Abundance, Distribution and Condition of *Acropora* Corals, Other Benthic Coral Reef Organisms, and Marine Debris in the Upper Florida Keys National Marine Sanctuary

2011 Quick Look Report and Data Summary




December 2011

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UNCW

NOAA CORAL REEF CONSERVATION PROGRAM

Florida Keys National Marine Sanctuary

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Suggested Citation

Miller SL, Chiappone M, Rutten LM (2011) Abundance, distribution, and condition of *Acropora* corals, other benthic coral reef organisms, and marine debris in the upper Florida Keys National Marine Sanctuary – 2011 Quick look report and data summary. CMS/UNCW, Key Largo, FL. 262 pp

Acknowledgements

Funding was provided by NOAA's Coral Reef Conservation Program, The Department of Commerce's 1535 Endangered Species Act Projects, and NOAA's Aquarius Reef Base (ARB) through the University of North Carolina-Wilmington. Boat and diving support were provided by ARB (R/V *Research Diver*, R/V *George F. Bond*), the upper Keys office of the FKNMS, and Quiescence Diving Services, Inc. J. Delaney (NOAA/FKNMS) assisted with permitting and S.G. Smith of RSMAS-UM assisted with the sampling design. This effort would not have been possible without O. Rutten, T. Roberts, S. Donahue, D. Mooney, S. Morton, and B. Valley of the FKNMS. Research was conducted in the Florida Keys under National Marine Sanctuary Permit FKNMS-2010-077.

Cover photo. Examples of benthic coral reef organisms and marine debris sampled during 2011 in the upper Florida Keys National Marine Sanctuary. Upper left: *Acropora palmata* at Elbow Reef SPA, Upper right: Marine debris surveys, Lower left: *Condylactis gigantea* at Turtle Rocks, Lower right: Molasses Reef marker.

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2011 Executive Summary

During 29 days of fieldwork from May 5 to September 10, 2011, scientists from the Center for Marine Science, University of North Carolina at Wilmington, surveyed the density, size, and condition of *Acropora* corals, other benthic coral reef organisms, including urchins, anemones, corallimorpharians, and mollusks, as well as marine debris abundance and impacts to the benthos in the upper Florida Keys National Marine Sanctuary (FKNMS) (Figure 1). Benthic surveys using two replicate 15-m transects were conducted using a two-stage stratified design (Smith et al. 2011) that partitioned the sampling domain by habitat type (cross-shelf location and depth), geographic region (upper, middle and lower Keys), and management zone (inside and outside of FKNMS no-take zones). A total of 280 sites were surveyed to document the status and trends of benthic coral reef organisms, with a specific focus in 2011 on populations of *Acropora* corals. Funding was provided by NOAA's Coral Reef Conservation Program and The Department of Commerce's 1535 Endangered Species Act Projects. Dive support was provided by NOAA's Aquarius Reef Base and the upper Keys office of the Florida Keys National Marine Sanctuary. The survey team also included personnel from Gray's Reef National Marine Sanctuary and the FKNMS Damage Assessment and Response Research Program (DARRP). To support work with our expanding partner groups, a Field Protocol Manual was produced in 2011 (www.people.uncw.edu/millers) to help guide sampling in 2012 for a system-wide assessment of *Acropora* populations, including the Florida Keys, the US Virgin Islands and Puerto Rico.

Nine coral reef and hard-bottom habitat types were sampled from inshore of Hawk Channel to the deeper fore-reef from 0.9 to 15.8 m depth during 2011. The habitats sampled included inshore patch reefs, mid-channel patch reefs, offshore patch reefs, back-reef rubble, shallow (< 6 m) hard-bottom, inner line reef tract spur and groove, platform margin high-relief spur and groove, 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 to include areas inside and outside of no-take zones. All 12 no-take zones from northern Key Largo to Alligator Reef, designated as Sanctuary Preservation Areas and Research Only Areas, were sampled. For the 280 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, two 15-m transects were used to inventory benthic coral reef organisms and marine debris, including data on: depth and topographic complexity; *Acropora* coral density, size, and condition; density, size and condition of all other scleractinian coral species; urchin density and size; anemone and corallimorpharian density; density and size of mollusks; and marine debris.

This report summarizes results and provides descriptive data for the benthic variables measured during 2011. The report is divided by chapter for each of the major categories of variables measured and includes data tables, figures, underwater photographs, and maps. The data collection effort by the survey team required 762 SCUBA and just over 381 hours of underwater bottom time.

