

Assessment of Benthic Coral Reef Organisms in Dry Tortugas National Park and the Western Florida Keys National Marine Sanctuary

2008 Quick Look Report and Data Summary



December 2009

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Cover photos. Benthic surveys and examples of habitats and coral reef organisms sampled in Dry Tortugas National Park and the western Florida Keys National Marine Sanctuary during May-June 2008.

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2008 Executive Summary

Surveys of benthic coral reef organisms found in habitats from ~2 m to 26 m depth were undertaken in the Dry Tortugas region during two 5-day research cruises (May 12-30, 2008) aboard the R/V *Fort Jefferson* and a subsequent 10-day research cruise (May 31-June 8, 2008) aboard the M/V *Spree* (Gulf Diving, Houston, TX). A total of 43 sites within Dry Tortugas National Park (DTNP) and the western region of the Florida Keys National Marine Sanctuary (FKNMS) were surveyed for species richness, coverage, abundance, size, and condition of a diversity of benthic coral reef organisms, including stony corals, gorgonians, algae, urchins, anemones, and corallimorpharians. Fieldwork during mid- to late-May was coordinated with National Park Service scientists (M. Patterson, A. Davis, B. Ruttenberg, R. Waara and B. Witcher) who concurrently installed permanent reef monitoring stations inside and outside of the newly designated Research Natural Area of DTNP. Fieldwork during early June was done in coordination with reef fish and spiny lobster surveys conducted by scientists from NOAA Fisheries, the University of Miami, and the Florida Fish and Wildlife Research Institute. This quick-look report provides a summary of the major findings and site-level data for the benthic variables measured at 43 sites visited during May-June 2008. The 2008 sampling adds to a growing spatial and temporal data set in the Tortugas region that complements similarly organized research cruises in 1999 (24 sites surveyed), 2000 (35 sites), 2002 (24 sites), and 2006 (45 sites), for a total of 171 sites surveyed from 1999 through 2008. The Tortugas regional sampling is part of a larger program dating back to 1999 that documents the status and condition of benthic coral reef resources throughout the Florida Keys ecosystem, with a focus on documenting spatial and temporal patterns in the abundance, size, and condition of benthic coral reef organisms in relation to the zoning action plan for the FKNMS.

Benthic surveys of hard-bottom and coral reef habitats in the Tortugas region were accomplished by a three to four person survey team represented by scientists from the Center for Marine Science-University of North Carolina at Wilmington (CMS/UNCW) and RSMAS-University of Miami. Enriched air Nitrox was used at most sites to allow for multiple daily dives within the 2.4 m to 26.2 m depth range surveyed. Surveys of the 43 sites required 173 dives and ~176 hours of underwater bottom time by the UNCW and UM team. An additional 118 dives constituting 86 hours of underwater bottom time was spent by NPS personnel installing a subset of their permanent monitoring stations inside and outside of the Research Natural Area (RNA) of Dry Tortugas National Park (DTNP). The 43 survey locations represented a variety of hard-bottom and coral reef habitat types within four management zones in the region: sites within the newly designated RNA of DTNP; sites within DTNP, but outside the RNA; sites within the Tortugas North no-fishing reserve; and sites outside of the Tortugas North Reserve, but within the FKNMS boundary. Bottom types surveyed represented eight habitat and depth strata encompassing

DTNP and the deeper Tortugas Bank: shallow (< 6 m) patch reefs and deeper (15-21 m) reef knolls, low-relief hard-bottom (< 6 m to 15 m), patchy hard-bottom (6-21 m), low-relief spur and groove (6-15 m), medium-profile reefs (< 6 to 21 m), high-relief spur and groove (6-15 m), and reef terraces (6-26 m). A stratified random sampling design using pre-existing benthic habitat and bathymetry data were used to allocate sampling effort (number of sites per habitat type) and to randomly select sites. The following benthic variables were measured in the Tortugas region during 2008: percent cover of biotic and abiotic components; species richness (number of species per 60 m² area) of sponges and benthic cnidarians; gorgonian densities by species; stony coral density, size, and condition by species; urchin densities and sizes (test diameters) by species; densities of anemones and corallimorpharians; and topographic measurements of minimum and maximum transect depth, maximum vertical relief, and estimations of coverage by relief categories. All of the variables were recorded underwater on pre-formatted plastic PVC slates, with data entered into a database entry program onboard to accomplish rapid data processing. Transects 15 m in length were used to obtain percent coverage using the linear point-intercept technique, while data on species richness and invertebrate densities and sizes were collected in belt transect areas using a 0.5 m scale bar along the same 15-m transects.

General impressions of the Tortugas region during 2008 from a benthic perspective are summarized as follows. The benthic sampling was concentrated along a band from the southwestern to northeastern area of DTNP, in addition to nine sites scattered across the Tortugas Bank, including Little Tortugas Bank and the Sherwood Forest areas. The eastern and southeastern areas of DTNP were not sampled due to inclement weather and time constraints. Relative to 2006, many of the areas surveyed in 2008 appeared to be recovering from tropical cyclones that impacted the region in previous years. Gorgonian recruitment was evident in areas scoured by storms that were largely denuded when surveyed in 2006. Reef terraces on Little Tortugas Bank and the northwestern Tortugas Bank (Sherwood Forest) are still in relatively good condition in terms of coral abundance, but coral cover has apparently declined from ~50% in 1999-2000 to less than 30% in 2008. In these same sites, we noticed a high prevalence of the brown alga *Lobophora variegata* that is now occupying space once covered by live coral. A few sites also exhibited relatively high prevalence of coral disease, especially by what we believe to be white plague, especially on Little Tortugas Bank. The reef terrace habitat west and northwest of Loggerhead Key in western DTNP (Loggerhead Forest) has also experienced declines in coral cover and exhibited relatively high prevalence of coral disease compared to previous years. The factors responsible for the increased disease prevalence observed compared to previous years are not known. The hypothesis that coral bleaching and other stressors increase susceptibility to disease has not been tested by us, but data from other regions

around the world suggest a relationship. The extent, severity, and degree of recovery from coral bleaching that occurred in 2005 are unknown.

Relative to 1999-2000, but in contrast to 2006, sea urchins, particularly *Diadema antillarum*, exhibited similar densities, but larger test sizes at many of the shallow-water patch reef, hard-bottom, and medium-profile reef areas sampled in DTNP. Although *Diadema* densities are still below the presumed historical (pre-1983) density level of ~1 individual per m² in certain habitats, urchin densities in the Tortugas region, especially within DTNP, are now generally lower than for similar habitats and depths along the rest of the Florida Keys reef tract. Of the 41 *Diadema* surveyed from the 43 sites, ~76% were > 4 cm in test diameter, while few recently settled recruits were encountered compared to previous years.

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). For the two *Acropora* coral species that occur in the region, both 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 (see the *Acropora* Biological Review Team summary at <http://sero.nmfs.noaa.gov/pr/pdf/050303%20status%20review.pdf>). Symptoms of degradation include declines in the abundances of corals, concurrent increases in algae, increased prevalence of disease, 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). The 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 what 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. 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 total reef area (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. Despite these considerations, there is no doubt 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 and larger-scale factors such as climate change.

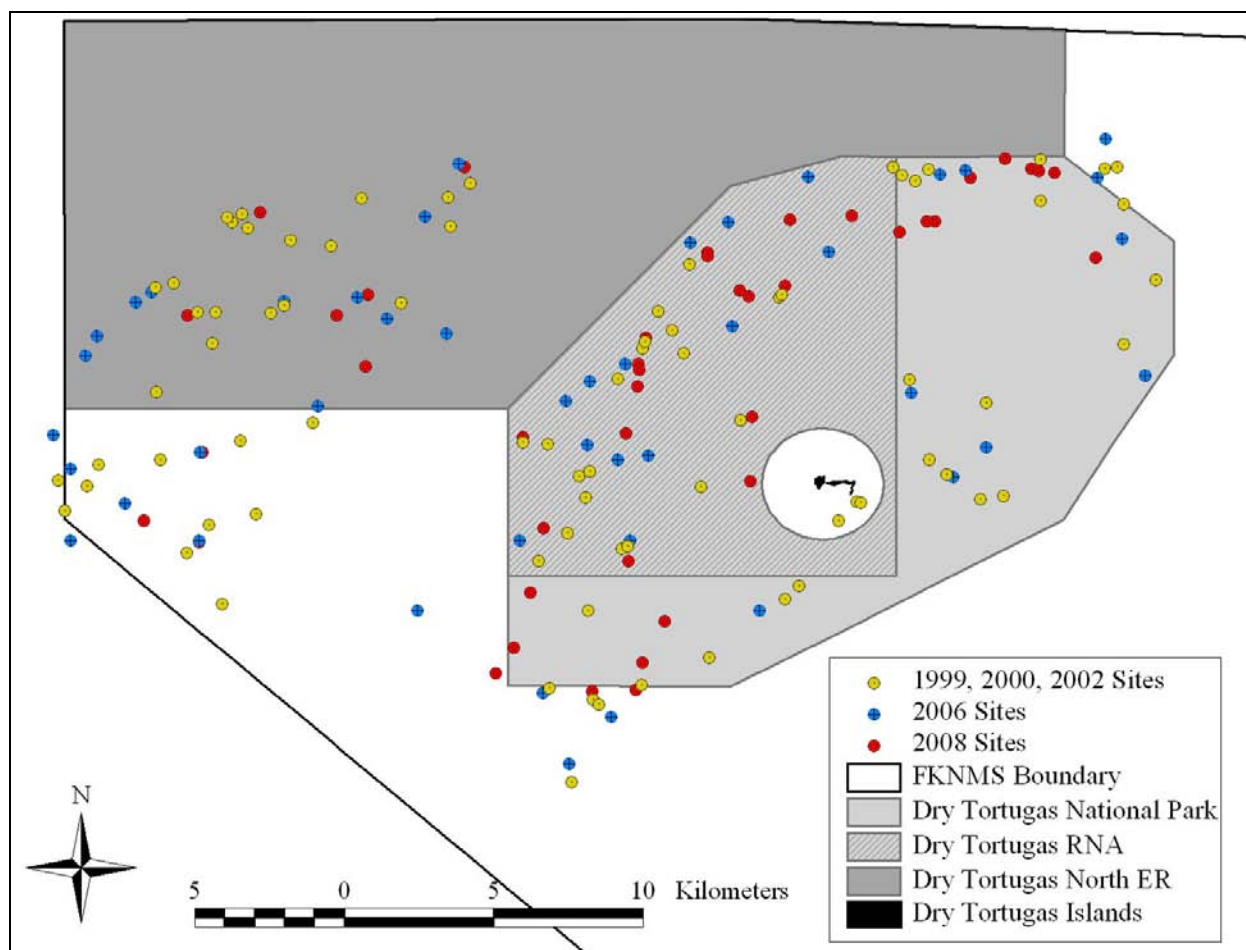
The Tortugas region has a long history of scientific study, summarized in earlier works such as Davis (1982) and Jaap et al. (1989), including several historical assessments of reef geomorphology and community structure dating back over a century (e.g. Shinn et al. 1977; Dustan 1985). The Dry Tortugas, near the western extent of the Florida Keys National Marine Sanctuary (FKNMS), include an island group 117 km west of Key West, which consists of an elevated atoll-like rim measuring about 27 km from southeast to northeast and 12 km wide that rests atop a Pleistocene mound (Shinn et al. 1989). Reefs are found along a discontinuous elevated rim of Holocene coral and several small sandy islands such as Loggerhead Key (site of the original Carnegie Institute Marine Laboratory), and Garden Key. Deep channels (~10-20 m depth) separate three major banks (Pulaski, Loggerhead, and Long Key) within what is now Dry Tortugas National Park (formerly Ft. Jefferson National Monument). The Tortugas region represents the western extent of extensive reef growth in the Florida Keys archipelago, with Holocene accumulations up to 17 m (55 feet) in some locations (Shinn et al. 1977). West of the shallow bank encompassing Dry Tortugas National Park is the Tortugas Bank, a deeper (> 12 m) water area extending to the western boundary of the FKNMS. Prior to research cruises in 1999 and 2000 by UNCW, NMFS, and RSMAS-UM, little scientific information existed on the benthic habitats of the Tortugas Bank and few mapping data existed except for the area within Dry Tortugas National Park (Davis 1982). Since 1999, however, fishery independent surveys and habitat mapping have elucidated the spatial pattern of habitats for much of the Tortugas Bank (Franklin et al. 2003), along with the responses of fishery organisms to spatial management zones (i.e. no-take reserves) protected from fishing (Ault et al. 2006).

In response to concerns about declining regional trends in coral reef habitats and multi-species reef fish stocks (see Ault et al. 2002), the FKNMS, National Park Service, State of Florida, and the Gulf of Mexico Fishery Management Council designated 518 km² of no-take ecological reserves that includes the Research Natural Area (RNA) within the park, but also two reserves further west: the Tortugas North Ecological Reserve encompassing the northern half of the Tortugas Bank, and the Tortugas South Ecological Reserve

encompassing the Riley's Hump area. Because of its up-current position located on the southwestern Florida shelf in the Florida Current, the Tortugas Region is widely considered to provide an essential source of larvae for many invertebrates and commercially important fishes to the Florida Keys region (Lee et al. 1994, Ault et al. 2006).

During just over three weeks of underwater fieldwork in the Florida Keys, we had the opportunity to sample 43 different locations stratified by habitat structure, depth, and management zone in the Tortugas region, encompassing both Dry Tortugas National Park (DTNP) and the western extent of the Florida Keys National Marine Sanctuary (FKNMS). The measured variables (coverage, species richness, abundance, size, condition) add to a growing spatial and temporal database 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, size, and condition of benthic coral reef algae invertebrates. Quick Look reports from previous years are available at <http://people.uncw.edu/millers>, including similar research cruises to the Tortugas region in 1999, 2000, 2002, and 2006 (Figure 1-1). 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 report, we provide a variable-by-variable summary of significant findings from the 2008 Tortugas region surveys. We have included comparisons to the 2006 surveyss, as well as a list of published and planned papers and other products developed from this effort. Accompanying tables and figures summarize site-level coverage, species richness, and density/size data for stony corals, gorgonians, urchins, and anemones/corallimorpharians.

Figure 1-1. Survey locations in Dry Tortugas National Park (DTNP) and the western Florida Keys National Marine Sanctuary (FKNMS) during 1999-2000, 2002, 2006, and 2008, showing the current locations of the Tortugas North Ecological Reserve (ER) and Research Natural Area (RNA), designated in 2000 and 2008, respectively.



II. Study area and methods

Tortugas study area description

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 generally extends ~2.5 km seaward from the shoreline and consists of hard-bottom, seagrass, and isolated inshore patch reefs (FMRI 1998). Along the main archipelago from Key West to near Miami 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 inner shelf waters and the Atlantic Ocean (Marszalek et al. 1977). 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 that taper off into the Florida Straits (Lidz 2006). Coral reef distribution reflects exchange processes between inner shelf waters (Florida Bay, Biscayne Bay, SW Florida shelf) 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).

West of the main Florida Keys archipelago is the Dry Tortugas, an island group 117 km west of Key West that consist of an elevated atoll-like rim of Holocene coral measuring about 27 km from southeast to northeast and 12 km wide. Reefs are found in a discontinuous elevated rim of Holocene coral and around several small sandy islands such as Loggerhead Key and Garden Key that rests atop a Pleistocene mound (Shinn et al. 1989). Deeper channels (~10-20 m deep) separate three major banks (Pulaski, Loggerhead, and Long Key) within Dry Tortugas National Park (DTNP). The Tortugas region represents the western extent of extensive reef growth in the Florida Keys archipelago, with Holocene accumulations up to 17 m thick (Shinn et al. 1977). West of the shallow bank, which is mostly within the boundaries of DTNP, is the Tortugas Bank, a deeper (> 12 m) water area extending to the western boundary of the FKNMS. Previous benthic habitat information for the Tortugas region is provided in both historical (Davis 1982) and more recent studies

(FMRI 1998, Franklin et al. 2003) and provided the basis for benthic and fish sampling in 2008 and previous years.

2008 sampling objectives

The 2008 sampling of benthic coral reef organisms in Dry Tortugas National Park (DTNP) and the western Florida Keys National Marine Sanctuary (FKNMS) included both the Research Natural Area (RNA) of DTNP and the no-take marine reserve (NTMR) in the Tortugas North area, along with corresponding reference habitats. Figure 2-1 illustrates the spatial distribution of all 171 sampling locations from 1999 to 2008. The 2008 surveys complement earlier efforts in the Tortugas region carried out during 1999-2002 (83 sites, Figure 2-2) and 2006 (45 sites, Figure 2-3), thus adding to a growing body of information on the status and condition of coral reef benthic resources in the Tortugas Region, not including similar surveys conducted in the rest of the Florida Keys ecosystem (see <http://people.uncw.edu/millers>). The goals of the UNCW hard-bottom and coral reef habitat assessment and monitoring effort in the Florida Keys are four-fold:

- To assess the community structure and condition of hard-bottom and coral reef habitats at multiple spatial scales, with particular reference to the no-take marine reserves (NTMR), including assessments of cross-shelf and along-shelf patterns, but also comparisons between no-take zones and corresponding reference sites;
- To assess coral population structure at multiple spatial scales, including among benthic habitat types, regions, and level of protection;
- To assess the condition of habitats related to potential changes due to protecting from fishing within NTMRs, but also changes that may occur at larger spatial scales related to regional or global phenomena; and
- To complement fishery-independent reef fish surveys with “fine-scale” or detailed habitat information, to facilitate experimental and modeling efforts for evaluating essential fishery habitat (in collaboration with Dr. Jerry Ault at RSMAS-UM and Dr. Jim Bohnsack at NOAA Fisheries).

To accomplish these goals, the 2008 Tortugas sampling built upon existing data collected during previous cruises to guide the underwater surveys at 43 sites during May-June 2008 (Figure 2-4). Our focus during 2008 was two-fold:

- To survey the complement of hard-bottom and coral reef habitats in the Tortugas region to assess habitat variability in community structure, abundance, and condition of benthic invertebrates and algae.
- To sample sites inside and outside of existing (Tortugas North NTMR, DTNP) and newly designated management areas (DTNP Research Natural Area). The 2008 work involved initial sampling of NPS permanent monitoring stations inside and outside of the RNA.

Together with the data collected during previous years, this project has amassed a relatively large data set for the Tortugas region on the abundance and habitat utilization patterns of algae and several invertebrate taxa, including stony corals, gorgonians, sponges, and echinoderms. These data are timely for providing population abundance estimates and trends for reef-building invertebrates, especially stony corals, as well as a temporal comparison of changes in benthic community structure inside and outside of areas protected from fishing. Moreover, these data allow for relevant comparisons with similar habitat types and depths with the rest of the Florida Keys that are subjected to differing levels of impacts such as coastal development and fishing pressure.

Logistics and field methodologies

A two-stage stratified random sampling design was used to allocate sampling effort and randomly select sites during 2008 following methods presented in Ault et al. (2006). A grid system constructed in a geographic information system (GIS) was used to overlay the existing habitat map of the Tortugas region that was developed from previous research cruises (see Franklin et al. 2003). Cells or blocks 200 m x 200 m in dimension were used to randomly select sites from the following habitat strata in Dry Tortugas National Park (including sites inside and outside of the RNA) and the Tortugas Bank, both within the Tortugas North no-take marine reserve (NTMR) and outside the reserve:

- Patchy low- and medium-relief hard-bottom (> 30% sand interspersed with hard-bottom)
- Low-relief hard-bottom and low-relief spur and groove (< 30% sand)
- Patch reefs
- High-relief spur and groove
- Medium-profile reefs
- High-relief reef terraces

The sampling design for assessing the species richness, abundance, size, and condition of benthic coral reef organisms encompassed 43 sites in the Tortugas region during May-June 2008 (Figure 2-4). Sites

were distributed from near the western edge of the Tortugas Bank to the northeastern extent of DTNP. Tables 2-1 lists the survey locations in chronological order, including data on habitat and transect depth range, as well as management zone. The sampling locations encompassed eight hard-bottom and coral reef types, not including depth differences, over the 2.4 to 26.2 m depth range surveyed. Habitats ranged from low-profile patchy and continuous hard-bottom (Figure 2-5) to high-relief spur and groove and reef terraces (Figure 2-6). Table 2-2 provides site-level depth range and topographic data for the sites, organized by habitat type, depth, and management zone. Of the 43 sites sampled during 2008, 31 were within the boundaries of DTNP, and of those, 14 sites were outside the RNA and 17 sites were within the RNA (Figure 2-4). Three sites on the shallower eastern bank, which is mostly encompassed with DTNP, were sampled south of the Park boundary. Another nine sites were sampled on the deeper Tortugas Bank to the west, including three sites south of the Tortugas North NTMR and six sites within the reserve.

The 2008 Tortugas region benthic surveys were similar in scope to those conducted in previous years (Figure 2-7). All of the variables were recorded underwater on pre-formatted plastic PVC slates, with data entered into a database entry program onboard to facilitate relatively rapid data processing. At each pre-determined site a GPS receiver was attached to a buoy to mark the transect positions. A Garmin® global positioning system receiver (model GPS76) was used to determine latitude and longitude. Four 15 m transects were deployed at each site in a haphazard fashion, but in a way that best represented the habitat at the randomly selected site coordinates. At NPS permanent monitoring stations, transects were placed along permanent stakes in a radial fashion out from the site center. 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. Along a 1-m band for each transect, divers estimated the coverage of relief categories (< 0.2 m, 0.2-0.5 m, 0.5-1 m, 1-1.5 m, and > 1.5 m) for hard complexity and soft complexity (gorgonians) features. Digital photographs of each site were taken to record general site features and organisms encountered.

Along each 15-m transect, percent cover of biotic and abiotic components was determined every 15 cm to yield 100 points per transect. The numbers of species of stony corals, gorgonians, and sponges were determined in a 0.5 swath on each side of the four transects, yielding a total sample area of 60 m² per site. Gorgonian densities by species were determined along two transects in 1 m x 8 m areas. Stony corals more than 4 cm in maximum diameter were counted, measured, and assessed for condition, including evidence of bleaching and disease, along two of the transects in 1 m x 10 m belts. Juvenile corals (< 4 cm

maximum diameter) were assessed by sampling ten randomly placed quadrats 0.68 m x 0.45 m in dimension along each of two transects. Urchin density and test diameter, as well as the density of anemones and corallimorpharians, were assessed in 15-m x 1-m belts along all four transects per site.

The 2008 sampling effort (43 sites) required 19 field days from May 12 through June 8. The May 2008 component was carried out during two 5-day research cruises (May 12-30, 2008) aboard the R/V *Fort Jefferson*, followed by a 10-day research cruise (May 31-June 8, 2008) aboard the M/V *Spree* (Gulf Diving, Houston, TX). The survey team consisted of personnel from the Center for Marine Science/UNCW (M. Chiappone and L. Rutten) and the University of Miami (M. Brandt and D. Swanson) (Table 4). The sampling effort depended upon four to six hours in the water daily by a three or four-person benthic team to sample. Typically 70-80 minutes per site were needed to sample all of the variables. Table 2-3 summarizes the diving statistics in the Tortugas region during 2008. Enriched air Nitrox was used at most sites to allow for multiple daily dives within the 2.4 m to 26.2 m depth range surveyed. Surveys of the 43 sites required 173 dives and ~176 hours of underwater bottom time by the UNCW and UM team. An additional 118 dives constituting 86 hours of underwater bottom time was spent by NPS personnel installing a subset of their permanent monitoring stations inside and outside of the Research Natural Area (RNA) of Dry Tortugas National Park (DTNP).

Figure 2-1. Composite map of survey locations in Dry Tortugas National Park (DTNP) and the western Florida Keys National Marine Sanctuary (FKNMS) during 1999-2000, 2002, 2006, and 2008, showing the current locations of the Tortugas North Ecological Reserve (ER) and Research Natural Area (RNA), designated in 2000 and 2008, respectively.

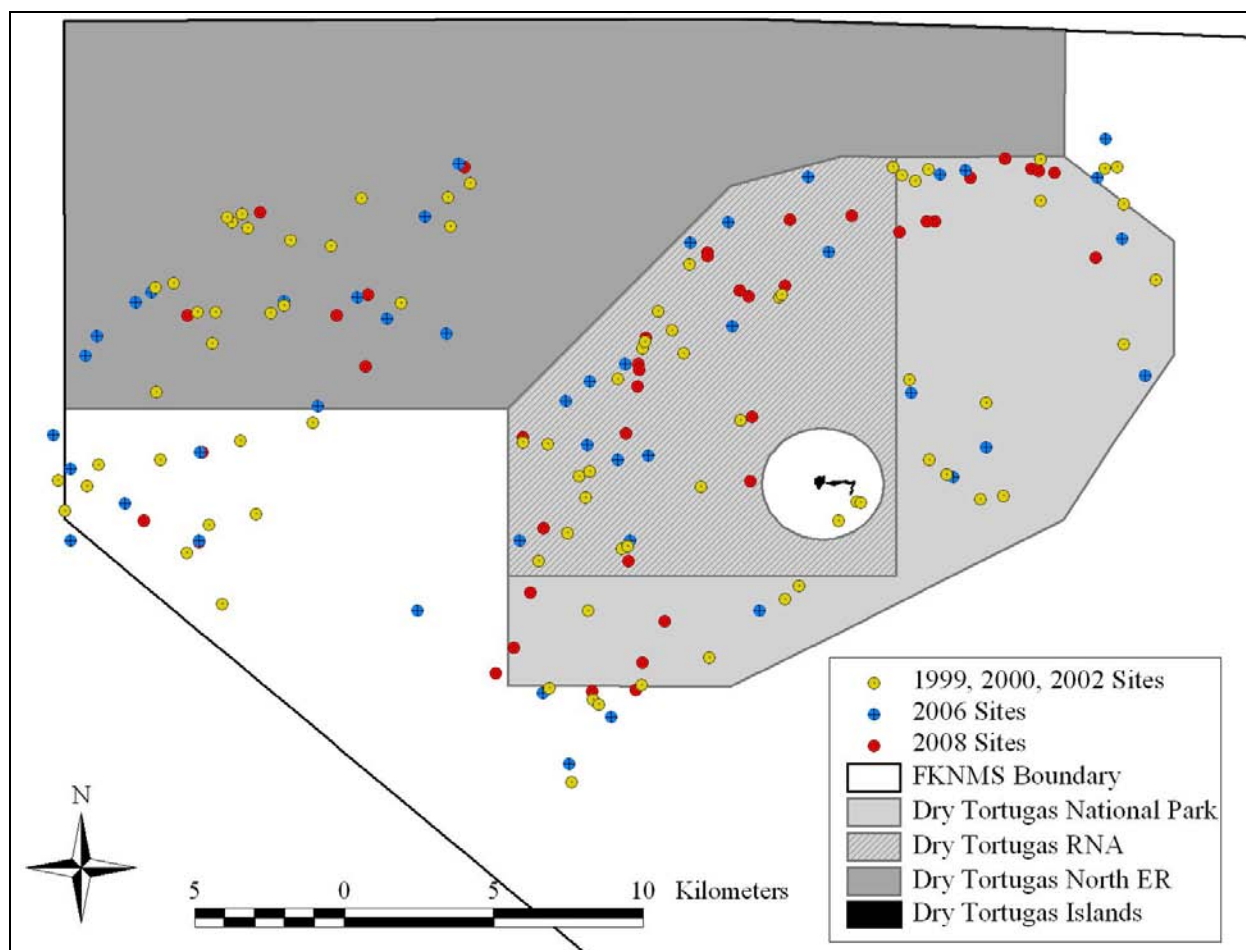


Figure 2-2. Survey locations in Dry Tortugas National Park (DTNP) and the western Florida Keys National Marine Sanctuary (FKNMS) during 1999, 2000, and 2002, showing the locations of the Tortugas North Ecological Reserve (ER) and Research Natural Area (RNA), designated in 2000 and 2008, respectively.

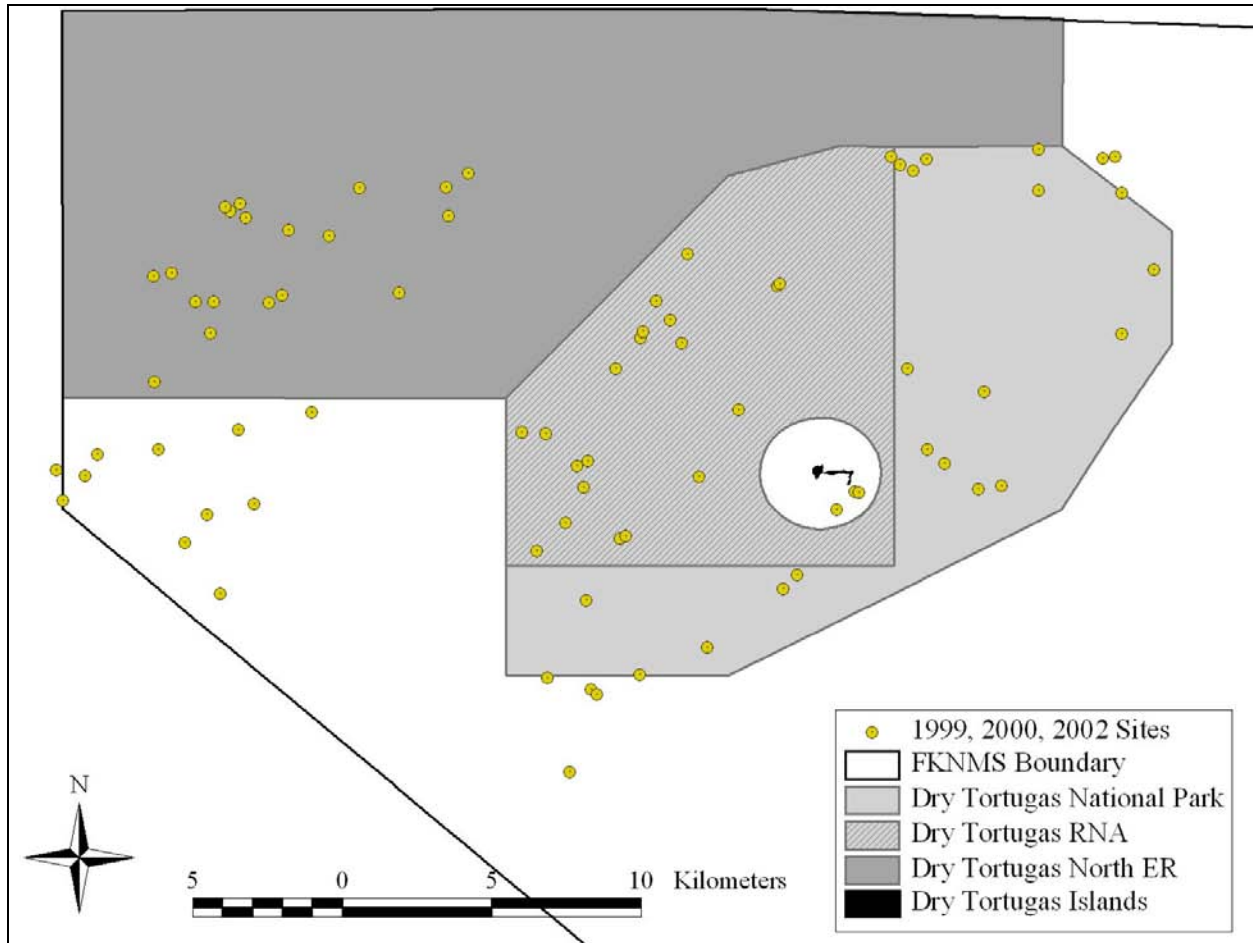


Figure 2-3. Survey locations in Dry Tortugas National Park (DTNP) and the western Florida Keys National Marine Sanctuary (FKNMS) during 2006, showing the locations of the Tortugas North Ecological Reserve (ER) and Research Natural Area (RNA), designated in 2000 and 2008, respectively.

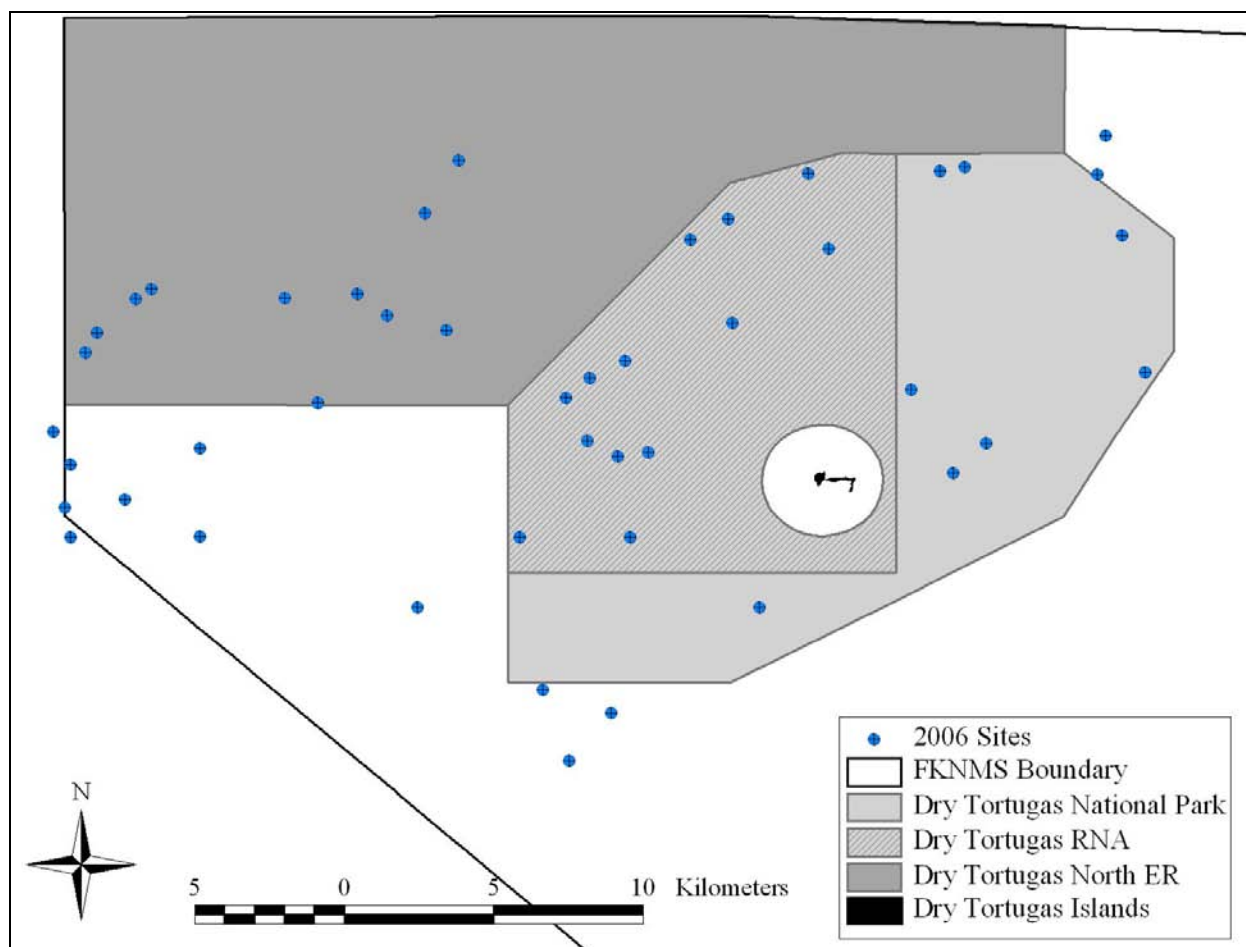


Figure 2-4. Sampling locations for benthic coral reef organisms in Dry Tortugas National Park (DTNP) and the western Florida Keys National Marine Sanctuary (FKNMS) during May-June 2008. Shown are the boundaries of the Research Natural Area (RNA) within DTNP, the Tortugas North Ecological Reserve, and the FKNMS.

