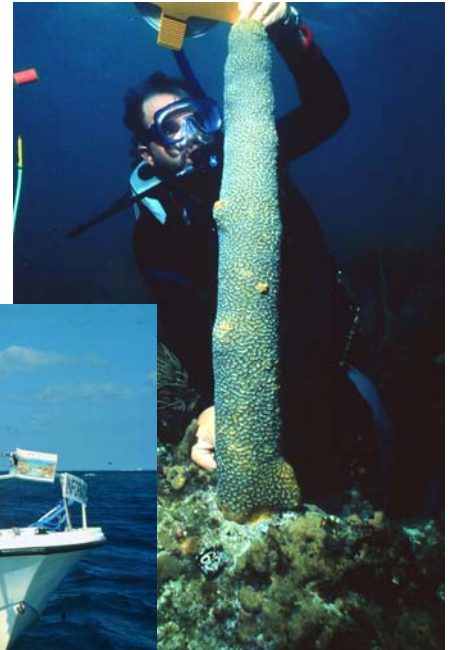


# Florida Keys National Marine Sanctuary Draft Revised Management Plan



February 2005

U.S. Department of Commerce

National Oceanic and  
Atmospheric Administration

National Ocean Service

National Marine Sanctuary Program

This document is the draft revised management plan for the Florida Keys National Marine Sanctuary. It replaces the management plan that was implemented in 1997 and will serve as the primary management document for the Sanctuary during the next five years.

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### **Note to Reader**

In an effort to make this document more user-friendly, we have included references to the Florida Keys National Marine Sanctuary web site rather than including the entire text of many bulky attachments or appendices that are traditionally included in management plans. Readers who do not have access to the Internet may call the Sanctuary office at (305) 743-2437 to request copies of any documents that are on the Sanctuary's web site. For readers with Internet access, the Sanctuary's web site can be found at: <http://floridakeys.noaa.gov>.

# ABOUT THIS DOCUMENT

This document is a report on the results of NOAA's five-year review of the strategies and activities detailed in the 1997 *Final Management Plan and Environmental Impact Statement* for the Florida Keys National Marine Sanctuary. It serves two primary purposes: 1) to update readers on the outcomes of successfully implemented strategies - in short, accomplishments that were merely plans on paper just five years ago; and, 2) to disseminate useful information about the Sanctuary and its management strategies, activities and products. The hope is that this information, which charts the next 5 years of Sanctuary management, will enhance the communication and cooperation so vital to protecting important national resources.

## *Sanctuary Characteristics*

The Florida Keys National Marine Sanctuary extends approximately 220 nautical miles southwest from the southern tip of the Florida peninsula. The Sanctuary's marine ecosystem supports over 6,000 species of plants, fishes, and invertebrates, including the nation's only living coral reef that lies adjacent to the continent. The area includes one of the largest seagrass communities in this hemisphere. Attracted by this tropical diversity, tourists spend more than thirteen million visitor days in the Florida Keys each year. In addition, the region's natural and man-made resources provide livelihoods for approximately 80,000 residents.

The Sanctuary is 2,900 square nautical miles of coastal waters, including the recent addition of the Tortugas Ecological Reserve. The Sanctuary overlaps six state parks and three state aquatic preserves. Three national parks have separate jurisdictions, and share a boundary with the Sanctuary. In addition, the region has some of the most significant maritime heritage and historical resources of any coastal community in the nation.

The Sanctuary faces specific threats, including direct human impacts such as ship groundings, pollution, and overfishing. Threats to the Sanctuary also include indirect human impacts, which are harder to identify but seem to be reflected in coral declines and increases in macroalgae and turbidity. More information about the Sanctuary can be found in this document and at the Sanctuary's web site: <http://floridakeys.noaa.gov>.

## *Management Plan Organization*

Within this document, the tools that the Sanctuary uses to achieve its goals, are presented under five management divisions: 1) Science; 2) Education, Outreach & Stewardship; 3) Enforcement & Resource Protection; 4) Resource Threat Reduction; and, 5) Administration, Community Relations, & Policy Coordination. Each management division contains two or more *action plans*, which are implemented through supporting *strategies* and *activities*. The strategies described in the 1997 *Management Plan* generally retain their designations in this document. As in the 1997 plan, two or more action plans may share a strategy where their goals and aims converge.

## *Accomplishments and Highlights*

The Sanctuary's programs and projects have made significant progress since the original management plan was implemented 1997. An overview of these accomplishments is provided in the Introduction. In addition, each action plan contains bulleted lists of accomplishments since the 1997 management plan was adopted.

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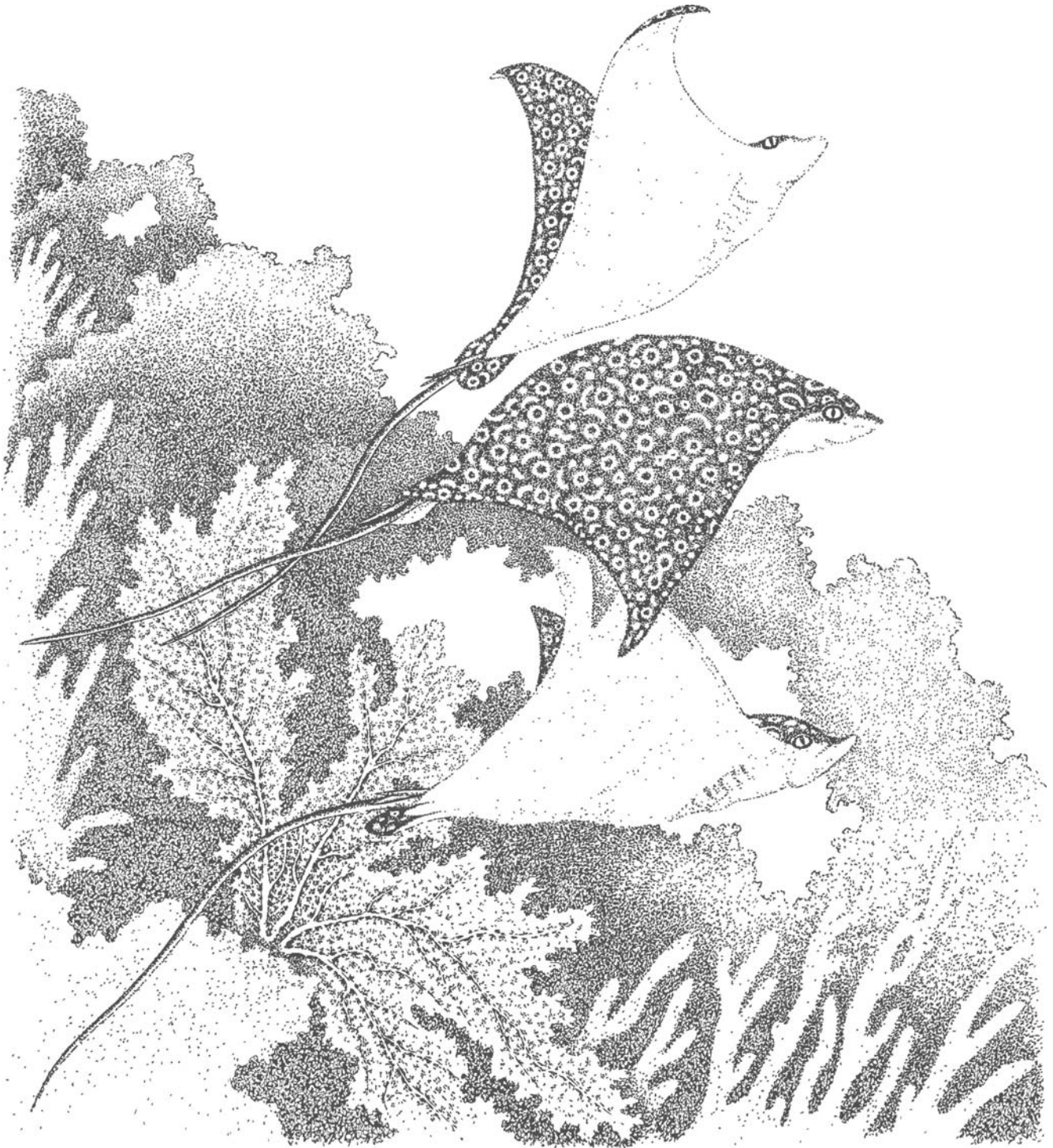
## Acronyms

ASA	Abandoned Shipwreck Act
ATBAs	Areas to Be Avoided
AWT	Advanced Wastewater Treatment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DARP	Damage Assessment and Restoration Program
DMR	Department of Marine Resources (Monroe County)
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
F.S.	Florida Statutes
FAC	Florida Administrative Code
FDACS	Florida Department of Agriculture and Consumer Services
FDHR	Florida Division of Historical Resources
FDEP	Florida Department of Environmental Protection
FFWCC	Florida Fish and Wildlife Conservation Commission
FKNMS	Florida Keys National Marine Sanctuary
FKNMSPA	Florida Keys National Marine Sanctuary Protection Act
FPS	Florida Park Service
FWRI	Fish and Wildlife Research Institute
FWS	Fish and Wildlife Service
GIS	Geographic Information System
GPS	Global Positioning System
HAZMAT	Hazardous Materials
MBTA	Migratory Bird Treaty Act
MEERA	Marine Ecosystem Event Response and Assessment
MHR	Maritime Heritage Resources
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NEPA	National Environmental Protection Act
NGO	Non-governmental Organization
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NMSA	National Marine Sanctuary Act
NMSP	National Marine Sanctuary Program
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
OSDS	On-Site Disposal System
PSSA	Particularly Sensitive Sea Area



SAV	Submerged Aquatic Vegetation
SCR	Submerged Cultural Resources
SEFSC	Southeast Fisheries Science Center
SFWMD	South Florida Water Management District
SPA	Sanctuary Preservation Area
SWIM	Surface Water Improvement and Management Act
SWM	Stormwater Management
TNC	The Nature Conservancy
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDOC	U.S. Department of Commerce
USDOI	U.S. Department of Interior
USDOS	U.S. Department of State
USDOT	U.S. Department of Transportation
USGS	U.S. Geological Survey
WMA	Wildlife Management Area

# 1.0 INTRODUCTION



## 1.1 The National Marine Sanctuary Program (NMSP)

The National Marine Sanctuary Program (NMSP) is a network of 13 marine protected areas (Figure 1.1), encompassing marine resources from Washington State to the Florida Keys, and Lake Huron to American Samoa. The National Oceanic and Atmospheric Administration's (NOAA) National Ocean Service (NOS) has managed the nation's marine sanctuaries since passage of the Marine Protection, Research and Sanctuaries Act of 1972. Title III of that Act is now called the National Marine Sanctuaries Act (NMSA), which is found in Appendix A.

Today, the national marine sanctuaries contain deep-ocean gardens, near-shore coral reefs, whale migration corridors, deep-sea canyons, and underwater archaeological sites. They range in size from one-quarter square mile in Fagatele Bay, American Samoa, to more than 5,300 square miles off Monterey Bay, California – one of the largest marine protected areas in the world. Together, these sanctuaries protect nearly 18,000 square miles of coastal and open ocean waters and habitats. While some activities are managed to protect resources, certain multiple uses, such as recreation, commercial fishing, and shipping are allowed to the extent that they are consistent with a sanctuary's resource protection mandates. Research, education, outreach, and enforcement activities are major components in each sanctuary's program of resource protection.

The NMSP is recognized around the world for its commitment to management of marine protected areas within which primary emphasis is placed on the protection of living marine resources and our nation's maritime heritage resources.

Figure 1.1. The National Marine Sanctuaries



### The NMSP Vision:

*People value marine sanctuaries as treasured places protected for future generations.*

### The NMSP Mission:

*To serve as the trustee for the national system of marine protected areas to conserve, protect, and enhance their biodiversity, ecological integrity and cultural legacy.*

## 1.2 The Florida Keys National Marine Sanctuary (FKNMS)

### *Historical Setting*

Warning signs of the fragility and finite nature of the region's marine resources have been present in the Florida Keys for years. In 1957, a group of conservationists and scientists met at Everglades National Park to discuss the demise of the coral reef resources at the hands of those attracted by its beauty and uniqueness. The conference resulted in the 1960 creation of the world's first underwater park, John Pennekamp Coral Reef State Park. However, in the following decade, public outcry continued over pollution, overfishing, physical impacts, overuse, and user conflicts. The concerns continued to be voiced by environmentalists and scientists alike throughout the 1970s and into the 1990s.

As a result, additional management efforts were instituted to protect the Keys' coral reefs. In the Upper Keys, Key Largo National Marine Sanctuary was established in 1975 to protect 103 square nautical miles of coral reef habitat from north of Carysfort Lighthouse to south of Molasses Reef. In the Lower Keys, the 5.32 square nautical mile Looe Key National Marine Sanctuary was established in 1981.

