

Monitoring Changes in the Fully Protected Zones of the Florida Keys National Marine Sanctuary

BRIAN D. KELLER, JOANNE DELANEY, and BILLY CAUSEY
Florida Keys National Marine Sanctuary
P.O. Box 500368
Marathon, Florida 33050 USA

ABSTRACT

The Florida Keys National Marine Sanctuary is a 9,850 km² marine protected area managed by the U.S. National Oceanic and Atmospheric Administration and the State of Florida. A comprehensive management plan was implemented in 1997 to protect and conserve marine resources of the Florida Keys, which include mangrove, seagrass, and coral reef habitats and their associated communities. One innovative aspect of the management plan is the creation of a network of 23 fully protected zones (marine reserves; 24 as of July 2001) that are designed to protect biodiversity and sensitive habitats, reduce user conflicts, and lessen concentrated impacts to marine organisms at heavily used reefs. An ongoing monitoring program is designed to determine effects of no-take protection on heavily exploited fishes and invertebrates, benthic communities, and human activities. Data on the abundance and size of fish, spiny lobster, and queen conch; algal cover; coral cover, diversity, and recruitment; and zone usage are collected from fully protected zones and adjacent reference sites. Preliminary reports indicate increases in the number and size of certain heavily exploited species such as spiny lobster within the fully protected zones. Slower-growing benthic species such as corals and sponges have not shown significant changes within protected areas, possibly because of the short period since implementation of the zoning plan (four years).

KEY WORDS: Florida Keys, marine protected areas, monitoring

INTRODUCTION

The only emergent coral reefs found off the continental U.S. are located in the Florida Keys, from south of Miami to the Dry Tortugas (Figure 1). The Florida Reef Tract comprises one of the largest coral reef systems of its type in the world, arching 356 km east and south of the Keys at a distance of 4.8 to 11.3 km offshore. Because the Upper and Lower Keys are protected from direct flow of water from the Gulf of Mexico, they are considered to have greater reef development than the Middle Keys (Robbin 1981, Shinn et al. 1989). All but the northernmost extent of the Florida Reef Tract lies within the boundaries of the Florida Keys National Marine Sanctuary (FKNMS or Sanctuary). The Sanctuary was designated in 1990 to protect and conserve nationally significant biological and cultural marine resources of the area, including critical coral reef habitats.

The Florida Keys National Marine Sanctuary covers 9,850 km². Over half of the Sanctuary is located in State of Florida territorial waters; the rest (42%) is in Federal waters. While there are many references in the popular literature describing the Florida Reef Tract as a barrier reef, there is a strong belief in the scientific community that it does not fit the definition of such a system. The Florida Reef Tract is more accurately described as a bank reef system, comprised of an almost continuous reef community with elongated reef habitats that lie parallel to one another and resemble a typical barrier reef system. Overall, the reef system along the Florida Keys consists of several distinct habitat types including nearshore patch reefs, mid-channel reefs, offshore patch reefs, seagrass beds, back reefs/reef flat, hardbottom communities, bank or transitional reefs, intermediate reefs, deep reefs, outlier reefs, and sand/soft bottom areas.

One of the most noticeable features of the bank reefs of the Florida Keys is seaward-facing spur-and-groove formations, constructional features formed in part by wave energy (U.S. DOC 1996). Tops of spurs were composed mainly of *Acropora palmata*, especially at depths less than five meters, until the demise of acroporids throughout much of the Caribbean region in the early 1980s. Grooves contain carbonate sand and reef rubble. These features may extend 1 to 2 km off the main reef, from depths of 1 to 10 m. Primary corals found in this area include the *Montastrea annularis* complex and *Montastrea cavernosa*, *Siderastrea siderea*, and *Millepora* spp. *Porites astreoides*, *P. porites*, and *Agaricia agaricites* are also common species. *Acropora cervicornis* and *A. palmata*, formerly common or dominant species at depths of 3 - 15 m, are present in very low abundance at this time. In addition to bank reefs, over 6,000 patch reefs that are circular to oval in shape lie along the Florida Reef Tract in 2 to 9 m of water.