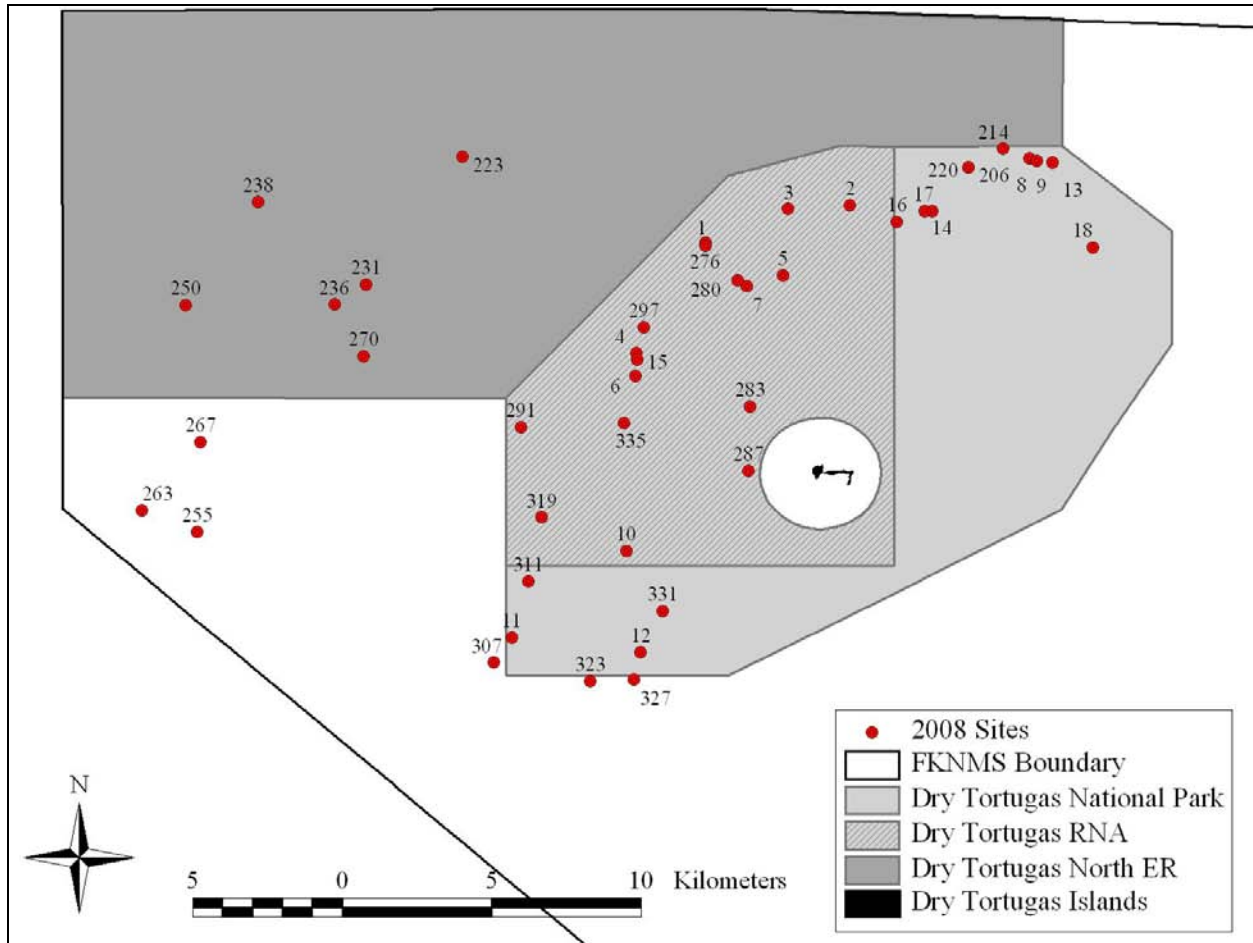


Figure 2-5. Examples of shallow-water hard-bottom and coral reef habitats surveyed within Dry Tortugas National Park, including the Research Natural Area, during May-June 2008.

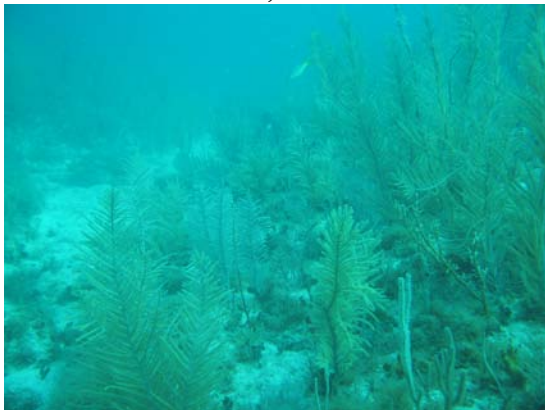
Staghorn patch reef – Site P283 Marker 7, DTNP, 3.7-6.1 m 24° 38.871'N, 82° 53.614'W 	Patchy hard-bottom – Site P1 NW of Texas Rock, 12.5-13.4 m 24° 38.871'N, 82° 53.614'W 
Low-relief hard-bottom – Site P14 West of Pulaski Shoal, 3.0-4.0 m 24° 42.386'N, 82° 50.297'W 	Low-relief spur and groove – Site P220 South of “J” Buoy, 8.5-9.4 m 24° 43.181'N, 82° 49.652'W 
High-relief spur and groove – Site P335 NW of Loggerhead Key, 6.1-8.5 m 24° 38.573'N, 82° 55.855'W 	High-relief reef terrace – Site P4 Loggerhead Forest, 15.2-18.6 m 24° 39.827'N, 82° 55.636'W 

Figure 2-6. Examples of low-relief hard-bottom and coral reef habitats surveyed within Dry Tortugas National Park, including the Research Natural Area, during May-June 2008.

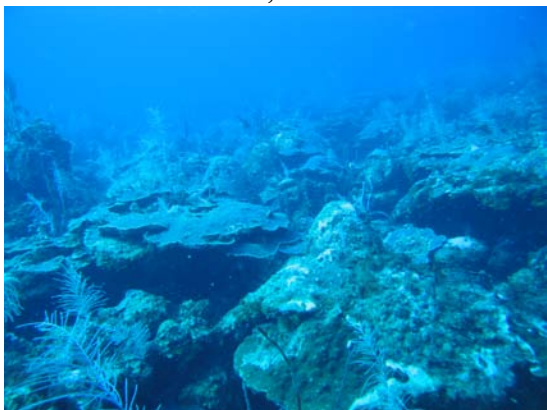
Patchy hard-bottom – Site B263 Southern Tortugas Bank, 14.6-15.8 m 24° 37.000'N, 83° 04.553'W 	Low-relief hard-bottom – Site B255 Southern Tortugas Bank, 14.3-15.5 m 24° 36.616'N, 83° 03.553'W 
Medium-profile reef – Site B231 Eastern Tortugas Bank, 21.0-21.6 m 24° 41.071'N, 83° 00.514'W 	Reef knoll – Site B250 Western Tortugas Bank, 16.5-19.8 m 24° 40.692'N, 83° 03.765'W 
High-relief reef terrace – Site B223 Sherwood Forest, 22.6-24.4 m 24° 43.371'N, 82° 58.772'W 	High-relief reef terrace – Site B238 Little Tortugas Bank, 24.1-26.2 m 24° 42.548'N, 83° 02.450'W 

Figure 2-7. Benthic surveys in the Dry Tortugas region during May-June 2008.

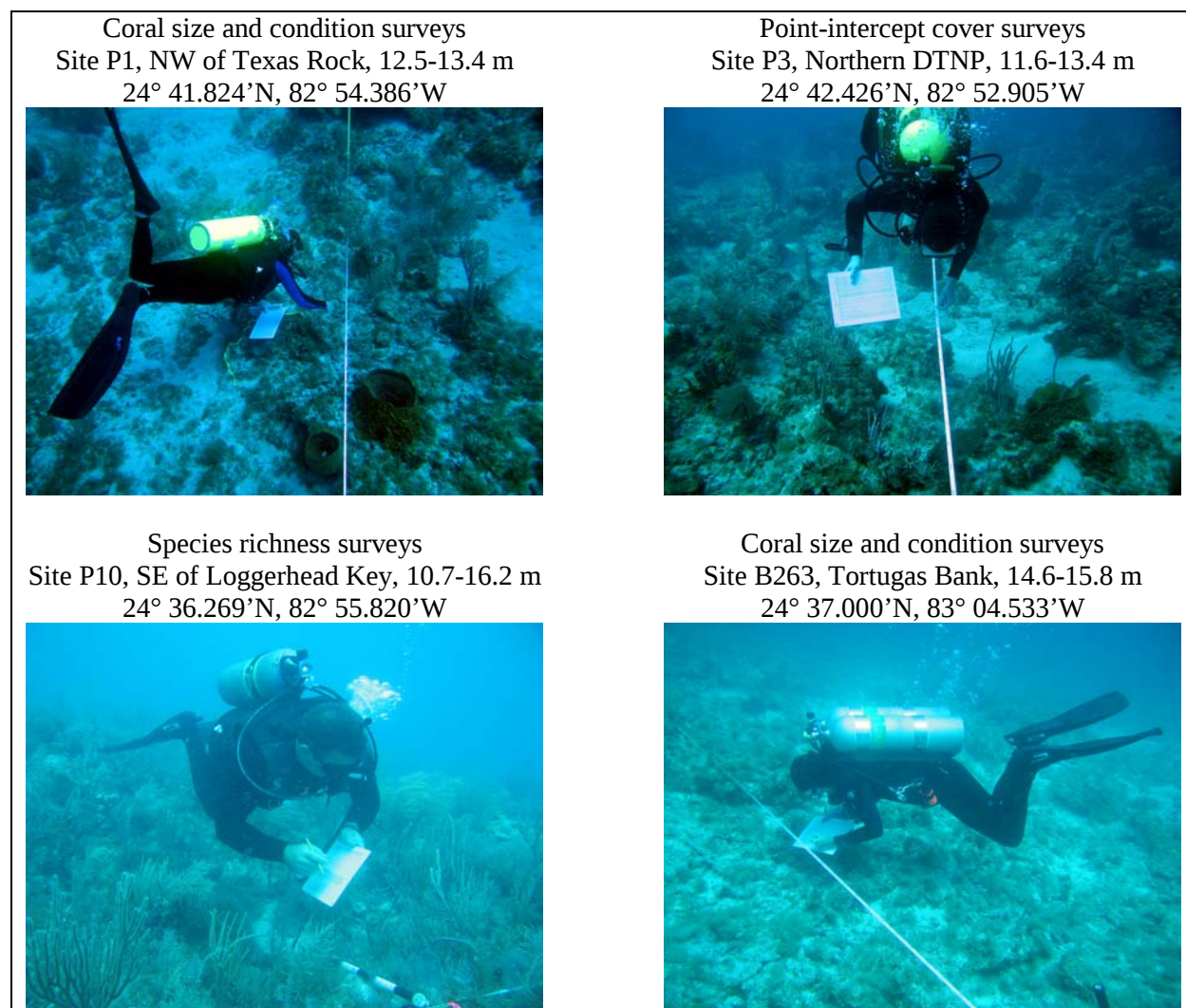


Table 2-1. Chronological list of survey site locations for benthic coral reef organisms in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western Florida Keys National Marine Sanctuary, during May-June 2008. Asterisked sites (**) are within the Research Natural Area of DTNP or the Tortugas North Reserve of the FKNMS. P = sites on the eastern (Park) bank, B = sites on the Tortugas Bank

Date	Site #	Site location	Latitude (N)	Longitude (W)	Habitat type (depth, m)
05/12/08	P1	NW of Texas Rock (I-33)**	24° 41.824	82° 54.386	Patchy hard-bottom (6-15 m)
05/13/08	P2	Northern DTNP (I-36b) **	24° 42.493	82° 51.788	High-relief spur and groove (6-15 m)
05/13/08	P3	Northern DTNP (I-63) **	24° 42.426	82° 52.905	Medium-profile reef (6-15 m)
05/14/08	P4	North of Loggerhead (I-5b) **	24° 39.827	82° 55.636	Reef terrace (15-21 m)
05/14/08	P5	North-central DTNP (I-44) **	24° 41.226	82° 52.999	High-relief spur and groove (6-15 m)
05/15/08	P6	North of Loggerhead (I-38) **	24° 39.418	82° 55.654	Low-relief spur and groove (6-15 m)
05/15/08	P7	NE of Loggerhead (I-26) **	24° 41.043	82° 53.654	Medium-profile reef (< 6 m)
05/16/08	P8	Northeast DTNP (O-82)	24° 43.337	82° 48.552	Medium-profile reef (6-15 m)
05/16/08	P9	Northeast DTNP (O-94)	24° 43.297	82° 48.423	Medium-profile reef (6-15 m)
05/26/08	P10	SE of Loggerhead (I-41)**	24° 36.269	82° 55.820	Medium-profile reef (6-15 m)
05/27/08	P11	SW DTNP (O-42)	24° 34.708	82° 57.882	Medium-profile reef (15-21 m)
05/27/08	P12	SW DTNP (O-84)	24° 34.438	82° 55.557	Medium-profile reef (6-15 m)
05/28/08	P13	NE DTNP (O-56)	24° 43.272	82° 48.135	Medium-profile reef (6-15 m)
05/28/08	P14	West of Pulaski (O-12b)	24° 42.386	82° 50.297	Low-relief hard-bottom (< 6 m)
05/29/08	P15	North of Loggerhead (I-50)**	24° 39.720	82° 55.620	Reef terrace (15-21 m)
05/29/08	P16	Northern DTNP (O-27)	24° 42.195	82° 50.936	Low-relief hard-bottom (< 6 m)
05/29/08	P17	Northern DTNP (O-92)	24° 42.388	82° 50.437	Medium-profile reef (< 6 m)
05/30/08	P18	Eastern DTNP (O-72)	24° 41.732	82° 47.401	Low-relief hard-bottom (< 6 m)
05/31/08	P206	NW of Pulaski Shoal	24° 43.181	82° 49.652	Reef terrace (6-15 m)
05/31/08	P214	Between "J" and "K" buoys	24° 43.514	82° 49.029	Reef terrace (6-15 m)
05/31/08	P220	South of "J" buoy	24° 43.181	82° 49.652	Low-relief spur and groove (6-15 m)
06/01/08	B223	Little Tortugas Bank**	24° 43.371	82° 58.772	Reef terrace (22-27 m)
06/01/08	B231	Tortugas Bank**	24° 41.071	83° 00.514	Medium-profile reef (15-21 m)
06/01/08	B236	Tortugas Bank**	24° 40.703	83° 01.076	Reef knoll (15-21 m)
06/02/08	B238	Sherwood Forest**	24° 42.548	83° 02.450	Reef terrace (22-27 m)
06/02/08	B250	Cooper's Reef**	24° 40.692	83° 03.765	Reef knoll (15-21 m)
06/03/08	B255	Southern Tortugas Bank	24° 36.616	83° 03.553	Low-relief hard-bottom (6-15 m)
06/03/08	B263	Tortugas Bank	24° 37.000	83° 04.553	Patchy hard-bottom (6-15 m)
06/03/08	B267	Tortugas Bank	24° 38.232	82° 03.490	Patchy hard-bottom (6-15 m)
06/04/08	B270	Eastern Tortugas Bank**	24° 39.772	83° 00.555	Patchy hard-bottom (15-21 m)
06/04/08	P276	NW DTNP**	24° 41.772	82° 54.386	Low-relief spur and groove (6-15 m)
06/04/08	P280	NW DTNP (Texas Rock) **	24° 41.145	82° 53.817	Medium-profile reef (6-15 m)
06/04/08	P283	NW DTNP (Marker 7) **	24° 38.871	82° 53.582	Staghorn patch reef (< 6 m)
06/05/08	P287	West of Ft. Jefferson**	24° 37.710	82° 53.614	Staghorn patch reef (< 6 m)
06/06/08	P291	West of Loggerhead Key**	24° 38.499	82° 57.719	Reef knoll (15-21 m)
06/06/08	P297	West of Brilliant Shoal**	24° 40.291	82° 55.498	Reef terrace (15-21 m)
06/07/08	P307	SW of DTNP (near "C" buoy)	24° 34.257	82° 58.204	Patchy hard-bottom (15-21 m)
06/07/08	P311	SW of Loggerhead Key	24° 35.713	82° 57.577	Medium-profile reef (15-21 m)
06/07/08	P319	SW of Loggerhead Reef**	24° 36.871	82° 57.340	Medium-profile reef (6-15 m)
06/08/08	P323	SW of "B" buoy	24° 33.926	82° 56.463	Low-relief hard-bottom (15-21 m)
06/08/08	P327	East of "B" buoy	24° 33.951	82° 55.689	Patchy hard-bottom (6-15 m)
06/08/08	P331	East of SW Channel	24° 35.186	82° 55.155	Medium-profile reef (6-15 m)
06/08/08	P335	NW of Loggerhead Key**	24° 38.573	82° 55.855	High-relief spur and groove (6-15 m)

Table 2-2. Site locations and physical data for benthic coral reef organism surveys in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western Florida Keys National Marine Sanctuary (FKNMS), during May-June 2008. Asterisked sites (**) are within the Research Natural Area (RNA) of DTNP or the Tortugas North Reserve of the FKNMS. Depth range and mean $\pm$ 1 SE maximum vertical relief are based upon four 15-m x 1-m transects per site.

Site number/site location	Latitude (N)	Longitude (W)	Depth range (m)	Max. vertical relief (cm)
<i>Staghorn patch reef (< 6 m)</i>				
RNA – Dry Tortugas National Park				
P283 – Northwestern DTNP (Marker 7)**	24° 38.871	82° 53.582	3.7-6.1	26 $\pm$ 5
P287 – West of Ft. Jefferson**	24° 37.710	82° 53.614	4.3-5.5	17 $\pm$ 2
<i>Patchy hard-bottom (6-15 m)</i>				
RNA – Dry Tortugas National Park				
P1 – NW of Texas Rock**	24° 41.824	82° 54.386	12.5-13.4	58 $\pm$ 7
Reference – FKNMS				
B327 – South of DTNP (East of "B" buoy)	24° 33.951	82° 55.689	13.1-13.7	27 $\pm$ 2
B267 – Tortugas Bank	24° 38.232	83° 03.490	13.4-14.0	39 $\pm$ 3
B263 – Tortugas Bank	24° 37.000	83° 04.553	14.6-15.8	38 $\pm$ 5
<i>Patchy hard-bottom (15-21 m)</i>				
Reference – FKNMS				
P307 – SW of DTNP (near "C" buoy)	24° 34.257	82° 58.204	18.0-18.9	38 $\pm$ 2
Tortugas North Ecological Reserve				
B270 – Eastern Tortugas Bank**	24° 39.772	83° 00.555	19.2-20.1	39 $\pm$ 2
<i>Low-relief hard-bottom (< 6 m)</i>				
Reference – Dry Tortugas National Park				
P18 – Eastern DTNP (O-72)	24° 41.732	82° 47.401	3.7-4.6	58 $\pm$ 6
P14 – West of Pulaski Shoal (O-12b)	24° 42.386	82° 50.297	3.0-4.0	52 $\pm$ 3
P16 – Northern DTNP (O-27)	24° 42.195	82° 50.936	2.4-4.0	40 $\pm$ 4
<i>Low-relief hard-bottom (6-15 m)</i>				
Reference – FKNMS				
B255 – Tortugas Bank (southern end)	24° 36.616	83° 03.553	14.3-15.5	34 $\pm$ 3
<i>Low-relief hard-bottom (15-21 m)</i>				
Reference – FKNMS				
B323 – South of DTNP (SW of "B" buoy)	24° 33.926	82° 56.463	16.5-18.0	48 $\pm$ 8
<i>Low-relief spur and groove (6-15 m)</i>				
Reference – Dry Tortugas National Park				
P220 – Northern DTNP (south of "J" buoy)	24° 43.181	82° 49.652	8.5-9.4	40 $\pm$ 4
RNA – Dry Tortugas National Park				
P276 – Northwestern DTNP**	24° 41.772	82° 54.386	12.2-13.4	51 $\pm$ 16
P6 – North of Loggerhead (I-38)**	24° 39.418	82° 55.654	9.8-14.3	116 $\pm$ 27
<i>Medium-profile reef (< 6 m)</i>				
Reference – Dry Tortugas National Park				
P17 – Northern DTNP (O-92)	24° 42.388	82° 50.437	4.0-5.8	78 $\pm$ 14
RNA – Dry Tortugas National Park				
P7 – NE of Loggerhead (I-26)**	24° 41.043	82° 53.654	4.0-5.2	92 $\pm$ 7
<i>Medium-profile reef (6-15 m)</i>				
RNA – Dry Tortugas National Park				
P3 – Northern DTNP (I-63)**	24° 42.426	82° 52.905	11.6-13.4	75 $\pm$ 7
P280 – Texas Rock**	24° 41.145	82° 53.817	6.4-8.2	49 $\pm$ 9
P10 – SE of Loggerhead (I-41)**	24° 36.269	82° 55.820	10.7-16.2	149 $\pm$ 89
P319 – SW of Loggerhead Reef**	24° 36.871	82° 57.340	11.0-11.6	45 $\pm$ 5

Site number/site location	Latitude (N)	Longitude (W)	Depth range (m)	Max. vertical relief (cm)
<i>Reference – Dry Tortugas National Park</i>				
P13 – Northeastern DTNP (O-56)	24° 43.272	82° 48.135	12.8-14.3	99 ± 11
P9 – Northeastern DTNP (O-94)	24° 43.297	82° 48.423	11.6-14.0	170 ± 72
P8 – Northeastern DTNP (O-82)	24° 43.337	82° 48.552	14.0-14.9	79 ± 9
P331 – East of SW Channel	24° 35.186	82° 55.155	11.6-12.8	49 ± 4
P12 – Southwestern DTNP (O-84)	24° 34.438	82° 55.557	11.6-14.9	63 ± 9
<i>Medium-profile reef (15-21 m)</i>				
<i>Reference – Dry Tortugas National Park</i>				
P311 – SW of Loggerhead Key	24° 35.713	82° 57.577	14.9-16.5	51 ± 6
P11 – Southwestern DTNP (O-42)	24° 34.708	82° 57.882	18.0-20.4	92 ± 8
<i>Reference – FKNMS</i>				
B231 – Tortugas Bank	24° 41.071	83° 00.514	21.0-21.6	56 ± 3
<i>High-relief spur and groove (6-15 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P2 – Northern DTNP (I-36b)**	24° 42.493	82° 51.788	8.5-12.5	131 ± 17
P5 – North-central DTNP (I-44)**	24° 41.226	82° 52.999	10.1-12.2	186 ± 29
P335 – NW of Loggerhead Key**	24° 38.573	82° 55.855	6.1-8.5	106 ± 12
<i>Reef knoll (15-21 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P291 – West of Loggerhead Key**	24° 38.499	82° 57.719	19.5-22.9	178 ± 18
<i>Tortugas North Ecological Reserve</i>				
B236 – Tortugas Bank**	24° 40.703	83° 01.076	15.8-17.7	105 ± 13
B250 – Cooper's Reef**	24° 40.692	83° 03.765	16.5-19.8	115 ± 6
<i>Reef terrace (6-15 m)</i>				
<i>Reference – Dry Tortugas National Park</i>				
P214 – Between "J" and "K" buoys	24° 43.514	82° 49.029	17.4-18.9	76 ± 11
P206 – NW of Pulaski Shoal	24° 43.181	82° 49.652	16.2-17.4	109 ± 10
<i>Reef terrace (15-21 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P297 – West of Brilliant Shoal**	24° 40.291	82° 55.498	15.5-17.1	116 ± 6
P15 – North of Loggerhead (I-50)**	24° 39.720	82° 55.620	15.5-17.1	124 ± 11
P4 – North of Loggerhead (I-5b)**	24° 39.827	82° 55.636	15.2-18.6	103 ± 7
<i>Reef terrace (22-27 m)</i>				
<i>Tortugas North Ecological Reserve</i>				
B223 – Little Tortugas Bank**	24° 43.371	82° 58.772	22.6-24.4	153 ± 13
B238 – Sherwood Forest**	24° 42.548	83° 02.450	24.1-26.2	188 ± 3

Table 2-3. SCUBA diving effort for benthic coral reef surveys in the Tortugas region during May-June 2008.

Scientific Diver	Affiliation	No. of dives	Depth range (ft)	Bottom time (hr)
<i>RSMAS-UM and CMS/UNCW</i>				
Marilyn Brandt	RSMAS-UM	52	11-81	51.52
Mark Chiappone	CMS-UNCW	52	13-82	52.28
Leanne Rutten	CMS-UNCW	47	12-81	49.48
Dione Swanson	RSMAS-UM	22	11-66	22.65
Subtotal		173	11-82	175.93
<i>National Park Service</i>				
Andy Davis	NPS	15	13-59	10.35
Matt Patterson	NPS	18	11-67	11.02
Benjamin Ruttenberg	NPS	33	11-68	27.62
Rob Waara	NPS	33	11-71	25.92
Brian Witcher	NPS	19	11-66	11.30
Subtotal		118	11-71	86.20
Total all divers		291	11-82	262.13

III. Species Richness and Cover

Species richness of stony corals, gorgonians, and sponges

Surveys of the number of species of stony corals (Milleporina and Scleractinia), gorgonians (Octocorallia), and sponges were conducted at all 43 Tortugas sites in 2008. Table 3-1 provides site-level species richness data (number of species per site and number of species per 15-m² transect). A total of 40 stony coral taxa were encountered, with a range of eight to 25 species per 60 m² sample area among sites. Similar to observations in 2006, mid-depth (6-15 m) medium-profile and high-relief spur and groove reefs, as well as shallower and deeper (15+ m) reef knoll and terrace habitats, generally yielded the greatest numbers of coral species (Figure 3-1). In contrast, shallower and patchy or continuous hard-bottom yielded fewer coral species.

A total of 31 gorgonian taxa were encountered during 2008, with site-level species richness ranging from two to 26 species (Table 3-1). Gorgonian site richness exhibited an opposite pattern to stony corals (Figure 3-1), illustrated by relatively high numbers of species on shallower (< 15 m), low- to medium-relief habitats and relatively low species richness on shallower and deeper reef knoll and reef terrace sites. Figure 3-3 illustrates the pattern of gorgonian species richness from the 2008 surveys, particularly the relatively diverse assemblages at several sites within DTNP.

A total of 78 sponge taxa were encountered among the 43 sites, with a range in site-level species richness of nine to 47 species (Table 3-1). Similar to previous years, sponge richness was generally at least twice as great as either for corals or gorgonians. Sponge species richness was relatively high (> 30 species per 60 m²) at most sites except for shallow (< 6 m) low-relief and medium-profile habitats (Figure 3-1). The geographic pattern of sponge species richness from the 2008 surveys indicates relatively diverse assemblages, especially on mid-depth and deeper reef habitats in the southwestern and northern areas of the park (Figure 3-4).

Invertebrate and algal cover

Benthic cover of abiotic (e.g. sand and rubble) and biotic features was assessed at all 43 Tortugas sites in 2008 using the linear point-intercept technique. Table 3-2 provides site-level cover data for corals, sponges, and the colonial zoanthid *Palythoa*, while Table 3-3 provides site-level data on the algae organized by major functional group. Coverage by milleporid hydrocorals (*Millepora alcicornis* and *M. complanata*) was very low among the 43 sites, with a maximum site-level coverage value of 4.3% (Table 3-2). Scleractinian coral cover was as high as 34% among the 43 sites (Table 3-2) and followed an expected habitat- and depth-related pattern documented in previous years (Figure 3-5). Shallow, lower-

relief sites exhibited low coral cover (< 5%), while deeper reef knoll and terrace habitats yielded substantially greater coral abundance (Figure 3-6). The reef terraces west and northwest of Loggerhead Key (Loggerhead Forest), as well as Little Bank and Sherwood Forest on the western Tortugas Bank, had relatively high coral cover largely consisting of mounding species such as *Colpophyllia*, *Montastraea*, and *Siderastrea*. Coral cover for the reef terraces in both the park and Tortugas Bank are similar to results from 2006 (~30%), but are substantially lower than initial surveys back in 1999-2000. Coverage by the colonial zoanthid *Palythoa* was generally < 5% at most sites (Table 3-2), except for a high-relief spur and groove site (P335) northwest of Loggerhead Key, where cover was ~25%. Total sponge cover was also generally low (< 5%) at most sites (Figure 3-5), except for two medium-profile reefs in the southwestern area of the park (Figure 3-7).

Coverage by algae was assessed mostly at the functional group level, except for macroalgae that were identified to the lowest taxonomic level possible in the field (e.g. *Halimeda*, *Dictyota*, and *Lobophora*). Table 3-3 and Figure 3-8 provide site-level coverage data for the functional groups of algae encountered during 2008, while Figures 3-9 to 3-11 show the spatial distribution of cyanobacteria/benthic diatom, macroalgae, and total algal cover. Coverage by cyanobacteria/benthic diatoms was generally low (< 5%) at most sites. However, relatively high coverage (11% to 31%) was recorded at two deeper (22-27 m) reef terrace sites: one on Little Bank and the other at Sherwood Forest. Crustose coralline algae generally covered < 10% of the substratum at most sites and there was no clear pattern among habitats or depths surveyed. Macroalgal cover was upwards of 63% of the substratum, but was usually lower (< 25%) on shallower (< 6 m) sites. Macroalgal cover was relatively high (> 50%) on some of the medium-profile reefs in the southern area of the park between 6 m and 21 m depth. Macroalgae, especially *Lobophora variegata*, were also prevalent along the western area of the park in the Loggerhead Forest reef terrace habitat.

Figure 3-1. Site species richness (no. species per 60 m²) for stony corals (top), gorgonians (middle), and sponges (bottom) at 43 survey locations in the Dry Tortugas region during May-June 2008. See Table 3-1 for habitat and depth designations. Site numbers beginning with “P” in Dry Tortugas National Park and those with “B” are within the FKNMS. Black bars indicate sites within the Research Natural Area of DTNP or the Tortugas North Reserve within the FKNMS.

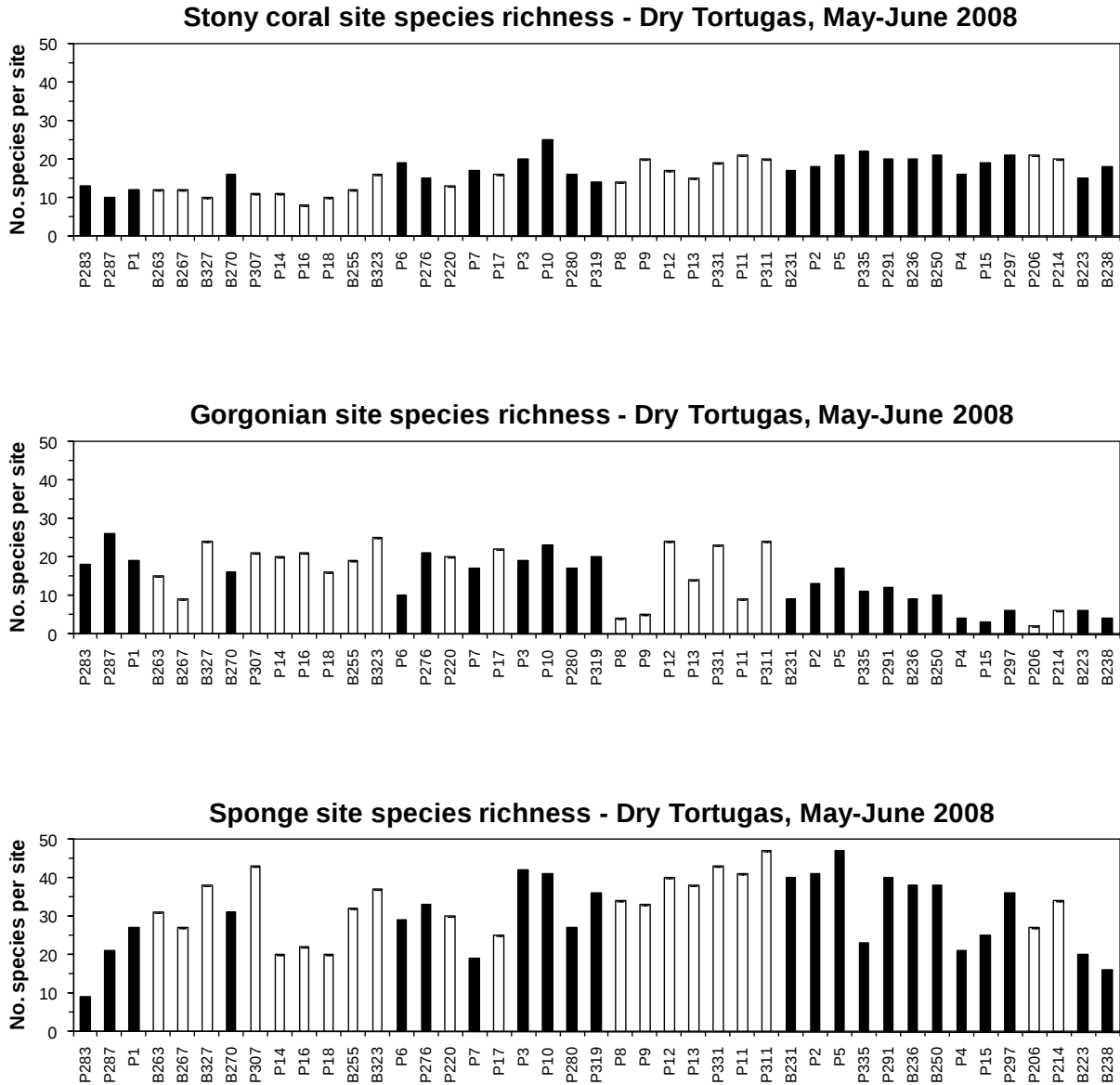


Figure 3-2. Spatial patterns of stony coral (*Milleporina* and *Scleractinia*) species richness (total species recorded per 60 m²) from surveys of 43 sites in the Dry Tortugas region during May-June 2008. Shown are the boundaries of the Research Natural Area (RNA) within DTNP, the Tortugas North Ecological Reserve, and the FKNMS.

