Keys NMS				
56 - Tavernier Rocks	6	0.170	0.043	0.025
55 - Tavernier Rocks	4	0.936	0.234	0.207
59 - Hen and Chickens SPA**	10	2.355	0.589	0.334
58 - Hen and Chickens SPA**	31	3.121	0.780	0.412
61 - Cheeca Rocks SPA**	2	0.057	0.014	0.008
60 - Cheeca Rocks SPA**	11	1.901	0.475	0.381
57 - NE of Cheeca Rocks SPA	42	8.371	2.093	1.159
54 - South of Duck Key	13	16.287	4.072	3.312
53 - South of Ohio Key	9	10.839	2.710	1.008
Middle Florida Keys Total (9)	128	44.038	1.223	0.472
Lower Florida Keys NMS				
103 - North of Looe Key RO	37	8.881	2.220	1.260
102 - North of Maryland Shoal	2	1.220	0.305	0.286
101 - North of Maryland Shoal	0	0	0	0
100 - North of Eastern Sambo	1	0.028	0.007	0.007
105 - Western Sambo ER**	1	0.028	0.007	0.007
104 - Western Sambo ER**	1	0.057	0.014	0.014
99 - West of Western Sambo	4	5.505	1.376	0.798
98 - Middle Ground	2	3.348	0.837	0.828
97 - Middle Ground	2	1.873	0.468	0.273
Lower Florida Keys Total (9)	50	20.940	0.582	0.258
Mid-channel Patch Reef Total (24)	**203**	**73.121**	**0.762**	**0.212**
Offshore patch reefs				
Upper Florida Keys NMS				
12 - South of BNP boundary	1	4.427	1.107	1.107
41 - North of Carysfort Reef SPA	6	34.164	8.541	7.728
11 - North of Carysfort Reef SPA	8	1.220	0.305	0.130
14 - Carysfort Reef SPA**	2	1.333	0.333	0.324
13 - Carysfort Reef SPA**	1	0	0	0
10 - North of Dry Rocks SPA	2	0.511	0.128	0.128
9 - SW of Grecian Rocks SPA	2	3.717	0.929	0.556
8 - Inshore of French Reef SPA	3	0.908	0.227	0.218
7 - Inshore of Pickles Reef	10	4.795	1.199	1.067
Upper Florida Keys Total (9)	35	51.075	1.419	0.902
Middle Florida Keys NMS				
65 - North of Davis Reef SPA	2	0.057	0.014	0.008
64 - North of Davis Reef SPA	3	1.419	0.355	0.211
63 - North of Davis Reef SPA	1	0.993	0.248	0.248
62 - North of Davis Reef SPA	6	21.934	5.483	5.296