Numerous studies have been completed that describe the inhabitants of the Florida Keys coral reef community. Over 520 species of fish have been identified from the Florida Keys overall (Starck 1968), which includes over 260 species of reef fish (Bohnsack et al. 1999). Three-hundred sixty-seven (367) taxa of algae have been identified (Littler and Littler 2000), as well as 117 species of sponges (Levy et al. 1996), 89 species of polychaete worms (Levy et al. 1996), and 128 species of echinoderms (Hendler et al. 1995). Surveys of fire corals, octocorals, stony corals, zooanthids, and corallimorpharians (false corals) found two species of fire coral, 55 species of octocoral, and 63 taxa of stony corals (U.S. DOC 1996, Levy et al. 1996).

With the designation of the Florida Keys National Marine Sanctuary in 1990, the entire coral reef tract of the Florida Keys was afforded certain levels of protection. Oil and hydrocarbon exploration, mining, and large shipping traffic and their resulting impacts are excluded from the Sanctuary. Anchoring on corals in shallow water is prohibited, as is touching coral, collecting living or dead coral, and taking live rock, a product of the aquarium trade. The Sanctuary has the authority to address discharges within its boundary as well as potential pollutants that originate from outside the Sanctuary, offering protection of water quality that is critical for coral reef health and vitality.

FKNMS FULLY PROTECTED ZONES

In addition to Sanctuary-wide regulations that address direct and indirect impacts to coral reef resources, the creation of fully protected zones preserves specific reef areas more completely. A network of 24 fully protected zones, which cover approximately 6% of the Sanctuary but protect 65% of shallow bank reef habitats and 10% of coral resources overall, were implemented in 1997 and 2001 (Figure 1). Lobstering, fishing, spearfishing, shell collecting, and other consumptive activities are prohibited in these areas. Most of the smaller zones (Sanctuary Preservation Areas) are located along the offshore reef tract and encompass the most heavily used spur-and-groove coral formations. The 30.8 km² Western Sambo Ecological Reserve protects offshore reef as well as all other habitats, including mangrove fringe, seagrasses, hardbottom communities, and patch reefs. The 517.9 km² Tortugas Ecological Reserve, established in July 2001 after a three-year collaborative design and planning process, is located in the westernmost portion of the Florida Reef Tract (Figure 1). The Tortugas Ecological Reserve conserves important deep-water reef resources and fish communities unique to this region of the Florida Keys. The Tortugas Ecological Reserve is also significant because it adjoins a proposed 157.8 km² Research Natural Area in the Dry Tortugas National Park, a zone where shallow seagrass, coral, sand, and mangrove communities will be conserved. Together, the Sanctuary's Tortugas Ecological Reserve and the National Park's Research Natural Area fully protect nearshore to deep reef habitats of the Tortugas region and form the largest, permanent marine reserve in the United States.

FKNMS ZONE MONITORING PROGRAM

A monitoring program that will determine effects of zoning on biodiversity, ecosystem structure and function, and human activities is measuring performance of these 24 fully protected zones. The Zone Monitoring Program uses a combination of academic and government scientists as well as volunteers to look at changes in ecosystem structure (species abundance and size) and function (processes such as fish grazing rates) that result from the cessation of human consumptive activities. Data on the abundance and size of fish and mobile invertebrates, macroalgal cover and biomass, changes in coral cover and diversity, coral recruitment, and zone usage are collected from inside reserve areas and adjacent reference sites. Below are brief summaries of findings to date of the effects of fully protected zones on these parameters.