Population assessments of *Acropora* corals conducted in 2011 represent a continuation of our surveys that focus on the habitat distribution, density, size, and condition of these two corals conducted since 2006. The surveys are in addition to population assessments of all coral species, including *Acropora* spp., conducted by this program in 1999-2001, 2005, 2009, and 2011, 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, in greater densities (up to 1.3 physiologic colonies 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 in back-reef rubble and high-relief spur and groove habitats. Population abundance estimates for the habitats surveyed indicate that there are approximately 2.59 million staghorn colonies (skeletal colonies) from the southern boundary of Biscayne National Park to Alligator Reef. However, most staghorn coral colonies are relatively small (< 250 cm^2 of live tissue surface area) and all thickets encountered were less than 1 m in maximum dimension. We estimate that approximately 66% of all staghorn corals in the upper FKNMS occur on mid-channel and offshore patch reefs, while the remaining 34% are distributed among shallow (< 6 m) hard-bottom and spur and groove reefs. Historically, staghorn coral occurred on some deeper fore-reef areas (especially low-relief spur and groove) in larger thickets of interlocking colonies, but no such thickets have been encountered during the past decade. In contrast to the pattern evident for *A. palmata*, it is estimated that nearly all (approximately 99%) of the staghorn corals present in the upper FKNMS occur outside of Sanctuary no-take zones. Of the condition categories assessed, bleaching (19 colonies, 7.4%) and predation (primarily damselfishes and snails) were the most common. Obvious signs of predation were found on 65 colonies, representing approximately 25% of the sampled staghorn corals. No disease-like symptoms or overgrowth by other organisms were encountered.

Relative to its congener, elkhorn coral (*Acropora palmata*) exhibited a narrower habitat distribution, with a few reefs supporting larger aggregations. The size range of skeletal colonies (n = 107) ranged from 3 to 268 cm, with an average of 66 ± 6 cm. Live tissue surface area of physiologic colonies ranged from 1 to 44,185 cm^2, with an average of 1,452 ± 217 cm^2. Among the habitat types sampled, elkhorn corals were only found on inner line reef tract and shallow spur and groove sites. In previous years, we encountered a few isolated colonies on offshore patch reefs, back-reef rubble, and shallow hard-bottom, but clearly most

colonies are presently restricted to shallow fore-reef areas in the upper FKNMS. Similar to previous years, elkhorn corals were most common and characterized by larger colony sizes on several high-relief spur and groove reefs, especially within FKNMS no-take zones such as South Carysfort Reef, Elbow Reef, Grecian Rocks, and French Reef; a similar pattern was also evident for colony size. We estimate that more than 90% of elkhorn corals occur in these high-density thickets. In contrast to the size structure of staghorn corals, there is a greater range in size and a greater abundance of larger (> 1 m diameter) elkhorn corals. Several shallow spur and groove reefs continue to support reasonably large thickets, with most patches approximately 15-20-m in diameter. Reefs where stands (not just isolated colonies) of elkhorn coral occur in the upper Florida Keys include (from north to south): South Carysfort Reef, Elbow Reef, Horseshoe Reef, Grecian Rocks, French Reef, Sand Island, and Molasses Reef. In contrast to staghorn corals, most (87%) of the elkhorn coral colonies in the upper FKNMS occur within Sanctuary no-take zones. Of the condition categories assessed, bleaching (65 colonies, 21.7%) and predation (47 colonies, 15.7%) were the most common adverse conditions encountered. No disease-like symptoms or overgrowth by other organisms that was causing tissue loss were documented.

Surveys for all scleractinian coral species were conducted at all 280 sites, in which replicate 10-m x 1-m belt transects were used to survey the number, size (max. diameter), and condition (percent live tissue, bleaching, disease, overgrowth, and predation) of corals. These data were used, in turn, to compute abundance estimates, prevalence of different conditions, and size structure. A total of 19,716 corals representing 40 species were identified, counted, measured, and assessed for condition. Ten species accounted for approximately 93% of all of the corals encountered, with *Siderastrea siderea*, *Porites astreoides*, *Agaricia agaricites*, *P. porites porites* the most abundant. Coral species could be broadly grouped into those that are ubiquitous and abundant in most of the habitats surveyed, those that are less abundant overall, but common in certain habitats (e.g. *Montastraea faveolata*), and rarer species (e.g. *Dendrogyra cylindrus*). Prevalence of different adverse conditions such as disease and bleaching were generally low, with prevalence estimates of 0.8% and 1.5%, respectively. Bleaching and overgrowth were the most common conditions noted. Many of the most common corals exhibited differences in frequency of occurrence and density among the habitats surveyed. Inshore, mid-channel, and offshore patch reefs continue to support relatively high densities of many species, especially the larger reef-building corals. Comparisons between FKNMS no-take zones and reference areas indicated generally greater densities, sizes, and abundances for most species. Because of the relatively small area of FKNMS no-take zones in the upper Keys, it is therefore not surprising that most of the corals occur outside of the no-take zones.