Site number/site location	No. items	Total wet weight (kg)	Mean wet weight (kg)	SE
89 - Coffins Patch SPA**	11	23.012	5.753	2.481
88 - Coffins Patch SPA**	2	1.249	0.312	0.303
Middle Florida Keys Total (6)	25	48.663	2.028	1.137
Lower Florida Keys NMS				
109 - East of Looe Key RO	2	1.873	0.468	0.459
110 - Looe Key Research Only**	3	4.682	1.170	1.105
111 - Looe Key Research Only**	14	5.079	1.270	0.444
107 - North of Pelican Shoal	5	2.497	0.832	0.419
112 - Western Sambo ER**	4	0.227	0.057	0.048
113 - Western Sambo ER**	0	0	0	0
106 - NE of E. Dry Rocks SPA	6	2.128	0.532	0.424
133 - NE of E. Dry Rocks SPA	9	6.640	1.660	0.954
Lower Florida Keys Total (8)	43	23.126	0.749	0.209
Offshore Patch Reef Total (23)	**103**	**122.864**	**1.345**	**0.457**
Inner line reef tract spur & groove				
Upper Florida Keys NMS				
32 - Turtle Rocks	1	0.454	0.114	0.114
31 - Inshore of Elbow Reef SPA	4	0.482	0.121	0.121
30 - North Dry Rocks	3	2.781	0.695	0.579
34 - Dry Rocks SPA**	0	0	0	0
33 - Dry Rocks SPA**	5	2.525	0.631	0.344
36 - Grecian Rocks SPA**	9	6.555	1.639	1.285
35 - Grecian Rocks SPA**	4	1.419	0.355	0.276
Upper Florida Keys Total (7)	26	14.216	0.508	0.214
Inner Line Reef Tract Total (7)	**26**	**14.216**	**0.508**	**0.214**
High-relief spur & groove				
Upper Florida Keys NMS				
23 - Carysfort Reef SPA**	0	0	0	0
22 - Carysfort Reef SPA**	1	0.936	0.234	0.234
21 - Maitland grounding site	1	0.454	0.114	0.114
24 - Elbow Reef SPA**	0	0	0	0
223 - Elbow Reef SPA**	4	0.085	0.021	0.014
19 - North of French Reef SPA	6	16.968	4.242	2.604
25 - French Reef SPA**	2	0.028	0.007	0.007
26 - French Reef SPA**	3	0.057	0.014	0.008
20 - Sand Island	21	1.277	0.319	0.216
18 - Sand Island	9	4.001	1.000	0.610
28 - Molasses Reef SPA**	3	5.335	1.334	1.315
27 - Molasses Reef SPA**	4	0.085	0.021	0.007
17 - Pickles Reef	4	2.525	0.631	0.575
16 - Pickles Reef	7	17.252	4.313	2.950
15 - Pickles Reef	1	0.085	0.021	0.021
Upper Florida Keys Total (15)	66	49.088	0.818	0.377
Middle Florida Keys NMS				
67 - Delta Shoal	6	0.482	0.121	0.102
66 - Delta Shoal	3	0.028	0.007	0.007
69 - Sombrero Key SPA**	4	0.057	0.014	0.008
266 - Sombrero Key SPA**	7	0.057	0.014	0.008
Middle Florida Keys Total (4)	20	0.624	0.039	0.027
Lower Florida Keys NMS				
124 - Looe Key SPA**	1	0.028	0.007	0.007
123 - Looe Key SPA**	3	1.646	0.411	0.402
120 - American Shoal	9	7.406	1.851	1.165
122 - American Shoal	1	0.085	0.021	0.021