Despite these efforts, oil drilling proposals and reports of deteriorating water quality occurred throughout the 1980s. At the same time, scientists were assessing coral bleaching and diseases, long-spined urchin die-offs, loss of living coral cover, a major seagrass die-off, and declining reef fish populations. Such threats prompted Congress to act. In 1988, Congress reauthorized the National Marine Sanctuary Program and ordered a feasibility study for possible expansion of Sanctuary sites in the Florida Keys - a directive that signaled that the health of the Keys ecosystem was of national concern.

The feasibility studies near Alligator Reef, Sombrero Key, and westward from American Shoal were overshadowed by several natural events and ship groundings that precipitated the designation of the Florida Keys National Marine Sanctuary (FKNMS). Three large ships ran aground on the coral reef during one 18-day period in the fall of 1989. Although people cite the ship groundings as the issue triggering Congressional action, it was, in fact, the cumulative degradation and the threat of oil drilling, along with the groundings. These multiple threats prompted Congressman Dante Fascell to introduce a bill into the House of Representatives in November of 1989. Congressman Fascell had long been an environmental supporter of South Florida and his action was very timely. Senator Bob Graham, also known for his support of environmental issues in Washington and as a Florida Governor, sponsored the bill in the Senate. Congress gave its bipartisan support, and on November 16, 1990, President George Bush signed the bill into law.

With designation of the Florida Keys National Marine Sanctuary in 1990, several protective measures were implemented immediately, such as prohibiting oil and hydrocarbon exploration, mining or otherwise altering the seabed, and restricting large shipping traffic. Additionally, protection to coral reef resources was extended by restricting anchoring on coral, touching coral, and collecting coral and live rock (a product of the aquarium trade). Discharges from within the Sanctuary and from areas outside the Sanctuary that could potentially enter and affect local resources were also restricted in an effort to comprehensively address water quality concerns.

### ***Administration and Legislation***

The Sanctuary uses an ecosystem approach to comprehensively address the variety of impacts, pressures, and threats to the Florida Keys marine ecosystem. It is only through this inclusive approach that the complex problems facing the coral reef community can be adequately addressed.

The goal of the Sanctuary is to protect the marine resources of the Florida Keys. It also aims to interpret the Florida Keys marine environment for the public and to facilitate human uses of the Sanctuary that are consistent with protection of this particular marine ecosystem. The Sanctuary is administered by NOAA and is jointly managed with the State of Florida under a co-trustee agreement. The Florida Governor and Cabinet, sitting as the Board of Trustees for the State of Florida, designated the Florida Department of Environmental Protection (FDEP) as the State's partner for Sanctuary management. Additionally, the Florida Fish and Wildlife Conservation Commission (FWC), created in 1999, enforces Sanctuary regulations in partnership with Sanctuary managers. FWC also houses the Fish and Wildlife Research Institute (FWRI), which conducts and coordinates scientific research and monitoring.

National Marine Sanctuaries are typically designated by the Secretary of Commerce through an administrative process established by the NMSA. However, recognizing the importance of the Florida Keys ecosystem and the degradation of the ecosystem due to direct and indirect physical impacts, Congress passed the Florida Keys National Marine Sanctuary and Protection Act (FKNMSPA) in 1990, (P.L. 101-605) (Appendix B) designating the Florida Keys National Marine Sanctuary. President George Bush signed the FKNMSPA into law on November 16, 1990.

The FKNMSPA requires the preparation of a comprehensive management plan and implementing regulations to protect Sanctuary resources. This draft *Revised Management Plan* responds to the FKNMSPA's requirements. The implementing regulations, effective as of 1 July 1997, are found at 15CFR922 and in Appendix C. The designation document for the FKNMS is found in Appendix D.

### ***Sanctuary Boundaries***

The Sanctuary's enabling legislation designated 2,800-square-nautical miles of coastal waters off the Florida Keys as the Florida Keys National Marine Sanctuary. The Sanctuary's boundary was amended in March 2001 when the Tortugas Ecological Reserve was designated, significantly increasing the marine resources requiring protection.

Currently, the boundary encompasses approximately 2,900 square nautical miles (9,800 square kilometers) of coastal and ocean waters and submerged land (Figure 1.2). The boundary extends southward on the Atlantic Ocean side of the Keys, from the northeastern-most point of the Biscayne National Park along the approximate 300-foot isobath for over 220 nautical miles to the Dry Tortugas National Park. The boundary extends more than 10 nautical miles to the west of the Park boundary, where it turns north and east. The northern boundary of the Sanctuary extends to the east where it intersects the boundary of the Everglades National Park. The Sanctuary waters on the north side of the Keys encompass a large area of the Gulf of Mexico and western Florida Bay. The boundary follows the Everglades National Park boundary and continues along the western shore of Manatee Bay, Barnes Sound, and Card Sound. The boundary then follows the southern boundary of Biscayne

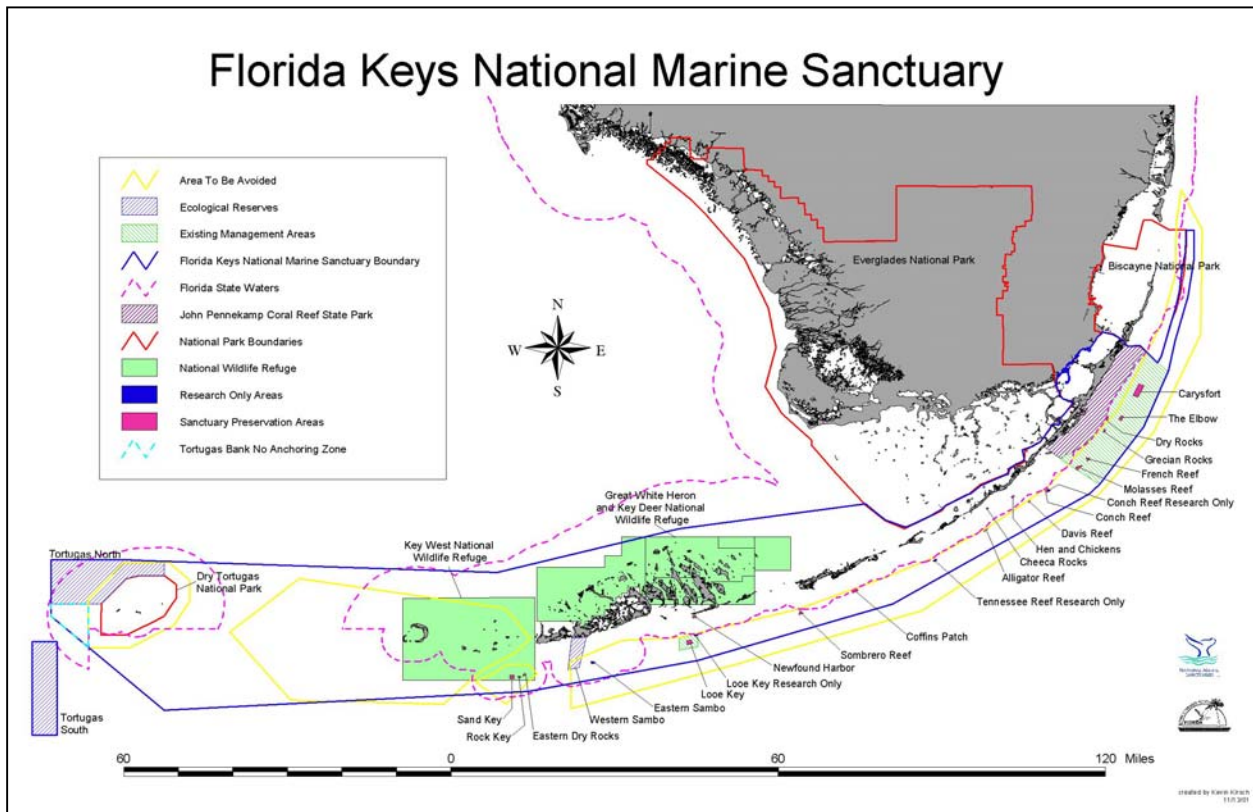
National Park and up its eastern boundary along the reef tract at a depth of approximately 60 feet until its northeastern-most point.

A separate, non-contiguous, 60 square nautical mile area off the westernmost portion of the Sanctuary is called the Tortugas Ecological Reserve South. The area's shallowest feature is Riley's Hump.

The Sanctuary boundary overlaps two previously existing National Marine Sanctuaries (Key Largo and Looe Key); four U.S. Fish and Wildlife Service (USFWS) refuges; six state parks, including John Pennekamp Coral Reef State Park; three state aquatic preserves; and other jurisdictions. Everglades National Park, Biscayne National Park and Dry Tortugas National Park are excluded from Sanctuary waters, but each shares a boundary with the Sanctuary.

The shoreward boundary of the Sanctuary is the mean high-water mark, except around the Dry Tortugas where it is the boundary of Dry Tortugas National Park. The Sanctuary boundary encompasses nearly the entire reef tract, all of the mangrove islands of the Keys, and a good portion of the region's seagrass meadows.

Figure 1.2. The Florida Keys National Marine Sanctuary Boundaries



### *Socio-Economic Context*

The environment and the economy are inextricably linked in the Florida Keys, making management and protection of existing resources and reducing impacts critical if the economy is to be sustained. Tourism is the number one industry in the Florida Keys, with over \$1.2 billion dollars being spent annually by over 3 million visitors. The majority of visitors participate in activities such as snorkeling, SCUBA diving, recreational fishing, viewing wildlife and studying nature. Recreational and commercial fishing are the next most important sectors of the local economy, annually contributing an estimated \$500 million and \$57 million respectively (<http://marineeconomics.noaa.gov>).

Because of the recreational and commercial importance of the marine resources of the Florida Keys, protecting these Sanctuary resources is valuable not only for the environment but also for the economy. The special marine resources of the region, which led to the area's designation as a National Marine Sanctuary, contribute to the high quality of life for residents and visitors. Without these unique marine resources, the quality of life and the economy of the Keys would decline.

## 1.3 The Management Plan Review Process

### *What is management plan review?*

In 1992, when Congress reauthorized the NMSA, it required all National Marine Sanctuaries to review their management plans every five years in order to monitor and evaluate the progress of the national mission to protect national resources. The Florida Governor and Cabinet, as trustees for the State, also mandated a five-year review of the Florida Keys National Marine Sanctuary Management Plan in their January 28, 1997 resolution.

The Sanctuary's management plan review creates a road map for future actions based on past experience and outcomes. The review reevaluates the goals and objectives, management techniques, strategies, and actions identified in the existing management plan. It provides the opportunity to take a close and comprehensive look at outcomes and plan for future management of the Sanctuary.

### *The 1997 Florida Keys National Marine Sanctuary Management Plan*

After the initial six-year FKNMS planning process, a comprehensive management plan for the Sanctuary was implemented in July 1997. The management plan focused on ten action plans which were largely non-regulatory in nature and involved educating citizens and visitors, using volunteers to build stewardship for local marine resources, appropriately marking channels and waterways, installing and maintaining mooring buoys for vessel use, surveying maritime heritage resources, and protecting water quality. In addition to action plans, the 1997 management plan designated five types of marine zones to reduce pressures in heavily used areas, protect critical habitats and species, and reduce user conflicts. The efficacy of the marine zones is monitored Sanctuary-wide under the Research and Monitoring Action Plan.

The implementing regulations for the FKNMS became effective July 1, 1997. The 1997 management plan was published in three volumes: Volume I is the Sanctuary management plan itself (which this document updates); Volume II describes the process used to develop the draft management alternatives, including environmental and socioeconomic impact analyses of the alternatives, and the environmental impact statement; Volume III contains appendices, including the texts of Federal and State legislation that designate and implement the Sanctuary. All three volumes of the 1997 management plan are available on the Sanctuary web site (<http://floridakeys.noaa.gov/>) and from the Sanctuary's Marathon office. Volume II is not being revised as part of this review. After public input, government review and final adoption of this five-year review and revised Management Plan, this document will replace Volumes I and III.

### *How does management plan review work?*

Review of the 1997 management plan began in early 2001 with a meeting in Tallahassee, Florida, among Federal and state partners responsible for Sanctuary management and various FKNMS and NMSP staff. The review included the Sanctuary Advisory Council (SAC) and the general public in every step of the process.

In the late spring and summer of 2001, FKNMS staff, working closely with the SAC, held scoping meetings and re-convened working groups that had been created during development of the 1997 plan. The scoping meetings were held in Marathon, Key Largo, and Key West, and gave the public the opportunity to meet with SAC members, Sanctuary managers, and FKNMS staff. The meetings



included round-table discussions on every action plan, and participants had the opportunity to move freely between the various topics being discussed at each table.

The scoping period for the revised management plan lasted from June 8 through July 20, 2001.

Approximately 30 comments were received - a sharp contrast to the more than 6000 public comments received during the comment period for the 1997 plan. In addition, the working groups held more than three dozen meetings between June and September 2001 to discuss, evaluate, revise and update action plans. SAC members and FKNMS staff who had served on the working groups presented the proposed revisions to the Sanctuary Advisory Council at three meetings in October 2001. The full advisory council recommended minor changes and approved each action plan in this document. The Advisory Council membership and Working Group membership lists are included in Appendix E.