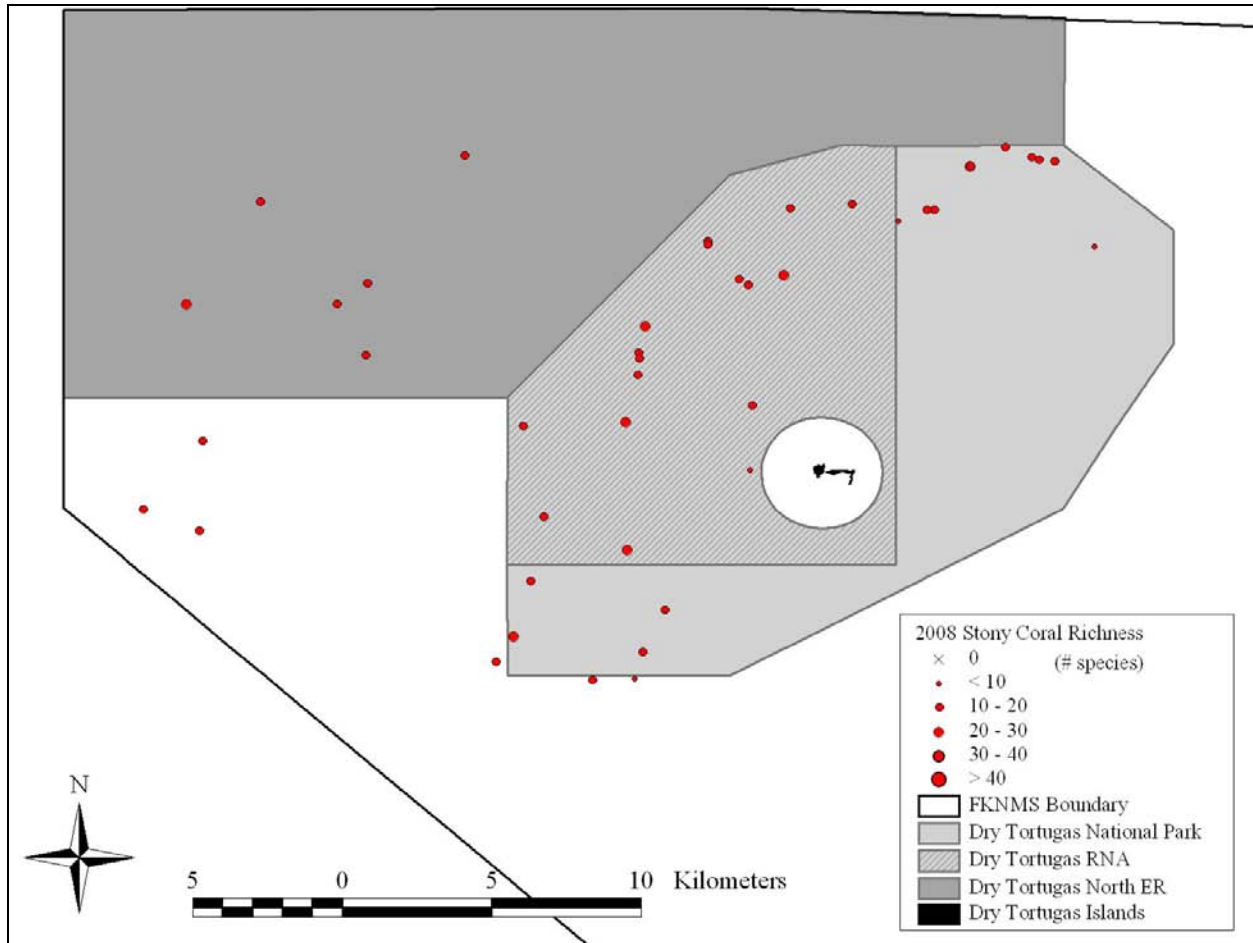


Figure 3-3. Spatial patterns of gorgonian (*Octocorallia*, *Alcyonaria*) species richness (total species recorded per 60 m²) from surveys of 43 sites in the Dry Tortugas region during May-June 2008. Shown are the boundaries of the Research Natural Area (RNA) within DTNP, the Tortugas North Ecological Reserve, and the FKNMS.

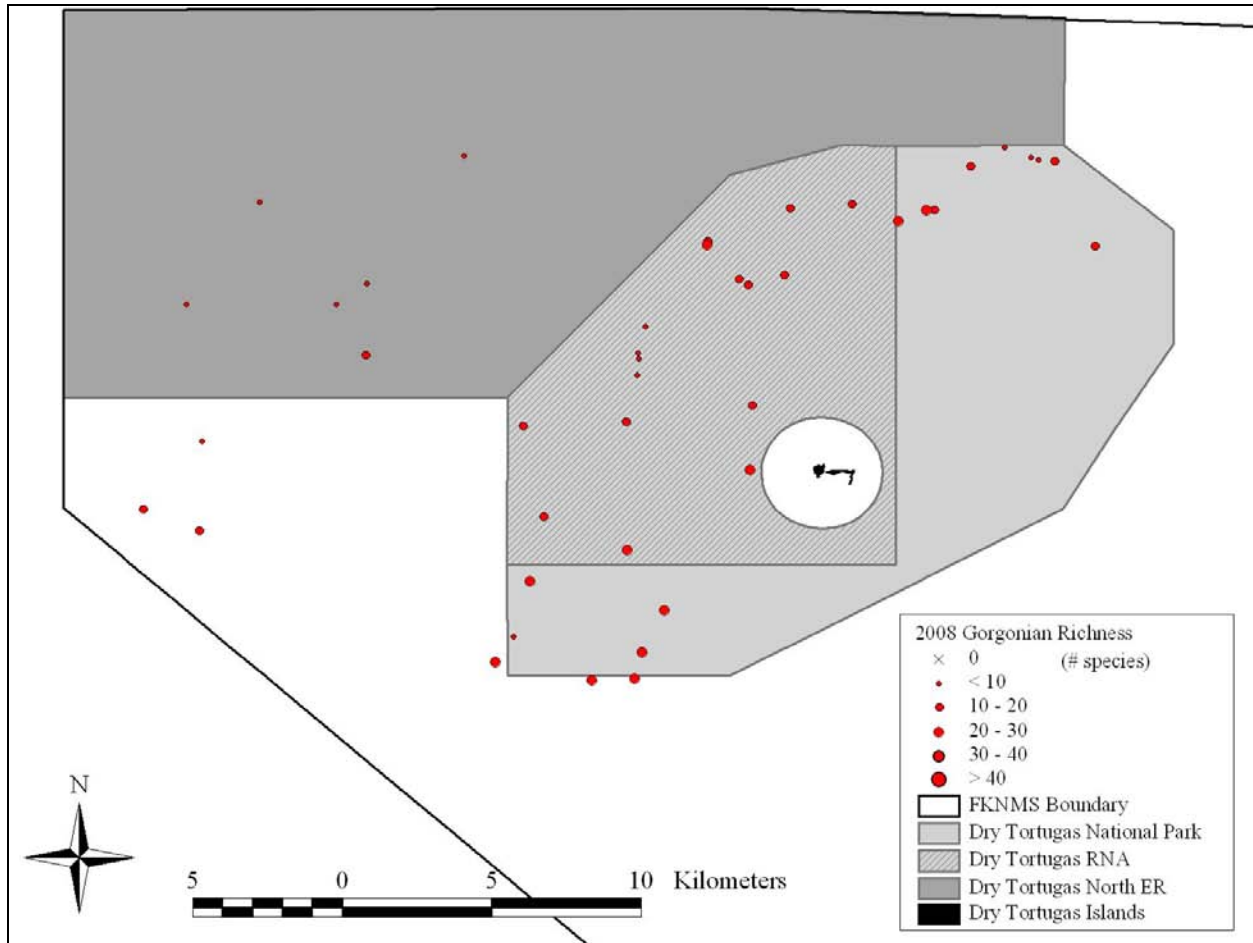


Figure 3-4. Spatial patterns of sponge species richness (total species recorded per 60 m²) from surveys of 43 sites in the Dry Tortugas region during May-June 2008. Shown are the boundaries of the Research Natural Area (RNA) within DTNP, the Tortugas North Ecological Reserve, and the FKNMS.

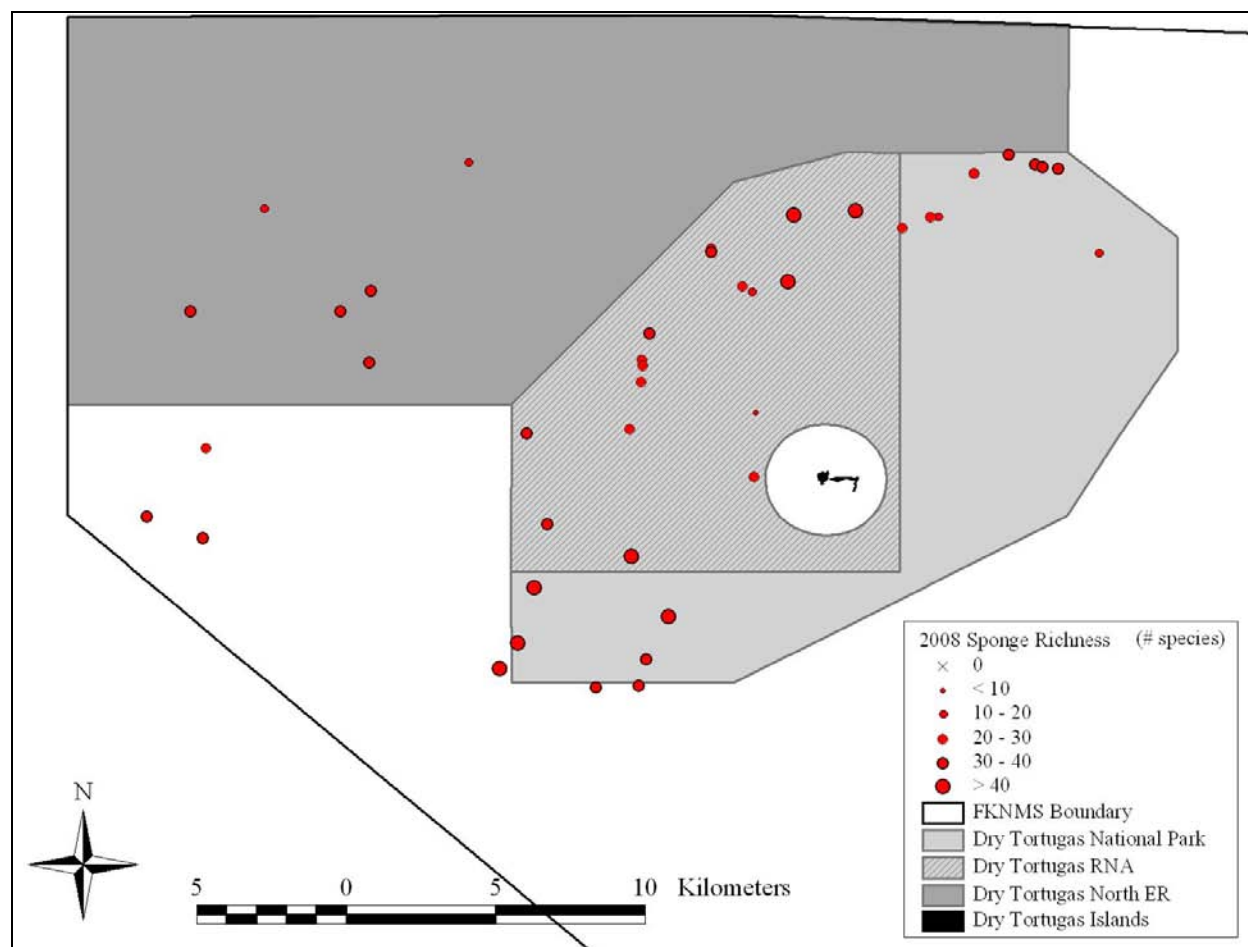


Figure 3-5. Mean (+ 1 SE) percent cover of stony corals (Milleporina and Scleractinia), sponges, and the colonial zoanthid *Palythoa* at survey locations in the Dry Tortugas region during May-June 2008. See Table 3-2 for habitat and depth designations. Site numbers beginning with “P” are in Dry Tortugas National Park and those with “B” are within the FKNMS. Black bars indicate sites within the Research Natural Area of DTNP or the Tortugas North Reserve within the FKNMS.

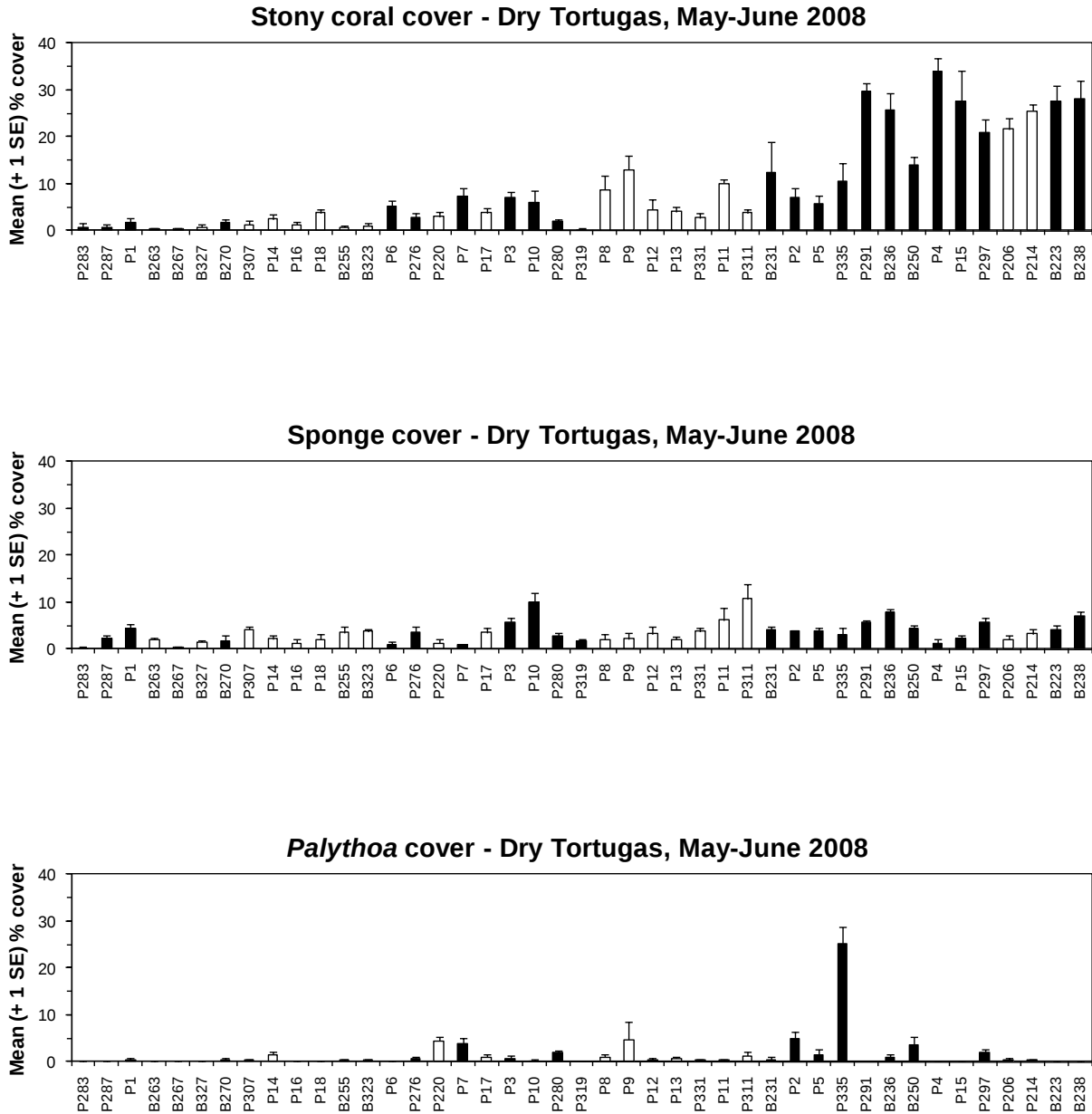


Figure 3-6. Spatial patterns of total coral cover from surveys of 43 sites in the Dry Tortugas region during May-June 2008. Data are based upon averages from surveys of 100 points per transect along four transects per site. Shown are the boundaries of the Research Natural Area (RNA) within DTNP, the Tortugas North Ecological Reserve, and the FKNMS.

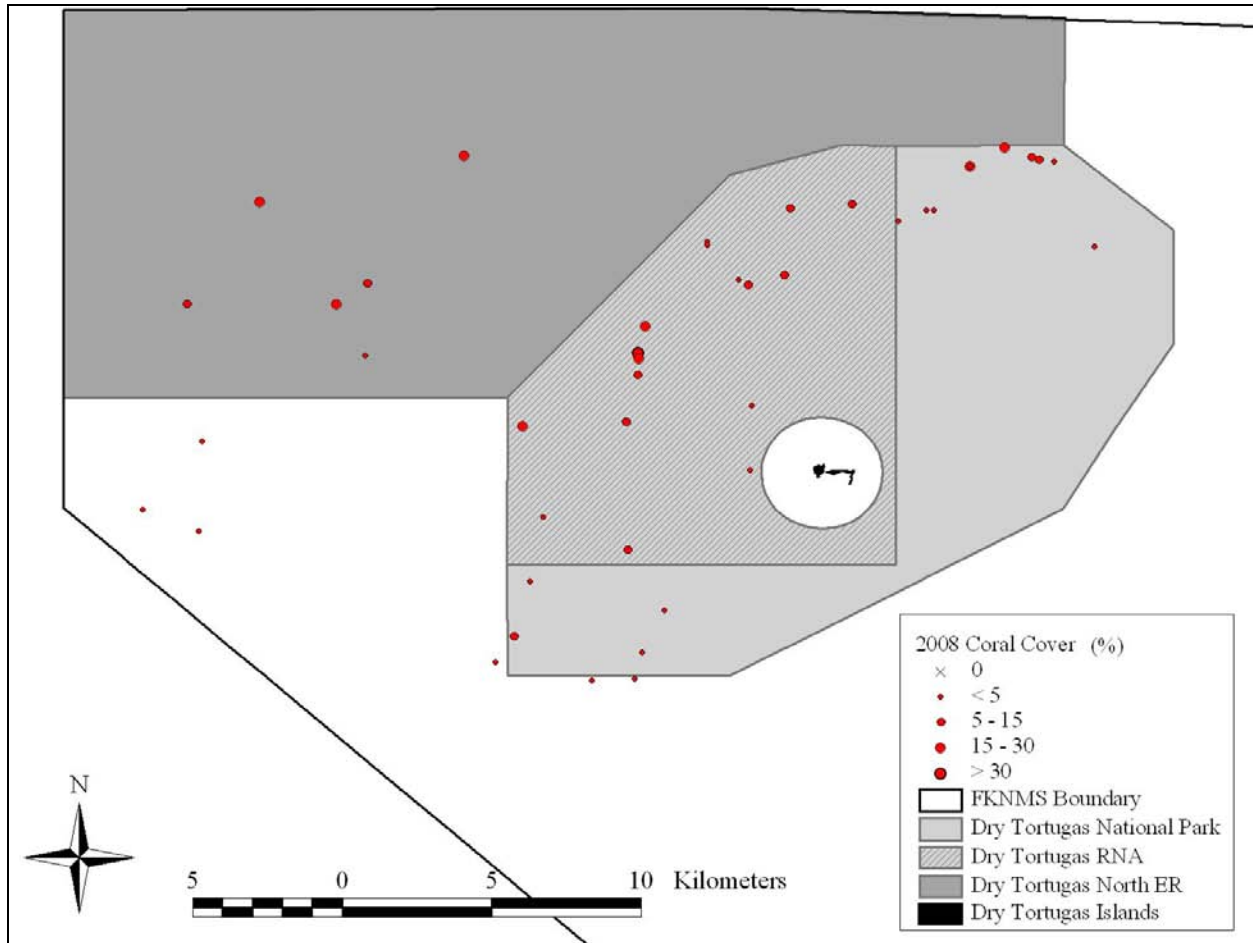


Figure 3-7. Spatial patterns of total sponge cover from surveys of 43 sites in the Dry Tortugas region during May-June 2008. Data are based upon averages from surveys of 100 points per transect along four transects per site. Shown are the boundaries of the Research Natural Area (RNA) within DTNP, the Tortugas North Ecological Reserve, and the FKNMS.

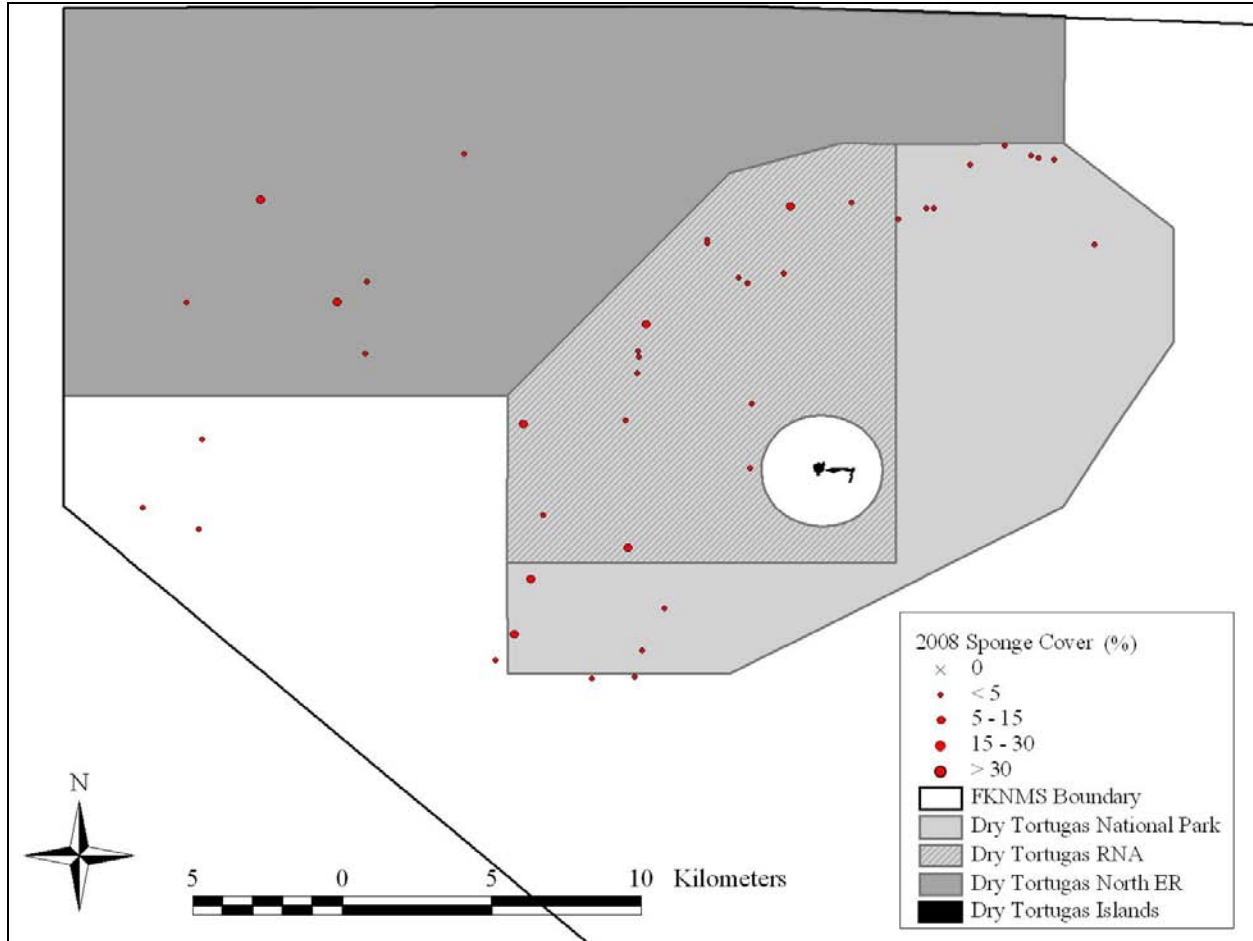


Figure 3-8. Mean (+ 1 SE) percent cover of turf algae, crustose coralline algae and macroalgae at survey locations in the Dry Tortugas region during May-June 2008. See Table 3-3 for habitat and depth designations. Site numbers beginning with “P” are in Dry Tortugas National Park and those with “B” are within the FKNMS. Black bars indicate sites within the Research Natural Area of DTNP or the Tortugas North Reserve within the FKNMS.

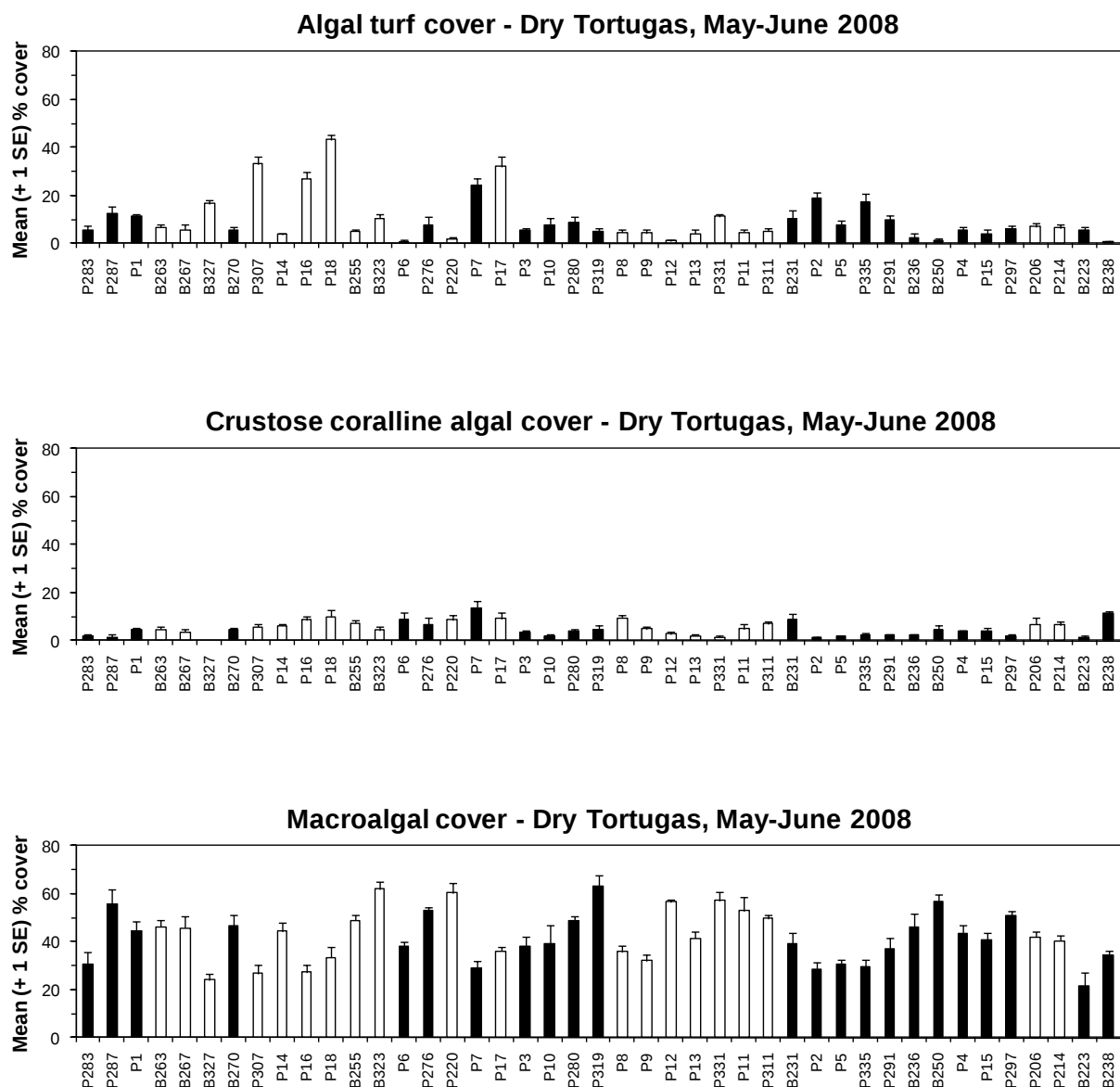


Figure 3-9. Spatial patterns of cyanobacteria/diatom algal cover from surveys of 43 sites in the Dry Tortugas region during May-June 2008. Data are based upon averages from surveys of 100 points per transect along four transects per site. Shown are the boundaries of the Research Natural Area (RNA) within DTNP, the Tortugas North Ecological Reserve, and the FKNMS.

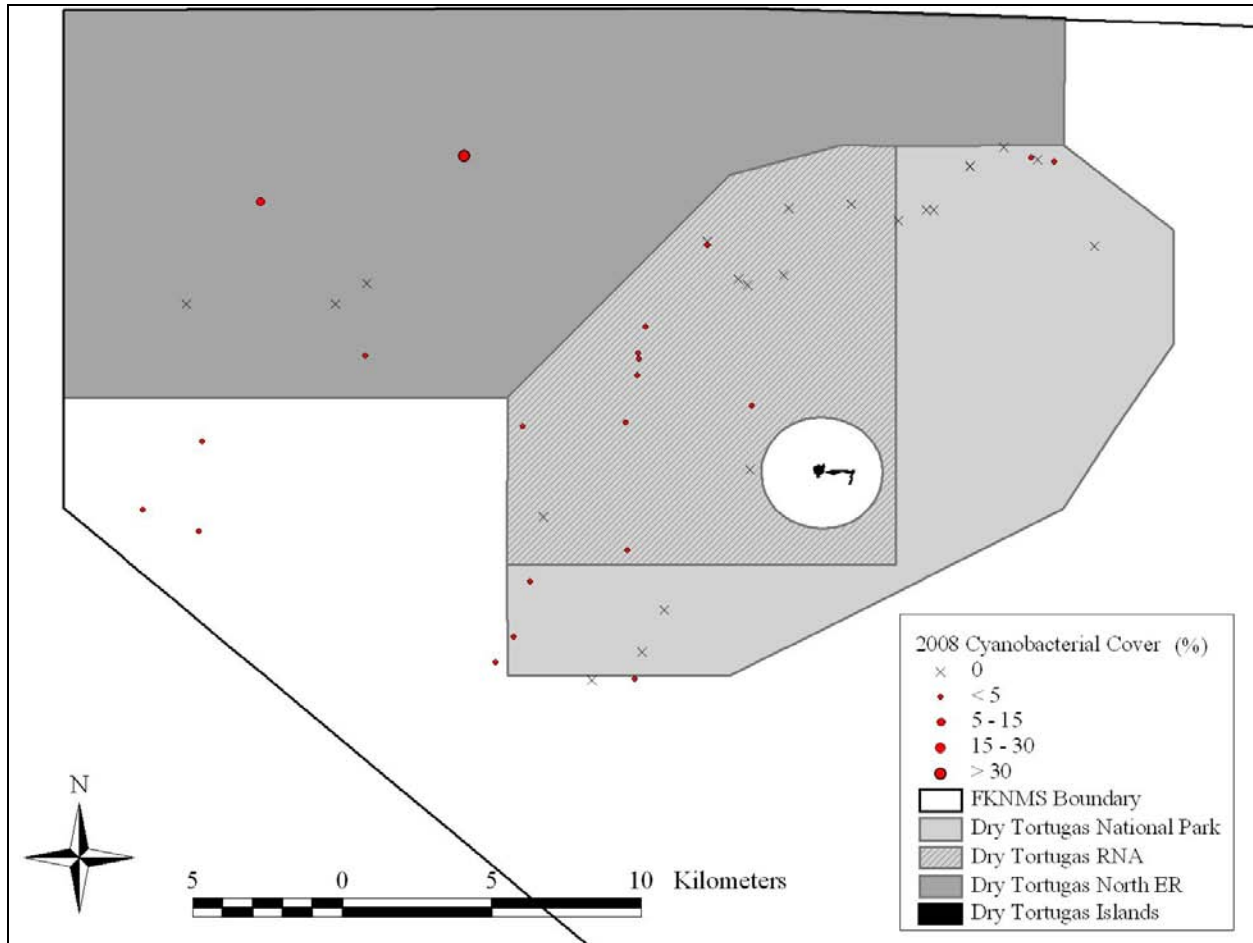


Figure 3-10. Spatial patterns of macroalgal cover from surveys of 43 sites in the Dry Tortugas region during May-June 2008. Data are based upon averages from surveys of 100 points per transect along four transects per site. Shown are the boundaries of the Research Natural Area (RNA) within DTNP, the Tortugas North Ecological Reserve, and the FKNMS. Macroalgae include frondose and foliose species such as *Halimeda*, *Lobophora*, and *Dictyota*.

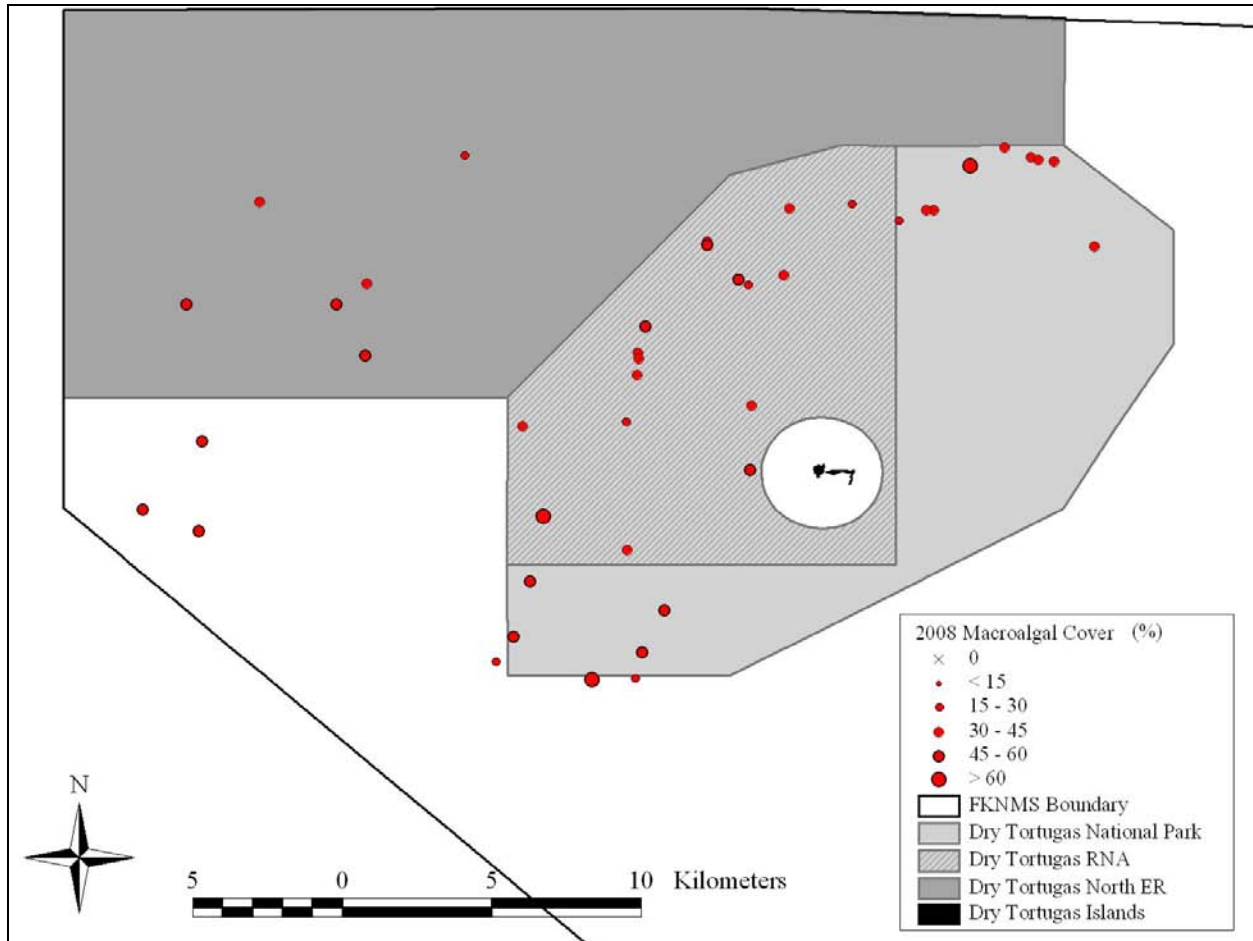


Figure 3-11. Spatial patterns of total algal cover (turfs, crustose corallines, macroalgae) from surveys of 43 sites in the Dry Tortugas region during May-June 2008. Data are based upon averages from surveys of 100 points per transect along four transects per site. Shown are the boundaries of the Research Natural Area (RNA) within DTNP, the Tortugas North Ecological Reserve, and the FKNMS.