Monitoring efforts during the three years since zone implementation (1997 - 2000) indicate that some heavily exploited species exhibit differences in abundance and size between fully protected zones and reference sites. Specifically, legal-sized spiny lobsters continue to be more abundant in Sanctuary Preservation Areas (SPAs) than in reference sites of comparable habitat (Cox et al. 2000). The average size of lobsters is larger and remains above the legal minimum size limit in the no-take SPAs, whereas lobsters found at reference sites have remained below legal size. This trend also holds true for the Western Sambo Ecological Reserve, where the mean size of lobsters within the reserve has been significantly larger than in reference areas in both the open and closed fishing seasons (Cox et al. 2002). Additionally, catch rates (number of lobsters per trap) are

higher within the Western Sambo Ecological Reserve than within two adjacent fished areas at all times of the year (Gregory 2002).

Overall, a high degree of variability has been documented with regard to reef fish abundance and size between no-take areas and reference sites (Bohnsack et al. 2002). At this time, clear trends for all exploited reef fish species have not been demonstrated. However, as would be expected with the added protection of no-take management, some species have shown increased abundance in the Sanctuary Preservation Areas over time (Bohnsack et al. 2002). Abundance data analyzed through 2000 show that mean densities (number of individuals per sample) for three of four exploited fish species are higher in the SPAs than in fished reference sites. Complementing these data is an overall increase in abundance of four species of snapper (Lutjanidae) and hogfish (*Lachnolaimus maximus*) at seven out of nine no-take areas monitored by volunteers before and after their establishment in 1997 (REEF 2002). As a result of these monitoring efforts, over 240 reef fish species have been documented in the Sanctuary, many for the first time.

As would be expected, the effects of no-take protection on animals such as queen conch and sea urchins that are not directly exploited and the slower-growing, bottom-dwelling species such as hard and soft corals and sponges (Miller et al. 2002) have not yet become apparent. A queen conch monitoring program has found no statistically significant differences in conch aggregation sizes, density, or abundance between no-take areas and reference sites (Glazer 2002). Two separate teams continue to document very low abundances of sea urchins, especially the long-spined urchin (*Diadema antillarum*; Fogarty and Enstrom 2002, Miller et al. 2002).

In general, the Sanctuary's coral reef monitoring projects have documented a high degree of variability over space (habitat type and region) and time for several ecosystem parameters such as coral cover, species richness, recruitment, and density of benthic invertebrates (Jaap et al. 2002, Miller et al. 2002, Ogden et al. 2002). At this time no consistent differences in coral recruitment between the no-take areas and reference sites have been observed (Miller et al. 2002, Ogden et al. 2002). Juvenile mortality rates varied between habitats and years, which is likely due to the effect of several large storm events in 1998 and 1999 (Ogden et al. 2002). Additionally, no significant differences in the percent cover of hard corals and sponges were noted between protected areas and reference sites (Miller et al. 2002). As documented by one monitoring program, coral cover has remained consistent within no-take and reference sites, suggesting that regional influences may be affecting coral health (Miller et al. 2002). Monitoring of macroalgal biomass indicates variability based on season, water depth, and region, with no major differences between no-take and reference sites noted at this time (Ogden et al. 2002). Preliminary field experiments on algal grazing rates suggest decreased herbivory within the no-take zones, but a significant trend has not yet been established. Researchers monitoring these parameters caution that the high variability of benthic components over space and time necessitates looking at the effects of no-take regulations on a decadal time scale.

Similar to the findings for the biological components of the Sanctuary s Zone Monitoring Program, socioeconomic monitoring indicates that zone usage is highly seasonal (McClellan and Tobias 2002). Non-consumptive diving charters frequent outer reef areas, both inside and outside of the no-take zones, primarily during the summer months. Fishing activity is also highly variable, which is to be expected given the sheer number of economically important recreational and commercial fisheries in the Florida Keys. Commercial lobster fishing comprises the majority of vessel activity observed by one monitoring program. Initial data suggest compliance with no-take regulations is relatively high because little illegal use of the no-take zones has been observed (McClellan and Tobias 2002). Preliminary data on financial performance of commercial fishermen indicate that displacement from the Western Sambo Ecological Reserve did not cause short-term financial losses (Murray et al. 2002). Additional socioeconomic research is underway (Leeworthy et al. 2002, Smith et al. 2002).