### *The Role of Sanctuary Management as Facilitators*

A Sanctuary management plan is designed to identify the best and most practical strategies to achieve common goals, while getting the most out of public investment. Achieving this aim cannot be accomplished solely through the authorities and resources of an individual Sanctuary management authority. It requires a broad partnership of programs, authorities, and resources, coordinated to meet the needs of both the sanctuary site and the broader region of which it is a part.

Consequently, the management plan review process first focuses on finding the most effective strategies to accomplish common goals. These strategies are the product of a process that brings together constituents, institutions, and interested parties in directed working groups to address specified problem areas. How these strategies are to be implemented – with whose authorities, investments, and personnel – is determined subsequently to developing the best strategies. While the Sanctuary program commits to carrying out specific strategies as budgets allow, in many cases implementation becomes the responsibility of other institutions such as state, Federal, or local partners, that have either the authorities, the appropriate program, and/or the resources required.

In this process, the sanctuary management plan becomes a framework in which the role of all partners is codified. The Sanctuary assumes the role of facilitator and integrator of a far larger body of activities and outcomes than are within the immediate authorities, programs, and resources of the site. This facilitation role provides the mechanism for continued implementation, evaluation, and adaptation of the partnership activities documented by the plan, ensuring its continuity and overall success.

## 1.4 Accomplishments

There have been many accomplishments in the sanctuary beginning with the authority established under the Florida Keys National Marine Sanctuary and Protection Act of 1990 and the implementation of the management plan in 1997. An overview of the Sanctuary's accomplishments is given here, and more details are provided within each Action Plan.

**1. Area To Be Avoided.** The "Area To Be Avoided" (ATBA) designation has resulted in a significant decrease in the number of major ship groundings on the coral reefs. As Figure 1.3 illustrates, prior to 1990 there was a major ship grounding involving vessels greater than 50 m in length, nearly every year, while only two have occurred since the creation of the ATBA. The International Maritime Organization agreed that the ATBA should be given additional strength as a Particularly Sensitive Sea Area (PSSA) in 2002 (see Accomplishment 5 below). The ATBA regulations are at 15 CFR Part 922, Subpart P, Appendix VII. Figure 1.4 shows the ATBA and the Sanctuary boundary.

Figure 1.3. Reef groundings of vessels greater than 50m before & after ATBA designation.

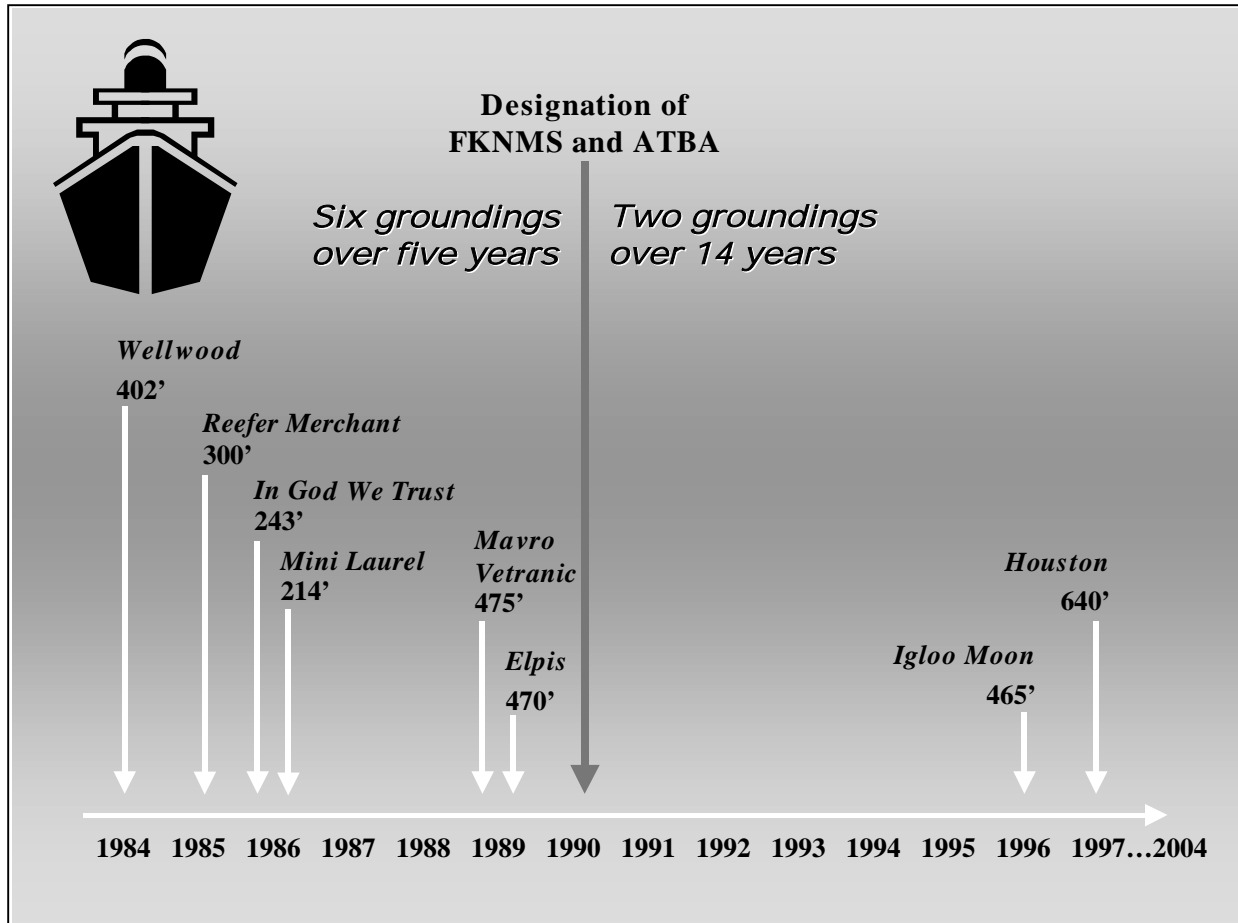
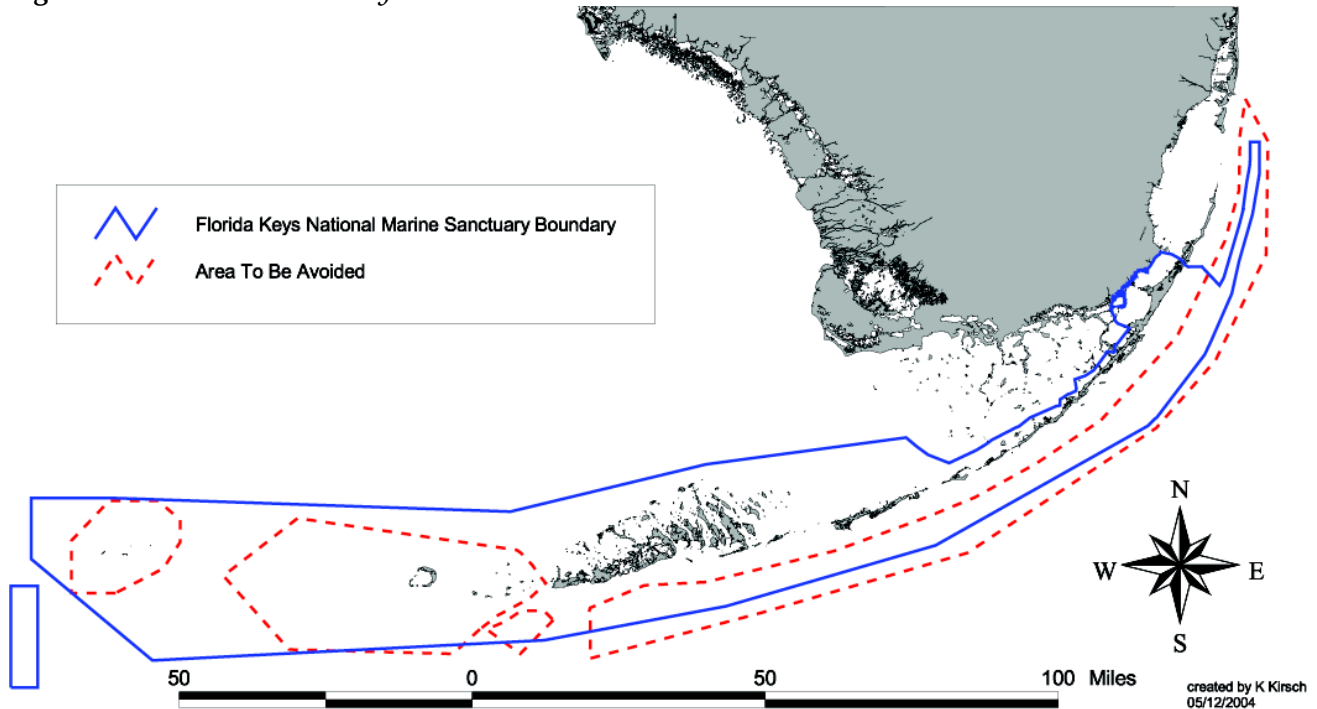


Figure 1.4. FKNMS boundary and ATBA



**2. Oil Drilling and Hard Mineral Mining Ban.** A ban on these activities was established when the Sanctuary was created, and has prevented these activities from occurring in the Sanctuary.

**3. The Water Quality Protection Program.** This program has produced the first Water Quality Protection Program for a national marine sanctuary and has fully implemented 26 of 49 high-priority activities, many of which are carried out in cooperation with other action plans.

**4. The Comprehensive Everglades Restoration Plan.** The Sanctuary continues to participate in the Comprehensive Everglades Restoration Plan. Sanctuary staff have been active on this project since 1993, including chairing a working group for the South Florida Ecosystem Restoration Task Force and staffing its science and education committees. The Sanctuary's participation seeks to protect the ecosystem's water quality by eliminating catastrophic releases of freshwater into Florida Bay following rain events.

**5. Designation of the Florida Keys as a Particularly Sensitive Sea Area.** In November 2002, the United Nations International Maritime Organization approved designation of the Florida Keys as a PSSA. The designation is not accompanied by additional rules and regulations, but seeks to elevate public awareness of the threat of oil spills and hazardous materials to sensitive marine environments and will ensure that the previously mentioned ATBA is noted not only on U.S. charts but also on nautical charts worldwide.

**6. Long-term and continuing progress in the Research and Monitoring and Zoning action plans.**

Research and Monitoring has produced significant scientific data, hypothesis testing, mapping, trend documentation, and wide dissemination of these findings. Especially notable is the Keys-wide benthic map which provides valuable information for Sanctuary managers. In addition to the new protected zone in the Tortugas Ecological Reserve, the Sanctuary's zoning programs continue to provide invaluable data that crosses simple category boundaries.

**7. Education, Public Outreach, Sanctuary Stewardship, and Volunteerism.** Through these inter-related efforts, information is flowing from scientists to managers and then to educators, who reach the next generation. More than 120,000 volunteer hours, a \$1.8 million value, have been donated to the Sanctuary between 1996 and 2000. Even more valuable than the dollar worth of the program is the stewardship created through volunteerism, which uniquely contributes to the long-term effectiveness of the Sanctuary.

**8. Enforcement and Regulations.** Both the city of Key West and the State of Florida have declared Florida Keys waters under their jurisdictions as "no-discharge" zones. Additional accomplishments in implementing the Enforcement and Regulatory Action Plans are largely a tribute to the cooperative efforts among the State, the Florida Fish and Wildlife Conservation Commission, the Florida Park Service, the U.S. Coast Guard and NOAA. Notable among these is the cross-deputization of state-certified law enforcement officers, which allows them to enforce some Federal laws, including fisheries regulations.