Seven urchin species comprising 1,958 individuals were counted and measured for test diameter (TD) surveyed during 2011. Similar to previous years, most (~79%) 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 and high-relief spur and groove reefs. Densities of the long-spined sea urchin (*Diadema antillarum*) are still relatively low by historical (pre-1983) standards; the maximum site-level density recorded during 2010 was only 0.267 individuals per m^2. However, two temporal trends are apparent relative to similar surveys from a decade ago. First, densities of *D. antillarum* have slowly increased since 1999, and the greatest 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. Second, there has been a notable increase in the average and maximum sizes of individuals encountered over the past 10 years. In 2011, individuals as large as 9.1 cm TD were recorded, which we never encountered in the Florida Keys prior to 2006. The average size of *D. antillarum* up until 2005 was < 3.0 cm TD, while 2011 yielded an average size of 4.2 cm TD (147 individuals); this average size includes 14 individuals measured in back-reef rubble sites where juveniles (< 2 cm TD) predominate. At sites where aggregations of urchins were found, there were clear and obvious impacts to the substratum. Thus, assuming these trends continue, and as more space becomes cleared of algae, it will be important to monitor potential changes to the benthos, for example, recruitment of corals and other invertebrates. For most of the species encountered, including *D. antillarum*, urchins tended to be more frequently encountered and occurred in greater densities on reference sites compared to no-take zones. Whether this result is due to greater urchin predation inside the no-take zones compared to reference areas is unknown.

Three anemone and three corallimorpharian species were encountered during 2011. Although more common in the lower Florida Keys region, which was not sampled this year, no individuals of *Bunodosoma granulifera*, *Epicystes crucifera*, the knobby anemone (*Heteractis lucida*), and the sun anemone (*Stichodactyla helianthus*) were encountered in the upper Keys during 2011. A total of 595 anemones were counted, mostly represented by *Bartholomea annulata* (81%) or *Condylactis gigantea* (14%). Anemones generally showed similar spatial patterns in abundance among habitats in 2011 compared to previous survey years, with *B. annulata* exhibiting the broadest habitat distribution and greatest frequency of occurrence and abundance. A total of 820 corallimorpharians were counted, of which approximately 96% were *Ricordea florida*, followed by *Discosoma sanctithomae* and *D. carlgreni*. Similar to previous years, *R. florida* was most abundant on mid-channel and offshore patch reefs, with mean densities as high as 9.8 individuals per m^2.

