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

2008 Quick Look Report and Data Summary




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Steven L. Miller, Mark Chiappone and Leanne M. Rutten

Center for Marine Science, University of North Carolina-Wilmington, 515 Caribbean Drive, Key Largo, Florida 33037, USA

UNCW

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Principal Investigator

Steven L. Miller, Center for Marine Science, University of North Carolina-Wilmington (UNCW), 515 Caribbean Drive, Key Largo, FL 33037, Tel: 305 451 0233, Fax: 305 453 9719, Email: millers@uncw.edu

Program Team

Mark Chiappone, Center for Marine Science, University of North Carolina-Wilmington, 515 Caribbean Drive, Key Largo, FL 33037, Email: chiappone@uncw.edu

Leanne M. Rutten, Center for Marine Science, University of North Carolina-Wilmington, 515 Caribbean Drive, Key Largo, FL 33037, Email: ruttenl@uncw.edu

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

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2008 Sampling Summary

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

Methods include a two-stage stratified random sampling design to partition the Florida Keys sampling domain by benthic habitat type, regional sector, and management zone. Five benthic habitat types were sampled from the inshore edge of Hawk Channel to the deeper fore-reef from 1.0 to 16.5 m depth, including: inshore and mid-channel patch reefs, offshore patch reefs, inner line spur and groove, platform margin spur and groove (< 6 m), and the deeper fore-reef (6-17 m) encompassing hard-bottom, patch hard-bottom, and low-relief spur and groove sites. Sites were also partitioned by regional sector (upper, middle, and lower Keys) and management zone within the FKNMS and included 22 of the 23 no-take zones from northern Key Largo to SW of Key West, designated as Sanctuary Preservation Areas, Ecological Reserves, and Special-use Areas/Research Only Areas. For the 145 sites sampled, latitude/longitude points were randomly generated in a geographic information system (GIS) incorporating available benthic habitat and bathymetry data for the sampling domain. At each site, four 15-m transects were deployed to inventory: depth and topographic complexity; *Acropora* coral presence-absence; gorgonian density and size, as well as gorgonian host occupation patterns by flamingo-tongue (*Cyphoma*) snails; density and size (test diameter) of urchins; density of anemones and corallimorpharians; and density, length, wet weight, and biological impacts of marine debris. These variables have been assessed periodically by our program over several years and add to a growing spatial and temporal data set to help ascertain the status and trends of various benthic organisms.

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

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

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

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

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

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

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

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

I. Introduction

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

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

information. Symptoms of degradation include declines in the abundances of corals, concurrent increases in algae, increased prevalence of disease and bleaching events, and overfishing. In addition to impacts from over-use and coastal development, there are a considerable array of natural phenomena affecting Florida Keys reefs such as atmospheric cold fronts because of high latitude, continental influence (Florida Bay-Atlantic Ocean exchange), and destructive tropical storms (Precht and Miller 2007). This multitude of stressors has made it difficult to discern the degree to which human activities have affected ecological integrity relative to natural system variability (Somerfield et al. 2008).

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

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

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

A significant part of the field effort in 2008 was devoted to documenting and retrieving marine debris, most of which is derelict fishing gear, from all of the sites visited. This represents a follow-up to similar surveys conducted in the FKNMS during 2000 and 2001 (Chiappone et al. 2002c, 2004). Fishing constitutes one of the most significant threats to marine biodiversity and ecosystem function, documented by a growing body of information on the numerous impacts to populations, community structure, and habitats (Dayton et al. 1995; Roberts 1995; Jennings and Polunin 1996). Besides the more obvious effects on species population structure, fishing activities may also reduce the structural complexity of habitats or cause corresponding changes in ecological processes such as competition and predation (Russ 1991; Jones and Syms 1998; Auster and Langton 1999). These patterns are most obvious in areas where explosives, poisons, or other destructive fishing methods are used (Hatcher et al. 1989). However, ecological effects can be expected in any area where traps, mobile fishing gear such as trawls, and potentially, even large numbers of recreational fishers operate (Russ 1991; Jennings and Lock 1996). The Florida Keys have a long history of commercial and recreational fisheries that target a great diversity of fish and invertebrate species using a multitude of gears (Tilmant 1989; Bohnsack et al. 1994). In terms of volume of seafood landed, the Florida Keys is the most important area in the state in landings, dockside value, and numbers of commercial fishing vessels, especially for highly valued invertebrate fisheries (Adams 1992). There are also significant, but largely undocumented effects of tens of thousands of recreational fishers who target hundreds of species using mostly hook-and-line and spear guns (Davis 1977; Bohnsack et al. 1994). The marine debris data collected in 2008 are particularly timely because this coastal ecosystem continues to experience a growing number of recreational fishers, and both commercial and recreational fishers exploit hundreds of invertebrates and fish species (Bohnsack et al. 1994; Ault et al. 1998). The 2008 study addressed several issues on marine debris occurrence in shallow-water coral reef and hard-bottom habitats. First, what is the spatial extent and frequency of marine debris at multiple spatial scales in the Florida Keys? Secondly, what factors, such as habitat type (depth) or management regime (closed or open to fishing) affect the spatial variability of marine debris occurrence? Thirdly, what

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