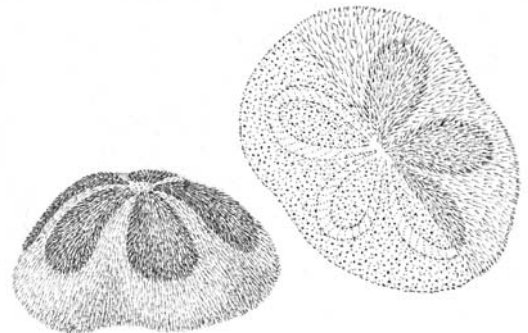
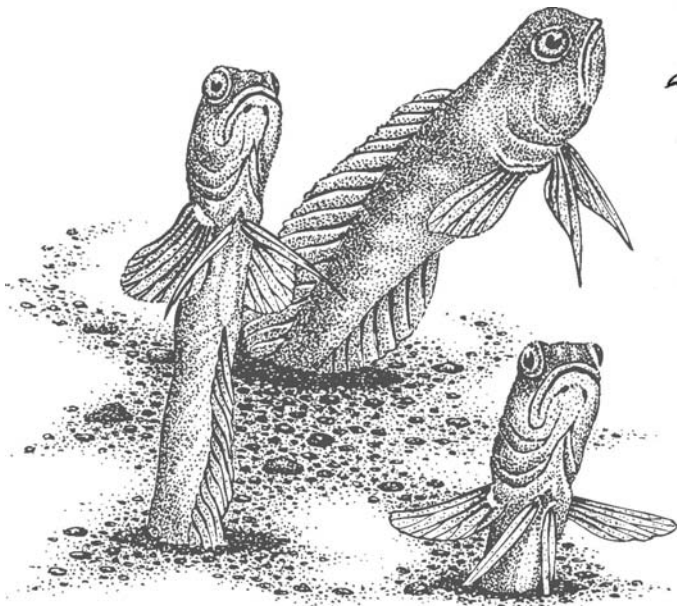
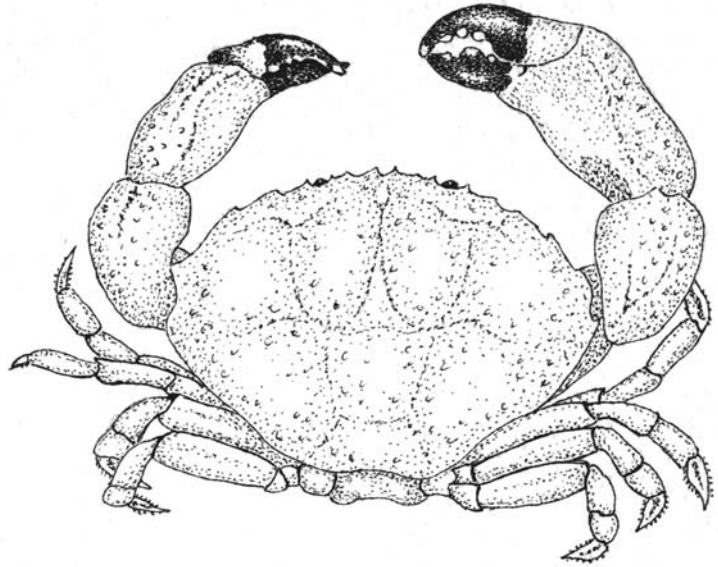
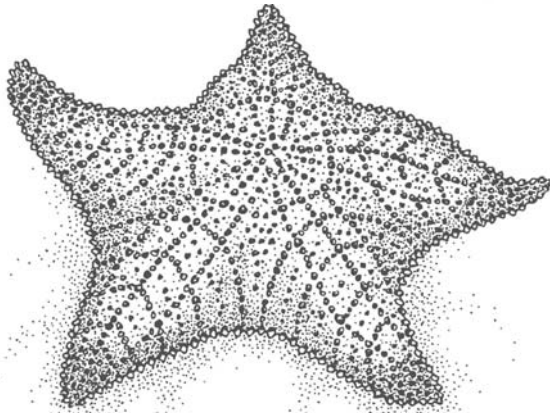
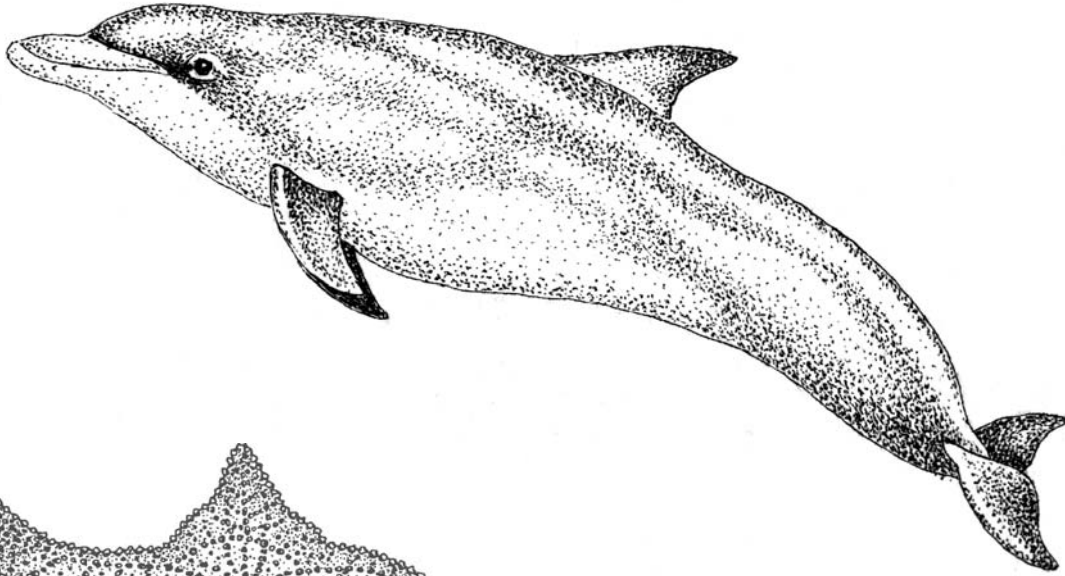
**9. Damage Assessment and Restoration.** The Damage Assessment and Restoration Action Plan is new to this document but is based on accumulated data and lessons learned since 1982. The cross-disciplinary strategies will prove useful in reducing the number of vessel groundings in Sanctuary waters as well as restoring Sanctuary resources damaged by vessels.

**10. Maritime Heritage Resources.** The Maritime Heritage Resources Action Plan includes a close partnership of the State, NOAA, and the Florida Advisory Council on Historic Preservation described in a 1998 programmatic agreement for resource management (see Appendix F). More recently, the 2002 discovery of a previously unknown wreck within the Sanctuary has brought about a community-endorsed research and interpretation plan for the site. Overall, the Action Plan represents excellent progress in balancing resource protection, investigation and interpretation.

**11. Mooring Buoys and Waterway Management (formerly Channel Marking).** The Mooring Buoy and Waterway Management Action Plans have implemented simple but effective strategies for reducing vessel damage to the coral reef and to seagrass beds. The long-term success of these programs – mooring buoy strategies have been used in local Sanctuary waters since 1981 when they were introduced at the Key Largo National Marine Sanctuary – has largely been due to a unique interface of education, outreach, enforcement, and research and monitoring activities.

**12. Operations.** Since 1997, the Sanctuary has integrated the administrative functions of two former sanctuaries – at Key Largo and Looe Key – into a single headquarters umbrella with two regional offices. This integration streamlined delivery of human resources, community relations, and policy development. It also resulted in a series of accomplishments, ranging from an updated electronic financial reporting system to the 130-episode television series, *Waterways*.

## 2.0 THE SANCTUARY ENVIRONMENT: A SUBTROPICAL ECOSYSTEM



## 2.1 Introduction

Adjacent to the Keys' land mass is a complex marine ecosystem that supports a variety of spectacular, unique, and nationally significant seagrass meadows, mangrove islands, and extensive living coral reefs. This ecosystem is the marine equivalent of a tropical rain forest in that it supports high levels of biological diversity, is fragile and easily susceptible to damage from human activities, and possesses great value to humans if properly conserved. The ecosystem supports over 6,000 species of plants, fishes, and invertebrates, including the nation's only coral reef that lies adjacent to the continent, and one of the largest seagrass communities in this hemisphere.

## 2.2 Living Marine Resources

The Florida Keys ecosystem contains one of North America's most diverse assemblages of flora and fauna. The Florida peninsula and Florida Keys serve as a partial barrier between the temperate waters of the Gulf of Mexico and the tropical to subtropical waters of the Atlantic Ocean, resulting in a unique distribution of marine organisms.

The coral reef tract, arching in a southwesterly direction for 220 miles, comprises one of the largest communities of its type in the world. It is the only emergent coral reef system off the continental U.S. All but the northernmost extent of the reef tract lies within the sanctuary.

The reef tract is a bank-barrier system comprised of an almost continuous reef community. One of its most noticeable features is its seaward-facing spur-and-groove formation. Over 6000 patch reefs, circular to oval in shape, lie in nearshore to offshore areas.

The ecosystem also supports one of the world's largest seagrass beds, among the richest, most productive, and most important submerged coastal communities. Seagrasses provide food and habitat for commercially and recreationally important species of fish and invertebrates. Without the seagrass community, the coral reef community would likely collapse.

Mangroves form an important component of the ecosystem, fringing most of the more than 1600 islands and 1800 miles of shoreline. Mangroves provide important ecological functions such as habitat for juvenile fishes and invertebrates, sediment traps, and surface area for attached organisms such as oysters, sponges, and algae.

The Florida Keys coral reef ecosystem is highly biologically diverse, and includes:

- 520 species of fish, including over 260 species of reef fish
- 367 species of algae
- 5 species of seagrasses
- 117 species of sponges
- 89 species of polychaete worms
- 128 species of echinoderms
- 2 species of fire coral
- 55 species of soft corals
- 63 species of stony corals

### *Coral Reefs and Coral Health*

The reefs of Florida have undergone change for millennia due to sea-level changes, storms, and other natural occurrences. More recently, human impacts have directly and indirectly damaged the reef structure and reef communities, and as a result corals are under stress.

In the Florida Keys, a decrease in coral cover and species diversity and an alarming increase in coral diseases and coral bleaching have been recorded in the Coral Reef/Hard-bottom Monitoring Project conducted by Florida's Fish and Wildlife Research Institute (FWRI). The project records biodiversity, coral condition (including diseases and bleaching), and coral cover at stations located in various habitat types. Since 1996, over 66 percent of the monitored sites have exhibited losses in stony coral

diversity, although some positive trends were noted in the 1999-2000 survey period. Significant gains and losses of several stony coral species have occurred both between years and over the entire sampling period, indicating fluctuations in coral species richness but no loss of species Sanctuary-wide.

In addition, FWRI monitoring has shown a declining trend in stony coral cover from 1996 to 2000, with the greatest relative change occurring in the Upper Keys. A reprieve from this decline has recently been observed and may be attributable to the lack of significant events such as bleaching, tropical storms, or hurricanes. As with species diversity, scientists find that coral cover is highly variable by both habitat type and region.

Recruitment (settlement of new individuals) of stony corals is an important factor in overall community dynamics. Two monitoring programs that are evaluating coral recruitment trends find that differences exist in coral recruitment among habitat types and regions. Juvenile corals in the lower Keys suffered significant mortality in 1998 due to a direct strike from Hurricane Georges.

Coral diseases increasingly threaten the overall health and vitality of reef systems in the Sanctuary. While over ten coral diseases are believed to exist at this time, only three pathogens have been positively identified. The monitoring project has documented increases in the number of research stations that contain diseased coral, the number of coral species with disease, and the number of diseases themselves. Regional differences in disease incidence have also been documented, with the highest concentration observed in the Key West and Lower Keys region.

Over the past 20 years, coral bleaching events in the Sanctuary have increased in frequency and duration. Massive coral bleaching was first recorded in the Lower Keys in 1983 along the outer reef tract, where shallow fore-reef habitats were the most affected areas. Bleaching expanded and intensified with events in 1987 and 1990, and culminated with massive coral bleaching in 1997 and 1998 that targeted inshore and offshore reefs throughout the Keys. Coral bleaching is undoubtedly responsible for some of the dramatic declines in stony coral cover observed Sanctuary-wide in the last five years. Similar observations of bleaching have been made regionally and internationally since 1987, and it is widely recognized that 1997 and 1998 were the worst coral bleaching years on record, causing significant loss of corals worldwide.

#### *Algae, Seagrasses, and Other Benthic Organisms*

Monitoring of benthic, or bottom, communities by the National Undersea Research Center at the University of North Carolina at Wilmington has documented that algae of various species dominate bottom habitats at all sites throughout the Sanctuary. Sponges and soft corals cover a much smaller percentage of the sea floor (from about 10 percent to 20 percent). Like algae, they are highly variable, depending on the region being surveyed and the time of year.

Seagrasses are comprehensively monitored by Florida International University as part of the Sanctuary's Water Quality Protection Program. Data indicate approximately 12,800 square kilometers of seagrass beds lie within and adjacent to the Sanctuary. Some variability in seagrass cover and abundance has been identified, although populations seem relatively stable. Continued monitoring will be invaluable for detecting human impacts on the seagrass communities.



### *Reef Fish*

Monitoring fish populations occurred for many years before the Sanctuary's designation and continues to this day. From 1979 through 1998, a total of 263 fish species representing 54 families were observed. Over half of all fish observed were from just ten species. Relatively few fish of legal size have been seen, which is consistent with several studies that indicate reef fish in the Florida Keys are highly overexploited.

Despite population declines throughout much of the Sanctuary, fish numbers in fully protected zones (Sanctuary Preservation Areas, Ecological Reserves, and Special-use and Research-only areas) are increasing to some degree. Years of data from one monitoring program show that the number of individuals of three exploited species are higher in protected zones than in fished sites. Researchers have also seen an overall increase in the average abundance of three snapper species at several sites after the sites were protected.

### *Mobile Invertebrates*

FWRI monitors mobile invertebrates, such as spiny lobster and queen conch. Spiny lobsters continue to be more abundant in the fully protected Sanctuary Preservation Areas and Ecological Reserves than outside these areas. Researchers have found their average size is larger and catch rates (number of lobsters per trap) are higher than in reference areas during both the open and closed fishing seasons.