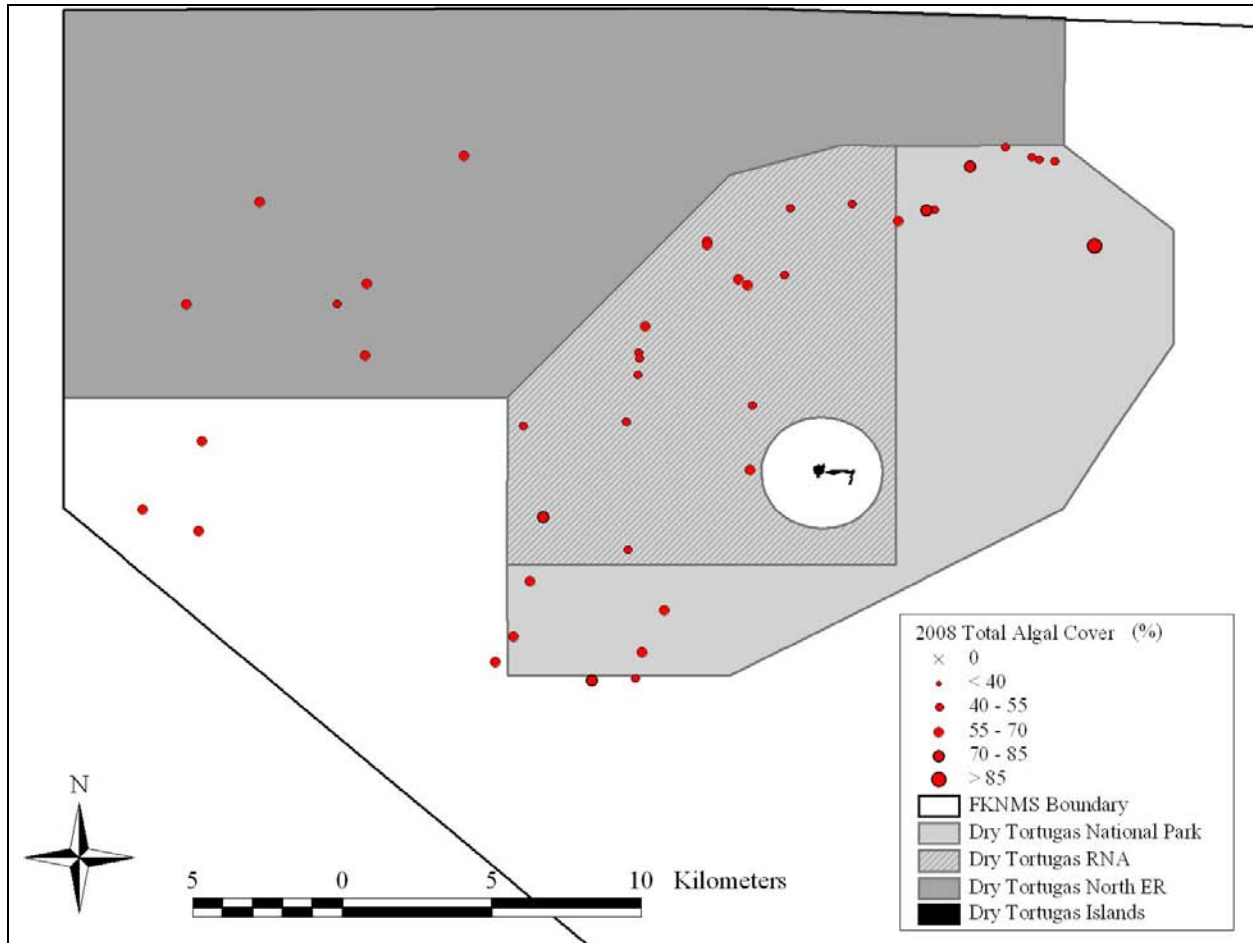


Table 3-1. Site species richness and mean $\pm$ 1 SE numbers of species per 15 m² for stony corals (Milleporina and Scleractinia), gorgonians (Octocorallia), and sponges in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western Florida Keys National Marine Sanctuary (FKNMS). Data are based upon surveys of four 15-m x 1-m belt transects per site at 43 sites during May-June 2008. Sites are arranged by habitat and depth. Asterisked sites (**) are within the Research Natural Area (RNA) of DTNP or the Tortugas North Reserve of the FKNMS.

Site number/site location	Stony Corals		Gorgonians		Sponges	
	Total Species	No. species per 15 m ²	Total Species	No. species per 15 m ²	Total Species	No. species per 15 m ²
<i>Staghorn patch reef (< 6 m)</i>						
RNA – Dry Tortugas National Park						
P283 – Northwestern DTNP (Marker 7)**	13	6.00 $\pm$ 1.29	18	11.50 $\pm$ 1.94	9	4.25 $\pm$ 0.48
P287 – West of Ft. Jefferson**	10	4.25 $\pm$ 0.75	26	19.75 $\pm$ 1.65	21	11.50 $\pm$ 1.32
<i>Patchy hard-bottom (6-15 m)</i>						
RNA – Dry Tortugas National Park						
P1 – NW of Texas Rock**	12	7.00 $\pm$ 0.71	19	14.75 $\pm$ 1.03	27	15.75 $\pm$ 1.97
Reference – FKNMS						
B327 – South of DTNP (East of "B" buoy)	10	4.50 $\pm$ 0.29	24	15.00 $\pm$ 2.04	38	23.00 $\pm$ 0.58
B267 – Tortugas Bank	12	5.75 $\pm$ 0.95	9	5.75 $\pm$ 0.48	27	13.25 $\pm$ 1.75
B263 – Tortugas Bank	12	6.75 $\pm$ 0.25	15	10.75 $\pm$ 0.25	31	16.50 $\pm$ 2.06
<i>Patchy hard-bottom (15-21 m)</i>						
Reference – FKNMS						
P307 – SW of DTNP (near "C" buoy)	11	6.50 $\pm$ 0.96	21	15.00 $\pm$ 2.20	43	26.75 $\pm$ 1.25
Tortugas North Ecological Reserve						
B270 – Eastern Tortugas Bank**	16	8.25 $\pm$ 1.84	16	13.25 $\pm$ 0.48	31	17.75 $\pm$ 0.75
<i>Low-relief hard-bottom (< 6 m)</i>						
Reference – Dry Tortugas National Park						
P18 – Eastern DTNP (O-72)	10	6.50 $\pm$ 0.65	16	10.75 $\pm$ 1.11	20	11.25 $\pm$ 0.63
P14 – West of Pulaski Shoal (O-12b)	11	7.75 $\pm$ 1.44	20	15.50 $\pm$ 0.96	20	11.75 $\pm$ 1.25
P16 – Northern DTNP (O-27)	8	6.00 $\pm$ 0.41	21	15.25 $\pm$ 1.11	22	10.50 $\pm$ 1.26
<i>Low-relief hard-bottom (6-15 m)</i>						
Reference – FKNMS						
B255 – Tortugas Bank (southern end)	12	6.25 $\pm$ 0.25	19	15.25 $\pm$ 1.03	32	21.00 $\pm$ 1.08
<i>Low-relief hard-bottom (15-21 m)</i>						
Reference – FKNMS						
B323 – South of DTNP (SW of "B" buoy)	16	7.50 $\pm$ 0.87	25	17.50 $\pm$ 1.85	37	24.75 $\pm$ 1.03
<i>Low-relief spur and groove (6-15 m)</i>						
Reference – Dry Tortugas National Park						
P220 – Northern DTNP (south of "J" buoy)	13	7.75 $\pm$ 1.11	20	13.75 $\pm$ 1.03	30	15.75 $\pm$ 1.49
RNA – Dry Tortugas National Park						
P276 – Northwestern DTNP**	15	7.75 $\pm$ 1.65	21	16.75 $\pm$ 1.60	33	21.00 $\pm$ 1.47
P6 – North of Loggerhead (I-38)**	19	11.50 $\pm$ 0.87	10	6.25 $\pm$ 0.48	29	17.75 $\pm$ 1.97
<i>Medium-profile reef (< 6 m)</i>						
Reference – Dry Tortugas National Park						
P17 – Northern DTNP (O-92)	16	8.25 $\pm$ 1.11	22	15.50 $\pm$ 1.19	25	14.00 $\pm$ 1.22
RNA – Dry Tortugas National Park						
P7 – NE of Loggerhead (I-26)**	17	11.50 $\pm$ 0.65	17	13.00 $\pm$ 1.08	19	10.00 $\pm$ 0.41
<i>Medium-profile reef (6-15 m)</i>						
RNA – Dry Tortugas National Park						
P3 – Northern DTNP (I-63)**	20	11.00 $\pm$ 1.41	19	13.25 $\pm$ 1.44	42	25.75 $\pm$ 2.14
P280 – Texas Rock**	16	10.75 $\pm$ 0.85	17	14.50 $\pm$ 1.04	27	14.25 $\pm$ 1.31

Site number/site location	Stony Corals		Gorgonians		Sponges	
	Total Species	No. species per 15 m ²	Total Species	No. species per 15 m ²	Total Species	No. species per 15 m ²
P10 – SE of Loggerhead (I-41)**	25	11.50 ± 1.66	23	17.50 ± 2.06	41	26.75 ± 1.18
P319 – SW of Loggerhead Reef**	14	7.00 ± 0.82	20	15.00 ± 2.80	36	22.50 ± 0.96
Reference – Dry Tortugas National Park						
P13 – Northeastern DTNP (O-56)	15	9.75 ± 0.48	14	8.50 ± 0.50	38	21.25 ± 2.29
P9 – Northeastern DTNP (O-94)	20	12.25 ± 0.25	5	3.75 ± 0.48	33	19.00 ± 1.08
P8 – Northeastern DTNP (O-82)	14	9.50 ± 0.87	4	2.75 ± 0.48	34	20.75 ± 1.80
P331 – East of SW Channel	19	10.00 ± 1.35	23	20.50 ± 0.65	43	26.75 ± 1.55
P12 – Southwestern DTNP (O-84)	17	9.75 ± 1.03	24	17.00 ± 1.63	40	26.00 ± 2.12
<i>Medium-profile reef (15-21 m)</i>						
Reference – Dry Tortugas National Park						
P311 – SW of Loggerhead Key	20	10.00 ± 2.04	24	17.75 ± 1.38	47	34.50 ± 0.50
P11 – Southwestern DTNP (O-42)	21	13.50 ± 1.71	9	7.50 ± 0.50	41	28.75 ± 1.49
Reference – FKNMS						
B231 – Tortugas Bank	17	9.75 ± 0.48	9	6.75 ± 0.25	40	23.75 ± 1.31
<i>High-relief spur and groove (6-15 m)</i>						
RNA – Dry Tortugas National Park						
P2 – Northern DTNP (I-36b)**	18	11.25 ± 1.11	13	6.50 ± 1.66	41	22.25 ± 1.93
P5 – North-central DTNP (I-44)**	21	14.75 ± 0.75	17	12.25 ± 1.03	47	29.00 ± 2.55
P335 – NW of Loggerhead Key**	22	14.50 ± 1.19	11	8.25 ± 0.48	23	16.25 ± 1.11
<i>Reef knoll (15-21 m)</i>						
RNA – Dry Tortugas National Park						
P291 – West of Loggerhead Key**	20	14.00 ± 0.71	12	7.25 ± 0.63	40	26.50 ± 0.87
Tortugas North Ecological Reserve						
B236 – Tortugas Bank**	20	12.25 ± 1.49	9	7.00 ± 0.71	38	23.25 ± 2.63
B250 – Cooper's Reef**	21	13.25 ± 0.25	10	7.00 ± 0.41	38	24.00 ± 1.15
<i>Reef terrace (6-15 m)</i>						
Reference – Dry Tortugas National Park						
P214 – Between "J" and "K" buoys	20	12.75 ± 0.63	6	3.25 ± 0.85	34	21.25 ± 0.75
P206 – NW of Pulaski Shoal	21	12.75 ± 0.63	2	1.75 ± 0.25	27	15.00 ± 2.27
<i>Reef terrace (15-21 m)</i>						
RNA – Dry Tortugas National Park						
P297 – West of Brilliant Shoal**	21	13.75 ± 0.85	6	3.75 ± 0.25	36	0.87 ± 1.55
P15 – North of Loggerhead (I-50)**	19	14.00 ± 0.91	3	2.25 ± 0.25	25	13.75 ± 0.85
P4 – North of Loggerhead (I-5b)**	16	12.50 ± 0.96	4	3.25 ± 0.25	21	9.75 ± 0.63
<i>Reef terrace (22-27 m)</i>						
Tortugas North Ecological Reserve						
B223 – Little Tortugas Bank**	15	13.50 ± 0.50	6	4.50 ± 0.50	20	13.50 ± 0.50
B238 – Sherwood Forest**	18	13.50 ± 0.50	4	4.00 ± 0.00	16	10.00 ± 1.00

Table 3-2. Mean $\pm$ 1 SE percent cover of *Millepora* hydrocorals, scleractinian corals, total stony corals, the colonial zoanthid *Palythoa*, and total sponges in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western Florida Keys National Marine Sanctuary (FKNMS). Data are based upon surveys of four 15-m transects per site (100 points per transect) at 43 sites during May-June 2008. Sites are arranged by habitat and depth and asterisked sites (***) are within the Research Natural Area (RNA) of DTNP or the Tortugas North Reserve of the FKNMS.

Site number/site location	<i>Millepora</i>	Scleractinia	Total coral	<i>Palythoa</i>	Sponges
<i>Staghorn patch reef (< 6 m)</i>					
RNA – Dry Tortugas National Park					
P283 – Northwestern DTNP (Marker 7)**	0 $\pm$ 0	0.75 $\pm$ 0.75	0.75 $\pm$ 0.75	0	0.25 $\pm$ 0.25
P287 – West of Ft. Jefferson**	0.50 $\pm$ 0.50	0.25 $\pm$ 0.25	0.75 $\pm$ 0.48	0	2.25 $\pm$ 0.63
<i>Patchy hard-bottom (6-15 m)</i>					
RNA – Dry Tortugas National Park					
P1 – NW of Texas Rock**	0.50 $\pm$ 0.29	1.25 $\pm$ 0.63	1.75 $\pm$ 0.85	0.50 $\pm$ 0.29	4.50 $\pm$ 0.96
Reference – FKNMS					
B327 – South of DTNP (East of "B" buoy)	0.50 $\pm$ 0.29	0.25 $\pm$ 0.25	0.75 $\pm$ 0.48	0	1.50 $\pm$ 0.29
B267 – Tortugas Bank	0 $\pm$ 0	0.25 $\pm$ 0.25	0.25 $\pm$ 0.25	0	0.25 $\pm$ 0.25
B263 – Tortugas Bank	0.25 $\pm$ 0.25	0 $\pm$ 0	0.25 $\pm$ 0.25	0	2.00 $\pm$ 0.41
<i>Patchy hard-bottom (15-21 m)</i>					
Reference – FKNMS					
P307 – SW of DTNP (near "C" buoy)	0.25 $\pm$ 0.25	1.00 $\pm$ 1.00	1.25 $\pm$ 0.95	0.25 $\pm$ 0.25	4.25 $\pm$ 0.63
Tortugas North Ecological Reserve					
B270 – Eastern Tortugas Bank**	0 $\pm$ 0	1.75 $\pm$ 0.75	1.75 $\pm$ 0.75	0.50 $\pm$ 0.29	1.75 $\pm$ 1.11
<i>Low-relief hard-bottom (< 6 m)</i>					
Reference – Dry Tortugas National Park					
P18 – Eastern DTNP (O-72)	3.00 $\pm$ 0.91	0.75 $\pm$ 0.48	3.75 $\pm$ 0.85	0	2.00 $\pm$ 1.22
P14 – West of Pulaski Shoal (O-12b)	0.75 $\pm$ 0.48	1.75 $\pm$ 0.85	2.50 $\pm$ 0.87	1.50 $\pm$ 0.65	2.25 $\pm$ 0.63
P16 – Northern DTNP (O-27)	0.25 $\pm$ 0.25	1.00 $\pm$ 0.71	1.25 $\pm$ 0.63	0	1.25 $\pm$ 0.75
<i>Low-relief hard-bottom (6-15 m)</i>					
Reference – FKNMS					
B255 – Tortugas Bank (southern end)	0.25 $\pm$ 0.25	0.50 $\pm$ 0.29	0.75 $\pm$ 0.25	0.25 $\pm$ 0.25	3.50 $\pm$ 1.26
<i>Low-relief hard-bottom (15-21 m)</i>					
Reference – FKNMS					
B323 – South of DTNP (SW of "B" buoy)	0 $\pm$ 0	1.00 $\pm$ 0.71	1.00 $\pm$ 0.71	0.25 $\pm$ 0.25	3.75 $\pm$ 0.48
<i>Low-relief spur and groove (6-15 m)</i>					
Reference – Dry Tortugas National Park					
P220 – Northern DTNP (south of "J" buoy)	1.00 $\pm$ 0.71	2.00 $\pm$ 0.91	3.00 $\pm$ 1.00	4.50 $\pm$ 0.87	1.25 $\pm$ 0.95
RNA – Dry Tortugas National Park					
P276 – Northwestern DTNP**	1.25 $\pm$ 0.48	1.50 $\pm$ 0.87	2.75 $\pm$ 1.11	0.75 $\pm$ 0.25	3.50 $\pm$ 1.32
P6 – North of Loggerhead (I-38)**	0.25 $\pm$ 0.25	5.00 $\pm$ 1.22	5.25 $\pm$ 1.25	0	1.00 $\pm$ 0.71
<i>Medium-profile reef (< 6 m)</i>					
Reference – Dry Tortugas National Park					
P17 – Northern DTNP (O-92)	0.75 $\pm$ 0.48	3.00 $\pm$ 1.35	3.75 $\pm$ 1.18	1.00 $\pm$ 0.71	3.50 $\pm$ 0.96
RNA – Dry Tortugas National Park					
P7 – NE of Loggerhead (I-26)**	2.00 $\pm$ 1.35	5.25 $\pm$ 0.75	7.25 $\pm$ 1.70	3.75 $\pm$ 1.25	1.00 $\pm$ 0.00
<i>Medium-profile reef (6-15 m)</i>					
RNA – Dry Tortugas National Park					
P3 – Northern DTNP (I-63)**	0.25 $\pm$ 0.25	6.75 $\pm$ 1.44	7.00 $\pm$ 1.35	0.75 $\pm$ 0.48	5.75 $\pm$ 0.85
P280 – Texas Rock**	0.75 $\pm$ 0.25	1.25 $\pm$ 0.48	2.00 $\pm$ 0.41	2.00 $\pm$ 0.41	2.75 $\pm$ 0.75
P10 – SE of Loggerhead (I-41)**	0.75 $\pm$ 0.48	5.25 $\pm$ 2.39	6.00 $\pm$ 2.65	0.25 $\pm$ 0.25	10.00 $\pm$ 1.87
P319 – SW of Loggerhead Reef**	0.25 $\pm$ 0.25	0 $\pm$ 0	0.25 $\pm$ 0.25	0	1.75 $\pm$ 0.48

Site number/site location	<i>Millepora</i>	<i>Scleractinia</i>	Total coral	<i>Palythoa</i>	Sponges
Reference – Dry Tortugas National Park					
P13 – Northeastern DTNP (O-56)	0 ± 0	4.00 ± 1.08	4.00 ± 1.08	0.75 ± 0.25	2.00 ± 0.71
P9 – Northeastern DTNP (O-94)	0 ± 0	13.00 ± 2.94	13.00 ± 2.94	4.75 ± 3.75	2.25 ± 1.31
P8 – Northeastern DTNP (O-82)	0 ± 0	8.75 ± 3.01	8.75 ± 3.01	1.00 ± 0.71	2.00 ± 1.08
P331 – East of SW Channel	0.75 ± 0.48	2.00 ± 0.71	2.75 ± 1.11	0.25 ± 0.25	3.75 ± 0.75
P12 – Southwestern DTNP (O-84)	0.25 ± 0.25	4.25 ± 2.32	4.50 ± 2.22	0.50 ± 0.29	3.25 ± 1.44
<i>Medium-profile reef (15-21 m)</i>					
Reference – Dry Tortugas National Park					
P311 – SW of Loggerhead Key	0.25 ± 0.25	3.50 ± 0.65	3.75 ± 0.85	1.25 ± 0.75	10.75 ± 3.12
P11 – Southwestern DTNP (O-42)	0.25 ± 0.25	9.75 ± 0.95	10.00 ± 1.00	0.25 ± 0.25	6.25 ± 2.56
Reference – FKNMS					
B231 – Tortugas Bank	0.25 ± 0.25	12.25 ± 6.42	12.50 ± 6.38	0.50 ± 0.50	4.00 ± 0.82
<i>High-relief spur and groove (6-15 m)</i>					
RNA – Dry Tortugas National Park					
P2 – Northern DTNP (I-36b)**	2.00 ± 1.35	5.00 ± 2.16	7.00 ± 2.20	5.00 ± 1.47	3.75 ± 0.25
P5 – North-central DTNP (I-44)**	0.75 ± 0.48	5.00 ± 1.58	5.75 ± 1.70	1.50 ± 1.19	3.75 ± 0.85
P335 – NW of Loggerhead Key**	4.25 ± 1.11	6.25 ± 2.78	10.50 ± 3.84	25.25 ± 3.66	3.00 ± 1.58
<i>Reef knoll (15-21 m)</i>					
RNA – Dry Tortugas National Park					
P291 – West of Loggerhead Key**	1.50 ± 0.96	28.25 ± 1.38	29.75 ± 1.70	0	5.75 ± 0.48
Tortugas North Ecological Reserve					
B236 – Tortugas Bank**	1.75 ± 1.03	24.00 ± 3.39	25.75 ± 3.71	1.00 ± 0.71	7.75 ± 0.75
B250 – Cooper's Reef**	3.00 ± 1.73	11.00 ± 0.58	14.00 ± 1.63	3.50 ± 1.71	4.50 ± 0.65
<i>Reef terrace (6-15 m)</i>					
Reference – Dry Tortugas National Park					
P214 – Between "J" and "K" buoys	0 ± 0	25.50 ± 1.55	25.50 ± 1.55	0.25 ± 0.25	3.25 ± 1.11
P206 – NW of Pulaski Shoal	0 ± 0	21.67 ± 2.33	21.67 ± 2.33	0.33 ± 0.33	2.00 ± 1.00
<i>Reef terrace (15-21 m)</i>					
RNA – Dry Tortugas National Park					
P297 – West of Brilliant Shoal**	0.25 ± 0.25	20.75 ± 2.84	21.00 ± 2.80	2.00 ± 0.71	5.75 ± 0.85
P15 – North of Loggerhead (I-50)**	0.50 ± 0.50	27.00 ± 7.04	27.50 ± 6.69	0	2.25 ± 0.75
P4 – North of Loggerhead (I-5b)**	0 ± 0	34.00 ± 2.68	34.00 ± 2.68	0	1.25 ± 0.75
<i>Reef terrace (22-27 m)</i>					
Tortugas North Ecological Reserve					
B223 – Little Tortugas Bank**	0 ± 0	27.50 ± 3.50	27.50 ± 3.50	0	4.00 ± 1.00
B238 – Sherwood Forest**	0 ± 0	28.00 ± 4.00	28.00 ± 4.00	0	7.00 ± 1.00

Table 3-3. Mean $\pm$ 1 SE percent cover of cyanobacteria/benthic diatoms, turf algae, crustose coralline algae (CCA), macroalgae (e.g. *Halimeda* and *Dictyota*) and total algae in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western Florida Keys National Marine Sanctuary (FKNMS). Data are based upon surveys of four 15-m transects per site (100 points per transect) at 43 sites during May-June 2008. Sites are arranged by habitat and depth and asterisked sites (**) are within the Research Natural Area (RNA) of DTNP or the Tortugas North Reserve of the FKNMS.

Site number/site location	Diatoms	Turf algae	CCA	Macroalgae	Total algae
<i>Staghorn patch reef (< 6 m)</i>					
RNA – Dry Tortugas National Park					
P283 – Northwestern DTNP (Marker 7)**	4.75 $\pm$ 3.75	5.50 $\pm$ 1.94	2.00 $\pm$ 0.91	30.50 $\pm$ 5.27	42.75 $\pm$ 4.77
P287 – West of Ft. Jefferson**	0 $\pm$ 0	12.75 $\pm$ 2.78	1.50 $\pm$ 1.19	55.50 $\pm$ 6.36	69.75 $\pm$ 4.33
<i>Patchy hard-bottom (6-15 m)</i>					
RNA – Dry Tortugas National Park					
P1 – NW of Texas Rock**	0 $\pm$ 0	11.50 $\pm$ 0.65	4.50 $\pm$ 0.65	44.50 $\pm$ 3.80	60.50 $\pm$ 3.66
Reference – FKNMS					
B327 – South of DTNP (East of "B" buoy)	0.75 $\pm$ 0.48	16.75 $\pm$ 1.44	0 $\pm$ 0	24.25 $\pm$ 2.56	41.75 $\pm$ 1.65
B267 – Tortugas Bank	2.25 $\pm$ 1.03	5.75 $\pm$ 2.14	3.50 $\pm$ 1.19	45.75 $\pm$ 5.07	57.25 $\pm$ 3.94
B263 – Tortugas Bank	2.00 $\pm$ 0.41	6.75 $\pm$ 1.38	4.75 $\pm$ 1.11	46.25 $\pm$ 2.87	59.75 $\pm$ 1.44
<i>Patchy hard-bottom (15-21 m)</i>					
Reference – FKNMS					
P307 – SW of DTNP (near "C" buoy)	0.25 $\pm$ 0.25	33.25 $\pm$ 2.78	5.75 $\pm$ 1.44	26.75 $\pm$ 3.64	66.00 $\pm$ 1.08
Tortugas North Ecological Reserve					
B270 – Eastern Tortugas Bank**	2.00 $\pm$ 1.41	5.50 $\pm$ 1.19	4.75 $\pm$ 0.75	46.75 $\pm$ 4.31	59.00 $\pm$ 4.56
<i>Low-relief hard-bottom (< 6 m)</i>					
Reference – Dry Tortugas National Park					
P18 – Eastern DTNP (O-72)	0 $\pm$ 0	43.25 $\pm$ 2.29	10.00 $\pm$ 2.80	33.50 $\pm$ 4.44	86.75 $\pm$ 0.95
P14 – West of Pulaski Shoal (O-12b)	0 $\pm$ 0	3.75 $\pm$ 0.75	6.25 $\pm$ 0.75	44.50 $\pm$ 3.30	54.50 $\pm$ 2.33
P16 – Northern DTNP (O-27)	0 $\pm$ 0	27.00 $\pm$ 2.68	8.75 $\pm$ 1.31	27.25 $\pm$ 3.04	63.00 $\pm$ 4.92
<i>Low-relief hard-bottom (6-15 m)</i>					
Reference – FKNMS					
B255 – Tortugas Bank (southern end)	0.25 $\pm$ 0.25	5.25 $\pm$ 0.85	7.25 $\pm$ 1.18	49.00 $\pm$ 2.04	61.75 $\pm$ 2.02
<i>Low-relief hard-bottom (15-21 m)</i>					
Reference – FKNMS					
B323 – South of DTNP (SW of "B" buoy)	0 $\pm$ 0	10.50 $\pm$ 1.66	4.50 $\pm$ 1.19	62.00 $\pm$ 3.00	77.00 $\pm$ 3.03
<i>Low-relief spur and groove (6-15 m)</i>					
Reference – Dry Tortugas National Park					
P220 – Northern DTNP (south of "J" buoy)	0 $\pm$ 0	2.00 $\pm$ 0.71	8.75 $\pm$ 2.02	60.50 $\pm$ 3.77	71.25 $\pm$ 4.75
RNA – Dry Tortugas National Park					
P276 – Northwestern DTNP**	0.25 $\pm$ 0.25	7.50 $\pm$ 3.52	6.50 $\pm$ 2.90	53.00 $\pm$ 1.58	67.25 $\pm$ 2.06
P6 – North of Loggerhead (I-38)**	0.25 $\pm$ 0.25	1.00 $\pm$ 0.58	8.75 $\pm$ 2.95	38.00 $\pm$ 2.16	48.00 $\pm$ 3.51
<i>Medium-profile reef (< 6 m)</i>					
Reference – Dry Tortugas National Park					
P17 – Northern DTNP (O-92)	0 $\pm$ 0	32.00 $\pm$ 4.06	9.25 $\pm$ 2.56	36.25 $\pm$ 1.55	77.50 $\pm$ 3.50
RNA – Dry Tortugas National Park					
P7 – NE of Loggerhead (I-26)**	0 $\pm$ 0	24.25 $\pm$ 3.09	13.75 $\pm$ 2.87	29.00 $\pm$ 3.19	67.00 $\pm$ 2.48
<i>Medium-profile reef (6-15 m)</i>					
RNA – Dry Tortugas National Park					
P3 – Northern DTNP (I-63)**	0 $\pm$ 0	5.50 $\pm$ 0.65	3.50 $\pm$ 0.65	38.25 $\pm$ 3.75	47.25 $\pm$ 3.20
P280 – Texas Rock**	0 $\pm$ 0	9.00 $\pm$ 2.04	3.75 $\pm$ 0.95	48.75 $\pm$ 1.89	61.50 $\pm$ 2.47
P10 – SE of Loggerhead (I-41)**	0.25 $\pm$ 0.25	7.75 $\pm$ 2.95	1.75 $\pm$ 0.85	39.25 $\pm$ 7.49	49.00 $\pm$ 5.26
P319 – SW of Loggerhead Reef**	0 $\pm$ 0	5.00 $\pm$ 1.22	4.75 $\pm$ 1.44	63.25 $\pm$ 4.50	73.00 $\pm$ 2.65

Site number/site location	Diatoms	Turf algae	CCA	Macroalgae	Total algae
<i>Reference – Dry Tortugas National Park</i>					
P13 – Northeastern DTNP (O-56)	0.25 ± 0.25	4.00 ± 1.68	2.00 ± 0.91	41.50 ± 2.99	47.75 ± 3.33
P9 – Northeastern DTNP (O-94)	0 ± 0	4.50 ± 1.32	5.00 ± 1.00	32.25 ± 2.43	41.75 ± 1.80
P8 – Northeastern DTNP (O-82)	0.25 ± 0.25	4.75 ± 0.85	9.50 ± 0.96	35.75 ± 2.84	50.25 ± 3.07
P331 – East of SW Channel	0 ± 0	11.25 ± 1.03	1.50 ± 0.65	57.25 ± 3.71	70.00 ± 3.29
P12 – Southwestern DTNP (O-84)	0 ± 0	1.25 ± 0.48	2.75 ± 1.03	56.75 ± 0.63	60.75 ± 0.63
<i>Medium-profile reef (15-21 m)</i>					
<i>Reference – Dry Tortugas National Park</i>					
P311 – SW of Loggerhead Key	0.25 ± 0.25	5.25 ± 0.95	7.00 ± 1.08	49.75 ± 1.38	62.25 ± 1.60
P11 – Southwestern DTNP (O-42)	0.25 ± 0.25	4.75 ± 1.11	5.00 ± 1.68	53.00 ± 5.45	63.00 ± 6.44
<i>Reference – FKNMS</i>					
B231 – Tortugas Bank	0 ± 0	10.25 ± 3.35	8.75 ± 2.25	39.00 ± 4.64	58.00 ± 4.30
<i>High-relief spur and groove (6-15 m)</i>					
<i>RNA – Dry Tortugas National Park</i>					
P2 – Northern DTNP (I-36b)**	0 ± 0	19.00 ± 2.48	1.50 ± 0.29	28.75 ± 2.87	49.25 ± 4.50
P5 – North-central DTNP (I-44)**	0 ± 0	7.75 ± 1.93	1.75 ± 0.25	30.75 ± 1.89	40.25 ± 1.93
P335 – NW of Loggerhead Key**	0.75 ± 0.75	17.50 ± 3.23	2.25 ± 0.85	29.75 ± 2.78	50.25 ± 5.41
<i>Reef knoll (15-21 m)</i>					
<i>RNA – Dry Tortugas National Park</i>					
P291 – West of Loggerhead Key**	4.25 ± 1.44	10.00 ± 1.96	2.25 ± 0.48	37.00 ± 4.42	53.50 ± 4.37
<i>Tortugas North Ecological Reserve</i>					
B236 – Tortugas Bank**	0 ± 0	2.50 ± 1.89	2.25 ± 0.25	46.00 ± 5.58	50.75 ± 5.19
B250 – Cooper's Reef**	0 ± 0	1.25 ± 0.63	4.75 ± 1.44	56.75 ± 3.15	62.75 ± 4.13
<i>Reef terrace (6-15 m)</i>					
<i>Reference – Dry Tortugas National Park</i>					
P214 – Between "J" and "K" buoys	0 ± 0	6.50 ± 1.66	6.50 ± 1.55	40.50 ± 2.36	53.50 ± 1.19
P206 – NW of Pulaski Shoal	0 ± 0	7.00 ± 1.53	6.67 ± 2.91	42.00 ± 2.08	55.67 ± 0.88
<i>Reef terrace (15-21 m)</i>					
<i>RNA – Dry Tortugas National Park</i>					
P297 – West of Brilliant Shoal**	4.00 ± 1.68	6.25 ± 1.31	2.00 ± 0.71	50.75 ± 1.80	63.00 ± 2.31
P15 – North of Loggerhead (I-50)**	0.75 ± 0.48	4.00 ± 2.00	4.25 ± 1.25	40.75 ± 2.84	49.75 ± 2.10
P4 – North of Loggerhead (I-5b)**	2.25 ± 1.11	5.75 ± 1.31	3.75 ± 0.48	43.25 ± 3.50	55.00 ± 2.92
<i>Reef terrace (22-27 m)</i>					
<i>Tortugas North Ecological Reserve</i>					
B223 – Little Tortugas Bank**	30.50 ± 2.50	5.50 ± 1.50	1.50 ± 0.50	21.50 ± 5.50	59.00 ± 6.00
B238 – Sherwood Forest**	10.50 ± 2.50	1.00 ± 0.00	11.50 ± 0.50	34.50 ± 1.50	57.50 ± 1.50

IV. Coral and Gorgonian Abundance

Coral density, size, and condition

A total of 820 m² of hard-bottom and coral reef habitat was surveyed for the abundance, size, and condition of stony coral colonies among the 43 Tortugas sites. Table 4-1 lists the site-level densities for *Millepora*, Scleractinia, and total stony corals. Of the 3,312 colonies sampled, 915 (28%) colonies were *Millepora* spp., most of which were *M. alcicornis*. A total of 2,397 scleractinian corals representing 40 taxa were identified, counted, and measured for colony condition. Site-level mean densities ranged from 0.25 to 10.92 colonies per m² (Table 4-1) and abundance patterns largely mirrored the pattern of coral cover, meaning greater coral densities were found on mid-depth (6-15 m) and deeper (> 15 m) medium and high-relief reef habitats (Figure 4-1). Deeper reef knoll and reef terrace habitats in both the park and on the Tortugas Bank generally yielded the greatest coral densities (Figure 4-2), observations similar to those in 2006 and previous years. For all 43 sites combined, the dominant scleractinian corals by colony abundance were *Porites astreoides* (497 colonies, 20.7%), *Montastraea cavernosa* (434 colonies, 18.1%), *M. faveolata* (276 colonies, 11.5%), and *Siderastrea siderea* (276 colonies, 11.5%), which comprised ~62% of the total corals sampled. Densities of *Acropora cervicornis* were extremely low at the sites visited during 2008 (maximum of 0.15 colonies per m²) and colonies of this species were only observed at four sites, three of which are shallow (6-15 m) medium-profile reefs within DTNP. For *Montastraea cavernosa*, mean densities of 1+ colonies per m² were recorded at 10 sites, all of which are medium-profile reefs, reef knolls, and reef terraces in both the park and on the Tortugas Bank. A similar pattern was found for *M. faveolata* and *Siderastrea siderea*. *Porites astreoides* was more broadly distributed than these species and was abundant on shallower low-relief hard-bottom and medium-profile reefs in addition to deeper reef habitats.