CONCLUSION

Coupling biological data with socioeconomic and use information is critical to assess both the ecological status of and community attitudes towards the Sanctuary s zone network. As evidenced by results after just three years, continued monitoring inside and outside of the no-take areas is necessary before trends can be identified. In 2002, State and Federal resource managers will reevaluate the use of zones as a management tool. At that time a comprehensive picture of how the zones are performing in light of natural variability will be presented.

LITERATURE CITED

- Bohnsack, J.A., D.B. McClellan, D.E. Harper, G.S. Davenport, G.J. Konoval, A.-M. Eklund, J.P. Contillo, S.K. Bolden, P.C. Fischel, G.S. Sandorf, J.C. Javech, M.W. White, M.H. Pickett, M.W. Hulsbeck, J.L. Tobias, J.S. Ault, G.A. Meester, S.G. Smith and J. Luo. 1999. Baseline data for evaluating fish populations in the Florida Keys, 1979-1998. NOAA Technical Memorandum NMFS-SEFSC-427. 61 pp.
- Bohnsack, J.A., D.B. McClellan, D.E. Harper, J. Ault, S. Smith, G. Meester, and J. Luo. 2002. Summary of FKNMS reef fish monitoring through 2000 (year 3). Pages 31-34 in: U.S. Department of Commerce. Sanctuary Monitoring Report 2000. Florida Keys National Marine Sanctuary, Marathon, Florida USA.
[www.fknms.nos.noaa.gov/research_monitoring/welcome.html]
- Cox, C., M.C. Darcy, and J.H. Hunt. 2002. Monitoring Caribbean spiny lobsters in the Florida Keys National Marine Sanctuary, 1997 - 2000. Pages 37-39 in: U.S. Department of Commerce. Sanctuary Monitoring Report 2000. Florida Keys National Marine Sanctuary, Marathon, Florida USA.
[www.fknms.nos.noaa.gov/research_monitoring/welcome.html]
- Fogarty, N.D. and M. Enstrom. 2002. Sea Stewards: a volunteer ecological monitoring program. Pages 27-30 in: U.S. Department of Commerce. Sanctuary Monitoring Report 2000. Florida Keys National Marine Sanctuary, Marathon, Florida USA.