Queen conch populations have remained low for the last decade despite a prohibition on their collection since 1985. Attempts to supplement wild populations with laboratory reared stock and experiments aimed at improving their reproduction are designed to ameliorate the long-term decline in queen conch populations in the region.

Sea urchins are also in very low abundances, especially the long-spined urchin, suggesting poor recovery of this species since its massive Caribbean-wide die-off in 1983. Two research efforts underway are exploring means by which populations of this key species may be restored.

## 2.3 Non-living Marine Resources

### *Maritime Heritage Resources*

The waters of the Florida Keys have some of the most significant maritime heritage and historical resources of any coastal community in the nation. Because of its unique geographical position on the European and American trade routes, shipwrecks in the Keys contain a record of the 500-year history of the Americas. Key West has been the crossroads of the Caribbean, and the sea has remained the common thread through the region's cultural and historic sites. The relative inaccessibility of underwater cultural sites has ensured that many delicate artifacts remain undisturbed. The importance of the region's maritime heritage resources is great, and the possibility exists for discovering some of the earliest archaeological sites in North America. A detailed description of the cultural and historical resources of the Florida Keys is contained in the "Description of the Affected Environment," of the Environmental Impact Statement (see Volume II of the Florida Keys Management Plan at <http://floridakeys.noaa.gov>).

### *Water Quality*

Many water-quality parameters have been monitored Sanctuary wide by Florida International University's Southeast Environmental Research Center since 1995 as part of the Water Quality Protection Program. Thus far, results indicate that some elements (dissolved oxygen, total organic nitrogen, and total organic carbon) are present in higher concentrations in surface waters, while other indicators (salinity, turbidity, nitrite, nitrate, ammonium, and total phosphorus) are higher in bottom waters.

Geographic differences in water quality include higher nutrient concentrations in the Middle and Lower Keys and lower nutrient concentrations in the Upper Keys and Dry Tortugas. Also, declining inshore-to-offshore trends across Hawk Channel have been noted for some parameters (nitrate, ammonium, silicate, total organic carbon and nitrogen, and turbidity).

Probably the most interesting findings thus far show increases over time in total phosphorus for the Dry Tortugas, Marquesas Keys, Lower Keys, and portions of the Middle and Upper Keys, and increases in nitrate in the Southwest Florida Shelf, Dry Tortugas, Marquesas Keys, and the Lower and Upper Keys. In contrast, total organic nitrogen decreased somewhat, mostly in the Southwest Florida Shelf, the Sluiceway, and the Lower and Upper Keys. These trends may be driven by regional circulation patterns arising from the Loop Current and Florida Current, and have changed as the period of record has increased.

Stationary instruments along the reef tract continuously monitor seawater parameters and ocean states. The data are analyzed by Florida Institute of Oceanography's SEAKEYS program and periodically transmitted to satellites and made available on the Internet. Additionally, water temperature data are recorded every two hours from a series of thermographs that the Sanctuary has maintained for the past ten years.

## 2.4 Threats to the Ecosystem

The deterioration of the marine ecosystem in South Florida is no longer a matter of debate. Visitors, residents and scientists alike have noted the precipitous decline in the health of the coral reef ecosystem. The threats causing these visible signs of decline are numerous and often complex, ranging from direct human impacts to global climate changes.

Direct human impacts include vessel groundings, anchor damage, destructive fishing, and damage to corals as a result of divers and snorkelers standing on them. Boat propellers and large ships have damaged over 30,000 acres of seagrasses and more than 20 acres of coral reef habitat in the Sanctuary.

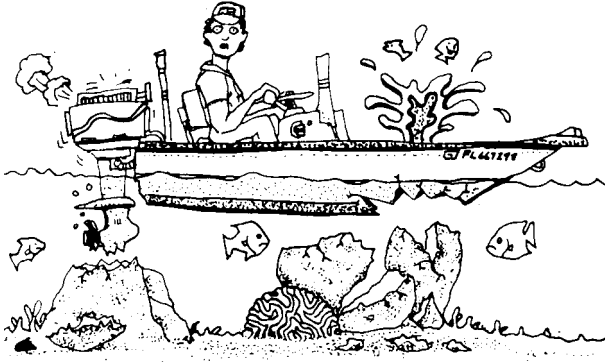
Most pressures stem from the 5 million annual visitors and 80,000 year-round residents. Their high levels of use in the Sanctuary have significant direct and indirect effects on the ecosystem. Sanctuary visitors primarily seek water-related recreation, including fishing, diving, snorkeling, and boating.

Although less immediate than direct physical damage to the corals, other stressors also significantly affect the Florida Keys ecosystem. Overfishing has dramatically altered fish and other animal populations on the coral reef, contributing to an imbalance in ecological relationships that are critical to sustaining a diversity of organisms. Eutrophication (an outcome of excess nutrients in the water, such as fertilizers) of nearshore waters is a documented problem. Wastewater and stormwater treatment and solid-waste disposal facilities are highly inadequate, directly affecting nearshore water quality. Some solutions to water quality problems are being implemented, but given the scope of the problem, more action is required.

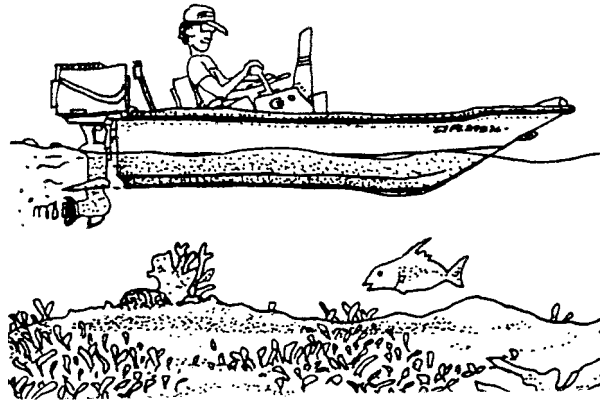
In Florida Bay, reduced freshwater flow has increased plankton blooms, sponge and seagrass die-offs, and fish kills. Since Florida Bay and nearshore waters provide important nursery and juvenile habitat for a variety of reef species, the declines in these areas affect the overall health and structure of offshore coral reefs. Therefore, regional strategies to address the quantity, quality, timing, and distribution of freshwater flows into the South Florida ecosystem and Florida Bay through the Comprehensive Everglades Restoration Plan are critical.

In addition, seasonal and yearly seawater temperature fluctuations, increasing solar radiation, and atmospheric changes all affect the ecosystem. The impacts are seen in coral disease and bleaching, which have increased in frequency, duration and range, coinciding with the ten warmest years on record. Under normal conditions, corals and reef organisms would be expected to tolerate and recover from sporadic events such as temperature variation. However, additional human-induced stresses are likely affecting the ability of these organisms to adequately recover from climate fluctuations.

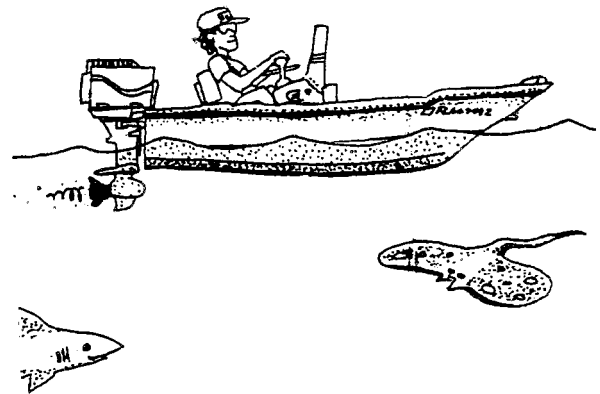
### 3.0 ACTION PLANS



**BROWN, BROWN, RUN AGROUND**



**GREEN, GREEN, NICE AND CLEAN**



**BLUE, BLUE, SAIL ON THROUGH**

## What Are Action Plans?

Action plans are the means by which the Sanctuary identifies and organizes the wide variety of management tools it employs to manage and protect its marine resources. “Road maps” for management, action plans articulate the programs and projects used to address the resource issues identified in the Sanctuary and to fulfill the purposes and policies of the NMSA. Each action plan is composed of *strategies* sharing common management objectives and *activities*, which are the specific actions the Sanctuary and its partners will take to implement the strategies.

## What Are The Action Plans In This Document?

The following chapters are the action plans that guide every aspect of sanctuary management. Readers should note that the 1997 *Final Management Plan* for the Sanctuary included ten action plans, presented in alphabetical order to address management needs related to:

- Channel/Reef Marking
- Education and Outreach
- Enforcement
- Mooring Buoys
- Regulatory
- Research and Monitoring
- Submerged Cultural Resources
- Water Quality
- Volunteer
- Zoning

In this revised management plan, four new action plans have been added: Science Management and Administration Action Plan, Damage Assessment and Restoration Action Plan, Operations Action Plan, and, Evaluation Action Plan. The Submerged Cultural Resources Action Plan has been changed to the Maritime Heritage Resources Action Plan, while the Channel/Reef Marking Action Plan has been renamed to more accurately reflect the intent, which is “Waterway Management”, and the word “Marine” has been added to the Zoning Action Plan to clarify the title.

### *Management Divisions*

In this revised management plan, the individual action plans have been grouped into five management divisions. This was done to both improve the organization of the plan as well as to highlight the management goals for each of the plans. The individual action plans for the Sanctuary are organized in the following divisions:

#### **Sanctuary Science**

- Science Management and Administration Action Plan
- Research and Monitoring Action Plan

#### **Education, Outreach and Stewardship**

- Education and Outreach Action Pan
- Volunteer Action Plan

#### **Enforcement and Resource Protection**

- Regulatory Action Plan
- Enforcement Action Plan
- Damage Assessment and Restoration Action Plan
- Maritime Heritage Resources Action Plan

**Resource Threat Reduction**

- Marine Zoning Action Plan
- Mooring Buoy Action Plan
- Waterway Management Action Plan
- Water Quality Action Plan

**Administration, Community Relations and Policy Coordination**

- Operations Action Plan
- Evaluation Action Plan

**Implementing Action Plans**

The FKNMS defines a place where many governmental and non-governmental organizations work in partnership to achieve the Sanctuary’s goals: protect resources and their conservation, recreational, ecological, historical, research, educational, or aesthetic values through comprehensive long-term management. This management plan describes these collective efforts, and its implementation relies on resources and efforts from a variety of partners. Table 3.1 describes the extent to which each of the action plans and strategies within this revised management plan can be implemented under three funding scenarios. Funding from both NOAA and other partners, (e.g. EPA, Monroe County, etc.) is considered in ranking the level of implementation.

*Table 3.1 Action Strategy Implementation Over Five Years Under Three Funding Scenarios*

Implementation* with NOAA Funding	Implementation* with Partner Funding	Scenario 1: Level Funding	Scenario 2: 5% per year increase	Scenario 3: 10% per year increase
● - High ◎ - Medium ○ - Low	◆ - High ◇ - Medium ◇ - Low			
<b>Sanctuary Science</b>				
Science Management and Administration Action Plan				
	Strategy B.11 – Issuance of Sanctuary Research Permits	●	●	●
	Strategy W.29 – Dissemination of Findings	◎	◎	●
	Strategy W.32 – Maintaining a Technical Advisory Committee	●	●	●
	Strategy W.34 – Regional Science Partnerships and Reviews	◎	◎	●
	Strategy W.35 – Data Management	◇	◇	◆
Research and Monitoring Action Plan				

\* Implementation ranking considers the priority of each strategy as well as the percentage of activities that could be initiated, maintained, and/or completed under differing funding scenarios.