The coral condition measurements conducted during 2008 included assessments of competition, predation, bleaching, and disease. As in previous years, the disease prevalence in the habitats and depth range surveyed was relatively low (less than 5%), and included black band, “white diseases” such as white plague, and dark spot syndrome. Similar to 2006, there were several locations in 2008 with higher disease prevalence observed, especially white plague. Several disease or disease-like conditions were noted during 2008: 1) dark spot syndrome affecting primarily *Siderastrea siderea* and *Stephanocoenia michelini*, 2) white plague that was affecting a variety of species, 3) dead white skeleton of unknown causes, perhaps caused by snail predation, and 4) tissue necrosis (Figure 4-3). A summary of the size and percent dead skeleton for some of the more common species, as well as the more important reef framework builders, is as follows. A total of 68 colonies of *Colpophyllia natans* were measured, with a range and mean in maximum diameter of 6-200 cm and 53 ± 6 cm, respectively. The percentage of the

colony that was dead skeleton (and not live tissue) ranged from 0% (completely alive) to 91%, with a mean of $20 \pm 3\%$. For *Diploria strigosa*, a total of 50 colonies measured, with a range and mean in maximum diameter of 4-40 cm and 14 ± 1 cm, respectively. The percentage of dead skeleton among the colonies ranged from 0% (completely alive) to 75%, with a mean of $10 \pm 3\%$. Of the 434 *Montastraea cavernosa* colonies measured, the maximum diameter ranged from 4-100 cm, with a mean of 21 ± 1 cm. Percent dead skeleton ranged from 0% (completely alive) to 99%, averaging $17 \pm 1\%$. A total of 276 colonies of *M. faveolata* and *Siderastrea siderea* were assessed, with a range in maximum diameter of 6-255 cm (mean of 54 ± 3 cm) and 4-70 cm (mean of 16 ± 1 cm), respectively. Percent dead skeleton for *M. faveolata* and *S. siderea* averaged $27 \pm 2\%$ and $15 \pm 3\%$, respectively. The most abundant coral sampled, *Porites astreoides*, ranged in maximum diameter from 2 cm to 79 cm (mean 9.8 ± 0.3 cm) and the mean percent dead skeleton averaged $11 \pm 1\%$.

Juvenile coral density

Scleractinian corals less ≤ 4.0 cm in maximum diameter were assessed in ten 0.65-cm x 0.48-cm quadrats sampled along each of two transects (6.24 m^2 per site) per site at the 43 Tortugas sites during May-June 2008 (except at site P276 = 5.62 m^2 , B231 = 5.93 m^2 , B223 = 3.12 m^2). Juveniles generally represent individuals that have recently (within 2 years) settled and survived. We can typically identify juvenile corals down to a size of ~ 0.5 cm. Table 4-2 summarizes site-level densities, as well as the number of scleractinian taxa observed as juveniles and the predominant species for each site. A total of 979 corals representing at least 30 scleractinian coral taxa were identified in quadrat surveys among the 43 sites. The range in mean juvenile densities was 0.96 to 8.01 per m^2 . Although mean juveniles densities of less than 5 per m^2 were recorded at 35 of the 43 sites, the range among sites was within the range observed in the rest of the Florida Keys. There was no clear pattern among habitats or depths in terms of total juvenile coral densities (Figure 4-1). The greatest number of species encountered (10-11 coral taxa) occurred at two patchy hard-bottom sites south of the park and on the eastern Tortugas Bank. Greater juvenile densities ($> 5 \text{ per m}^2$) were generally recorded from mid-depth (6-15) and deeper (15-21 m) low-relief or patchy hard-bottom on the Tortugas Bank, or medium-profile reefs at 15-21 m deep within DTNP (Figure 4-4). In contrast, deeper (15+ m) and higher-relief reef knoll and terrace habitats yielded low numbers of coral taxa and densities of juvenile corals.

Of the 979 juvenile corals identified and counted during 2008, four species comprised 71% of all juvenile corals encountered: *Siderastrea siderea* (228 juveniles, 23% of the total), *Porites astreoides* (202 juveniles, 21%), *Montastraea cavernosa* (154 juveniles, 16%), and *Stephanocoenia michelini* (108 juveniles, 11%). One or more of these species tended to dominant the juvenile assemblage at most of the

sites sampled during 2008 (Table 4-1). One pattern that is noteworthy is the predominance of broadcast spawning species dominating the juvenile coral assemblage, which may partly be a reflection of the depth of the habitats surveyed in the Tortugas region. Although *P. astreoides* dominates the juvenile coral assemblage in many habitats in the rest of the Florida Keys, and juveniles of *S. siderea* are abundant in the patch reef environment, the Tortugas region is clearly unique in terms of the relative abundance pattern.

Gorgonian density

Gorgonians were sampled in replicate 8-m x 1-m belt transect areas per site at all 43 Tortugas sites except site B223, where only one transect was sampled. A total of 7,896 colonies were recorded from surveys of 680 m² of hard-bottom and coral reef habitat. Table 4-3 provides site-level densities and the dominant species for the 43 Tortugas sites sampled in 2008. Mean gorgonian densities tended to be greater on shallower (< 15 m) and lower relief sites, similar to surveys in previous years. Mean site-level densities of gorgonians ranged from 1.5 to 32.8 colonies per m² (Figure 4-1). Relatively high densities (> 20 colonies per m²) were recorded from patch reefs previously dominated by staghorn coral (*Acropora cervicornis*), shallow (< 6 m) and deeper (6-15 m) hard-bottom areas, and shallow (< 6 m) medium-profile reefs within the park (Figure 4-5). Several of the deeper reef habitats (medium-profile reefs and reef terraces) in both DTNP and the Tortugas Bank had abundant encrusting gorgonians comprised of *Briareum asbestinum* and *Erythropodium caribaeorum*. Four species comprised nearly 50% of all gorgonians found among the 43 sites: *B. asbestinum* (1,181 colonies, 15% of the total), *E. caribaeorum* (690 colonies, 9%), *Plexaura flexuosa* (1,059 colonies, 13%), and the sea plumes *Pseudopterogorgia americana* (833 colonies, 11%), and *P. acerosa* (671 colonies, 9%). Areas near the southern extent of the park and the central Tortugas Bank are still relatively denuded relative to 1999-2000, but are recovering relative to 2006 after a series of tropical cyclones passed through the Tortugas region in 2005.

Figure 4-1. Mean (+ 1 SE) density (no. colonies/m²) of corals and gorgonians in the Dry Tortugas region during May-June 2008. See Table 4-1 for habitat and depth designations.

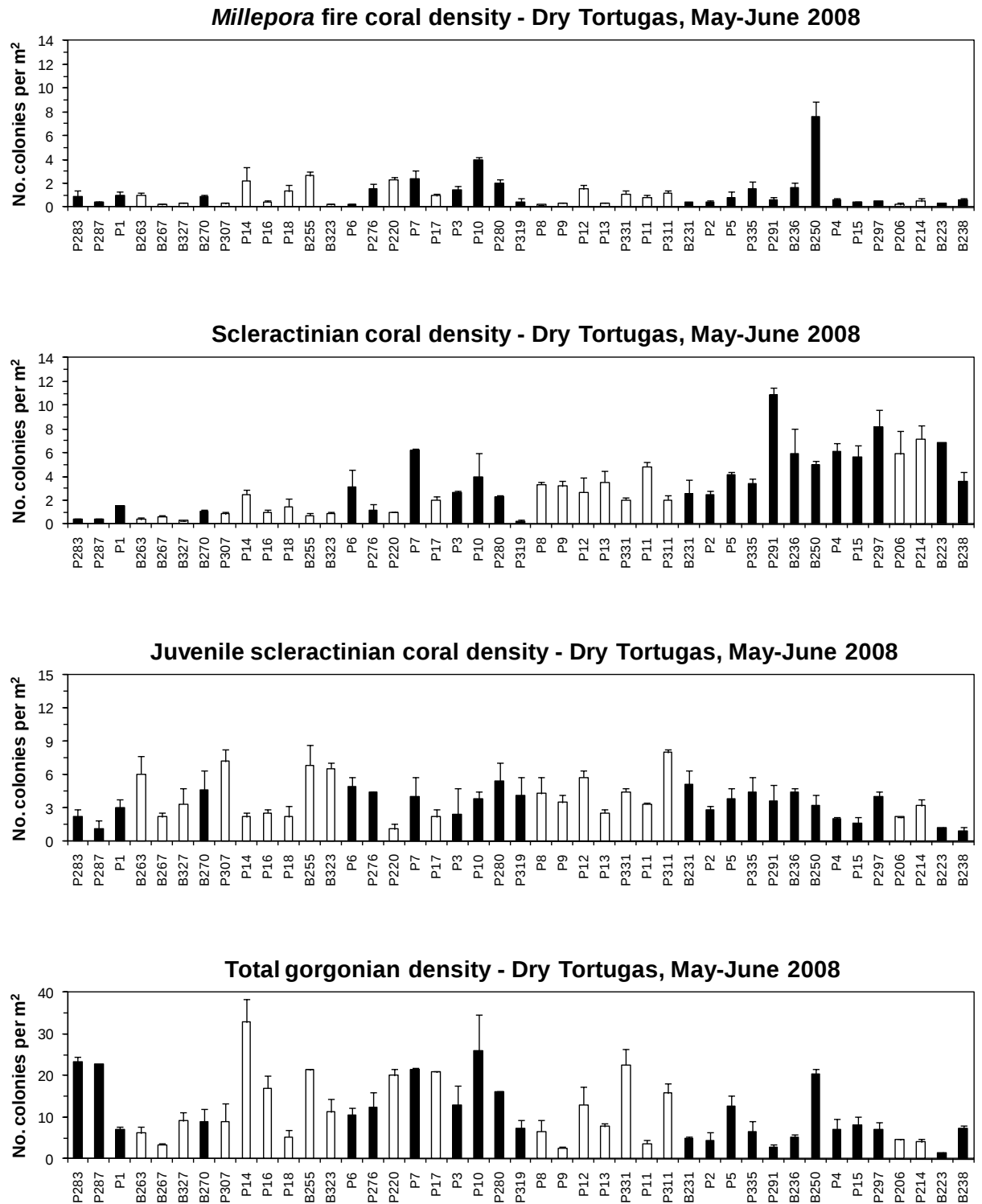


Figure 4-2. Spatial patterns of scleractinian coral density (no. colonies per m²) from surveys of 43 sites in the Dry Tortugas region during May-June 2008. Data are based upon averages from surveys of two replicate 10-m² belt transects per site. Shown are the boundaries of the Research Natural Area (RNA) within DTNP, the Tortugas North Ecological Reserve, and the FKNMS.

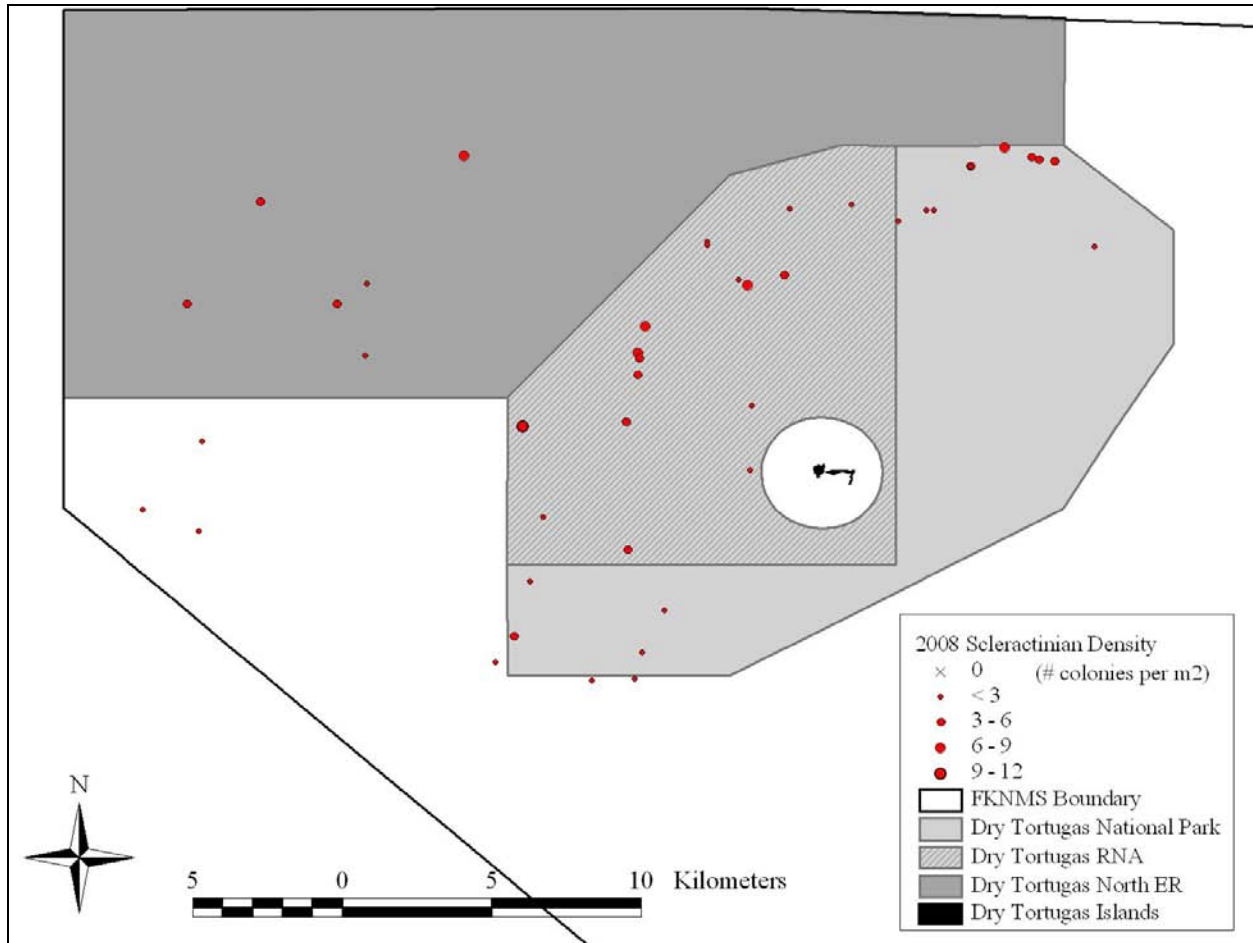


Figure 4-3. Disease-like symptoms, coral overgrowth, and predation on scleractinian reef corals in the Dry Tortugas region during May-June 2008.

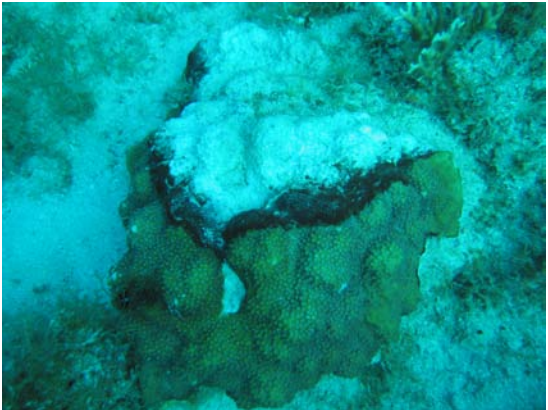
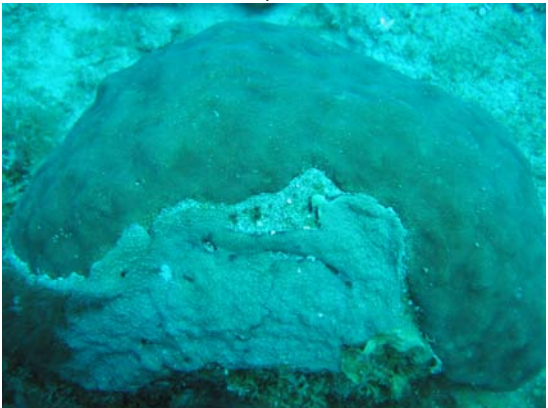
<i>Siderastrea siderea</i> – Site #5 <i>Cliona delitrix</i> boring, North-central DTNP 24° 41.226'N, 82° 52.999'W 	<i>Stephanocoenia michelini</i> - Site #11 Snail predation, Southwestern DTNP 24° 34.708'N, 82° 57.882'W 
<i>Montastraea faveolata</i> – Site #13 Black-band disease, Northeastern DTNP 24° 43.272'N, 82° 48.135'W 	<i>Siderastrea siderea</i> – Site #14 Dark-spot syndrome, West of Pulaski Shoal 24° 42.386'N, 82° 50.297'W 
<i>Stephanocoenia michelini</i> – Site #15 Gorgonian overgrowth, North of Loggerhead 24° 39.720'N, 82° 55.620'W 	<i>Montastraea faveolata</i> – Site #223 White plague, Little Tortugas Bank 24° 43.371'N, 82° 58.772'W 

Figure 4-4. Spatial patterns of juvenile (< 4 cm max. diameter) scleractinian coral density (no. colonies per m²) from surveys of 43 sites in the Dry Tortugas region during May-June 2008. Data are based upon averages from surveys of two replicate 3.12-m² belt transects per site. Shown are the boundaries of the Research Natural Area (RNA) within DTNP, the Tortugas North Ecological Reserve, and the FKNMS.

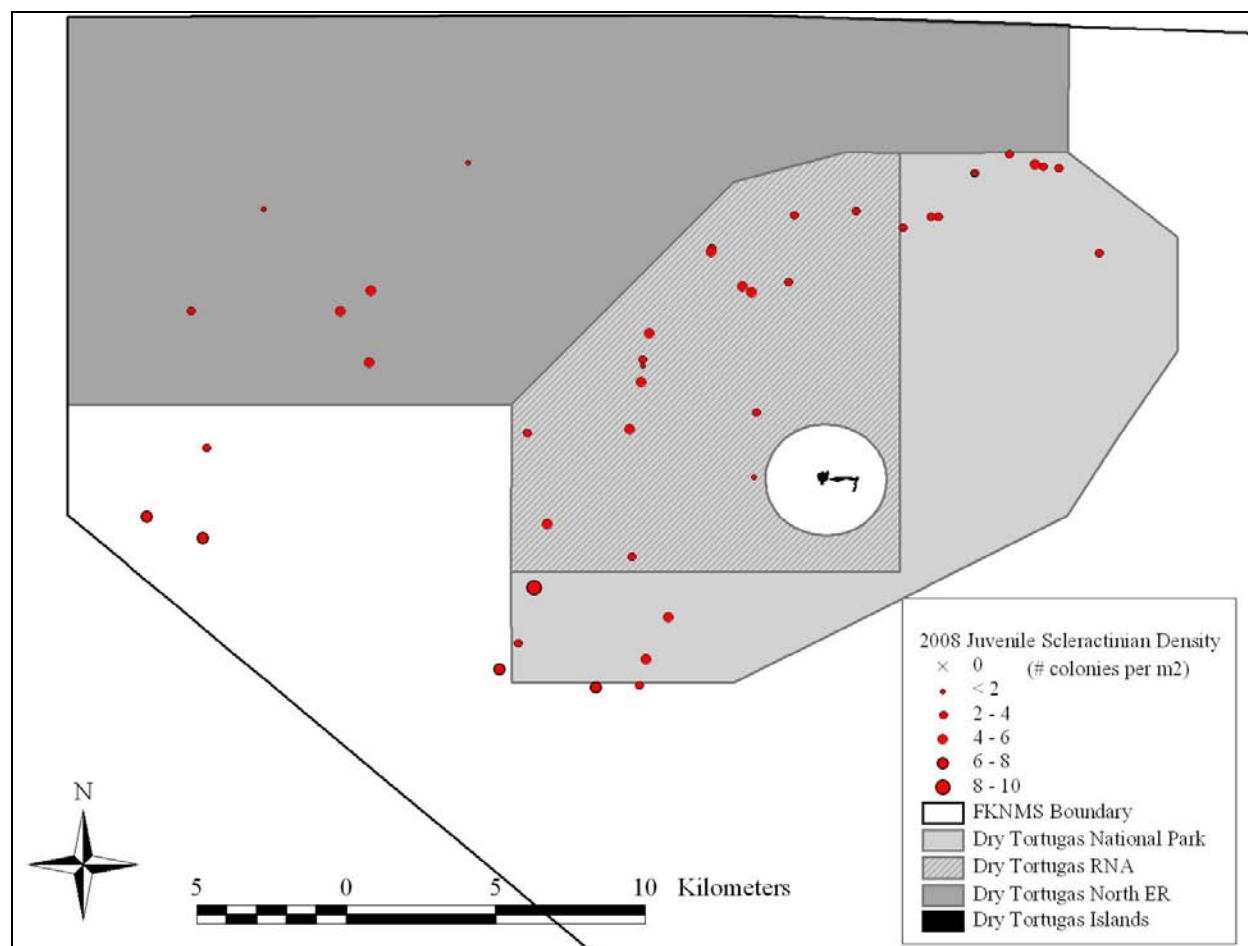


Figure 4-5. Spatial patterns of total gorgonian density (no. colonies per m²) from surveys of 43 sites in the Dry Tortugas region during May-June 2008. Data are based upon averages from surveys of two replicate 8-m² belt transects per site. Shown are the boundaries of the Research Natural Area (RNA) within DTNP, the Tortugas North Ecological Reserve, and the FKNMS.

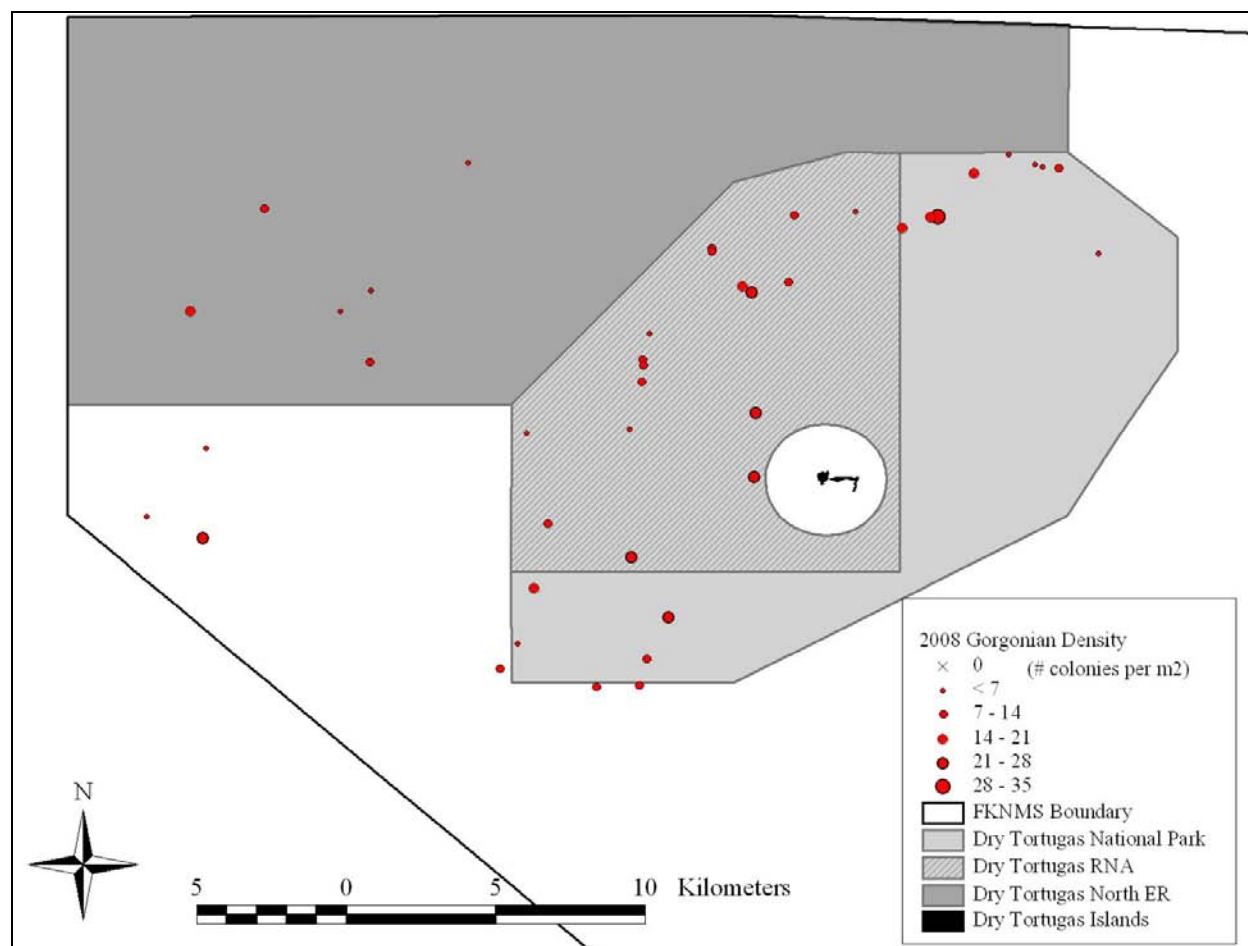


Table 4-1. Numbers of colonies (N) and mean $\pm$ 1 SE colony densities (no. per m²) of milleporid hydrocorals, total scleractinian corals, and total stony corals in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western Florida Keys National Marine Sanctuary (FKNMS). Data are based upon surveys of two 10-m x 1-m transects (20 m²) per site at 43 sites during May-June 2008, except at sites P291 (12 m²), B236 (17 m²), B250 (14 m²), P214 (18 m²), P206 (16 m²), P297 (16 m²), and B223 (7 m²). Sites are arranged by habitat and depth. Asterisk sites (**) are within the Research Natural Area (RNA) of DTNP or the Tortugas North Reserve of the FKNMS.

Site number/site location	<i>Millepora</i> spp.		Scleractinian corals		Total stony corals	
	N	No. per m ²	N	No. per m ²	N	No. per m ²
<i>Staghorn patch reef (< 6 m)</i>						
RNA – Dry Tortugas National Park						
P283 – NW DTNP (Marker 7)**	17	0.85 $\pm$ 0.55	8	0.40 $\pm$ 0.10	25	1.25 $\pm$ 0.65
P287 – West of Ft. Jefferson**	9	0.45 $\pm$ 0.05	8	0.40 $\pm$ 0.10	17	0.85 $\pm$ 0.15
<i>Patchy hard-bottom (6-15 m)</i>						
RNA – Dry Tortugas National Park						
P1 – NW of Texas Rock**	20	1.00 $\pm$ 0.30	31	1.55 $\pm$ 0.05	51	2.55 $\pm$ 0.25
Reference – FKNMS						
B327 – South of DTNP (East of "B" buoy)	7	0.35 $\pm$ 0.05	6	0.30 $\pm$ 0.00	13	0.65 $\pm$ 0.05
B267 – Tortugas Bank	4	0.20 $\pm$ 0.10	13	0.65 $\pm$ 0.05	17	0.85 $\pm$ 0.05
B263 – Tortugas Bank	20	1.00 $\pm$ 0.20	8	0.40 $\pm$ 0.20	28	1.40 $\pm$ 0.40
<i>Patchy hard-bottom (15-21 m)</i>						
Reference – FKNMS						
P307 – SW of DTNP (near "C" buoy)	6	0.30 $\pm$ 0.10	17	0.85 $\pm$ 0.15	23	1.15 $\pm$ 0.25
Tortugas North Ecological Reserve						
B270 – Eastern Tortugas Bank**	17	0.85 $\pm$ 0.15	22	1.10 $\pm$ 0.10	39	1.95 $\pm$ 0.05
<i>Low-relief hard-bottom (< 6 m)</i>						
Reference – Dry Tortugas National Park						
P18 – Eastern DTNP (O-72)	27	1.35 $\pm$ 0.55	29	1.45 $\pm$ 0.65	56	2.80 $\pm$ 1.20
P14 – West of Pulaski Shoal (O-12b)	44	2.20 $\pm$ 1.20	50	2.50 $\pm$ 0.40	94	4.70 $\pm$ 0.80
P16 – Northern DTNP (O-27)	9	0.45 $\pm$ 0.15	20	1.00 $\pm$ 0.20	29	1.45 $\pm$ 0.35
<i>Low-relief hard-bottom (6-15 m)</i>						
Reference – FKNMS						
B255 – Tortugas Bank (southern end)	53	2.65 $\pm$ 0.35	14	0.70 $\pm$ 0.20	67	3.35 $\pm$ 0.55
<i>Low-relief hard-bottom (15-21 m)</i>						
Reference – FKNMS						
B323 – South of DTNP (SW of "B" buoy)	4	0.20 $\pm$ 0.10	18	0.90 $\pm$ 0.10	22	1.10 $\pm$ 0.00
<i>Low-relief spur and groove (6-15 m)</i>						
Reference – Dry Tortugas National Park						
P220 – Northern DTNP (south of "J" buoy)	46	2.30 $\pm$ 0.20	20	1.00 $\pm$ 0.00	66	3.30 $\pm$ 0.20
RNA – Dry Tortugas National Park						
P276 – Northwestern DTNP**	31	1.55 $\pm$ 0.45	24	1.20 $\pm$ 0.50	55	2.75 $\pm$ 0.95
P6 – North of Loggerhead (I-38)**	4	0.20 $\pm$ 0.10	62	3.10 $\pm$ 1.50	66	3.30 $\pm$ 1.40
<i>Medium-profile reef (< 6 m)</i>						
Reference – Dry Tortugas National Park						
P17 – Northern DTNP (O-92)	19	0.95 $\pm$ 0.15	41	2.05 $\pm$ 0.25	60	3.00 $\pm$ 0.10
RNA – Dry Tortugas National Park						
P7 – NE of Loggerhead (I-26)**	47	2.35 $\pm$ 0.75	124	6.20 $\pm$ 0.10	171	8.55 $\pm$ 0.85
<i>Medium-profile reef (6-15 m)</i>						
RNA – Dry Tortugas National Park						
P3 – Northern DTNP (I-63)**	28	1.40 $\pm$ 0.40	54	2.70 $\pm$ 0.10	82	4.10 $\pm$ 0.30
P280 – Texas Rock**	40	2.00 $\pm$ 0.30	45	2.25 $\pm$ 0.15	85	4.25 $\pm$ 0.45

Site number/site location	Millepora spp.		Scleractinian corals		Total stony corals	
	N	No. per m ²	N	No. per m ²	N	No. per m ²
P10 – SE of Loggerhead (I-41)**	80	4.00 ± 0.20	80	4.00 ± 2.00	160	8.00 ± 2.20
P319 – SW of Loggerhead Reef**	9	0.45 ± 0.25	5	0.25 ± 0.15	14	0.70 ± 0.40
Reference – Dry Tortugas National Park						
P13 – Northeastern DTNP (O-56)	7	0.35 ± 0.05	70	3.50 ± 1.00	77	3.85 ± 0.95
P9 – Northeastern DTNP (O-94)	7	0.35 ± 0.05	64	3.20 ± 0.40	71	3.55 ± 0.35
P8 – Northeastern DTNP (O-82)	4	0.20 ± 0.00	67	3.35 ± 0.15	71	3.55 ± 0.15
P331 – East of SW Channel	22	1.10 ± 0.30	41	2.05 ± 0.15	63	3.15 ± 0.15
P12 – Southwestern DTNP (O-84)	30	1.50 ± 0.40	54	2.70 ± 1.20	84	4.20 ± 0.80
<i>Medium-profile reef (15-21 m)</i>						
Reference – Dry Tortugas National Park						
P311 – SW of Loggerhead Key	24	1.20 ± 0.20	41	2.05 ± 0.35	65	3.25 ± 0.55
P11 – Southwestern DTNP (O-42)	16	0.80 ± 0.20	97	4.85 ± 0.35	113	5.65 ± 0.55
Reference – FKNMS						
B231 – Tortugas Bank	8	0.40 ± 0.00	51	2.55 ± 1.15	59	2.95 ± 1.15
<i>High-relief spur and groove (6-15 m)</i>						
RNA – Dry Tortugas National Park						
P2 – Northern DTNP (I-36b)**	9	0.45 ± 0.15	49	2.45 ± 0.35	58	2.90 ± 0.20
P5 – North-central DTNP (I-44)**	16	0.80 ± 0.50	83	4.15 ± 0.25	99	4.95 ± 0.25
P335 – NW of Loggerhead Key**	31	1.55 ± 0.55	68	3.40 ± 0.40	99	4.95 ± 0.95
<i>Reef knoll (15-21 m)</i>						
RNA – Dry Tortugas National Park						
P291 – West of Loggerhead Key**	7	0.58 ± 0.25	131	10.92 ± 0.58	138	11.50 ± 0.33
Tortugas North Ecological Reserve						
B236 – Tortugas Bank**	29	1.62 ± 0.48	95	5.95 ± 2.05	124	7.57 ± 1.57
B250 – Cooper's Reef**	107	7.64 ± 1.21	70	5.00 ± 0.29	177	12.64 ± 1.50
<i>Reef terrace (6-15 m)</i>						
Reference – Dry Tortugas National Park						
P214 – Between "J" and "K" buoys	9	0.48 ± 0.23	131	7.15 ± 1.15	140	7.63 ± 1.38
P206 – NW of Pulaski Shoal	4	0.20 ± 0.20	102	5.90 ± 1.90	106	6.10 ± 2.10
<i>Reef terrace (15-21 m)</i>						
RNA – Dry Tortugas National Park						
P297 – West of Brilliant Shoal**	8	0.50 ± 0.00	130	8.13 ± 1.50	138	8.63 ± 1.50
P15 – North of Loggerhead (I-50)**	8	0.40 ± 0.10	112	5.60 ± 1.00	120	6.00 ± 1.10
P4 – North of Loggerhead (I-5b)**	13	0.65 ± 0.05	122	6.10 ± 0.70	135	6.75 ± 0.75
<i>Reef terrace (22-27 m)</i>						
Tortugas North Ecological Reserve						
B223 – Little Tortugas Bank**	2	0.29	48	6.86 ±	50	7.14
B238 – Sherwood Forest**	13	0.65 ± 0.05	72	3.60 ± 0.80	85	4.25 ± 0.85

Table 4-2. Numbers of species, juveniles, and mean $\pm$ 1 SE densities of juvenile (< 4 cm max. diameter) scleractinian corals in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western Florida Keys National Marine Sanctuary (FKNMS). Data are based upon surveys of ten 0.65-cm x 0.48-cm quadrats sampled along each of two transects (6.24 m² per site) at 43 sites during May-June 2008 (except at P276 = 5.62 m², B231 = 5.93 m², B223 = 3.12 m²). Sites are arranged by habitat and depth. Asterisk sites (**) are within the Research Natural Area (RNA) of DTNP or the Tortugas North Reserve of the FKNMS.