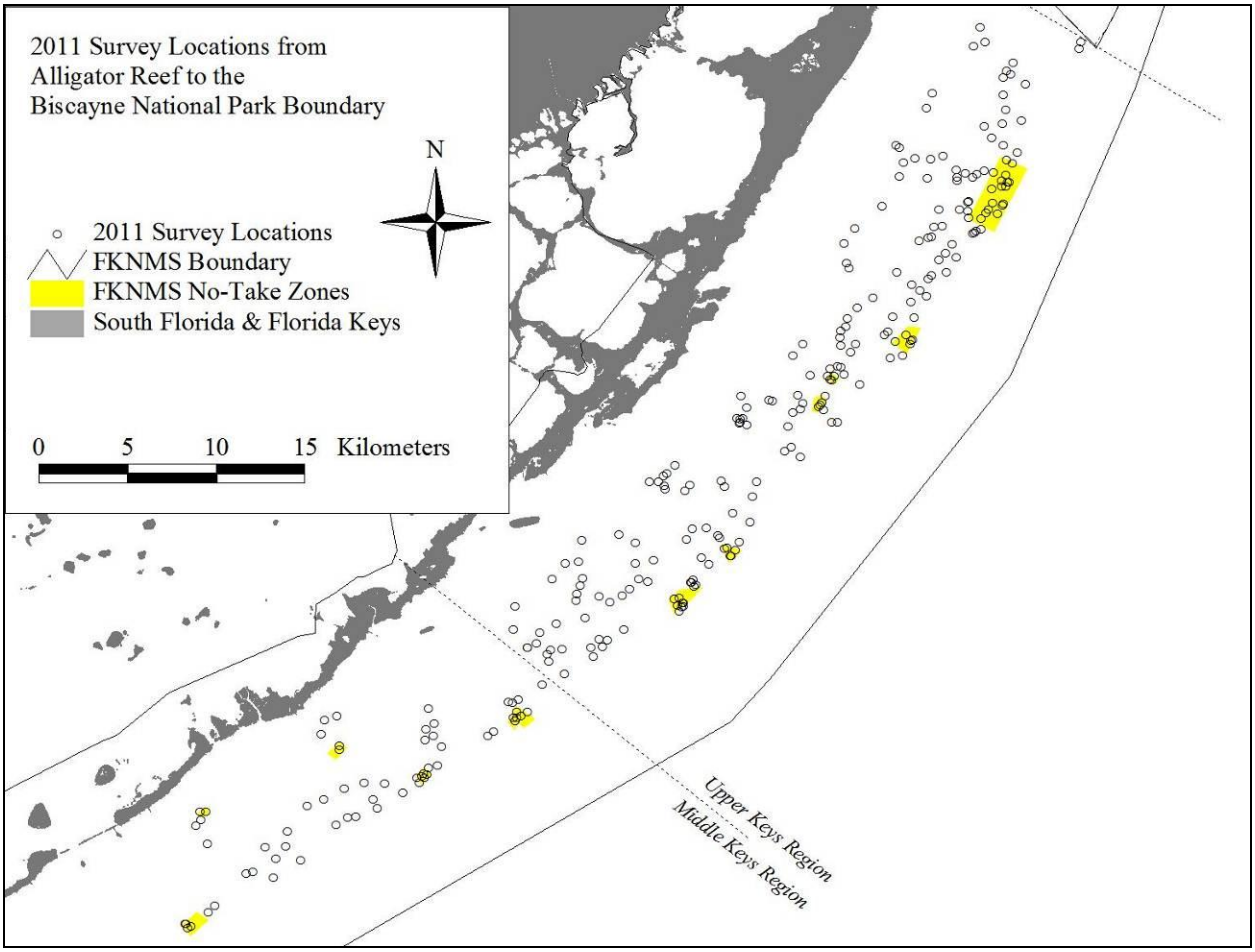
Surveys of the abundance, size, and substratum occupancy patterns of mollusks continued during 2011. All nudibranchs encountered, the sacoglossan *Elysia* (*Tridachia*) *crispata* (lettuce sea slug), and four gastropod species (*Coralliophila* sp., *Leucozonia nassa*, *Thais deltoidea*, and *Strombus gigas*) were enumerated and measured for shell length; in addition, the substratum occupied by a mollusk at the time of the survey was also noted. Seven nudibranch species were encountered, including several undescribed species. All but one of the 69 lettuce sea slugs (*E. crispata*) recorded were found on shallow, high-relief spur and groove reefs. Of the gastropods inventoried, the deltoid rock snail (*T. deltoidea*), an important micro-herbivore of turf algae, was the most abundant (221 individuals), with most individuals occurring on high-relief spur and groove reefs. Approximately 94% of the individuals encountered were found either occupying algal turf or crustose coralline algae. Of the 147 corallivorous snails (*Coralliophila* sp.) recorded, all but one individual were found on live coral tissue. Comparison to previous surveys suggests that *Coralliophila* snail abundance is increasing and that a greater diversity of coral species is experiencing snail predation. Particularly noteworthy was the diversity of coral species (13 species) encountered during 2011 with active snail predation, including species of *Acropora*, *Agaricia*, *Diploria*, and *Montastraea*.