	Strategy W.33 - Ecological Research and Monitoring	⊙◇	⊙◇	●◆
	Strategy Z.6 - Marine Zone Monitoring	⊙	⊙	●
	Strategy W.36 - Conducting Socioeconomic Research	●	●	●
	Strategy F.3 - Researching Queen Conch Population Enhancement Methods	●◆	●◆	●◆
	Strategy F.7 - Researching Impacts from Artificial Reefs	⊙◇	⊙◇	●◆
	Strategy F.6 - Fisheries Sampling	⊙◇	⊙◇	●◆
	Strategy F.11 - Evaluating Fishing Gear/Method Impacts	○◇	○◇	⊙◇
	Strategy F.15 - Assessing Sponge Fishery Impacts	⊙◇	⊙◇	●◆
	Strategy W.18 - Conducting Pesticide Research	○◇	○◇	⊙◇
	Strategy W.22 - Assessing Wastewater Pollutants Impacts	●◆	●◆	●◆
	Strategy W.23 - Researching Other Pollutants and Water Quality Issues	⊙◇	⊙◇	●◆
	Strategy W.24 - Researching Florida Bay Influences	⊙◇	⊙◇	●◆
	Strategy W.21 - Developing Predictive Models	⊙◇	⊙◇	●◆
<b>Education, Outreach and Stewardship</b>				
Outreach and Education Action Plan				
	Strategy E.4 - Developing Training, Workshops and School Programs	○	⊙	⊙
	Strategy E.6 - Continuing the Education Working Group	●	●	●
	Strategy E.10 - Establishing Public Forums	⊙	⊙	●
	Strategy E.11 - Participating in Special Events	⊙	⊙	●
	Strategy E.1 - Printed Product Development and Distribution	○	○	⊙
	Strategy E.2 - Continued Distribution of Audio-Visual Materials	⊙	●	●
	Strategy E.3 - Continue Development of Signs, Displays, Exhibits, and Visitor Centers	⊙	⊙	⊙
	Strategy E.5 - Applying Various Technologies	⊙	⊙	⊙
	Strategy E.12 - Professional Development of Outreach and Education Staff	○	○	⊙
Volunteer Action Plan				
	Strategy V.1 - Maintaining Volunteer Programs	⊙	⊙	⊙
	Strategy V.2 - Working with Other Organization/ Agency Volunteer Programs	○	○	○
	Strategy V.3 - Providing Support for Volunteer Activities	○	○	⊙
<b>Enforcement and Research Protection</b>				
Regulatory Action Plan				
	Strategy R.1 - Maintaining the Existing Permit Program	⊙	⊙	●
	Strategy R.2 - Regulatory Review	⊙	⊙	●
Enforcement Action Plan				
	Strategy B.6 - Acquiring Additional Enforcement Personnel	●	●	●
Damage Assessment and Restoration Action Plan				
	Strategy B.18 - Injury Prevention	○	○	⊙
	Strategy B.19 - Implementing DARP Notification and Response Protocols	○	○	⊙
	Strategy B.20 - Damage Assessment and Documentation	⊙◇	⊙◇	●◇
	Strategy B.21 - Case Management	◆	◆	◆
	Strategy B.22 - Habitat Restoration	◇	◇	◆
	Strategy B.23 - Data Management	○	⊙	⊙
Maritime Heritage Resources Action Plan				

	Strategy MHR.1 - MHR Permitting	●◆	●◆	●◆
	Strategy MHR.2 - Establishing an MHR Inventory	○◆	○◆	◎◆
	Strategy MHR.3 - MHR Research and Education	○◇	○◇	◎◆
	Strategy MHR.4 - Ensuring Permit Compliance through Enforcement	●◆	●◆	●◆
	Strategy MHR.5 - Ensuring Interagency Coordination	●◆	●◆	●◆
<b>Resource Threat Reduction</b>				
Marine Zoning Action Plan				
	Strategy Z.1 - Wildlife Management Areas	○	◎	●
	Strategy Z.2 - Ecological Reserves	◎	●	●
	Strategy Z.3 - Sanctuary Preservation Areas	○	◎	●
	Strategy Z.4 - Existing Management Areas	●	●	●
	Strategy Z.5 - Special-use Areas	○	◎	●
Mooring Buoy Action Plan				
	Strategy B.15 - Mooring Buoy Management	●	●	●
Waterway Management Action Plan				
	Strategy B.1 - Boat Access	◆	◆	◆
	Strategy B.4 - Waterway Management/Marking	◆	◆	◆
Water Quality Action Plan				
	Strategy W.19 - Florida Bay Freshwater Flow	●◆	●◆	●◆
	Strategy W.3 - Addressing Wastewater Management Systems	◇	◇	◆
	Strategy W.5 - Developing and Implementing Water Quality Standards	◇	◇	◇
	Strategy W.7 - Resource Monitoring of Surface Discharges	◆	◆	◆
	Strategy W.11 - Stormwater Retrofitting	◇	◇	◆
	Strategy W.14 - Instituting Best Management Practices	◆	◆	◆
	Strategy B.7 - Pollution Discharges	◎◆	◎◆	●◆
	Strategy L.1 - Elimination of Wastewater Discharge from Vessels	◎◆	◎◆	●◆
	Strategy L.3 - Marina Operations	◆	◆	◆
	Strategy L.7 - Assessing Solid Waste Disposal Problem Sites	◇	◇	◆
	Strategy W.15 - HAZMAT Response	○◆	○◆	◎◆
	Strategy W.16 - Spill Reporting	○◆	○◆	◎◆
	Strategy L.10 - HAZMAT Handling	◇	◇	◆
	Strategy W.17 - Refining the Mosquito Spraying Program	◇	◇	◆
	Strategy W.10 - Addressing Canal Water Quality	◇	◇	◆
<b>Administration</b>				
Operations Action Plan				
	Strategy OP.1 - Addressing Administrative Policy Issues	◎	◎	◎
	Strategy OP.2 - Addressing Resource Policy Issues	◎	◎	◎
	Strategy OP.3 - Addressing Legal Issues	◎	◎	●
Evaluation Action Plan				
	Strategy EV.1 - Measuring Sanctuary Performance Over Time	●	●	●



## 3.1 SANCTUARY SCIENCE

The Sanctuary Science management division consists of two action plans: Science Management and Administration, and Research and Monitoring. An effective science program requires management and administration that focuses on coordinating research and monitoring projects, communicating findings of the program, and engaging in other regional science efforts. This coordination role is substantial with participation from a number of government, academic and non-governmental scientists. Permitting is a component of this action plan, along with other critical aspects of administering an effective science program.

The monitoring component of the Research and Monitoring Action Plan has established a baseline of information on spatial patterns and temporal trends in natural resources and other components of the ecosystem. To improve our understanding of patterns and trends, research elucidates:

- Cause-and-effect relationships of specific ecological interactions;
- Processes that shape ecosystem structure and function; and,
- How management actions or other factors modify ecosystem processes.

Research and monitoring projects investigate fundamental processes and specific topics in support of science-based management. The resulting scientific findings are used to:

- Evaluate the effectiveness of the Sanctuary and its management actions;
- Distinguish between the effects of human activities and natural variability;
- Develop hypotheses about causal relationships that can then be investigated; and,
- Validate models that guide management actions.

## 3.1.2 Research and Monitoring Action Plan

### *Introduction*

#### *Overview*

Congress mandates that Sanctuary managers identify research priorities and the funds needed to improve the management and preservation of the Florida Keys coral reef ecosystem. The marine ecosystem of the Florida Keys is diverse and complex, and many of its physical and ecological processes and their interrelationships are not well known. Although many resource impacts are obvious and severe, they are often not documented or quantified, and their causes may be even less clear or unknown.

The purpose of monitoring is to establish a baseline of information on natural resources and other components of the ecosystem, and to measure changes over time. As monitoring studies gather data, they have the potential to detect significant changes in natural resources that result from management actions or from other causes. The findings of research projects must also help managers and scientists identify cause-and-effect relationships that generate ecological patterns and trends, and stressors and other factors that threaten the health of the coral reef ecosystem.

The Sanctuary's Water Quality Protection Program established comprehensive, long-term monitoring of three components of the ecosystem: water quality, coral reefs and hard-bottom communities, and seagrasses. The Marine Zone Monitoring Program documents effects of 24 fully protected marine zones, including the Tortugas Ecological Reserve, that were implemented in 1997 and 2001. Monitoring projects in this program document trends in ecological processes, reef fishes, spiny lobster, queen conch, other invertebrates, and benthic community structure within fully protected marine zones and nearby reference areas. Social and economic parameters are also being surveyed. Together, these monitoring programs provide Sanctuary managers with basic information about the state of the Florida Keys coral reef ecosystem and changes resulting from a key management action – marine zoning.

#### *U.S. Coral Reef Task Force*

It has long been recognized that research and monitoring efforts in the Florida Keys must be focused on priority issues. The *1997 Management Plan* summarizes early workshops and symposia that helped define key issues for scientists around the world. More recently, the 1998 Hawaii Coral Reef Monitoring Workshop; the 1999 International Conference on Scientific Aspects of Coral Reef Assessment, Monitoring, and Restoration; the Ninth and Tenth International Coral Reef Symposia (2000 and 2004); the 2002 *Acropora* Workshop in Miami; the 2003 Coral Reefs, Climate, and Coral Bleaching Workshop in Hawaii; the 2004 *Diadema* workshop in Miami; and the 2002 and 2004 workshops of the Coral Disease and Health Consortium (Charleston, Key Largo, and Madison) all have added to the sense of urgency.

Another significant development was the 1998 establishment of the U.S. Coral Reef Task Force. In 2000, the Task Force issued *The National Action Plan to Conserve Coral Reefs*, which included the following statement about monitoring:

“Successful coral reef conservation requires adaptive management that responds quickly to changing environmental conditions. This, in turn, depends upon monitoring programs that track trends in coral reef health and reveal significant trends in the condition – before irreparable harm occurs.

Monitoring can also play a vital role in guiding and supporting the establishment of complex or potentially controversial management strategies such as no-take ecological reserves, fishing gear restrictions or habitat restoration, by documenting the impacts of gaps in existing management schemes and illustrating the effectiveness of new measures over time.”

The *National Action Plan* notes that accurate mapping and rigorous monitoring and assessment directly contribute to coral reef conservation by:

- Documenting the status of ecologically and economically important reef species.
- Tracking and assessing changes in reef communities in response to environmental stressors or specific human activities and uses.
- Evaluating the effectiveness of specific management strategies and identifying directions for future adaptive responses.
- Evaluating the natural recovery and/or restoration of injured or degraded reefs.
- Enabling informed decisions about the location of potentially harmful activities.
- Providing baselines for assessing catastrophic damage from natural or manmade events such as storms, diseases, vessel groundings, and toxic spills.
- Serving as an early warning system for identifying declines in coral reef health.

The *National Action Plan* also points out that modern coral reef ecology is still a comparatively young discipline, and many phenomena remain only partially understood, particularly as they relate to coral reef conservation. For example, the causes and impacts of many coral reef stressors remain uncertain, as do many of the fundamental ecological processes that determine the structure, condition, and dynamics of healthy coral reef communities and the recovery of impaired systems.

As a result, the coral reef conservation community is at a great disadvantage because threats to coral reefs apparently are increasing faster than the scientific knowledge base needed to understand and ameliorate them through active conservation measures. Without significant effort to strategically target research on coral reef conservation issues, further losses of live coral may be widespread across the Florida Reef Tract within our lifetimes. At present, research on coral reef ecosystems - both basic and applied - is insufficient to meet these needs. Moreover, further efforts are needed to identify and target critical knowledge gaps through cooperative assessment and planning by federal and state resource and funding agencies with responsibilities for coral reef ecosystems.

In order to obtain a peer-reviewed evaluation of its research and monitoring efforts, the Sanctuary convened a meeting in December 2000, at which principal investigators presented findings of their monitoring and research projects to an independent Science Advisory Panel. In turn, the panel provided recommendations, which have been incorporated into the *Comprehensive Science Plan*. This plan links research and monitoring to specific management objectives to help ensure science-based management of Sanctuary resources.

### ***Goals and Objectives***

The goal of the Sanctuary’s Research and Monitoring Action Plan is to provide the knowledge necessary to make informed decisions concerning the protection of the biological diversity and natural ecosystem processes of the Sanctuary and its resources.

The objectives of this action plan are to:

- Encourage and provide support for research and monitoring that lead to better understanding of key ecological processes and criteria for recognizing ecological change; and
- Use research and monitoring results to evaluate management actions and improve them accordingly.

### ***Implementation***

The Sanctuary's Research and Monitoring Action Plan will be implemented by a coordinated framework of Federal, state, and local agencies in cooperation with academic and research institutions. In many cases, academic institutions take the lead in implementing strategies and activities that deal with predictive modeling, research, or monitoring. The FKNMS, FDEP, and FWC, however, have the lead responsibility for overall program implementation. The EPA, programs within NOAA other than the FKNMS, and other agencies and organizations will continue to provide leadership in implementing many research and monitoring strategies.

### ***Priorities***

The Research and Monitoring Action Plan includes 13 strategies. Five strategies from the 1997 *Management Plan* have not been included here because of the low likelihood of implementing low-priority strategies over the next five years (see "Previous Strategies at the end of this Action Plan). The highest-ranking strategies are Ecological Research and Monitoring and Marine Zone Monitoring. Strategies of high or medium priority typically seek to develop information to evaluate water quality and ecosystem health. High- and medium-priority activities also result in information useful to marine zoning, boating, and fisheries management.

### ***Geographic Focus***

All research and monitoring strategies apply to the entire Sanctuary. However, some strategies may include components applicable to specific areas, such as fully protected marine zones. It is important to recognize that some ecosystem patterns and trends within the Sanctuary may be caused by larger-scale phenomena such as variable oceanic circulation features and weather cycles.

### ***Personnel***

The staff required to implement the Research and Monitoring Action Plan are a mix of personnel from the agencies and organizations listed in the detailed discussion of each strategy. When EPA or FWC is the lead agency for implementing a strategy, Sanctuary personnel assist in directing the activities. Researchers are registered through a regional permitting system (see the Science Management and Administration Action Plan).

Scientists from universities, research institutions, and environmental firms are involved in research and monitoring activities on a long- or short-term basis. NOAA, FDEP, or FWC personnel dedicated to research and monitoring activities direct the remaining activities.

### ***Sanctuary Employees***

Science activities require three full-time Sanctuary employees: a science coordinator, a research interpreter, and an assistant. The Sanctuary Superintendent and Regional Managers also are actively involved in these activities. Additional Sanctuary staff assists many science projects, including vessel and diving support.