Site number/site location	Species	Juveniles	No. per m ²	Dominant species
<i>Staghorn patch reef (< 6 m)</i>				
RNA – Dry Tortugas National Park				
P283 – NW DTNP (Marker 7)**	6	14	2.24 $\pm$ 0.64	<i>D. strigosa</i> 21%, <i>F. fragum</i> 36%, <i>P. porites</i> 21%
P287 – West of Ft. Jefferson**	7	7	1.12 $\pm$ 0.80	<i>D. strigosa</i> 14%, <i>E. fastigiata</i> 14%, <i>M. areolata</i> 14%, <i>S. siderea</i> 14%, <i>S. michelini</i> 14%
<i>Patchy hard-bottom (6-15 m)</i>				
RNA – Dry Tortugas National Park				
P1 – NW of Texas Rock**	5	19	3.04 $\pm$ 0.80	<i>M. cavernosa</i> 21%, <i>P. astreoides</i> 47%, <i>S. michelini</i> 21%
Reference – FKNMS				
B327 – South of DTNP (East of "B" buoy)	6	21	3.37 $\pm$ 1.44	<i>S. radians</i> 14%, <i>S. siderea</i> 48%, <i>S. michelini</i> 14%
B267 – Tortugas Bank	7	14	2.24 $\pm$ 0.32	<i>P. astreoides</i> 21%, <i>S. radians</i> 14%, <i>S. siderea</i> 21%
B263 – Tortugas Bank	8	38	6.09 $\pm$ 1.60	<i>M. cavernosa</i> 37%, <i>P. astreoides</i> 11%, <i>S. siderea</i> 18%, <i>S. michelini</i> 11%
<i>Patchy hard-bottom (15-21 m)</i>				
Reference – FKNMS				
P307 – SW of DTNP (near "C" buoy)	11	45	7.21 $\pm$ 1.12	<i>M. cavernosa</i> 16%, <i>O. diffusa</i> 11%, <i>S. siderea</i> 42%, <i>S. michelini</i> 11%
Tortugas North Ecological Reserve				
B270 – Eastern Tortugas Bank**	10	29	4.65 $\pm$ 1.76	<i>M. cavernosa</i> 10%, <i>P. astreoides</i> 14%, <i>S. siderea</i> 24%, <i>S. michelini</i> 21%
<i>Low-relief hard-bottom (< 6 m)</i>				
Reference – Dry Tortugas National Park				
P18 – Eastern DTNP (O-72)	3	14	2.24 $\pm$ 0.96	<i>P. astreoides</i> 64%, <i>S. radians</i> 29%
P14 – West of Pulaski Shoal (O-12b)	5	14	2.24 $\pm$ 0.32	<i>P. astreoides</i> 57%, <i>P. porites</i> 14%, <i>S. radians</i> 14%
P16 – Northern DTNP (O-27)	3	16	2.56 $\pm$ 0.32	<i>P. astreoides</i> 44%, <i>S. radians</i> 44%, <i>S. siderea</i> 13%
<i>Low-relief hard-bottom (6-15 m)</i>				
Reference – FKNMS				
B255 – Tortugas Bank (southern end)	7	43	6.89 $\pm$ 1.76	<i>M. cavernosa</i> 42%, <i>S. siderea</i> 37%
<i>Low-relief hard-bottom (15-21 m)</i>				
Reference – FKNMS				
B323 – South of DTNP (SW of "B" buoy)	9	41	6.57 $\pm$ 0.48	<i>M. cavernosa</i> 27%, <i>S. radians</i> 20%, <i>S. michelini</i> 27%
<i>Low-relief spur and groove (6-15 m)</i>				
Reference – Dry Tortugas National Park				

Site number/site location	Species	Juveniles	No. per m ²	Dominant species
P220 – Northern DTNP (south of "J" buoy) RNA – Dry Tortugas National Park	6	7	1.12 ± 0.48	<i>M. areolata</i> 14%, <i>M. annularis</i> 14%, <i>P. astreoides</i> 14%, <i>P. porites</i> 14%, <i>S. siderea</i> 29%, <i>S. michelini</i> 14%
P276 – Northwestern DTNP**	8	25	4.45 ± 0.04	<i>M. cavernosa</i> 16%, <i>P. astreoides</i> 32%, <i>S. radians</i> 20%, <i>S. siderea</i> 12%
P6 – North of Loggerhead (I-38)**	9	31	4.97 ± 0.80	<i>M. cavernosa</i> 16%, <i>P. astreoides</i> 23%, <i>P. porites</i> 23%, <i>S. siderea</i> 13%
<i>Medium-profile reef (< 6 m)</i>				
Reference – Dry Tortugas National Park				
P17 – Northern DTNP (O-92) RNA – Dry Tortugas National Park	7	14	2.24 ± 0.64	<i>S. radians</i> 57%
P7 – NE of Loggerhead (I-26)**	7	25	4.01 ± 1.76	<i>P. astreoides</i> 52%, <i>P. porites</i> 12%, <i>S. radians</i> 16%
<i>Medium-profile reef (6-15 m)</i>				
RNA – Dry Tortugas National Park				
P3 – Northern DTNP (I-63)**	5	15	2.40 ± 2.40	<i>M. cavernosa</i> 20%, <i>P. astreoides</i> 33%, <i>P. porites</i> 13%, <i>S. siderea</i> 13%, <i>S. michelini</i> 20%
P280 – Texas Rock**	7	34	5.45 ± 1.60	<i>M. cavernosa</i> 12%, <i>P. astreoides</i> 38%, <i>P. porites</i> 29%
P10 – SE of Loggerhead (I-41)**	5	24	3.85 ± 0.64	<i>M. cavernosa</i> 17%, <i>P. astreoides</i> 21%, <i>S. siderea</i> 50%
P319 – SW of Loggerhead Reef** Reference – Dry Tortugas National Park	9	26	4.17 ± 1.60	<i>P. astreoides</i> 19%, <i>S. radians</i> 15%, <i>S. siderea</i> 35%
P13 – Northeastern DTNP (O-56)	5	16	2.56 ± 0.32	<i>M. cavernosa</i> 14%, <i>P. astreoides</i> 63%, <i>S. radians</i> 13%, <i>S. michelini</i> 13%
P9 – Northeastern DTNP (O-94)	8	22	3.53 ± 0.64	<i>P. astreoides</i> 36%, <i>S. radians</i> 14%, <i>S. siderea</i> 14%
P8 – Northeastern DTNP (O-82)	6	27	4.33 ± 1.44	<i>P. astreoides</i> 52%, <i>S. siderea</i> 26% <i>M. cavernosa</i> 14%, <i>Scolymia</i> spp. 25%, <i>S. radians</i> 18%, <i>S. siderea</i> 25%, <i>S. michelini</i> 11%
P331 – East of SW Channel	7	28	4.49 ± 0.32	<i>M. cavernosa</i> 31%, <i>P. astreoides</i> 22%, <i>S. siderea</i> 22%, <i>S. michelini</i> 17%
P12 – Southwestern DTNP (O-84)	7	36	5.77 ± 0.64	
<i>Medium-profile reef (15-21 m)</i>				
Reference – Dry Tortugas National Park				
P311 – SW of Loggerhead Key	7	50	8.01 ± 1.32	<i>M. cavernosa</i> 26%, <i>P. astreoides</i> 10%, <i>S. siderea</i> 50%
P11 – Southwestern DTNP (O-42) Reference – FKNMS	7	21	3.37 ± 0.16	<i>M. cavernosa</i> 14%, <i>Scolymia</i> spp. 14%, <i>S. siderea</i> 29%, <i>S. michelini</i> 24%
B231 – Tortugas Bank	6	30	5.13 ± 1.28	<i>M. cavernosa</i> 33%, <i>S. siderea</i> 30%, <i>S. michelini</i> 27%
<i>High-relief spur and groove (6-15 m)</i>				
RNA – Dry Tortugas National Park				
P2 – Northern DTNP (I-36b)**	5	18	2.88 ± 0.32	<i>M. cavernosa</i> 22%, <i>P. astreoides</i> 33%, <i>S. siderea</i> 28%, <i>S. michelini</i> 11%
P5 – North-central DTNP (I-44)**	8	24	3.85 ± 0.96	<i>M. cavernosa</i> 21%, <i>P. astreoides</i> 33%, <i>S. siderea</i> 17%
P335 – NW of Loggerhead Key**	6	28	4.49 ± 1.28	<i>P. astreoides</i> 14%, <i>S. radians</i> 11%, <i>S. siderea</i> 43%, <i>S. michelini</i> 21%

Site number/site location	Species	Juveniles	No. per m ²	Dominant species
<i>Reef knoll (15-21 m)</i>				
RNA – Dry Tortugas National Park				
P291 – West of Loggerhead Key** Tortugas North Ecological Reserve	6	23	3.69 ± 1.44	<i>M. cavernosa</i> 17%, <i>S. radians</i> 17%, <i>S. siderea</i> 18%, <i>S. michelini</i> 13%
B236 – Tortugas Bank**	7	28	4.49 ± 0.32	<i>P. astreoides</i> 11%, <i>S. siderea</i> 46%, <i>S. michelini</i> 21% <i>A. agaricites</i> 15%, <i>M. cavernosa</i> 20%, <i>P. astreoides</i> 30%, <i>S. radians</i> 10%, <i>S. siderea</i> 20%
B250 – Cooper's Reef**	6	20	3.21 ± 0.96	
<i>Reef terrace (6-15 m)</i>				
Reference – Dry Tortugas National Park				
P214 – Between "J" and "K" buoys	6	20	3.21 ± 0.64	<i>A. agaricites</i> 10%, <i>P. astreoides</i> 55%, <i>P. porites</i> 15%, <i>S. michelini</i> 10%
P206 – NW of Pulaski Shoal	5	14	2.24 ± 0.00	<i>A. agaricites</i> 21%, <i>S. siderea</i> 14%
<i>Reef terrace (15-21 m)</i>				
RNA – Dry Tortugas National Park				
P297 – West of Brilliant Shoal**	9	25	4.01 ± 0.48	<i>S. radians</i> 24%, <i>S. siderea</i> 28%, <i>S. michelini</i> 24% <i>A. agaricites</i> 10%, <i>M. decactis</i> 10%, <i>M. cavernosa</i> 10%, <i>M. ferox</i> 21%, <i>P. astreoides</i> 10%, <i>P. porites</i> 10%, <i>S. siderea</i> 20%, <i>S. michelini</i> 10%
P15 – North of Loggerhead (I-50)**	8	10	1.60 ± 0.64	
P4 – North of Loggerhead (I-5b)**	6	13	2.08 ± 0.16	<i>M. cavernosa</i> 31%, <i>S. siderea</i> 31%
<i>Reef terrace (22-27 m)</i>				
Tortugas North Ecological Reserve				
B223 – Little Tortugas Bank**	2	4	1.28	<i>A. agaricites</i> 25%, <i>P. astreoides</i> 75%
B238 – Sherwood Forest**	4	6	0.96 ± 0.32	<i>A. agaricites</i> 33%, <i>P. astreoides</i> 33%, <i>S. radians</i> 17%, <i>S. michelini</i> 17%

Table 4-3. Numbers of colonies (N) and mean $\pm$ 1 SE colony densities (no. per m²) for gorgonians in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western Florida Keys National Marine Sanctuary (FKNMS). Data are based upon surveys of two 8-m x 1-m transects per site at 43 sites during May-June 2008 (except at site B223 = 8 m²). Sites are arranged by habitat and depth. Asterisk sites (**) are within the Research Natural Area (RNA) of DTNP or the Tortugas North Reserve of the FKNMS.

Site number/site location	N	No. per m ²	Dominant species
<i>Staghorn patch reef (< 6 m)</i>			
RNA – Dry Tortugas National Park			
P283 – NW DTNP (Marker 7)**	373	23.31 $\pm$ 1.31	<i>P. acerosa</i> 55%, <i>P. americana</i> 20%
P287 – West of Ft. Jefferson**	363	22.69 $\pm$ 0.06	<i>P. flexuosa</i> 17%
<i>Patchy hard-bottom (6-15 m)</i>			
RNA – Dry Tortugas National Park			
P1 – NW of Texas Rock**	113	7.06 $\pm$ 0.69	<i>E. succinea</i> 12%, <i>G. ventalina</i> 14%, <i>P. flexuosa</i> 18%, <i>P. americana</i> 14%
Reference – FKNMS			
B327 – South of DTNP (East of "B" buoy)	147	9.19 $\pm$ 1.94	<i>M. elongata</i> 36%
B267 – Tortugas Bank	55	3.44 $\pm$ 0.19	<i>G. ventalina</i> 15%, <i>P. acerosa</i> 13%, <i>P. americana</i> 60%
B263 – Tortugas Bank	99	6.19 $\pm$ 1.56	<i>E. fusca</i> 13%, <i>G. ventalina</i> 10%, <i>P. acerosa</i> 18%, <i>P. americana</i> 29%
<i>Patchy hard-bottom (15-21 m)</i>			
Reference – FKNMS			
P307 – SW of DTNP (near "C" buoy)	145	9.06 $\pm$ 4.31	<i>E. caribaeorum</i> 28%, <i>E. fusca</i> 10%, <i>E. succinea</i> 13%
Tortugas North Ecological Reserve			
B270 – Eastern Tortugas Bank**	141	8.81 $\pm$ 3.06	<i>E. fusca</i> 16%, <i>E. succinea</i> 16%, <i>P. acerosa</i> 11%, <i>P. americana</i> 26%
<i>Low-relief hard-bottom < 6 m)</i>			
Reference – Dry Tortugas National Park			
P18 – Eastern DTNP O-72)	84	5.25 $\pm$ 1.75	<i>E. tourneforti</i> 14%, <i>G. ventalina</i> 26%, <i>P. flexuosa</i> 27%
P14 – West of Pulaski Shoal O-12b)	525	32.81 $\pm$ 5.69	<i>E. tourneforti</i> 23%, <i>P. flexuosa</i> 28%, <i>P. flagellosa</i> 12%
P16 – Northern DTNP O-27)	273	17.06 $\pm$ 2.81	<i>E. mammosa</i> 19%, <i>E. tourneforti</i> 21%, <i>P. flexuosa</i> 21%
<i>Low-relief hard-bottom 6-15 m)</i>			
Reference – FKNMS			
B255 – Tortugas Bank southern end)	342	21.38 $\pm$ 0.25	<i>M. elongata</i> 12%, <i>P. americana</i> 30%
<i>Low-relief hard-bottom 15-21 m)</i>			
Reference – FKNMS			
B323 – South of DTNP SW of "B" buoy)	180	11.25 $\pm$ 3.13	<i>M. elongata</i> 28%, <i>P. flexuosa</i> 10%, <i>P. americana</i> 13%
<i>Low-relief spur and groove 6-15 m)</i>			
Reference – Dry Tortugas National Park			
P220 – Northern DTNP south of "J" buoy)	322	20.13 $\pm$ 1.50	<i>E. fusca</i> 13%, <i>E. succinea</i> 19%, <i>P. flexuosa</i> 21%, <i>P. americana</i> 19%
RNA – Dry Tortugas National Park			
P276 – Northwestern DTNP**	198	12.38 $\pm$ 3.63	<i>E. fusca</i> 16%, <i>E. succinea</i> 14%, <i>G. ventalina</i> 11%, <i>P. flexuosa</i> 11%
P6 – North of Loggerhead I-38)**	169	10.56 $\pm$ 1.81	<i>B. asbestinum</i> 91%
<i>Medium-profile reef < 6 m)</i>			
Reference – Dry Tortugas National Park			
P17 – Northern DTNP O-92)	334	20.88 $\pm$ 0.13	<i>E. tourneforti</i> 14%, <i>P. flexuosa</i> 41%

Site number/site location	N	No. per m ²	Dominant species
RNA – Dry Tortugas National Park			
P7 – NE of Loggerhead I-26)**	344	21.50 ± 0.38	<i>G. ventalina</i> 20%, <i>P. flexuosa</i> 36%, <i>P. homomalla</i> 10%
<i>Medium-profile reef 6-15 m)</i>			
RNA – Dry Tortugas National Park			
P3 – Northern DTNP I-63)**	205	12.81 ± 4.69	<i>B. asbestinum</i> 31%, <i>E. succinea</i> 17%, <i>P. flexuosa</i> 20%
P280 – Texas Rock**	257	16.06 ± 0.31	<i>E. succinea</i> 15%, <i>G. ventalina</i> 16%, <i>P. flexuosa</i> 16%, <i>P. americana</i> 20%
P10 – SE of Loggerhead I-41)**	418	26.13 ± 8.50	<i>B. asbestinum</i> 9%, <i>E. caribaeorum</i> 8%, <i>P. bipinnata</i> 37%
P319 – SW of Loggerhead Reef**	118	7.38 ± 1.88	<i>G. ventalina</i> 13%, <i>P. flexuosa</i> 20%, <i>P. americana</i> 21%
Reference – Dry Tortugas National Park			
P13 – Northeastern DTNP O-56)	125	7.81 ± 0.69	<i>E. caribaeorum</i> 14%, <i>E. fusca</i> 43%, <i>E. succinea</i> 10%, <i>P. flexuosa</i> 22%, <i>P. americana</i> 12%
P9 – Northeastern DTNP O-94)	42	2.63 ± 0.38	<i>B. asbestinum</i> 83%, <i>E. caribaeorum</i> 14%
P8 – Northeastern DTNP O-82)	105	6.56 ± 2.81	<i>B. asbestinum</i> 56%, <i>E. caribaeorum</i> 39%
P331 – East of SW Channel	362	22.63 ± 3.88	<i>E. caribaeorum</i> 14%, <i>E. succinea</i> 11%, <i>M. flavida</i> 11%, <i>P. flexuosa</i> 18%
P12 – Southwestern DTNP O-84)	207	12.94 ± 4.44	<i>E. caribaeorum</i> 12%, <i>E. fusca</i> 16%, <i>E. succinea</i> 11%, <i>P. flexuosa</i> 15%
<i>Medium-profile reef 15-21 m)</i>			
Reference – Dry Tortugas National Park			
P311 – SW of Loggerhead Key	252	15.75 ± 2.25	<i>B. asbestinum</i> 18%, <i>E. caribaeorum</i> 27%, <i>E. succinea</i> 12%, <i>P. flexuosa</i> 11%
P11 – Southwestern DTNP O-42)	59	3.69 ± 0.81	<i>E. caribaeorum</i> 20%, <i>P. flexuosa</i> 27%, <i>P. acerosa</i> 15%
Reference – FKNMS			
B231 – Tortugas Bank	80	5.00 ± 0.38	<i>B. asbestinum</i> 38%, <i>E. caribaeorum</i> 34%, <i>E. succinea</i> 11.3%
<i>High-relief spur and groove 6-15 m)</i>			
RNA – Dry Tortugas National Park			
P2 – Northern DTNP I-36b)**	72	4.50 ± 2.00	<i>B. asbestinum</i> 13%, <i>E. caribaeorum</i> 29%, <i>E. succinea</i> 17%, <i>G. ventalina</i> 15%, <i>P. flexuosa</i> 13%
P5 – North-central DTNP I-44)**	203	12.69 ± 2.44	<i>B. asbestinum</i> 45%, <i>G. ventalina</i> 13.8%, <i>P. flexuosa</i> 11%
P335 – NW of Loggerhead Key**	106	6.63 ± 2.38	<i>B. asbestinum</i> 12%, <i>E. caribaeorum</i> 58%, <i>P. americana</i> 16%
<i>Reef knoll 15-21 m)</i>			
RNA – Dry Tortugas National Park			
P291 – West of Loggerhead Key**	44	2.75 ± 0.63	<i>B. asbestinum</i> 18%, <i>E. caribaeorum</i> 18%, <i>P. acerosa</i> 27.3%, <i>P. americana</i> 25%
Tortugas North Ecological Reserve			
B236 – Tortugas Bank**	84	5.25 ± 0.50	<i>B. asbestinum</i> 13%, <i>E. caribaeorum</i> 32%, <i>E. succinea</i> 12%, <i>P. acerosa</i> 14%, <i>P. americana</i> 23%
B250 – Cooper's Reef**	325	20.31 ± 1.31	<i>B. asbestinum</i> 31%, <i>E. caribaeorum</i> 13%, <i>P. acerosa</i> 44%, <i>P. americana</i> 11%
<i>Reef terrace 6-15 m)</i>			
Reference – Dry Tortugas National Park			
P214 – Between "J" and "K" buoys	66	4.13 ± 0.63	<i>B. asbestinum</i> 58%, <i>E. caribaeorum</i> 35%
P206 – NW of Pulaski Shoal	73	4.56 ± 0.31	<i>B. asbestinum</i> 77%, <i>E. caribaeorum</i> 23%
<i>Reef terrace 15-21 m)</i>			
RNA – Dry Tortugas National Park			
P297 – West of Brilliant Shoal**	111	6.94 ± 1.94	<i>B. asbestinum</i> 59%, <i>E. caribaeorum</i> 39%

Site number/site location	N	No. per m ²	Dominant species
P15 – North of Loggerhead I-50)**	131	8.19 ± 2.06	<i>B. asbestinum</i> 92%
P4 – North of Loggerhead I-5b)**	114	7.13 ± 2.38	<i>B. asbestinum</i> 75%, <i>P. acerosa</i> 16%
<i>Reef terrace 22-27 m)</i>			
Tortugas North Ecological Reserve			
B223 – Little Tortugas Bank**	12	1.50	<i>B. asbestinum</i> 50%, <i>E. caribaeorum</i> 17%, <i>P. acerosa</i> 17%
B238 – Sherwood Forest**	118	7.38 ± 0.50	<i>B. asbestinum</i> 44%, <i>P. acerosa</i> 41%

V. Urchins

Sea urchin abundances and test sizes were recorded within four 15-m x 1-m belt transects per site at the 43 Tortugas sampling locations during 2008, except at sites B223 and B238, where only two transects per site were sampled. The urchin surveys complement similar efforts dating back to 1999 in both the Tortugas region and the rest of the Florida Keys, and document continued, but slow recovery of the once ubiquitous long-spined sea urchin *Diadema antillarum*. From the 2,520 m² total sampling area, four species were encountered: *Diadema antillarum*, *Echinometra lucunter*, *E. viridis*, and *Eucidaris tribuloides* (Figure 5-1). These same four species were recorded from 46 sites in the region during 2006. In contrast to 2006, however, densities were generally lower for most species in 2008, particularly *D. antillarum*. Of the 111 urchins identified and counted, the most abundant species was *D. antillarum* (41 individuals, 37% of the total), followed by *E. tribuloides* (37 individuals, 33%), *E. viridis* (31 individuals, 28%), and *E. lucunter* (2 individuals, 2%).

Diadema antillarum was recorded from just 15 sites (35% site presence) and the highest site-level densities were 0.20 ± 0.08 individuals per m² (Table 5-1). Only two sites had densities greater than or equal to 0.1 individual per m² (Table 5-1), one a shallow (< 6 m) hard-bottom site and the other a medium-profile reef in DTNP (Figure 5-2). In 2006, site-level densities were as high as 0.37 individuals per m² on some of the patch reefs near the central and western areas of DTNP. Most of the *D. antillarum* encountered during 2008 were found in relatively shallow habitats (< 15 m) within the park (Figure 5-3). The test diameters (TD) of the 41 individuals encountered ranged from 0.9 cm to 9.2 cm, with an overall mean of 5.3 ± 0.3 cm. The size distribution in 2008 was skewed towards larger individuals (> 5 cm TD), which comprised 59% of all the urchins encountered. Recently settled juveniles (~1 month to 1 year) were rare during the May-June sampling period (Figure 5-4). In contrast, a total of 98 individuals were recorded from 46 sites in 2008, yielding a substantially smaller mean test size of 1.8 ± 0.2 cm and a predominance of recently settled juveniles.

Two *Echinometra* species were recorded in 2008. In contrast to 2006, no relatively large aggregations of *E. lucunter* were found at the sites sampled in 2008. *E. lucunter* was only recorded from two sites, both of which are staghorn patch reef mounds near Ft. Jefferson (Table 5-2). The two individuals recorded were 1.3 cm and 2.0 cm TD. *E. viridis* was recorded from 13 sites (30% site presence) and site-level densities were as high as 0.13 ± 0.08 individuals per m² (Table 5-3). Only two sites had mean densities greater than 0.1 individuals per m², represented by either shallow (< 6 m) hard-bottom or medium-profile reefs in DTNP (Table 5-3), similar to the pattern for *D. antillarum*. The test diameters (TD) of the 31 *E. viridis*

encountered ranged from 1.5 cm to 3.8 cm, with an overall mean of 2.6 ± 0.1 cm. The size distribution in 2008 reflected the predominance (71%) of individuals in the 2.0-2.9 cm TD range (Figure 5-4).

Eucidaris tribuloides was found at nine sites (21% site presence) and site-level densities were as high as 0.22 ± 0.05 individuals per m^2 (Table 5-4). Only two sites yielded mean densities greater than 0.1 individuals per m^2 , which were either shallow (< 6 m) hard-bottom or staghorn patch reef habitats in DTNP (Figure 5-2). The tests diameters (TD) of the 37 *E. tribuloides* encountered ranged from 2.0 cm to 4.1 cm, with an overall mean of 2.9 ± 0.1 cm. The size distribution in 2008 illustrates the predominance of individuals in the 2.0-4.0 cm TD range (Figure 5-4).

Figure 5-1. Sea urchin species observed in the Dry Tortugas during May-June 2008. Not shown is *Echinometra lucunter* (rock boring urchin).

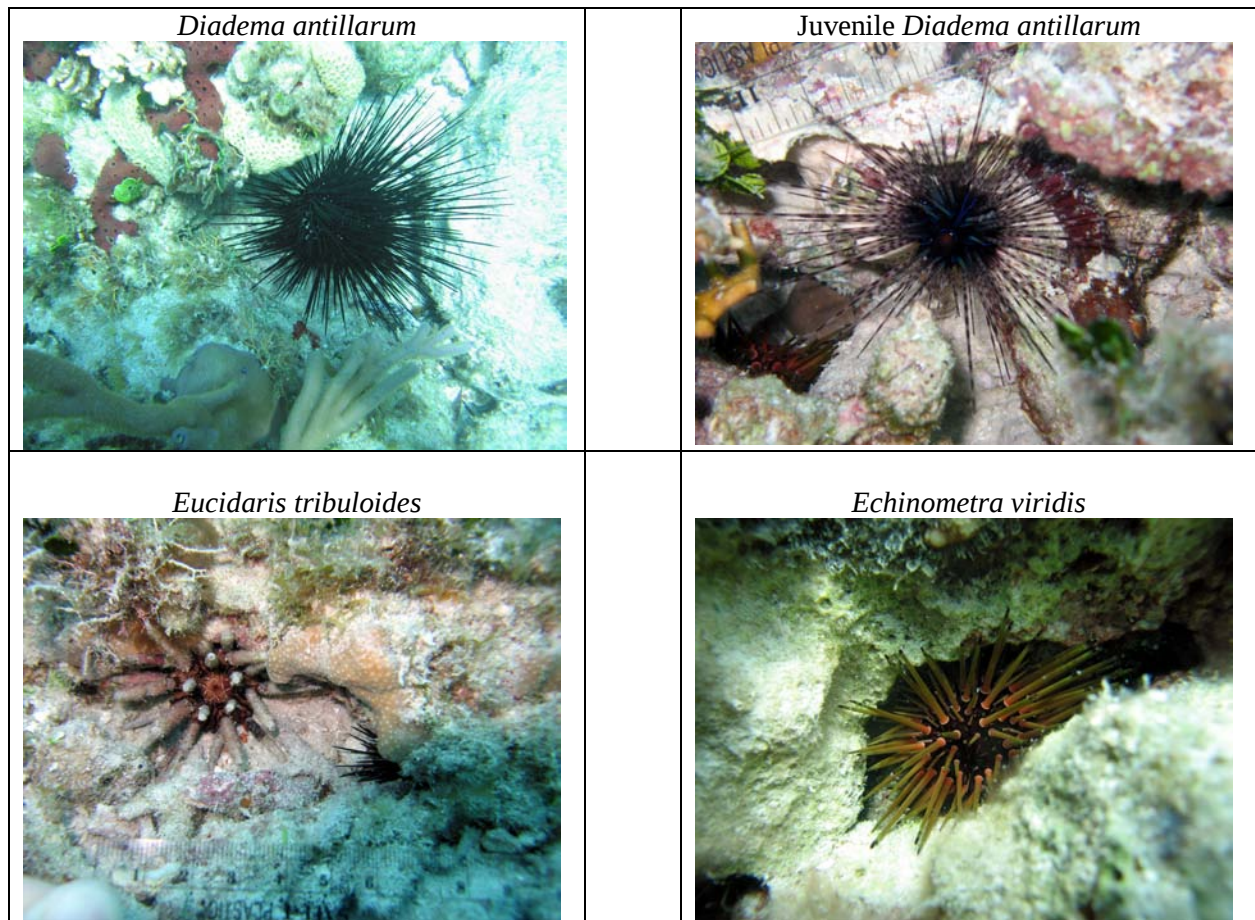


Figure 5-2. Mean (+ 1 SE) densities (no. individuals/m²) of sea urchins in the Dry Tortugas region during May-June 2008. Data are based upon averages from surveys of four replicate 15-m x 1-m belt transects per site. See Table 5-1 for habitat and depth designations.

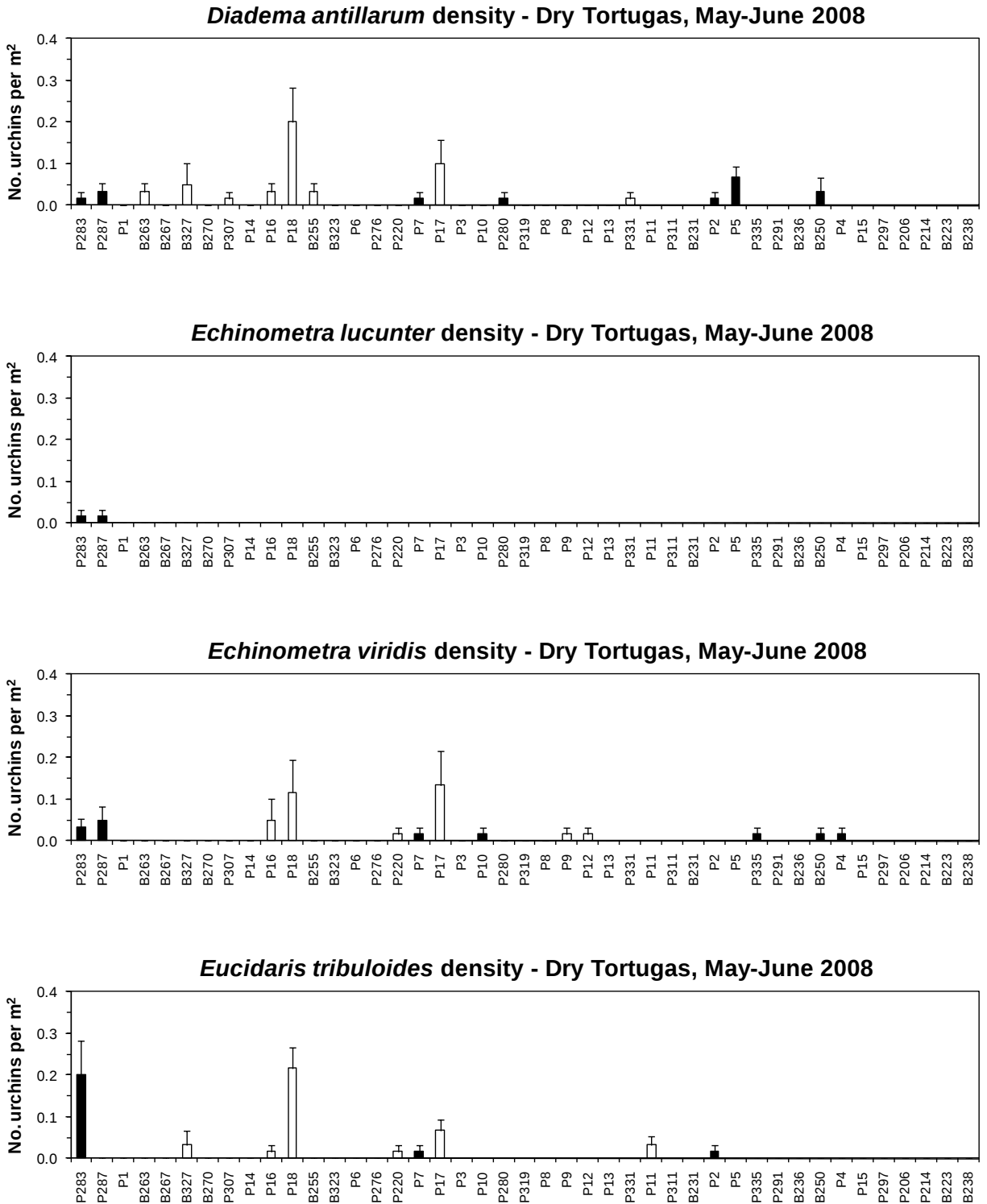


Figure 5-3. Spatial patterns of *Diadema antillarum* urchin density (no. individuals per m²) from surveys of 43 sites in the Dry Tortugas region during May-June 2008. Shown are the boundaries of the Research Natural Area (RNA) within DTNP, the Tortugas North Ecological Reserve, and the FKNMS.