Site number/site location	No. items	Total wet weight (kg)	Mean wet weight (kg)	SE
119 - Maryland Shoal	2	0.227	0.057	0.048
121 - Maryland Shoal	0	0	0	0
118 - Pelican Shoal	13	0.170	0.043	0.014
117 - Pelican Shoal	4	4.994	1.249	1.101
116 - No Name Reef	0	0	0	0
322 - Eastern Sambo RO**	3	0.568	0.142	0.142
125 - Eastern Sambo RO**	0	0	0	0
127 - Western Sambo ER**	1	0.028	0.007	0.007
126 - Western Sambo ER**	2	0.057	0.014	0.008
115 - East of E. Dry Rocks SPA	5	2.894	0.724	0.270
129 - Eastern Dry Rocks SPA**	3	1.816	0.454	0.317
128 - Eastern Dry Rocks**	8	2.156	0.539	0.492
327 - Rock Key SPA**	0	0	0	0
130 - Rock Key SPA**	0	0	0	0
131 - Sand Key SPA**	4	0.113	0.028	0.012
328 - Sand Key SPA**	5	0.085	0.021	0.014
114 - Western Dry Rocks	4	0.113	0.028	0.020
Lower Florida Keys Total (21)	68	22.386	0.267	0.106
High-relief Spur & Groove Total (40)	**154**	**72.099**	**0.451**	**0.156**
Fore-reef (6-15 m)				
Upper Florida Keys NMS				
42 - South of BNP boundary	3	1.021	0.255	0.246
52 - Carysfort Reef SPA**	2	3.859	0.965	0.955
51 - Carysfort Reef SPA**	1	0.057	0.014	0.014
50 - SW of Carysfort Reef SPA	4	0.028	0.007	0.007
40 - SW of Carysfort Reef SPA	17	7.122	1.781	1.209
39 - North of Elbow Reef SPA	5	0.624	0.156	0.111
245 - Elbow Reef SPA**	2	10.470	2.618	2.618
46 - Elbow Reef SPA**	0	0	0	0
38 - SW of Elbow Reef SPA	2	0.085	0.021	0.014
49 - South of Elbow Reef SPA	10	0.227	0.057	0.048
37 - Dixie Shoal	3	0.141	0.035	0.035
48 - Dixie Shoal	0	0	0	0
47 - SW of Molasses Reef SPA	9	11.066	2.767	1.204
Upper Florida Keys Total (13)	58	34.700	0.667	0.288
Middle Florida Keys NMS				
81 - Conch Reef SPA**	1	0.142	0.035	0.035
80 - Conch Reef SPA**	1	0.341	0.085	0.085
82 - Conch Reef RO**	1	0.908	0.227	0.227
279 - Conch Reef RO**	23	0.851	0.213	0.141
84 - Davis Reef SPA**	1	0.028	0.007	0.007
83 - Davis Reef SPA**	2	8.399	2.100	2.081
79 - SW of Crocker Reef	9	20.515	5.129	3.444
78 - SW of Crocker Reef	5	5.562	1.390	1.074
85 - Alligator Reef SPA**	7	0.284	0.071	0.052
68 - Alligator Reef SPA**	7	11.010	2.752	2.724
77 - SW of Alligator Reef SPA	7	18.728	4.682	4.213
87 - Tennessee Reef RO**	13	8.144	2.036	1.171
86 - Tennessee Reef RO**	5	14.244	3.561	2.583
76 - NE of Tennessee Light	14	2.355	0.589	0.298
75 - East of Coffins Patch SPA	1	0.028	0.007	0.007
293 - Sombrero Key SPA**	5	6.072	1.518	1.461
96 - Sombrero Key SPA**	2	0.170	0.043	0.034
73 - West of Sombrero Key SPA	7	14.358	3.589	2.750
71 - South of Moser Channel	1	1.362	0.341	0.341
72 - South of Moser Channel	0	0	0	0
70 - South of Moser Channel	3	0.482	0.121	0.071
90 - South of Moser Channel	0	0	0	0
Middle Florida Keys Total (22)	115	113.982	1.295	0.354

Site number/site location	No. items	Total wet weight (kg)	Mean wet weight (kg)	SE
Lower Florida Keys NMS				
136 - South of Bahia Honda Key	6	1.986	0.497	0.468
138 - South of Bahia Honda Key	6	0.539	0.135	0.066
137 - South of Bahia Honda Key	3	7.973	1.993	1.489
135 - West of Looe Key SPA	3	0.738	0.184	0.121
134 - West of Pelican Shoal	0	0	0	0
139 - Eastern Sambo RO**	0	0	0	0
336 - Eastern Sambo RO**	0	0	0	0
141 - Western Sambo ER**	0	0	0	0
140 - Western Sambo ER**	1	0.142	0.035	0.035
143 - West of Western Sambo	0	0	0	0
132 - East of E. Dry Rocks SPA	0	0	0	0
346 - Rock Key SPA**	3	0.170	0.043	0.034
149 - Rock Key SPA**	1	0.057	0.014	0.014
347 - Sand Key SPA**	0	0	0	0
150 - Sand Key SPA**	2	0.482	0.121	0.111
142 - SW of Sand Key SPA	2	0.028	0.007	0.007
Lower Florida Keys Total (16)	27	12.115	0.189	0.124
Fore-reef Total (51)	**200**	**160.798**	**0.788**	**0.184**

VIII. Conclusions and future efforts

Survey results from 2008 add to a growing dataset on the distribution, abundance, size, and condition of benthic coral reef organisms in the Florida Keys National Marine Sanctuary, as well as neighboring State and National Parks. For many of the variables assessed, we have developed a 10-year record to evaluate the efficacy of zoning strategies in the context of larger-scale environmental variability. Benthic surveys completed in 2008 included a follow-up effort to sampling conducted in 2000-2001 that evaluated the spatial extent and impacts of marine debris, with a particular focus on comparisons inside and outside of most of the Sanctuary no-fishing zones. It is important to note our analyses not reported here will yield domain-wide abundance estimates for the benthic invertebrates sampled, and population estimates structured by habitat, regional sector, and for individual no-take marine reserves.