### *Volunteers*

Volunteers assist several research and monitoring strategies. Volunteers are being sought for Artificial Reefs, Water Quality Monitoring, and Ecological Research and Monitoring activities. A Sanctuary volunteer coordinator will direct associated research and monitoring activities.

### *Evaluating Program Effectiveness*

The FKNMS conducts periodic evaluations to determine the effectiveness of research and monitoring activities and prepares a *Comprehensive Science Plan*. The evaluations identify strategies and activities that are ineffective or inadequate; evaluations also suggest new activities. In addition, the five-year reviews of the Sanctuary Management Plan include evaluations of the Science Program by a Sanctuary Advisory Council working group.

### *Accomplishments*

There have been substantive accomplishments in the Sanctuary's Science Program since implementation of the 1997 management plan. Accomplishments fall into two categories: implementation and coordination, and data collection and dissemination. Examples include:

- A Benthic Habitat Map of the Sanctuary, produced in close cooperation with state and Federal partners.
- A 10-volume *Site Characterization of the Sanctuary*, detailing living and non-living resources.
- On-going monitoring projects of the Water Quality Protection Program: water quality, seagrasses, and coral reef and hard-bottom communities.
- On-going meteorological and oceanographic near-real-time data from seven SEAKEYS/C-MAN arrays and additional oceanographic sensors.
- Implementation of the Marine Zone Monitoring Program in 1997, with on-going projects investigating ecological processes, reef fishes, spiny lobster, queen conch, other invertebrates, benthic community structure, and social and economic parameters.
- Support of Special Studies and independently funded research projects.
- On-going Keys-wide monitoring since 1989 to record water temperature at 32 reef sites.

### *Strategies*

There are 13 strategies in the Research and Monitoring Action Plan:

- W.33 Ecological Research and Monitoring
- Z.6 Marine Zone Monitoring
- W.36 Conducting Socioeconomic Research
- F.3 Researching Queen Conch Population Enhancement Methods
- F.7 Researching Impacts From Artificial Reefs
- F.6 Fisheries Sampling
- F.11 Evaluating Fishing Gear/Method Impacts
- F.15 Assessing Sponge Fishery Impacts
- W.18 Conducting Pesticide Research
- W.22 Assessing Wastewater Pollutants Impacts
- W.23 Researching Other Pollutants and Water Quality Issues
- W.24 Researching Florida Bay Influences
- W.21 Developing Predictive Models

Each of these strategies is detailed below. Table 3.3 provides estimated costs for implementation of each strategy over the next five years.

**Table 3.3 Estimated Costs of the Research and Monitoring Action Plan**

Research and Monitoring Action Plan Strategies	Estimated Annual Cost (in thousands)*					Total Estimated 5 Year Cost
	YR 1	YR 2	YR 3	YR 4	YR 5	
W.33: Ecological Research and Monitoring	2,500	2,600	2,700	2,800	2,900	13,500
Z.6: Marine Zone Monitoring	800	850	850	900	950	4,350
W.36: Conducting Socioeconomic Research	250	250	275	275	300	1,350
F.3: Researching Queen Conch Population Enhancement Methods	100	105	110	115	120	550
F.7: Researching Impacts From Artificial Reefs	25	25	25	25	30	130
F.6: Fisheries Sampling	500	525	550	575	600	2,750
F.11: Evaluating Fishing Gear/Method Impacts	100	105	110	115	120	550
F.15: Assessing Sponge Fishery Impacts	100	105	110	115	120	550
W.18: Conducting Pesticide Research	100	105	110	115	120	550
W.22: Assessing Wastewater Pollutants Impacts	200	210	220	230	240	1,100
W.23: Researching Other Pollutants and Water Quality Issues	250	250	275	275	300	1,350
W.24: Researching Florida Bay Influences	1,300	1,350	1,400	1,450	1,500	7,000
W.21: Developing Predictive Models	200	210	220	230	240	1,100
<b>Total Estimated Annual Cost</b>	<b>6,425</b>	<b>6,690</b>	<b>6,955</b>	<b>7,220</b>	<b>7,540</b>	<b>34,830</b>

\* Contributions from outside funding sources also anticipated.

## STRATEGY W.33 ECOLOGICAL RESEARCH AND MONITORING

### *Strategy Summary*

The purpose of this strategy is to detect status and trends of various ecological parameters in order to discern local and system-wide effects of human and natural disturbances on natural resources and to assess the overall health of the ecosystem.

The initial science program emphasized characterizations, surveys, and monitoring, which have yielded comprehensive baseline data on water quality, coral reef and hard-bottom communities, seagrasses, and important fishery species. As was recommended by an independent Science Advisory Panel in December 2000, the Sanctuary's science program needs to include more research on ecological processes. This mechanistic level of understanding will enable resource managers to determine whether management actions are feasible to remedy patterns or trends determined by monitoring projects.

The Sanctuary is the lead agency for the overall implementation of the Ecological Research and Monitoring Program, working with the EPA, FWC, academic and nongovernmental organizations, and the Technical Advisory Committee. The *Comprehensive Science Plan* identifies and prioritizes specific research and monitoring needs to meet management objectives.

### *Activities (7)*

**(1) Continue Status and Trends Monitoring of Water Quality, Coral Reef and Hard-bottom Communities, and Seagrasses.** This activity produces long-term, comprehensive information on Sanctuary-wide status and trends of water quality parameters and biological resources. Water quality parameters being monitored include temperature, salinity, dissolved oxygen, turbidity, relative fluorescence, light attenuation, nutrients, chlorophyll, and alkaline phosphatase activity. Biological monitoring of coral reef and hard-bottom communities and seagrasses is also being conducted.

Status: On-going.

Implementation: The Southeast Environmental Research Center, Florida International University, has monitored water quality since 1995. The FWC/Fish and Wildlife Research Institute has monitored coral reef and hard-bottom communities since 1996. Monitoring of seagrasses has been conducted by the Southeast Environmental Research Center and Department of Biology, Florida International University, since 1996.

**(2) Continue Volunteer Monitoring Program.** Monitoring by trained volunteers yields useful, cost-effective data and provides positive engagement for a variety of stakeholders. The Reef Environmental Education Foundation, in cooperation with NOAA, manages surveys of reef fishes by volunteers. The Ocean Conservancy manages a volunteer program, Reef Ecosystem CONdition) Program (RECON), for assessing coral reef health. The Dolphin Ecology Project conducts research on Atlantic Bottlenose Dolphin. Surveys are conducted as part of the Atlantic and Gulf Rapid Reef Assessment (AGRRA) Program. Volunteers also monitor sea-turtle beaches and nesting sites and support a turtle-stranding network. (This activity is also part of the Volunteer Action Plan.)

*Status:* On-going.

*Implementation:* The Reef Environmental Education Foundation has monitored reef fishes in the Sanctuary since 1994. The Ocean Conservancy's RECON program has been active since 2002. The Dolphin Ecology Project began in 2000. AGRRA surveys in the Sanctuary began in 2003.

**(3) Determine Response to Episodic Events.** Sanctuary management requires centralized information about algal blooms, fish kills, large patches of discolored water, and other unusual episodes to determine whether a management action would be appropriate.

*Status:* On-going.

*Implementation:* The Mote Marine Laboratory's Tropical Research Laboratory, in cooperation with the Sanctuary, is conducting the Marine Ecosystem Event Response and Assessment project (MEERA).

**(4) Continue Stakeholder Monitoring and Research.** The Sanctuary supports monitoring and research projects that are developed by stakeholders because of opportunities to directly engage constituents in Sanctuary resource issues and to increase our understanding of the ecosystem. Sanctuary support includes assistance with project design, coordinating stakeholder projects with other research activities, providing vessel support and assistance with field work, issuance of research permits, assistance with identifying potential funding sources, and letters of support for grant proposals.

*Status:* On-going.

*Implementation:* The Sanctuary supports a *Diadema* restoration project led by two stakeholders in collaboration with the University of North Carolina at Wilmington/National Undersea Research Center at Key Largo and members of the research community. In addition to discussing the design of the project and initial findings, Sanctuary staff helped secure initial funding through NOAA and assisted the stakeholders in identifying additional funding sources.

**(5) Initiate Research and Monitoring of Mangroves, Sedimentation Rates, Types and Causes of Turbidity, and Ecosystem Indicators.** This activity documents changes to the extent of mangrove vegetation by using historical aerial photography and other records. There is also a need to monitor sedimentation rates and to investigate turbidity types and causes. Researchers



will seek to link ecosystem indicators to performance measures established for the Comprehensive Everglades Restoration Plan.

Status – No action has been taken.

Implementation – The Sanctuary will be the lead agency for this activity; the FWC and FDEP will have primary roles. Sanctuary staff will include this activity in a request for proposals.

**(6) *Initiate or Expand Research and Monitoring of Marine-life Species.*** In light of changes in fish community structure that may result from the network of fully protected marine zones, there is a need for more data on marine herbivores and fish cleaners. Other fisheries, such as the aquarium and shell trades, have unknown ecosystem impacts and need investigation. For example, collectors annually gather and sell large numbers of sea biscuits, an important consumer of dead organic material; the ecological effects of its collection may be significant. This activity highlights the need to investigate components of the ecosystem that generally are overlooked in lieu of studies of habitats and commercially important species.

Status: On-going.

Implementation: The University of North Carolina at Wilmington/National Undersea Research Center at Key Largo collects data on distribution and abundance of some marine-life species through its Rapid Ecological Assessment surveys. The Sanctuary will be the lead agency, in cooperation with the FWC. This strategy is also included in the Volunteer, Outreach and Education, and Water Quality Action Plans. Sanctuary staff will include this activity in a request for proposals.

**(7) *Long-Term Monitoring of Water Temperature.*** Extreme water temperature fluctuations in the FKNMS have been linked to bleaching and disease in reef corals and mass mortality of seagrass in Florida Bay. Recording thermographs are deployed throughout the Florida Reef Tract to monitor this important environmental parameter.

Status: On-going.

Implementation: Initiated in 1989, this program has expanded to include 34 stations from Miami to the Dry Tortugas in depth that range from 5 to 70 ft. The thermographs sample at 2-hour intervals and are secured on the seabed in theft-proof housings. The units are serviced annually and recalibrated every 2 years FKNMS staff oversee the program, including deploying and recovering instruments, downloading thermographs, and providing data to management and other user groups.

## STRATEGY Z.6 MARINE ZONE MONITORING

### *Strategy Summary*

There are five types of marine zones in the Sanctuary: Wildlife Management Areas, Ecological Reserves, Sanctuary Preservation Areas, Special-use (Research-only) Areas, and Existing Management Areas. Marine zone monitoring occurs in the three types of marine zones that are fully protected from consumptive activities (“no-take zones”): Ecological Reserves, Sanctuary Preservation Areas, and Special-use (Research-only) Areas. The purpose of this strategy is to determine the effectiveness of fully protected marine zones as a management action for the conservation and sustainable use of marine resources. The basic design of these monitoring studies is to compare surveys within and outside of fully protected marine zones. Some studies, such as monitoring of reef fishes by NOAA Fisheries/Southeast Fisheries Science Center and the Reef Environmental Education Foundation, include surveys prior to implementation of the fully protected marine zones, enabling an optimal BACI (before/after, control/impact) sampling design. Initial findings of the Marine Zone Monitoring Program are in the 1998 and 1999 *Zone Performance Reviews*, the *Sanctuary Monitoring Report 2000*, and the *Sanctuary Science Report 2001: An Ecosystem Report Card* (available at [http://floridakeys.noaa.gov/research\\_monitoring/](http://floridakeys.noaa.gov/research_monitoring/)).

### *Activities (3)*

**(1) Develop Baseline Data.** Before monitoring begins, a baseline survey of existing resources in Ecological Reserves, Sanctuary Preservation Areas, and Special-use Areas must be conducted. The surveys characterize the status of important marine species and their habitats.

*Status:* Surveys of Western Sambo Ecological Reserve have been completed as part of long-term monitoring projects, and characterization studies of the Tortugas Ecological Reserve were completed prior to its implementation. Surveys of Sanctuary Preservation Areas were conducted prior to or soon after their implementation. Surveys of Special-use Areas were conducted.

*Implementation:* The University of North Carolina at Wilmington/National Undersea Research Center at Key Largo conducts Rapid Ecological Assessments of benthic communities, and the Dauphin Island Sea Lab conducts additional coral reef community surveys at three fully protected zones and reference areas. NOAA Fisheries/Southeast Fisheries Science Center and the Reef Environmental Education Foundation conduct surveys of reef fishes. The FWC/ Fish and Wildlife Research Institute conducts surveys of spiny lobster and queen conch.

**(2) Monitor Marine Zones and Utilize as Controls.** Research and monitoring of the Sanctuary marine zones determine the degree to which the zones meet goals and objectives for protecting natural resources, as well as human-use patterns, attitudes and compliance. In order to determine where additional Special-use Areas might be appropriate, it is necessary to compile and review data on use patterns and areas of high resource impact. Additional data will be gathered to address particular concerns, including issues identified by the SAC and the public.

