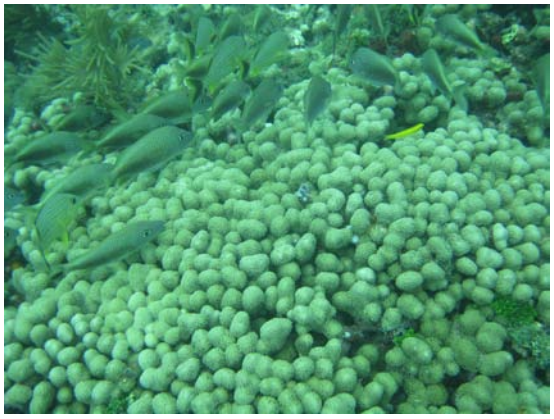
Abundance, Distribution and Condition of Benthic Coral Reef Organisms in the Upper Florida Keys National Marine Sanctuary

2010 Quick Look Report and Data Summary



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NOAA CORAL REEF CONSERVATION PROGRAM

Florida Keys National Marine Sanctuary

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

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2010 Executive Summary

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

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

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

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

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

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

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

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

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

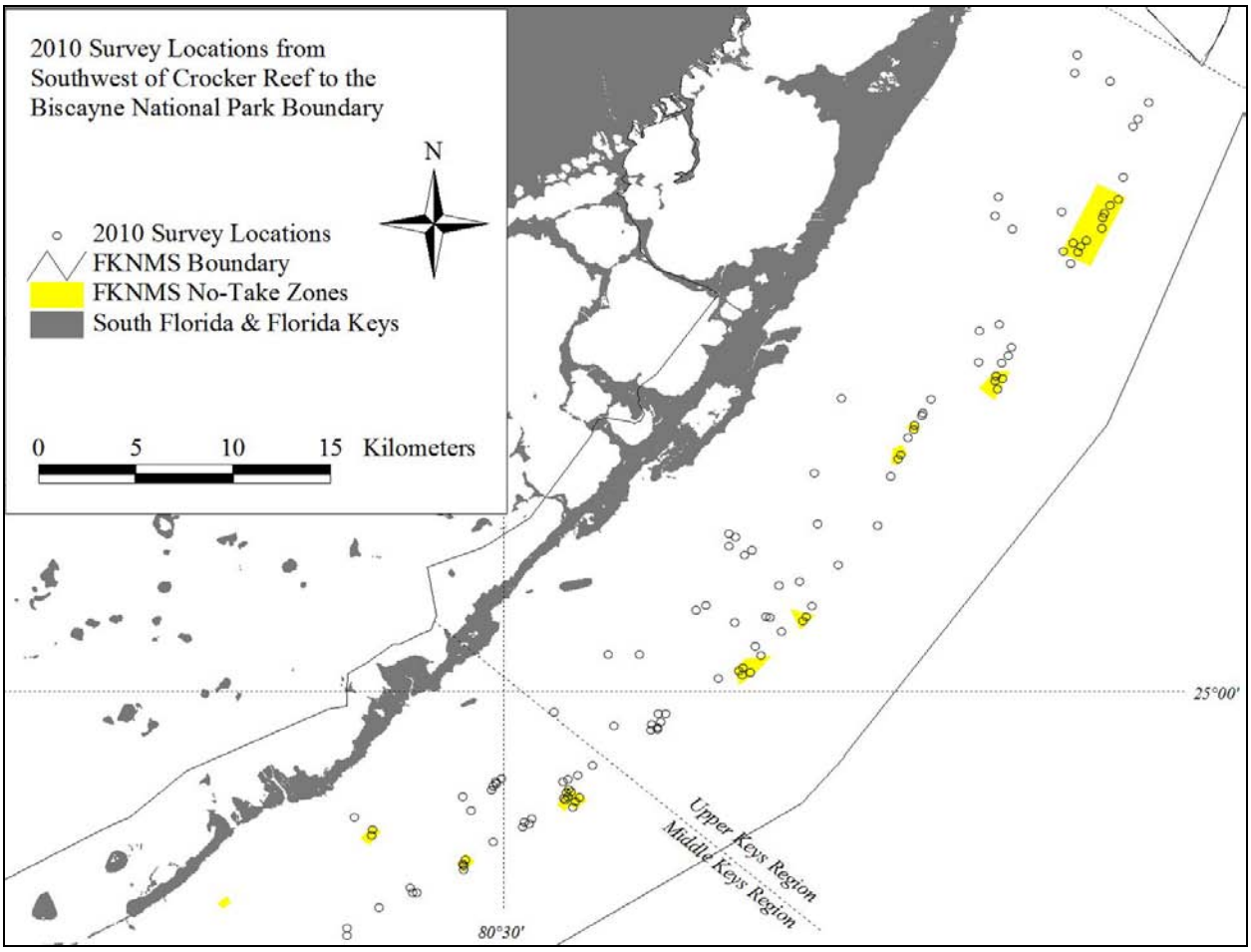
Five anemone species and two corallimorpharian species were encountered during 2010. Although more common in the lower Florida Keys region, which was not sampled this year, no individuals of the knobby anemone (*Heteractis lucida*), the sun anemone (*Stichodactyla helianthus*) or the corallimorpharian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

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

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

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

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



I. Introduction

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

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

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

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