Acropora corals

For *Acropora* corals, transect surveys of presence-absence and frequency of occurrence yielded results similar to what we documented in both 2006 and 2007. The distribution and abundance patterns of the two species are clearly different, perhaps necessitating discrete management approaches. Significant *A. palmata* stands remain at only a handful of sites, all of which are high-relief spur and groove reefs on the inner or outer platform margin, and most of which are within existing FKNMS no-take zones. Tissue damaged caused by snails and damselfishes, as well as physical impacts from lost fishing gear continue. In contrast, mid-channel and offshore patch reefs yielded the greatest proportion of sites and transects where *A. cervicornis* was present, while the species was rare on the shallower and deeper platform margin. With over 5,000 patch reef sites on the south Florida shelf, *A. cervicornis* is currently variably distributed and the factors responsible for this pattern are not clear. It is noteworthy that few patch reef areas are included within the existing FKNMS zoning framework as no-take zones. In general, patch reefs represent many of the best remaining reefs in the region in terms of coral abundance and diversity, in addition to their importance as habitat for *A. cervicornis*. Why patch reefs appear to be in relatively good condition compared to the offshore spur-and-groove habitats is an important research and management question.

Urchins

Urchin density and size estimates during 2008 continue a decade-long record of population status in the Florida Keys. Results indicate that since 1999, *Diadema antillarum* prevalence and average size both have increased. However, maximum site-level densities are still at least one order of magnitude lower than before the Caribbean mass mortality event in 1983-84 and the second dieback in the Florida Keys that occurred during 1991. Increasing *Diadema* density and size are likely to result in corresponding

changes in coral-algal relationships and thus represents an important aspect of our monitoring effort. Other urchin species exhibit spatial distribution and abundance patterns similar to historical observations, with high densities of *Echinometra* on some patch reefs and *Eucidaris tribuloides* abundant on the shallow fore-reef.

Anemones and corallimorpharians

Anemone and corallimorpharian surveys indicated similar patterns in species distribution and abundance with historical observations dating back to 1999. Most anemones were either found in low densities among most habitats, or were relatively rare and confined to a few habitats. The three corallimorpharian species were particularly abundant in the patch reef environment, especially in Sanctuary no-take zones. The degree to which the distribution and abundance patterns of these organisms are affected by the marine aquarium trade is not well known. In 2009, we will be collaborating with the Florida Fish & Wildlife Research Institute to combine ocean-side and nearshore-Florida Bay-Biscayne Bay surveys, along with fishery-dependent data on landings and aggregation locations, to provide both fishery-dependent and independent assessments.

Marine debris

A concerted effort to document the spatial extent, amount, and impacts of marine debris in 2008 indicates similar results with surveys dating back eight years ago. Marine debris, most of which is derelict angling and trap gear, is ubiquitous in the Sanctuary, even within no-take zones. The sheer amount of debris recovered is testament to an increasingly visited and exploited marine ecosystem. We believe that the site-level data can help focus coordinated efforts to remove marine debris entangled on benthic biota. The amount of marine debris found in no-take zones has obvious management implications related to education and enforcement.

Future plans

In 2009, we plan to conduct a synoptic inventory of the abundance, size, and condition of coral reef benthos from northern Biscayne National Park to near the Marquesas Keys. Data will be collected on species richness, cover, animal densities, and sizes. We also plan to incorporate surveys of marine debris as well, as we will be concentrating on FKNMS no-take zones and comparable reference areas. Results from this program were recently presented at the Florida Academy of Sciences meeting in March 2008 and the International Coral Reef Symposium in Ft. Lauderdale during July 2008, in which three manuscripts on *Acropora* coral status, urchins, and Florida Keys reef status were submitted. Survey results from 2008 will be presented at the upcoming Florida Academy of Sciences meeting in March 2009

and the International Marine Conservation Congress in May 2009. A list of previous publications based on results from this program follows. We also have several manuscripts drafted on the distribution and abundance of corals, gorgonians, and sponges, that we are going to complete after our 2009 surveys so we can provide nearly a decade-long – and Keyswide – report on these prominent components of the benthic community.

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