- [www.fknms.nos.noaa.gov/research_monitoring/welcome.html]
- Glazer, R. 2002. Queen conch population monitoring in the FKNMS fully protected zones. Pages 44-45 in: U.S. Department of Commerce. Sanctuary Monitoring Report 2000. Florida Keys National Marine Sanctuary, Marathon, Florida USA. [www.fknms.nos.noaa.gov/research_monitoring/welcome.html]
- Gregory, D.R. 2002. Sentinel lobster fisheries project for the Florida Keys National Marine Sanctuary. Pages 40-43 in: U.S. Department of Commerce. Sanctuary Monitoring Report 2000. Florida Keys National Marine Sanctuary, Marathon, Florida USA. [www.fknms.nos.noaa.gov/research_monitoring/welcome.html]
- Hendler, G., J.E. Miller, D.L. Pawson, and P.M. Kier. 1995. *Sea Stars, Sea Urchins, and Allies: Echinoderms of Florida and the Caribbean*. Smithsonian Institution Press, Washington, DC. 390 pp.
- Jaap, W.C., J. Wheaton, K. Hackett, M. Lybolt, M.K. Callahan, J.W. Porter, C. Tsokos, and G. Yanev. 2002. U.S. EPA/FKNMS coral reef monitoring project. Pages 12-16 in: U.S. Department of Commerce. Sanctuary Monitoring Report 2000. Florida Keys National Marine Sanctuary, Marathon, Florida USA.
- Leeworthy, B., P. Wiley, G. Johns, F. Bell, and M. Bonn. 2002. Monitoring of Sanctuary use patterns, and market and nonmarket economic values of Sanctuary resources. Page 50 in: U.S. Department of Commerce. Sanctuary Monitoring Report 2000. Florida Keys National Marine Sanctuary, Marathon, Florida USA. [www.fknms.nos.noaa.gov/research_monitoring/welcome.html]
- Levy, J.M., M. Chiappone, and K.M. Sullivan. 1996. Invertebrate Infauna and Epifauna of the Florida Keys and Florida Bay. Site Characterization for the Florida Keys National Marine Sanctuary and Environs, Volume 5. The Nature Conservancy, Arlington, Virginia USA. 166 pp.
- Littler, D.S. and M.M. Littler. 2000. *Caribbean Reef Plants*. Offshore Graphics, Inc., Washington, DC. 542 pp.
- McClellan, D.B. and J.L. Tobias. 2002. Aerial survey of vessel usage and marine animal occurrences in the FKNMS, 1992-2000. Pages 46-48 in: U.S. Department of Commerce. Sanctuary Monitoring Report 2000. Florida Keys National Marine Sanctuary, Marathon, Florida USA. [www.fknms.nos.noaa.gov/research_monitoring/welcome.html]
- Miller, S.L., D.W. Swanson, and M. Chiappone. 2002. Rapid assessment and monitoring of fully protected zones in the FKNMS. Pages 22-26 in: U.S. Department of Commerce. Sanctuary Monitoring Report 2000. Florida Keys National Marine Sanctuary, Marathon, Florida USA. [www.fknms.nos.noaa.gov/research_monitoring/welcome.html]
- Murray, T., M. Shivlani, and B. Leeworthy. 2002. Socioeconomic monitoring of commercial fishing panels. Page 49 in: U.S. Department of Commerce. Sanctuary Monitoring Report 2000. Florida Keys National Marine Sanctuary, Marathon, Florida USA. [www.fknms.nos.noaa.gov/research_monitoring/welcome.html]
- Ogden, J.C., R.B. Aronson, M.W. Miller, S.R. Smith, and T. Murdoch. 2002. Dynamics of coral reef benthic communities. Pages 19-21 in: U.S. Department of

- Commerce. *Sanctuary Monitoring Report 2000*. Florida Keys National Marine Sanctuary. Marathon, Florida USA.
[www.fknms.nos.noaa.gov/research_monitoring/welcome.html]
- Reef Environmental Education Foundation (REEF). 2002. Volunteer reef fish monitoring in the Florida Keys National Marine Sanctuary's fully protected zones. Pages 35-36 in: *U.S. Department of Commerce. Sanctuary Monitoring Report 2000*. Florida Keys National Marine Sanctuary. Marathon, Florida USA.
[www.fknms.nos.noaa.gov/research_monitoring/welcome.html]
- Robbin, D.M. 1981. Subaerial CaCO₃ crust: A tool for timing reef initiating and defining sea level changes. *Proceedings of the Fourth International Coral Reef Symposium 1*:575-579.
- Shinn, E.A., B.H. Lidz, R.B. Halley, J.H. Hudson, and J.L. Kindinger. 1989. Reefs of Florida and the Dry Tortugas. Field Trip Guidebook T176. American Geophysical Union. Washington, D.C. USA. 53 pp.
- Smith, R., T. Maher, and B. Leeworthy. 2002. Monitoring use patterns surrounding sites for new artificial reefs. Page 51 in: *U.S. Department of Commerce. Sanctuary Monitoring Report 2000*. Florida Keys National Marine Sanctuary. Marathon, Florida USA.
- Starck, W.A. 1968. A list of fishes of Alligator Reef, Florida with comments on the nature of the Florida reef fish fauna. *Undersea Biology 1*:4-40.
- U.S. Department of Commerce (U.S. DOC). 1996. Strategy for Stewardship: Florida Keys National Marine Sanctuary Final Management Plan/Environmental Impact Statement. 3 volumes. Florida Keys National Marine Sanctuary. Marathon, Florida USA.
- U.S. Department of Commerce. 2002. *Sanctuary Monitoring Report 2000*. Florida Keys National Marine Sanctuary. Marathon, Florida USA. 51 pp.
[www.fknms.nos.noaa.gov/research_monitoring/welcome.html]