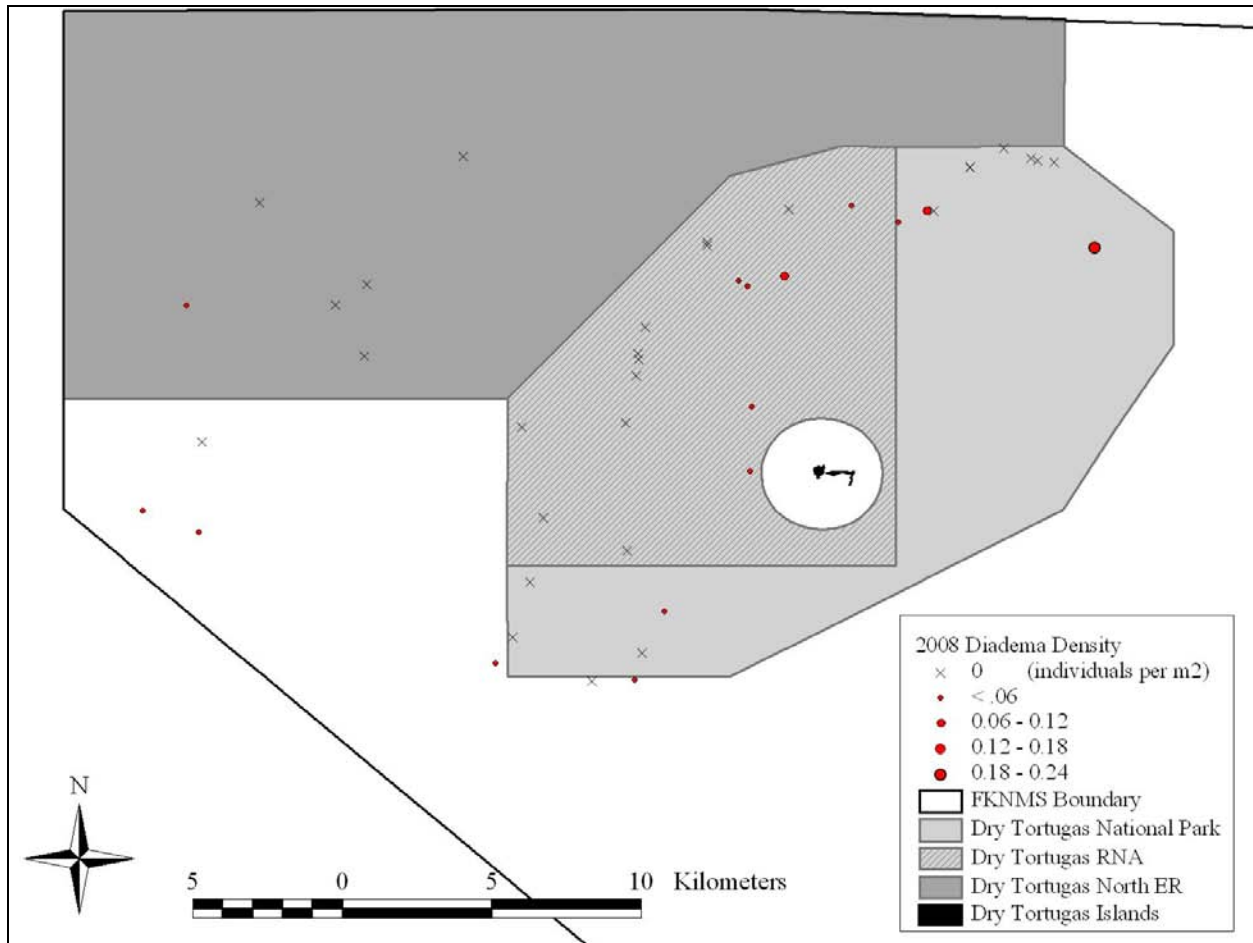


Figure 5-4. Size frequency distributions of sea urchins in the Dry Tortugas from all sites and habitat types sampled during May-June 2008.

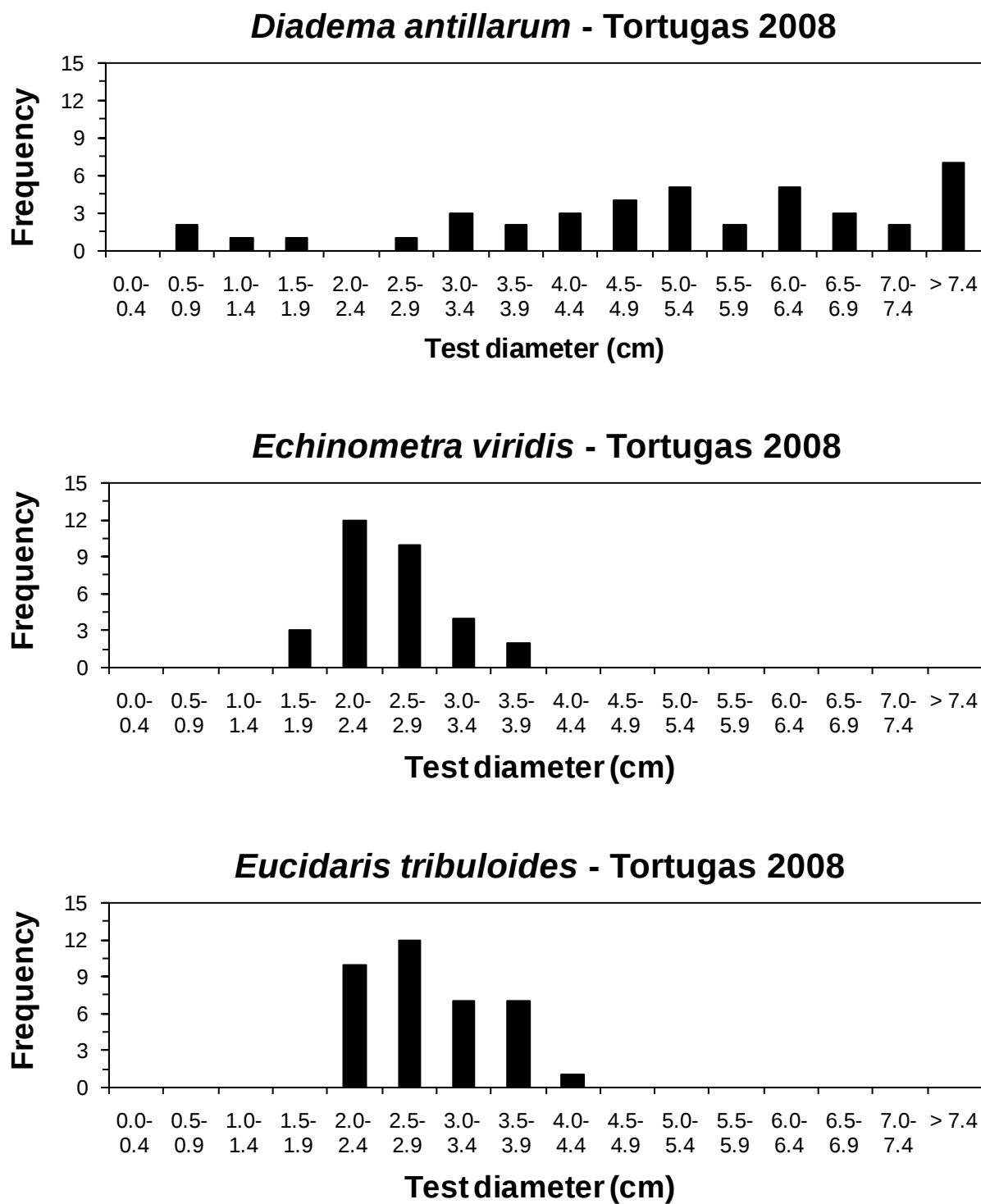


Table 5-1. Mean $\pm$ 1 SE transect frequency, density (no. individuals per m²), test diameter, and numbers of individuals (N) sampled for the urchin *Diadema antillarum* in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western Florida Keys National Marine Sanctuary (FKNMS). Data are based upon surveys of four 15-m x 1-m transects per site at 43 sites during May-June 2008. Sites are arranged by habitat and depth. Asterisked sites (***) are within the Research Natural Area (RNA) of DTNP or the Tortugas North Reserve of the FKNMS.

Site number/site location	Frequency	N	No. per m ²	Mean size (cm)
<i>Staghorn patch reef (< 6 m)</i>				
RNA – Dry Tortugas National Park				
P283 – Northwestern DTNP (Marker 7)**	25 $\pm$ 25	1	0.017 $\pm$ 0.017	1.7
P287 – West of Ft. Jefferson**	50 $\pm$ 29	2	0.033 $\pm$ 0.019	1.2 $\pm$ 0.3
<i>Patchy hard-bottom (6-15 m)</i>				
RNA – Dry Tortugas National Park				
P1 – NW of Texas Rock**	0 $\pm$ 0	0	0 $\pm$ 0	
Reference – FKNMS				
B327 – South of DTNP (East of "B" buoy)	25 $\pm$ 25	3	0.050 $\pm$ 0.050	5.3 $\pm$ 0.1
B267 – Tortugas Bank	0 $\pm$ 0	0	0 $\pm$ 0	
B263 – Tortugas Bank	50 $\pm$ 29	2	0.033 $\pm$ 0.019	5.1 $\pm$ 0.3
<i>Patchy hard-bottom (15-21 m)</i>				
Reference – FKNMS				
P307 – SW of DTNP (near "C" buoy)	25 $\pm$ 25	1	0.017 $\pm$ 0.017	6.2
Tortugas North Ecological Reserve				
B270 – Eastern Tortugas Bank**	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Low-relief hard-bottom (< 6 m)</i>				
Reference – Dry Tortugas National Park				
P18 – Eastern DTNP (O-72)	100 $\pm$ 0	12	0.200 $\pm$ 0.082	6.3 $\pm$ 0.6
P14 – West of Pulaski Shoal (O-12b)	0 $\pm$ 0	0	0 $\pm$ 0	
P16 – Northern DTNP (O-27)	50 $\pm$ 29	2	0.033 $\pm$ 0.019	3.5 $\pm$ 0.6
<i>Low-relief hard-bottom (6-15 m)</i>				
Reference – FKNMS				
B255 – Tortugas Bank (southern end)	50 $\pm$ 29	2	0.033 $\pm$ 0.019	3.4 $\pm$ 0.2
<i>Low-relief hard-bottom (15-21 m)</i>				
Reference – FKNMS				
B323 – South of DTNP (SW of "B" buoy)	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Low-relief spur and groove (6-15 m)</i>				
Reference – Dry Tortugas National Park				
P220 – Northern DTNP (south of "J" buoy)	0 $\pm$ 0	0	0 $\pm$ 0	
RNA – Dry Tortugas National Park				
P276 – Northwestern DTNP**	0 $\pm$ 0	0	0 $\pm$ 0	
P6 – North of Loggerhead (I-38)**	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Medium-profile reef (< 6 m)</i>				
Reference – Dry Tortugas National Park				
P17 – Northern DTNP (O-92)	75 $\pm$ 25	6	0.100 $\pm$ 0.058	6.8 $\pm$ 0.3
RNA – Dry Tortugas National Park				
P7 – NE of Loggerhead (I-26)**	25 $\pm$ 25	1	0.017 $\pm$ 0.017	5.2
<i>Medium-profile reef (6-15 m)</i>				
RNA – Dry Tortugas National Park				
P3 – Northern DTNP (I-63)**	0 $\pm$ 0	0	0 $\pm$ 0	
P280 – Texas Rock**	25 $\pm$ 25	1	0.017 $\pm$ 0.017	0.9
P10 – SE of Loggerhead (I-41)**	0 $\pm$ 0	0	0 $\pm$ 0	
P319 – SW of Loggerhead Reef**	0 $\pm$ 0	0	0 $\pm$ 0	

Site number/site location	Frequency	N	No. per m ²	Mean size (cm)
<i>Reference – Dry Tortugas National Park</i>				
P13 – Northeastern DTNP (O-56)	0 ± 0	0	0 ± 0	
P9 – Northeastern DTNP (O-94)	0 ± 0	0	0 ± 0	
P8 – Northeastern DTNP (O-82)	0 ± 0	0	0 ± 0	
P331 – East of SW Channel	25 ± 25	1	0.017 ± 0.017	6.3
P12 – Southwestern DTNP (O-84)	0 ± 0	0	0 ± 0	
<i>Medium-profile reef (15-21 m)</i>				
<i>Reference – Dry Tortugas National Park</i>				
P311 – SW of Loggerhead Key	0 ± 0	0	0 ± 0	
P11 – Southwestern DTNP (O-42)	0 ± 0	0	0 ± 0	
<i>Reference – FKNMS</i>				
B231 – Tortugas Bank	0 ± 0	0	0 ± 0	
<i>High-relief spur and groove (6-15 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P2 – Northern DTNP (I-36b)**	25 ± 25	1	0.017 ± 0.047	5.8
P5 – North-central DTNP (I-44)**	75 ± 35	4	0.067 ± 0.027	4.4 ± 0.4
P335 – NW of Loggerhead Key**	0 ± 0	0	0 ± 0	
<i>Reef knoll (15-21 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P291 – West of Loggerhead Key**	0 ± 0	0	0 ± 0	
<i>Tortugas North Ecological Reserve</i>				
B236 – Tortugas Bank**	0 ± 0	0	0 ± 0	
B250 – Cooper's Reef**	25 ± 25	2	0.033 ± 0.033	7.7 ± 0.8
<i>Reef terrace (6-15 m)</i>				
<i>Reference – Dry Tortugas National Park</i>				
P214 – Between "J" and "K" buoys	0 ± 0	0	0 ± 0	
P206 – NW of Pulaski Shoal	0 ± 0	0	0 ± 0	
<i>Reef terrace (15-21 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P297 – West of Brilliant Shoal**	0 ± 0	0	0 ± 0	
P15 – North of Loggerhead (I-50)**	0 ± 0	0	0 ± 0	
P4 – North of Loggerhead (I-5b)**	0 ± 0	0	0 ± 0	
<i>Reef terrace (22-27 m)</i>				
<i>Tortugas North Ecological Reserve</i>				
B223 – Little Tortugas Bank**	0 ± 0	0	0 ± 0	
B238 – Sherwood Forest**	0 ± 0	0	0 ± 0	

Table 5-2. Mean $\pm$ 1 SE transect frequency, density (no. individuals per m²), test diameter, and numbers of individuals (N) sampled for the urchin *Echinometra lucunter* in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western Florida Keys National Marine Sanctuary (FKNMS). Data are based upon surveys of four 15-m x 1-m transects per site at 43 sites during May-June 2008. Sites are arranged by habitat and depth. Asterisked sites (***) are within the Research Natural Area (RNA) of DTNP or the Tortugas North Reserve of the FKNMS.

Site number/site location	Frequency	N	No. per m ²	Mean size (cm)
<i>Staghorn patch reef (< 6 m)</i>				
RNA – Dry Tortugas National Park				
P283 – Northwestern DTNP (Marker 7)**	25 $\pm$ 25	1	0.017 $\pm$ 0.017	2.0
P287 – West of Ft. Jefferson**	25 $\pm$ 25	1	0.017 $\pm$ 0.017	1.3
<i>Patchy hard-bottom (6-15 m)</i>				
RNA – Dry Tortugas National Park				
P1 – NW of Texas Rock**	0 $\pm$ 0	0	0 $\pm$ 0	
Reference – FKNMS				
B327 – South of DTNP (East of "B" buoy)	0 $\pm$ 0	0	0 $\pm$ 0	
B267 – Tortugas Bank	0 $\pm$ 0	0	0 $\pm$ 0	
B263 – Tortugas Bank	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Patchy hard-bottom (15-21 m)</i>				
Reference – FKNMS				
P307 – SW of DTNP (near "C" buoy)	0 $\pm$ 0	0	0 $\pm$ 0	
Tortugas North Ecological Reserve				
B270 – Eastern Tortugas Bank**	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Low-relief hard-bottom (< 6 m)</i>				
Reference – Dry Tortugas National Park				
P18 – Eastern DTNP (O-72)	0 $\pm$ 0	0	0 $\pm$ 0	
P14 – West of Pulaski Shoal (O-12b)	0 $\pm$ 0	0	0 $\pm$ 0	
P16 – Northern DTNP (O-27)	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Low-relief hard-bottom (6-15 m)</i>				
Reference – FKNMS				
B255 – Tortugas Bank (southern end)	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Low-relief hard-bottom (15-21 m)</i>				
Reference – FKNMS				
B323 – South of DTNP (SW of "B" buoy)	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Low-relief spur and groove (6-15 m)</i>				
Reference – Dry Tortugas National Park				
P220 – Northern DTNP (south of "J" buoy)	0 $\pm$ 0	0	0 $\pm$ 0	
RNA – Dry Tortugas National Park				
P276 – Northwestern DTNP**	0 $\pm$ 0	0	0 $\pm$ 0	
P6 – North of Loggerhead (I-38)**	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Medium-profile reef (< 6 m)</i>				
Reference – Dry Tortugas National Park				
P17 – Northern DTNP (O-92)	0 $\pm$ 0	0	0 $\pm$ 0	
RNA – Dry Tortugas National Park				
P7 – NE of Loggerhead (I-26)**	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Medium-profile reef (6-15 m)</i>				
RNA – Dry Tortugas National Park				
P3 – Northern DTNP (I-63)**	0 $\pm$ 0	0	0 $\pm$ 0	
P280 – Texas Rock**	0 $\pm$ 0	0	0 $\pm$ 0	
P10 – SE of Loggerhead (I-41)**	0 $\pm$ 0	0	0 $\pm$ 0	
P319 – SW of Loggerhead Reef**	0 $\pm$ 0	0	0 $\pm$ 0	

Site number/site location	Frequency	N	No. per m ²	Mean size (cm)
<i>Reference – Dry Tortugas National Park</i>				
P13 – Northeastern DTNP (O-56)	0 ± 0	0	0 ± 0	
P9 – Northeastern DTNP (O-94)	0 ± 0	0	0 ± 0	
P8 – Northeastern DTNP (O-82)	0 ± 0	0	0 ± 0	
P331 – East of SW Channel	0 ± 0	0	0 ± 0	
P12 – Southwestern DTNP (O-84)	0 ± 0	0	0 ± 0	
<i>Medium-profile reef (15-21 m)</i>				
<i>Reference – Dry Tortugas National Park</i>				
P311 – SW of Loggerhead Key	0 ± 0	0	0 ± 0	
P11 – Southwestern DTNP (O-42)	0 ± 0	0	0 ± 0	
<i>Reference – FKNMS</i>				
B231 – Tortugas Bank	0 ± 0	0	0 ± 0	
<i>High-relief spur and groove (6-15 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P2 – Northern DTNP (I-36b)**	0 ± 0	0	0 ± 0	
P5 – North-central DTNP (I-44)**	0 ± 0	0	0 ± 0	
P335 – NW of Loggerhead Key**	0 ± 0	0	0 ± 0	
<i>Reef knoll (15-21 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P291 – West of Loggerhead Key**	0 ± 0	0	0 ± 0	
<i>Tortugas North Ecological Reserve</i>				
B236 – Tortugas Bank**	0 ± 0	0	0 ± 0	
B250 – Cooper's Reef**	0 ± 0	0	0 ± 0	
<i>Reef terrace (6-15 m)</i>				
<i>Reference – Dry Tortugas National Park</i>				
P214 – Between "J" and "K" buoys	0 ± 0	0	0 ± 0	
P206 – NW of Pulaski Shoal	0 ± 0	0	0 ± 0	
<i>Reef terrace (15-21 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P297 – West of Brilliant Shoal**	0 ± 0	0	0 ± 0	
P15 – North of Loggerhead (I-50)**	0 ± 0	0	0 ± 0	
P4 – North of Loggerhead (I-5b)**	0 ± 0	0	0 ± 0	
<i>Reef terrace (22-27 m)</i>				
<i>Tortugas North Ecological Reserve</i>				
B223 – Little Tortugas Bank**	0 ± 0	0	0 ± 0	
B238 – Sherwood Forest**	0 ± 0	0	0 ± 0	

Table 5-3. Mean $\pm$ 1 SE transect frequency, density (no. individuals per m²), test diameter, and numbers of individuals (N) sampled for the urchin *Echinometra viridis* in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western Florida Keys National Marine Sanctuary (FKNMS). Data are based upon surveys of four 15-m x 1-m transects per site at 43 sites during May-June 2008. Sites are arranged by habitat and depth. Asterisked sites (***) are within the Research Natural Area (RNA) of DTNP or the Tortugas North Reserve of the FKNMS.

Site number/site location	Frequency	N	No. per m ²	Mean size (cm)
<i>Staghorn patch reef (< 6 m)</i>				
RNA – Dry Tortugas National Park				
P283 – Northwestern DTNP (Marker 7)**	50 $\pm$ 29	2	0.033 $\pm$ 0.019	2.4 $\pm$ 0.1
P287 – West of Ft. Jefferson**	50 $\pm$ 29	3	0.050 $\pm$ 0.032	2.0 $\pm$ 0.3
<i>Patchy hard-bottom (6-15 m)</i>				
RNA – Dry Tortugas National Park				
P1 – NW of Texas Rock**	0 $\pm$ 0	0	0 $\pm$ 0	
Reference – FKNMS				
B327 – South of DTNP (East of "B" buoy)	0 $\pm$ 0	0	0 $\pm$ 0	
B267 – Tortugas Bank	0 $\pm$ 0	0	0 $\pm$ 0	
B263 – Tortugas Bank	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Patchy hard-bottom (15-21 m)</i>				
Reference – FKNMS				
P307 – SW of DTNP (near "C" buoy)	0 $\pm$ 0	0	0 $\pm$ 0	
Tortugas North Ecological Reserve				
B270 – Eastern Tortugas Bank**	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Low-relief hard-bottom (< 6 m)</i>				
Reference – Dry Tortugas National Park				
P18 – Eastern DTNP (O-72)	50 $\pm$ 29	7	0.117 $\pm$ 0.079	2.9 $\pm$ 0.3
P14 – West of Pulaski Shoal (O-12b)	0 $\pm$ 0	0	0 $\pm$ 0	
P16 – Northern DTNP (O-27)	25 $\pm$ 25	3	0.050 $\pm$ 0.050	2.5 $\pm$ 0.2
<i>Low-relief hard-bottom (6-15 m)</i>				
Reference – FKNMS				
B255 – Tortugas Bank (southern end)	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Low-relief hard-bottom (15-21 m)</i>				
Reference – FKNMS				
B323 – South of DTNP (SW of "B" buoy)	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Low-relief spur and groove (6-15 m)</i>				
Reference – Dry Tortugas National Park				
P220 – Northern DTNP (south of "J" buoy)	25 $\pm$ 25	1	0.017 $\pm$ 0.017	2.8
RNA – Dry Tortugas National Park				
P276 – Northwestern DTNP**	0 $\pm$ 0	0	0 $\pm$ 0	
P6 – North of Loggerhead (I-38)**	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Medium-profile reef (< 6 m)</i>				
Reference – Dry Tortugas National Park				
P17 – Northern DTNP (O-92)	50 $\pm$ 29	8	0.133 $\pm$ 0.082	2.8 $\pm$ 0.1
RNA – Dry Tortugas National Park				
P7 – NE of Loggerhead (I-26)**	25 $\pm$ 25	1	0.017 $\pm$ 0.017	3.0
<i>Medium-profile reef (6-15 m)</i>				
RNA – Dry Tortugas National Park				
P3 – Northern DTNP (I-63)**	0 $\pm$ 0	0	0 $\pm$ 0	
P280 – Texas Rock**	0 $\pm$ 0	0	0 $\pm$ 0	
P10 – SE of Loggerhead (I-41)**	25 $\pm$ 25	1	0.017 $\pm$ 0.017	2.1
P319 – SW of Loggerhead Reef**	0 $\pm$ 0	0	0 $\pm$ 0	

Site number/site location	Frequency	N	No. per m ²	Mean size (cm)
<i>Reference – Dry Tortugas National Park</i>				
P13 – Northeastern DTNP (O-56)	0 ± 0	0	0 ± 0	
P9 – Northeastern DTNP (O-94)	25 ± 25	1	0.017 ± 0.017	2.4
P8 – Northeastern DTNP (O-82)	0 ± 0	0	0 ± 0	
P331 – East of SW Channel	0 ± 0	0	0 ± 0	
P12 – Southwestern DTNP (O-84)	25 ± 25	1	0.017 ± 0.017	2.8
<i>Medium-profile reef (15-21 m)</i>				
<i>Reference – Dry Tortugas National Park</i>				
P311 – SW of Loggerhead Key	0 ± 0	0	0 ± 0	
P11 – Southwestern DTNP (O-42)	0 ± 0	0	0 ± 0	
<i>Reference – FKNMS</i>				
B231 – Tortugas Bank	0 ± 0	0	0 ± 0	
<i>High-relief spur and groove (6-15 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P2 – Northern DTNP (I-36b)**	0 ± 0	0	0 ± 0	
P5 – North-central DTNP (I-44)**	0 ± 0	0	0 ± 0	
P335 – NW of Loggerhead Key**	25 ± 25	1	0.017 ± 0.017	2.7
<i>Reef knoll (15-21 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P291 – West of Loggerhead Key**	0 ± 0	0	0 ± 0	
<i>Tortugas North Ecological Reserve</i>				
B236 – Tortugas Bank**	0 ± 0	0	0 ± 0	
B250 – Cooper's Reef**	25 ± 25	1	0.017 ± 0.017	1.8
<i>Reef terrace (6-15 m)</i>				
<i>Reference – Dry Tortugas National Park</i>				
P214 – Between "J" and "K" buoys	0 ± 0	0	0 ± 0	
P206 – NW of Pulaski Shoal	0 ± 0	0	0 ± 0	
<i>Reef terrace (15-21 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P297 – West of Brilliant Shoal**	0 ± 0	0	0 ± 0	
P15 – North of Loggerhead (I-50)**	0 ± 0	0	0 ± 0	
P4 – North of Loggerhead (I-5b)**	25 ± 25	1	0.017 ± 0.017	2.4
<i>Reef terrace (22-27 m)</i>				
<i>Tortugas North Ecological Reserve</i>				
B223 – Little Tortugas Bank**	0 ± 0	0	0 ± 0	
B238 – Sherwood Forest**	0 ± 0	0	0 ± 0	

Table 5-4. Mean $\pm$ 1 SE transect frequency, density (no. individuals per m²), test diameter, and numbers of individuals (N) sampled for the urchin *Eucidaris tribuloides* in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western Florida Keys National Marine Sanctuary (FKNMS). Data are based upon surveys of four 15-m x 1-m transects per site at 43 sites during May-June 2008. Sites are arranged by habitat and depth. Asterisked sites (***) are within the Research Natural Area (RNA) of DTNP or the Tortugas North Reserve of the FKNMS.

Site number/site location	Frequency	N	No. per m ²	Mean size (cm)
<i>Staghorn patch reef (< 6 m)</i>				
RNA – Dry Tortugas National Park				
P283 – Northwestern DTNP (Marker 7)**	100 $\pm$ 0	12	0.200 $\pm$ 0.082	2.9 $\pm$ 0.2
P287 – West of Ft. Jefferson**	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Patchy hard-bottom (6-15 m)</i>				
RNA – Dry Tortugas National Park				
P1 – NW of Texas Rock**	0 $\pm$ 0	0	0 $\pm$ 0	
Reference – FKNMS				
B327 – South of DTNP (East of "B" buoy)	25 $\pm$ 25	2	0.033 $\pm$ 0.033	2.2 $\pm$ 0.0
B267 – Tortugas Bank	0 $\pm$ 0	0	0 $\pm$ 0	
B263 – Tortugas Bank	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Patchy hard-bottom (15-21 m)</i>				
Reference – FKNMS				
P307 – SW of DTNP (near "C" buoy)	0 $\pm$ 0	0	0 $\pm$ 0	
Tortugas North Ecological Reserve				
B270 – Eastern Tortugas Bank**	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Low-relief hard-bottom (< 6 m)</i>				
Reference – Dry Tortugas National Park				
P18 – Eastern DTNP (O-72)	100 $\pm$ 0	13	0.217 $\pm$ 0.050	3.0 $\pm$ 0.1
P14 – West of Pulaski Shoal (O-12b)	0 $\pm$ 0	0	0 $\pm$ 0	
P16 – Northern DTNP (O-27)	25 $\pm$ 25	1	0.017 $\pm$ 0.017	2.8
<i>Low-relief hard-bottom (6-15 m)</i>				
Reference – FKNMS				
B255 – Tortugas Bank (southern end)	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Low-relief hard-bottom (15-21 m)</i>				
Reference – FKNMS				
B323 – South of DTNP (SW of "B" buoy)	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Low-relief spur and groove (6-15 m)</i>				
Reference – Dry Tortugas National Park				
P220 – Northern DTNP (south of "J" buoy)	25 $\pm$ 25	1	0.017 $\pm$ 0.017	3.4
RNA – Dry Tortugas National Park				
P276 – Northwestern DTNP**	0 $\pm$ 0	0	0 $\pm$ 0	
P6 – North of Loggerhead (I-38)**	0 $\pm$ 0	0	0 $\pm$ 0	
<i>Medium-profile reef (< 6 m)</i>				
Reference – Dry Tortugas National Park				
P17 – Northern DTNP (O-92)	75 $\pm$ 25	4	0.067 $\pm$ 0.027	2.9 $\pm$ 0.2
RNA – Dry Tortugas National Park				
P7 – NE of Loggerhead (I-26)**	25 $\pm$ 25	1	0.017 $\pm$ 0.017	2.5
<i>Medium-profile reef (6-15 m)</i>				
RNA – Dry Tortugas National Park				
P3 – Northern DTNP (I-63)**	0 $\pm$ 0	0	0 $\pm$ 0	
P280 – Texas Rock**	0 $\pm$ 0	0	0 $\pm$ 0	
P10 – SE of Loggerhead (I-41)**	0 $\pm$ 0	0	0 $\pm$ 0	
P319 – SW of Loggerhead Reef**	0 $\pm$ 0	0	0 $\pm$ 0	

Site number/site location	Frequency	N	No. per m ²	Mean size (cm)
<i>Reference – Dry Tortugas National Park</i>				
P13 – Northeastern DTNP (O-56)	0 ± 0	0	0 ± 0	
P9 – Northeastern DTNP (O-94)	0 ± 0	0	0 ± 0	
P8 – Northeastern DTNP (O-82)	0 ± 0	0	0 ± 0	
P331 – East of SW Channel	0 ± 0	0	0 ± 0	
P12 – Southwestern DTNP (O-84)	0 ± 0	0	0 ± 0	
<i>Medium-profile reef (15-21 m)</i>				
<i>Reference – Dry Tortugas National Park</i>				
P311 – SW of Loggerhead Key	0 ± 0	0	0 ± 0	
P11 – Southwestern DTNP (O-42)	50 ± 29	2	0.033 ± 0.019	2.2 ± 0.2
<i>Reference – FKNMS</i>				
B231 – Tortugas Bank	0 ± 0	0	0 ± 0	
<i>High-relief spur and groove (6-15 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P2 – Northern DTNP (I-36b)**	25 ± 25	1	0.017 ± 0.017	3.6
P5 – North-central DTNP (I-44)**	0 ± 0	0	0 ± 0	
P335 – NW of Loggerhead Key**	0 ± 0	0	0 ± 0	
<i>Reef knoll (15-21 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P291 – West of Loggerhead Key**	0 ± 0	0	0 ± 0	
<i>Tortugas North Ecological Reserve</i>				
B236 – Tortugas Bank**	0 ± 0	0	0 ± 0	
B250 – Cooper's Reef**	0 ± 0	0	0 ± 0	
<i>Reef terrace (6-15 m)</i>				
<i>Reference – Dry Tortugas National Park</i>				
P214 – Between "J" and "K" buoys	0 ± 0	0	0 ± 0	
P206 – NW of Pulaski Shoal	0 ± 0	0	0 ± 0	
<i>Reef terrace (15-21 m)</i>				
<i>RNA – Dry Tortugas National Park</i>				
P297 – West of Brilliant Shoal**	0 ± 0	0	0 ± 0	
P15 – North of Loggerhead (I-50)**	0 ± 0	0	0 ± 0	
P4 – North of Loggerhead (I-5b)**	0 ± 0	0	0 ± 0	
<i>Reef terrace (22-27 m)</i>				
<i>Tortugas North Ecological Reserve</i>				
B223 – Little Tortugas Bank**	0 ± 0	0	0 ± 0	
B238 – Sherwood Forest**	0 ± 0	0	0 ± 0	

VI. Anemones and Corallimorpharians

Surveys of anemone and corallimorpharian abundance were conducted along four 15-m x 1-m belt transects per site at all 43 Tortugas sites, except at sites B223 and B238, where only two transects per site were sampled. Figure 6-1 provides underwater photographs of six of the eight species encountered during 2008. Six anemone species (Cnidaria, Actiniaria) were encountered during surveys of 2,520 m² of benthic habitat: *Bartholomea annulata*, *Bunodosoma granulifera*, *Condylactis gigantea*, *Epicystes crucifera*, *Heteractis lucida*, and *Lebrunia danae*. Five of these species were also encountered in 2006, but the recording of *B. granulifera* was the first time we have seen this species in either the Tortugas or the rest of the Florida Keys. Tables 6-1 and 6-2 provide site-level density information for the six anemone species. Of the 633 anemones counted, *E. crucifera* (410 individuals, 65% of all anemones) and *L. danae* (152 individuals, 24%) were the most common anemones, followed by *B. annulata* (59 individuals, 9%), *H. lucida* (7 individuals, 1%), *C. gigantea* (4 individuals, 0.6%), and *B. granulifera* (1 individual, 0.2%). These relative abundance patterns mirrored observations in 2006. Two species, *B. annulata* (present at 26 sites) and *L. danae* (present at 29 sites), were the most broadly distributed anemones (Table 6-1), while *E. crucifera* exhibited the greatest site-level densities when it was encountered (Table 6-2). While *E. crucifera* was only found at 16 sites, mean densities (no. individuals per m²) were as high 3.33 ± 0.69 , with greater densities on shallow (< 6 m) hard-bottom sites and medium-profile reefs within DTNP (Figure 6-2). *Lebrunia danae* tended to be more abundant on shallower (< 15 m), but higher-relief sites within DTNP, including medium-profile and high-relief spur and groove reefs.