Surveys of marine debris, including lost hook-and-line and lobster and crab trap fishing gear, carried out in 2011 represent a continuation of similar efforts conducted in the Florida Keys in 2000, 2001, 2008, and 2010. Data collected in 2011 included the type and frequency (density) of debris, the length of angling gear and lobster/crab trap rope, the total wet weight of debris recovered, as well as the frequency of benthic coral reef organisms impacted by tissue abrasion from debris entanglement. A total of 679 debris items were encountered. Marine debris was found at about 71% of sites (63%) and in all habitats, including the 12 no-take zones surveyed. Nearly 62% 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 and crab trap gear (25%) and other items such as glass, metals, and plastics. Just over 0.5 km of angling gear, mostly represented by monofilament and fishing wire, was recovered, along with 1.145 km of lobster/crab trap rope, and ~243 kg of debris (approximately 0.534 tons) was recovered from the seabed. A total of 363 sessile invertebrates represented by milleporid hydrocorals (44 colonies), scleractininian corals (89 colonies), gorgonians (195 colonies), sponges (32 individuals), and *Palythoa* (3 individuals) were recorded with abrasions from entanglement with marine debris, usually fishing gear.

Impacts to the benthos from the January 2010 cold-front event, perhaps the worst hypothermal event since the winter of 1976-77, continue to be apparent in particular areas of the upper Florida Keys. Large numbers of patch reefs in the Cannon Patch/Higdons Reef area, Mosquito Bank, Tavernier Rocks, and the

Cheeca Rocks area appear to have suffered the most mortality, especially larger *Montastraea* colonies, as well as gorgonians, as evidenced by the larger numbers of dead, upright gorgonian skeletons. However, areas further offshore of inshore patch reef and shallow bank areas appeared to have suffered little damage from the January 2010 event. Finally, we witnessed more lionfish in 2011 than ever before, as evidenced by greater site prevalence and more individuals (usually 3-6 in a 100-m^2 area). Lionfish were particularly common in habitats such as patch reefs with large coral heads or overhangs.

Figure 1. Sampling locations for *Acropora* corals, other benthic coral reef organisms, and marine debris in the upper Florida Keys National Marine Sanctuary during May-September 2011. A total of 280 sites were surveyed for coral density, size, and condition, including *Acropora* corals, as well as urchins, anemones, corallimorpharians, mollusks, and marine debris from the southern boundary of Biscayne National Park to Alligator Reef.



I. Introduction

Like many coral reef ecosystems, the Florida Keys have exhibited significant change in recent decades, including the loss of coral cover and urchins (*Diadema antillarum*) due to disease, as well as hypo- and hyperthermal events that have resulted in significant coral loss due to bleaching (Jaap 1984; Aronson and Precht 2001; Chiappone et al. 2002; Lirman et al. 2011). 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 array of stressors makes it challenging 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 Florida Keys National Marine Sanctuary (FKNMS). To evaluate potential changes in no-take management zones, it is necessary to also document changes caused by natural system variability, 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 now a 13-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.

In 2011, during 29 days of fieldwork in the upper Florida Keys, we sampled 280 sites stratified by cross-shelf habitat type, along-shelf position, and management zone from the southern boundary of Biscayne National Park to Alligator Reef within the upper region of the FKNMS. Surveys of *Acropora* corals included assessments of colony density at two different levels (skeletal colonies and physiologic colonies), as well as colony size, and condition. Surveys of all other scleractinian corals included assessments of density, size class, estimates of percent live tissue vs. dead skeleton, and condition assessments of bleaching disease, predation, and overgrowth. Other benthic coral reef organisms were surveyed for abundance and size, including urchins, anemones, corallimorpharians, and mollusks. Marine

debris surveys continued in 2011 and consisted of measurements of the frequency, density, length, and weight of debris, as well as counts of benthic invertebrates exhibiting abrasion stress from debris entanglement. Our program team was joined by scientists from Grays Reef National Marine Sanctuary and the Damage Assessment and Restoration Research Program of the FKNMS. Funding was provided by NOAA's Coral Reef Conservation Program and the Department of Commerce's 1535 Endangered Species Act Projects, Boat and diving support were provided by NOAA's Aquarius Reef Base Program and the upper Keys office of the Florida Keys National Marine Sanctuary.

The 2011 surveys 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, with a particular focus on *Acropora* corals (see previous Quick Look reports at http://people.uncw.edu/millers), which is part of a Florida and U.S. Caribbean effort to determine the population status of these species. In the Florida Keys, 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. This report is divided into several sections to summarize the observations and data collected for each of the major classes of variables measured during 2011. Accompanying summary tables, underwater images, and maps are included to illustrate some of the spatial patterns observed for the variables measured along a ~50 km stretch of the upper Florida Keys from northern Key Largo to Islamorada.