A total of 440 corallimorpharians represented by three species were encountered during 2008: *Discosoma carlgreni*, *D. sanctithomae*, and *Ricordea florida* (Table 6-3). These same three species were also found in 2006 among 46 sites and exhibited similar relative abundance patterns. *R. florida* was the most common (370 individuals, 84% of all corallimorphs), followed by *D. sanctithomae* (68 individuals, 15%) and *D. carlgreni* (2 individuals, 0.5%). *D. carlgreni* was only recorded from two of the 43 sites, while *D. sanctithomae* was recorded from nine sites (Table 6-3). *D. sanctithomae* was most abundant on shallow (< 6 m) medium-profile reefs within DTNP, where mean site-level densities were as high as 0.45 ± 0.38 individuals per m². Besides being the most abundant corallimorpharian, *R. florida* was also the most broadly distributed species, recorded from 21 out of the 43 sites. Densities were relatively high (> 0.5 individuals per m²) on shallow hard-bottom and medium-profile reefs within DTNP, while no individuals were found on reef knoll and terrace habitats in both the park and on the Tortugas Bank (Figure 6-2).

Figure 6-1. Anemones and corallimorpharians (Cnidaria, Anthozoa) surveyed for density and habitat distribution in the Dry Tortugas region during May-June 2008. Not shown, but encountered within transects, are the anemone *Bunodosoma granulifera* and the corallimorpharian *Discosoma carlgreni*.

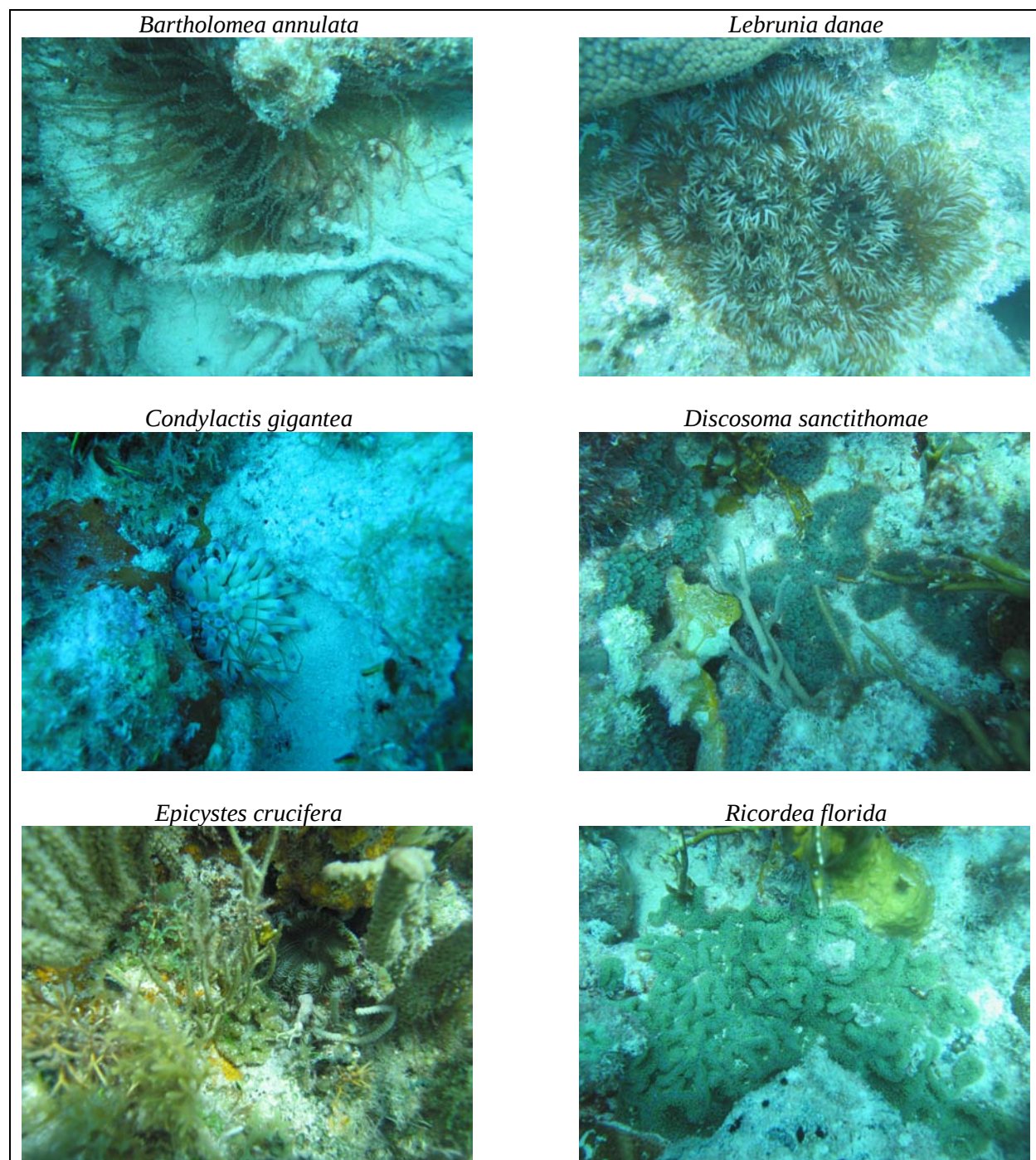


Figure 6-2. Mean (± 1 SE) densities (no. individuals/m²) of the anemones *Epicystes crucifera* and *Lebrunia danae* and the corallimorpharian *Ricordea florida* in the Dry Tortugas region during May-June 2008. Data are based upon surveys of four replicate 15-m x 1-m belt transects per site. See Table 6-1 for habitat and depth designations. Site numbers beginning with “P” are in Dry Tortugas National Park and those with “B” are within the FKNMS. Black bars indicate sites within the Research Natural Area of DTNP or the Tortugas North Reserve within the FKNMS.

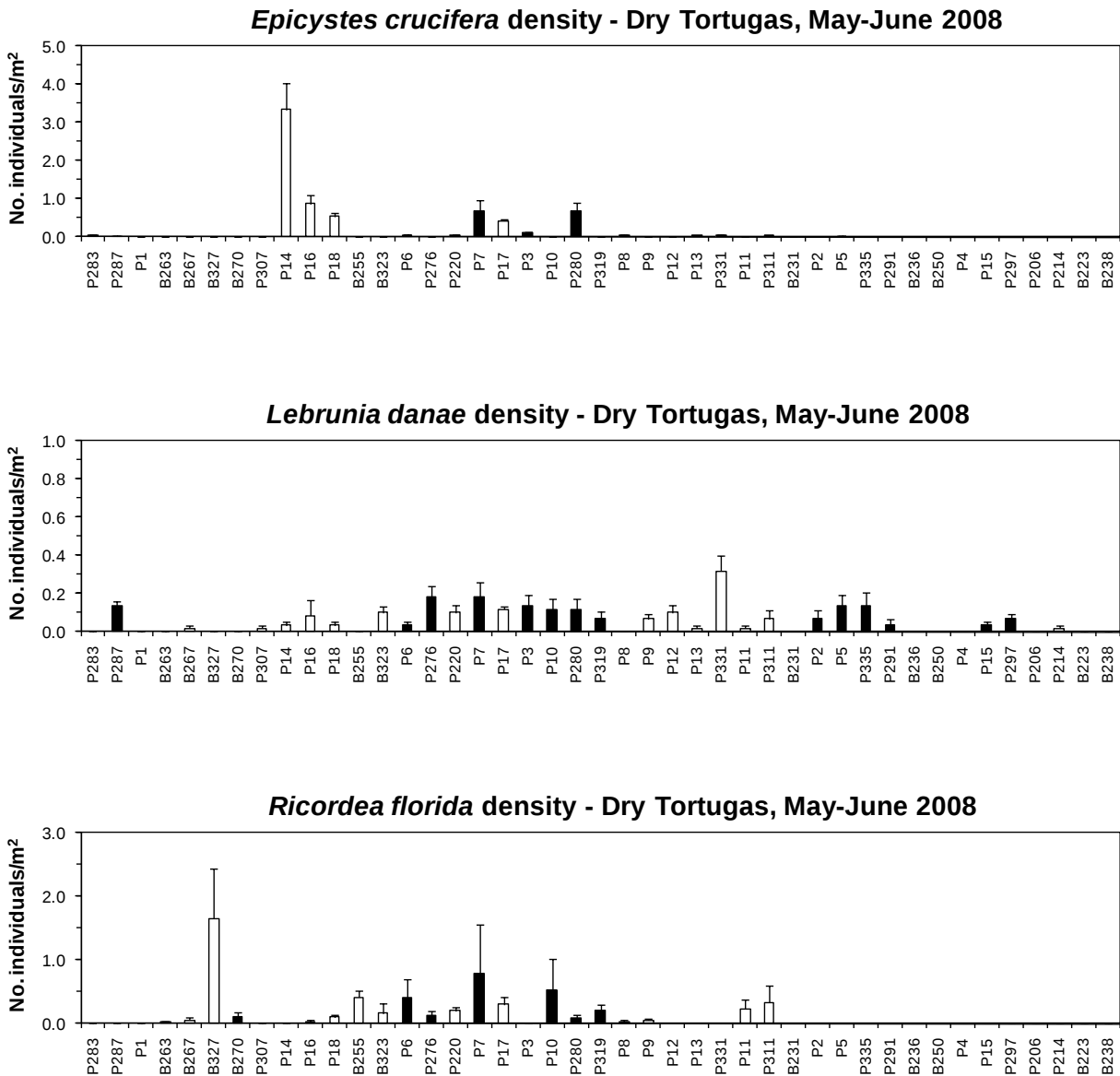


Table 6-1. Numbers of individuals (N) and mean $\pm$ 1 SE densities (no. per m²) of the anemones *Bartholomea annulata*, *Bunodosoma granulifera*, and *Condylactis gigantea* in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western FKNMS. Data are based four 15-m x 1-m sampled transects (60 m²) per site at 43 sites during May-June 2008. Asterisked sites (***) are within the Research Natural Area (RNA) of DTNP or the Tortugas North Reserve of the FKNMS.

Site number/site location	<i>B. annulata</i>		<i>B. granulifera</i>		<i>C. gigantea</i>	
	N	No. per m ²	N	No. per m ²	N	No. per m ²
<i>Staghorn patch reef (< 6 m)</i>						
RNA – Dry Tortugas National Park						
P283 – Northwestern DTNP (Marker 7)**	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
P287 – West of Ft. Jefferson**	3	0.050 $\pm$ 0.032	0	0 $\pm$ 0	0	0 $\pm$ 0
<i>Patchy hard-bottom (6-15 m)</i>						
RNA – Dry Tortugas National Park						
P1 – NW of Texas Rock**	2	0.033 $\pm$ 0.019	0	0 $\pm$ 0	0	0 $\pm$ 0
Reference – FKNMS						
B327 – South of DTNP (East of "B" buoy)	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
B267 – Tortugas Bank	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
B263 – Tortugas Bank	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
<i>Patchy hard-bottom (15-21 m)</i>						
Reference – FKNMS						
P307 – SW of DTNP (near "C" buoy)	1	0.017 $\pm$ 0.017	0	0 $\pm$ 0	0	0 $\pm$ 0
Tortugas North Ecological Reserve						
B270 – Eastern Tortugas Bank***	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
<i>Low-relief hard-bottom (< 6 m)</i>						
Reference – Dry Tortugas National Park						
P18 – Eastern DTNP (O-72)	1	0.017 $\pm$ 0.017	0	0 $\pm$ 0	0	0 $\pm$ 0
P14 – West of Pulaski Shoal (O-12b)	4	0.067 $\pm$ 0.027	0	0 $\pm$ 0	0	0 $\pm$ 0
P16 – Northern DTNP (O-27)	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
<i>Low-relief hard-bottom (6-15 m)</i>						
Reference – FKNMS						
B255 – Tortugas Bank (southern end)	1	0.017 $\pm$ 0.017	0	0 $\pm$ 0	0	0 $\pm$ 0
<i>Low-relief hard-bottom (15-21 m)</i>						
Reference – FKNMS						
B323 – South of DTNP (SW of "B" buoy)	1	0.017 $\pm$ 0.017	0	0 $\pm$ 0	0	0 $\pm$ 0
<i>Low-relief spur and groove (6-15 m)</i>						
Reference – Dry Tortugas National Park						
P220 – Northern DTNP (south of "J" buoy)	3	0.050 $\pm$ 0.017	0	0 $\pm$ 0	0	0 $\pm$ 0
RNA – Dry Tortugas National Park						
P276 – Northwestern DTNP**	3	0.050 $\pm$ 0.017	0	0 $\pm$ 0	0	0 $\pm$ 0
P6 – North of Loggerhead (I-38)**	0	0 $\pm$ 0	0	0 $\pm$ 0	1	0.017 $\pm$ 0.017
<i>Medium-profile reef (< 6 m)</i>						
Reference – Dry Tortugas National Park						
P17 – Northern DTNP (O-92)	0	0 $\pm$ 0	1	0.017 $\pm$ 0.017	0	0 $\pm$ 0
RNA – Dry Tortugas National Park						
P7 – NE of Loggerhead (I-26)**	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
<i>Medium-profile reef (6-15 m)</i>						
RNA – Dry Tortugas National Park						
P3 – Northern DTNP (I-63)**	2	0.033 $\pm$ 0.033	0	0 $\pm$ 0	0	0 $\pm$ 0
P280 – Texas Rock**	1	0.017 $\pm$ 0.017	0	0 $\pm$ 0	0	0 $\pm$ 0
P10 – SE of Loggerhead (I-41)**	3	0.050 $\pm$ 0.050	0	0 $\pm$ 0	0	0 $\pm$ 0
P319 – SW of Loggerhead Reef**	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0

Site number/site location	<i>B. annulata</i>		<i>B. granulifera</i>		<i>C. gigantea</i>	
	N	No. per m ²	N	No. per m ²	N	No. per m ²
Reference – Dry Tortugas National Park						
P13 – Northeastern DTNP (O-56)	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
P9 – Northeastern DTNP (O-94)	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
P8 – Northeastern DTNP (O-82)	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
P331 – East of SW Channel	2	0.033 ± 0.019	0	0 ± 0	1	0.017 ± 0.017
P12 – Southwestern DTNP (O-84)	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
<i>Medium-profile reef (15-21 m)</i>						
Reference – Dry Tortugas National Park						
P311 – SW of Loggerhead Key	0	0 ± 0	0	0 ± 0	0	0 ± 0
P11 – Southwestern DTNP (O-42)	0	0 ± 0	0	0 ± 0	1	0.017 ± 0.017
Reference – FKNMS						
B231 – Tortugas Bank	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
<i>High-relief spur and groove (6-15 m)</i>						
RNA – Dry Tortugas National Park						
P2 – Northern DTNP (I-36b)**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
P5 – North-central DTNP (I-44)**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
P335 – NW of Loggerhead Key**	12	0.200 ± 0.054	0	0 ± 0	0	0 ± 0
<i>Reef knoll (15-21 m)</i>						
RNA – Dry Tortugas National Park						
P291 – West of Loggerhead Key**	0	0 ± 0	0	0 ± 0	0	0 ± 0
Tortugas North Ecological Reserve						
B236 – Tortugas Bank**	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
B250 – Cooper's Reef**	0	0 ± 0	0	0 ± 0	0	0 ± 0
<i>Reef terrace (6-15 m)</i>						
Reference – Dry Tortugas National Park						
P214 – Between "J" and "K" buoys	1	0.017 ± 0.017	0	0 ± 0	0	0 ± 0
P206 – NW of Pulaski Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
<i>Reef terrace (15-21 m)</i>						
RNA – Dry Tortugas National Park						
P297 – West of Brilliant Shoal**	1	0.017 ± 0.017	0	0 ± 0	1	0.017 ± 0.017
P15 – North of Loggerhead (I-50)**	3	0.050 ± 0.032	0	0 ± 0	0	0 ± 0
P4 – North of Loggerhead (I-5b)**	6	0.100 ± 0.058	0	0 ± 0	0	0 ± 0
<i>Reef terrace (22-27 m)</i>						
Tortugas North Ecological Reserve						
B223 – Little Tortugas Bank**	0	0 ± 0	0	0 ± 0	0	0 ± 0
B238 – Sherwood Forest**	0	0 ± 0	0	0 ± 0	0	0 ± 0

Table 6-2. Table 6-1. Numbers of individuals (N) and mean $\pm$ 1 SE densities (no. per m²) of the anemones *Epicyastes crucifera*, *Heteractis lucida*, and *Lebrunia danae* in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western FKNMS. Data are based four 15-m x 1-m sampled transects (60 m²) per site at 43 sites during May-June 2008. Asterisked sites (**) are within the Research Natural Area (RNA) of DTNP or the Tortugas North Reserve of the FKNMS.

Site number/site location	<i>E. crucifera</i>		<i>H. lucida</i>		<i>L. danae</i>	
	N	No. per m ²	N	No. per m ²	N	No. per m ²
<i>Staghorn patch reef (< 6 m)</i>						
RNA – Dry Tortugas National Park						
P283 – Northwestern DTNP (Marker 7)**	2	0.033 $\pm$ 0.019	0	0 $\pm$ 0	0	0 $\pm$ 0
P287 – West of Ft. Jefferson**	1	0.017 $\pm$ 0.017	0	0 $\pm$ 0	8	0.133 $\pm$ 0.027
<i>Patchy hard-bottom (6-15 m)</i>						
RNA – Dry Tortugas National Park						
P1 – NW of Texas Rock**	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
Reference – FKNMS						
B327 – South of DTNP (East of "B" buoy)	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
B267 – Tortugas Bank	0	0 $\pm$ 0	0	0 $\pm$ 0	1	0.017 $\pm$ 0.017
B263 – Tortugas Bank	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
<i>Patchy hard-bottom (15-21 m)</i>						
Reference – FKNMS						
P307 – SW of DTNP (near "C" buoy)	0	0 $\pm$ 0	0	0 $\pm$ 0	1	0.017 $\pm$ 0.017
Tortugas North Ecological Reserve						
B270 – Eastern Tortugas Bank**	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
<i>Low-relief hard-bottom (< 6 m)</i>						
Reference – Dry Tortugas National Park						
P18 – Eastern DTNP (O-72)	32	0.533 $\pm$ 0.105	0	0 $\pm$ 0	2	0.033 $\pm$ 0.019
P14 – West of Pulaski Shoal (O-12b)	200	3.333 $\pm$ 0.690	0	0 $\pm$ 0	2	0.033 $\pm$ 0.019
P16 – Northern DTNP (O-27)	52	0.867 $\pm$ 0.226	0	0 $\pm$ 0	5	0.083 $\pm$ 0.083
<i>Low-relief hard-bottom (6-15 m)</i>						
Reference – FKNMS						
B255 – Tortugas Bank (southern end)	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
<i>Low-relief hard-bottom (15-21 m)</i>						
Reference – FKNMS						
B323 – South of DTNP (SW of "B" buoy)	0	0 $\pm$ 0	0	0 $\pm$ 0	6	0.100 $\pm$ 0.033
<i>Low-relief spur and groove (6-15 m)</i>						
Reference – Dry Tortugas National Park						
P220 – Northern DTNP (south of "J" buoy)	2	0.033 $\pm$ 0.019	0	0 $\pm$ 0	6	0.100 $\pm$ 0.043
RNA – Dry Tortugas National Park						
P276 – Northwestern DTNP**	0	0 $\pm$ 0	0	0 $\pm$ 0	11	0.183 $\pm$ 0.057
P6 – North of Loggerhead (I-38)**	3	0.050 $\pm$ 0.017	0	0 $\pm$ 0	2	0.033 $\pm$ 0.019
<i>Medium-profile reef (< 6 m)</i>						
Reference – Dry Tortugas National Park						
P17 – Northern DTNP (O-92)	25	0.417 $\pm$ 0.057	0	0 $\pm$ 0	7	0.117 $\pm$ 0.017
RNA – Dry Tortugas National Park						
P7 – NE of Loggerhead (I-26)**	40	0.667 $\pm$ 0.294	0	0 $\pm$ 0	11	0.183 $\pm$ 0.079
<i>Medium-profile reef (6-15 m)</i>						
RNA – Dry Tortugas National Park						
P3 – Northern DTNP (I-63)**	6	0.100 $\pm$ 0.019	0	0 $\pm$ 0	8	0.133 $\pm$ 0.061
P280 – Texas Rock**	40	0.667 $\pm$ 0.226	0	0 $\pm$ 0	7	0.117 $\pm$ 0.057
P10 – SE of Loggerhead (I-41)**	0	0 $\pm$ 0	0	0 $\pm$ 0	7	0.117 $\pm$ 0.057
P319 – SW of Loggerhead Reef**	0	0 $\pm$ 0	0	0 $\pm$ 0	4	0.067 $\pm$ 0.038

Site number/site location	<i>E. crucifera</i>		<i>H. lucida</i>		<i>L. danae</i>	
	N	No. per m ²	N	No. per m ²	N	No. per m ²
Reference – Dry Tortugas National Park						
P13 – Northeastern DTNP (O-56)	1	0.017 ± 0.017	0	0 ± 0	1	0.017 ± 0.017
P9 – Northeastern DTNP (O-94)	0	0 ± 0	0	0 ± 0	4	0.067 ± 0.027
P8 – Northeastern DTNP (O-82)	2	0.033 ± 0.019	0	0 ± 0	0	0 ± 0
P331 – East of SW Channel	2	0.033 ± 0.019	0	0 ± 0	19	0.317 ± 0.083
P12 – Southwestern DTNP (O-84)	0	0 ± 0	0	0 ± 0	6	0.100 ± 0.043
<i>Medium-profile reef (15-21 m)</i>						
Reference – Dry Tortugas National Park						
P311 – SW of Loggerhead Key	1	0.017 ± 0.017	0	0 ± 0	4	0.067 ± 0.047
P11 – Southwestern DTNP (O-42)	0	0 ± 0	0	0 ± 0	1	0.017 ± 0.017
Reference – FKNMS						
B231 – Tortugas Bank	0	0 ± 0	0	0 ± 0	0	0 ± 0
<i>High-relief spur and groove (6-15 m)</i>						
RNA – Dry Tortugas National Park						
P2 – Northern DTNP (I-36b)**	0	0 ± 0	0	0 ± 0	4	0.067 ± 0.047
P5 – North-central DTNP (I-44)**	1	0.017 ± 0.017	0	0 ± 0	8	0.133 ± 0.061
P335 – NW of Loggerhead Key**	0	0 ± 0	4	0.067 ± 0.000	8	0.133 ± 0.072
<i>Reef knoll (15-21 m)</i>						
RNA – Dry Tortugas National Park						
P291 – West of Loggerhead Key**	0	0 ± 0	0	0 ± 0	2	0.033 ± 0.033
Tortugas North Ecological Reserve						
B236 – Tortugas Bank**	0	0 ± 0	0	0 ± 0	0	0 ± 0
B250 – Cooper's Reef**	0	0 ± 0	0	0 ± 0	0	0 ± 0
<i>Reef terrace (6-15 m)</i>						
Reference – Dry Tortugas National Park						
P214 – Between "J" and "K" buoys	0	0 ± 0	1	0.017 ± 0.017	1	0.017 ± 0.017
P206 – NW of Pulaski Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
<i>Reef terrace (15-21 m)</i>						
RNA – Dry Tortugas National Park						
P297 – West of Brilliant Shoal**	0	0 ± 0	1	0.017 ± 0.017	4	0.067 ± 0.027
P15 – North of Loggerhead (I-50)**	0	0 ± 0	0	0 ± 0	2	0.033 ± 0.019
P4 – North of Loggerhead (I-5b)**	0	0 ± 0	0	0 ± 0	0	0 ± 0
<i>Reef terrace (22-27 m)</i>						
Tortugas North Ecological Reserve						
B223 – Little Tortugas Bank**	0	0 ± 0	0	0 ± 0	0	0 ± 0
B238 – Sherwood Forest**	0	0 ± 0	1	0.033 ± 0.033	0	0 ± 0

Table 6-3. Numbers of individuals (N) and mean $\pm$ 1 SE densities (no. per m²) of the corallimorpharians *Discosoma carlgreni*, *D. sanctithomae*, and *Ricordea florida* in Dry Tortugas National Park (DTNP) and the Tortugas Bank, western FKNMS. Data are based upon surveys of four 15-m x 1-m transects (60 m²) per site at 43 sites during May-June 2008. Sites are arranged by habitat and depth. Asterisked sites (**) are within the Research Natural Area (RNA) of DTNP or the Tortugas North Reserve of the FKNMS.

Site number/site location	<i>D. carlgreni</i>		<i>D. sanctithomae</i>		<i>R. florida</i>	
	N	No. per m ²	N	No. per m ²	N	No. per m ²
<i>Staghorn patch reef (< 6 m)</i>						
RNA – Dry Tortugas National Park						
P283 – Northwestern DTNP (Marker 7)**	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
P287 – West of Ft. Jefferson**	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
<i>Patchy hard-bottom (6-15 m)</i>						
RNA – Dry Tortugas National Park						
P1 – NW of Texas Rock**	0	0 $\pm$ 0	0	0 $\pm$ 0	19	0.317 $\pm$ 0.074
Reference – FKNMS						
B327 – South of DTNP (East of "B" buoy)	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
B267 – Tortugas Bank	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
B263 – Tortugas Bank	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
<i>Patchy hard-bottom (15-21 m)</i>						
Reference – FKNMS						
P307 – SW of DTNP (near "C" buoy)	0	0 $\pm$ 0	0	0 $\pm$ 0	3	0.050 $\pm$ 0.050
Tortugas North Ecological Reserve						
B270 – Eastern Tortugas Bank**	0	0 $\pm$ 0	0	0 $\pm$ 0	1	0.017 $\pm$ 0.017
<i>Low-relief hard-bottom (< 6 m)</i>						
Reference – Dry Tortugas National Park						
P18 – Eastern DTNP (O-72)	1	0.017 $\pm$ 0.017	6	0.100 $\pm$ 0.100	0	0 $\pm$ 0
P14 – West of Pulaski Shoal (O-12b)	0	0 $\pm$ 0	7	0.117 $\pm$ 0.117	99	1.650 $\pm$ 0.791
P16 – Northern DTNP (O-27)	0	0 $\pm$ 0	0	0 $\pm$ 0	6	0.100 $\pm$ 0.079
<i>Low-relief hard-bottom (6-15 m)</i>						
Reference – FKNMS						
B255 – Tortugas Bank (southern end)	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0
<i>Low-relief hard-bottom (15-21 m)</i>						
Reference – FKNMS						
B323 – South of DTNP (SW of "B" buoy)	0	0 $\pm$ 0	0	0 $\pm$ 0	2	0.033 $\pm$ 0.019
<i>Low-relief spur and groove (6-15 m)</i>						
Reference – Dry Tortugas National Park						
P220 – Northern DTNP (south of "J" buoy)	0	0 $\pm$ 0	1	0.017 $\pm$ 0.017	10	0.167 $\pm$ 0.145
RNA – Dry Tortugas National Park						
P276 – Northwestern DTNP**	0	0 $\pm$ 0	0	0 $\pm$ 0	25	0.417 $\pm$ 0.103
P6 – North of Loggerhead (I-38)**	0	0 $\pm$ 0	1	0.017 $\pm$ 0.017	6	0.100 $\pm$ 0.043
<i>Medium-profile reef (< 6 m)</i>						
Reference – Dry Tortugas National Park						
P17 – Northern DTNP (O-92)	0	0 $\pm$ 0	9	0.150 $\pm$ 0.150	8	0.133 $\pm$ 0.061
RNA – Dry Tortugas National Park						
P7 – NE of Loggerhead (I-26)**	1	0.017 $\pm$ 0.017	27	0.450 $\pm$ 0.384	25	0.417 $\pm$ 0.275
<i>Medium-profile reef (6-15 m)</i>						
RNA – Dry Tortugas National Park						
P3 – Northern DTNP (I-63)**	0	0 $\pm$ 0	6	0.100 $\pm$ 0.100	12	0.200 $\pm$ 0.061
P280 – Texas Rock**	0	0 $\pm$ 0	0	0 $\pm$ 0	18	0.300 $\pm$ 0.111
P10 – SE of Loggerhead (I-41)**	0	0 $\pm$ 0	0	0 $\pm$ 0	47	0.783 $\pm$ 0.783
P319 – SW of Loggerhead Reef**	0	0 $\pm$ 0	0	0 $\pm$ 0	0	0 $\pm$ 0

Site number/site location	<i>D. carlgreni</i>		<i>D. sanctithomae</i>		<i>R. florida</i>	
	N	No. per m ²	N	No. per m ²	N	No. per m ²
<i>Reference – Dry Tortugas National Park</i>						
P13 – Northeastern DTNP (O-56)	0	0 ± 0	0	0 ± 0	2	0.033 ± 0.019
P9 – Northeastern DTNP (O-94)	0	0 ± 0	0	0 ± 0	5	0.083 ± 0.063
P8 – Northeastern DTNP (O-82)	0	0 ± 0	0	0 ± 0	32	0.533 ± 0.490
P331 – East of SW Channel	0	0 ± 0	0	0 ± 0	3	0.050 ± 0.032
P12 – Southwestern DTNP (O-84)	0	0 ± 0	0	0 ± 0	13	0.217 ± 0.092
<i>Medium-profile reef (15-21 m)</i>						
<i>Reference – Dry Tortugas National Park</i>						
P311 – SW of Loggerhead Key	0	0 ± 0	7	0.117 ± 0.117	0	0 ± 0
P11 – Southwestern DTNP (O-42)	0	0 ± 0	0	0 ± 0	0	0 ± 0
<i>Reference – FKNMS</i>						
B231 – Tortugas Bank	0	0 ± 0	0	0 ± 0	0	0 ± 0
<i>High-relief spur and groove (6-15 m)</i>						
<i>RNA – Dry Tortugas National Park</i>						
P2 – Northern DTNP (I-36b)**	0	0 ± 0	4	0.067 ± 0.067	14	0.233 ± 0.150
P5 – North-central DTNP (I-44)**	0	0 ± 0	0	0 ± 0	20	0.333 ± 0.271
P335 – NW of Loggerhead Key**	0	0 ± 0	0	0 ± 0	0	0 ± 0
<i>Reef knoll (15-21 m)</i>						
<i>RNA – Dry Tortugas National Park</i>						
P291 – West of Loggerhead Key**	0	0 ± 0	0	0 ± 0	0	0 ± 0
<i>Tortugas North Ecological Reserve</i>						
B236 – Tortugas Bank**	0	0 ± 0	0	0 ± 0	0	0 ± 0
B250 – Cooper's Reef**	0	0 ± 0	0	0 ± 0	0	0 ± 0
<i>Reef terrace (6-15 m)</i>						
<i>Reference – Dry Tortugas National Park</i>						
P214 – Between "J" and "K" buoys	0	0 ± 0	0	0 ± 0	0	0 ± 0
P206 – NW of Pulaski Shoal	0	0 ± 0	0	0 ± 0	0	0 ± 0
<i>Reef terrace (15-21 m)</i>						
<i>RNA – Dry Tortugas National Park</i>						
P297 – West of Brilliant Shoal**	0	0 ± 0	0	0 ± 0	0	0 ± 0
P15 – North of Loggerhead (I-50)**	0	0 ± 0	0	0 ± 0	0	0 ± 0
P4 – North of Loggerhead (I-5b)**	0	0 ± 0	0	0 ± 0	0	0 ± 0
<i>Reef terrace (22-27 m)</i>						
<i>Tortugas North Ecological Reserve</i>						
B223 – Little Tortugas Bank**	0	0 ± 0	0	0 ± 0	0	0 ± 0
B238 – Sherwood Forest**	0	0 ± 0	0	0 ± 0	0	0 ± 0

VII. Conclusions and Future Efforts

Survey results from 2008 in the Dry Tortugas region add to a growing dataset on the distribution, abundance, size, and condition of benthic coral reef organisms in the Florida Keys National Marine Sanctuary and specifically for the Tortugas region. Previous Quick Look Reports and data summaries, along with peer-reviewed publications, contribute to a growing volume of information collected in the larger Florida Keys ecosystem by our group and others, encompassing reef fishes, spiny lobster, and benthic coral reef organisms (Franklin et al. 2003, Ault et al. 2006, <http://people.uncw.edu/millers>). For many of the variables assessed, we have now compiled 10 years of data, starting in 1999, to evaluate the distribution and structure of coral reef and hard-bottom habitats within the Tortugas region. Data taken prior to and after the designation of the Tortugas North Ecological Reserve in the FKNMS and the Research Natural Area of DTNP will help resource managers determine the effects of extractive activities relative to other influences on the abundance and condition of benthic coral reef resources (Ault et al. 2006). Our plan is to compile results from the 1999-2008 sampling missions to help characterize the habitats in the region and to provide comparisons with spatial and temporal patterns using similar data collected in the rest of the Florida Keys. In addition to specific analyses for manuscripts, we plan to re-evaluate our existing habitat classification to further optimize our allocation strategy for future surveys. We also intend to continue to work closely with NMFS, RSMAS-UM, and FIU to compare community structure and condition variables with existing water quality, geological, and reef fish survey data.

The Dry Tortugas has a long history of scientific study, exemplified by several studies that have investigated the biology and geology of the area (e.g. Shinn et al. 1977, Davis 1982, Dustan 1985, Jaap et al. 1989). geomorphology and community structure dating back over a century (e.g. Shinn et al. 1977, Dustan 1985). In addition to representing the western extent of significant coral reef development in the Florida Keys archipelago, the area has been of long-standing importance due to its up-current location relative to the rest of the Florida Keys, and the lack of shoreline development. On the other hand, the region is not so remote that it totally escapes continental influence due to its proximity to the Florida mainland, as well as by oceanographic processes in the Caribbean, Gulf of Mexico, and the southwest Florida shelf. Indeed, Davis (1982), among many others, have emphasized the importance of the relative isolation of the Dry Tortugas as a benchmark for understanding natural dynamics versus changes and patterns caused by human activities. If anything, historical and recent observations document that substantial changes can occur in benthic communities and fish assemblages in the absence of known or obvious human influences due to tropical cyclones, winter cold-air outbreaks, “black-water” events, and disease (Davis 1982, Jaap et al. 1989, Ault et al. 2006). Such changes have occurred, even with national monument, national park, and national marine sanctuary designations over the past 30 years. For example, major mortality of staghorn corals (*Acropora cervicornis*)

occurred throughout the Tortugas region after the 1976-77 cold-air outbreak, where nearly all of the mapped staghorn corals in 1976 were dead by 1977 (Davis 1982). Changes in reef fish abundance have been attributed to protection in spatial management zones closed to fishing, but patterns in abundance and size are also influenced by recruitment events and storm-induced mortality (Ault et al. 2006).

The Dry Tortugas region is biologically significant for its complex habitats (Davis 1982, Franklin et al. 2003), diverse marine resources, and contribution to the recruitment and productivity of species, including recreationally and commercially important organisms (Ault et al. 2006). Because of its relatively remote location along the southwestern edge of the Florida shelf, the region benefits from ocean circulation patterns that appear to allow both local retention and regional distribution of larvae, especially important for down-current locations that have experienced further resource declines (Ault et al. 2002).

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