*Status:* On-going.

*Implementation:* An interdisciplinary team (Florida Institute of Oceanography, Dauphin Island Sea Lab, Bermuda Biological Station for Research, and NOAA Fisheries/Southeast Fisheries Science Center) monitors the Western Sambo Ecological Reserve, Eastern Sambo Research-only Area, Carysfort Sanctuary Preservation Area, and reference sites in order to detect functional changes (predation, herbivory, and coral recruitment) and structural changes (population abundance and size structure) that result from the restriction of consumptive activities. The University of Florida/Florida Sea Grant/Monroe County Cooperative Extension Service, in collaboration with a commercial fisher, conducted an additional shorter-term investigation of spiny lobster “spillover” at the Western Sambo Ecological Reserve and adjacent reference sites. Coordination of existing research and monitoring and the implementation of new programs will occur in the Tortugas Ecological Reserve, as described in the *Final Supplemental Environmental Impact Statement/Supplemental Management Plan* for the Tortugas Ecological Reserve. The focus of ecological monitoring of Sanctuary Preservation Areas, Special-use (Research-only) Areas, and reference sites is on detecting structural changes (population abundance and size structure) that result from the restriction of consumptive activities. These monitoring studies examine benthic community structure (University of North Carolina at Wilmington/National Undersea Research Center at Key Largo), reef fishes (NOAA Fisheries/Southeast Fisheries Science Center and the Reef Environmental Education Foundation), and spiny lobster and queen conch (FWC/ Fish and Wildlife Research Institute). Monitoring of human-use patterns, attitudes, and compliance with marine zone regulations is being conducted by an interdisciplinary team (NOAA/National Ocean Service/Special Projects Division, University of Miami/Rosenstiel School of Marine and Atmospheric Science, and Thomas J. Murray & Associates). NOAA is the lead agency for organizing the activity; however, partnerships, contracts, and agreements with other academic, agency, or non-governmental programs will likely be required for full implementation.

**(3) Utilize Marine Zones as Research Areas.** For all three types of fully protected marine zones, permitted researchers may conduct non-invasive experiments to address management strategies.

*Status:* Some research projects are being conducted in Ecological Reserves and Sanctuary Preservation Areas. Looe Key and Conch Reef have longer-term data sets.

*Implementation:* Academic and agency scientists conduct research projects. Grants to implement this strategy have been provided by NOAA/NOS/NCCOS/Coastal Ocean Program, EPA/Special Studies, and NOAA/National Undersea Research Program.

## STRATEGY W.36 CONDUCTING SOCIOECONOMIC RESEARCH

### *Strategy Summary*

Continue researching the socioeconomic impacts of Sanctuary management on user groups. This research is necessary to achieve a management objective identified by the SAC: "Providing a management system which is in harmony with an environment whose long-term ecological, economic, and sociological principles are understood, and which will allow appropriate sustainable uses." Socioeconomic issues include consequences to fishers who were displaced by implementation of fully protected zones in 1997 and 2001, user-group perceptions about changes in natural resources associated with management actions such as zoning, use patterns of Sanctuary waters, and user-group valuation of Sanctuary resources.

### *Activities (4)*

**(1) Utilize Ecological Reserves, Sanctuary Preservation Areas, and Special-use Areas for Socioeconomic Research.** Data are needed to test hypotheses about detrimental socioeconomic impacts of marine zoning and user-group perceptions about changes in natural resources within the Sanctuary. User-group perceptions of changes in natural resources can be compared with quantitative ecological data.

*Status:* Several socioeconomic studies are underway.

*Implementation:* In 1998, the socioeconomic program (a collaboration of NOAA/National Ocean Service/Special Projects Division, University of Miami/Rosenstiel School of Marine and Atmospheric Science, and Thomas J. Murray & Associates) began to monitor commercial fisheries. Panels of fishers displaced by Sanctuary Preservation Areas and the Western Sambo Ecological Reserve were created. Their catch and financial performance are being tracked. One panel consists of Keys-wide fishers who were not impacted by the areas. In addition, a panel was constructed of Tortugas fishers and three years of baseline data were obtained before creation of the Tortugas Ecological Reserve. In 2000-2001, NOAA formed a multi-agency partnership to estimate the economic value of southeast Florida's artificial and natural reefs. Additional information was gathered on the use of artificial reefs and on residents' support for additional fully protected marine areas (<http://marineeconomics.noaa.gov/>). In addition, the study completed a five-year comparison of visitors and residents who used reefs (1995-96 and 2000-01). Importance and satisfaction ratings for 25 natural resource attributes (e.g., water clarity, coral cover, diversity of marine life, etc.), facilities and services in the Florida Keys were compared (<http://marineeconomics.noaa.gov/SocmonFK/impsat.pdf>).

**(2) Monitor Use Patterns of the Entire Sanctuary and the Market and Non-market Economic Values of Sanctuary Resources.** This effort will provide data and analysis to examine use and valuation of artificial and natural reefs by residents and visitors.

*Status:* On-going.

*Implementation:* Baseline data on recreation and tourism were developed in 1995-96. In 2000-2001, many of the 1995-96 measurements were updated and some measurements of direct reef use (artificial and natural reefs separately) were made. (<http://marineeconomics.noaa.gov/SocmonFK/impsat.pdf>). In 2000-2001, a study was conducted on recreation and tourism in the four-county southeast Florida area that includes

the Sanctuary. Artificial and natural reef use by residents and visitors was a major focus. The report establishes links between the economy and reef use and develops estimates of the recreational value of the reefs (<http://marineeconomics.noaa.gov/>).

**(3) Monitor Use Patterns on Existing Artificial and Natural Reefs Surrounding Sites for Sinking New Artificial Reefs.** This effort will provide data and analysis to test the hypothesis that sinking a new artificial reef in a natural reef environment will reduce use on the surrounding natural reefs.

Status: On-going.

Implementation: In 2001, two pre-sinking and post-sinking data collection efforts were planned. Efforts to monitor the impact of sinking the *Spiegel Grove* off Key Largo were initiated in 2001. A second effort proposes studies that will be implemented in the event that the *U.S.S. Hoyt Vandenberg* is sunk off Key West. The State is a partner in the proposed *Vandenberg* study.

**(4) Support Science of Socioeconomic Analysis of Marine Protected Areas.** Very little is known about applied socioeconomic analysis to marine protected areas. Funding support will be provided for scientists to meet and share information on this subject.

Status: On-going.

Implementation: In 2000 and 2001, the socioeconomic program partnered with NOAA/National Ocean Service/International Programs Office, to fund technical sessions on the socioeconomics of marine protected areas.

## STRATEGY F.3 RESEARCHING QUEEN CONCH POPULATION ENHANCEMENT METHODS

### *Strategy Summary*

Research has investigated optimal approaches to increasing queen conch populations through release of aquaculture-reared juveniles. Research to date has determined that rearing juveniles to a size suitable for release in the field is cost-prohibitive. Results are being shared with interested parties for possible continuation of aquaculture-based population enhancement. Further research utilizing reciprocal transplants supports the efficacy of moving queen conch from non-reproductive, inshore environments to reproductive, offshore environments. On-going research is investigating possible endocrine disruption of queen conch near shore.

### *Activities (2)*

**(1) *Transplant Queen Conch from Inshore to Offshore Environments.*** Research has determined that moving queen conch from non-reproductive, inshore environments to reproductive, offshore environments is a cost-effective method for increasing reproductive output.

Status: On-going.

Implementation: This activity is an existing priority of the FWC/FWRI and is supported by volunteers. This activity is also included in the Volunteer Action Plan.

**(2) *Investigate the Cause of Reproductive Failure of Inshore Queen Conch.*** Research on various snails in other parts of the world has shown that snails are susceptible to endocrine disruption caused by various anthropogenic contaminants. This activity will determine the cause of reproductive failure, possibly by endocrine disruption, of queen conch in the Keys.

Status: On-going.

Implementation: The FWC/FWRI, in collaboration with the University of Florida, has obtained a grant from the NOAA/NOS/NCCOS/Coastal Ocean Program to investigate anthropogenic effects on queen conch reproductive development.

## STRATEGY F.7 RESEARCHING IMPACTS FROM ARTIFICIAL REEFS

### *Strategy Summary*

A number of artificial reefs (intentionally sunk ships) have been placed in the Sanctuary. The impacts of these structures on fish and invertebrate populations and habitats, and the longevity of these structures, are not known. Research is needed on these topics to determine whether the placement of artificial reefs is consistent with goals and objectives of the Sanctuary.

### *Activities (3)*

***(1) Investigate Impacts of Artificial Reefs on Fish and Invertebrate Populations for Long-term Management Including Location, Size, and Materials.*** The effects of artificial reefs on fish and invertebrate abundance and community composition and on other Sanctuary resources will be assessed. The longevity of artificial reefs composed of different materials will be evaluated. Appropriate artificial reef locations will be determined, based in part on these findings.

*Status:* On-going.

*Implementation:* Impacts on reef fishes of the *Spiegel Grove* are being investigated by the Reef Environmental Education Foundation. Permit holders are responsible for these investigations with oversight from Sanctuary staff.

***(2) Monitor and Evaluate Habitat Modification Caused by the Installation of Artificial Reefs.*** This activity complements Activity 1; information on habitat modifications caused by artificial reefs is a necessary element of evaluating consistency of artificial reefs with Sanctuary goals and objectives. Soft sediments may be altered during installation of artificial reefs, and water flows around these structures are likely to continue to modify soft sediments and their associated communities. Nearby hard-bottom habitats may also experience modifications as a result of altered flows and other factors associated with artificial reefs.

*Status:* No action has been taken.

*Implementation:* Permit holders are responsible for these investigations with oversight from Sanctuary staff.

***(3) Assess and Develop Regulations for Artificial Reef Construction and Evaluate Habitat Suitability for Artificial Reefs.***

*Status:* No action has been taken.

*Implementation:* Permit holders assess and report the impacts and benefits of artificial reefs. This activity is included in the Volunteer and Regulatory Action Plans.

## STRATEGY F.6 FISHERIES SAMPLING

### *Strategy Summary*

An improved fisheries sampling program requires improving the spatial resolution of commercial and recreational fisheries-dependent and fisheries-independent sampling programs to provide statistics on catch and effort. This can be accomplished by establishing smaller sampling areas. Fisheries-independent samples measure pre-recruits of economically important species in the statistical areas. Regulations will be developed and implemented in accordance with FWC and the protocols for consistent regulations (see also Strategy R.2, Activity 6 in the Regulatory Action Plan).

### *Activities (3)*

**(1) Evaluate and Enhance Existing Census Programs.** Existing commercial landing and recreational creel census programs continue to be evaluated and improved to provide statistically based management information for regulating take. This includes the assessment and modification of information types and mandatory vs. voluntary information. To increase the resolution, smaller sampling areas should be considered by NOAA Fisheries/Southeast Fisheries Science Center (SEFSC) and FWC. Estimation of private recreational fishing activity and catch should also be considered for a more complete assessment of scope and sources of fisheries impacts.

*Status:* Several on-going projects.

*Implementation:* The FWC and National Marine Fisheries Service (NMFS) are the lead agencies for implementing this activity. The National Park Service and the South Atlantic and Gulf of Mexico Fishery Management Councils provide primary support. NOAA Fisheries/SEFSC has taken a yearly census of fish populations for 15 years at the Key Largo and Looe Key National Marine Sanctuaries. Since 1986, the FWC/FWRI has administered a commercial fishery-dependent monitoring program that includes the snapper-grouper complex, pompano, dolphin, mackerel, spiny lobster, amberjack, and stone crab. The FWC/FWRI is also conducting a fisheries-dependent monitoring program for charter boats.

**(2) Continue a Fishery Pre-recruitment Monitoring Effort.** A fisheries pre-recruitment monitoring effort has been initiated for the long-term prediction of fishery stocks for Sanctuary management. This effort is independent of commercial monitoring activities. The FWC has begun implementation of fishery pre-recruitment monitoring efforts for other areas in the State. Several statistical areas have been established, and this activity will evaluate and implement the programs to that level. It has not been possible to monitor all species at all areas.

*Status:* On-going.

*Implementation:* The FWC has partially implemented a statewide fisheries pre-recruitment monitoring program that includes the Sanctuary.



**(3) Investigate Life Histories of Fishery Species.** For most fishery species, scientific studies of complete life histories are lacking. Life histories describe the ecology of an organism's life cycle, e.g., survival from stage to stage, stage-specific feeding and habitat utilization, adult reproduction, and life span. These investigations should include species on the FWC marine life list.

Status: No action has been taken.

Implementation: NOAA and FWC are the lead agencies for implementing this activity.

## STRATEGY F.11 EVALUATING FISHING GEAR/METHOD IMPACTS

### *Strategy Summary*

Approximately half-a-million lobster traps and a million stone crab traps are deployed in Sanctuary waters during the fishing seasons for these species, which last eight months and seven months, respectively. The habitat impacts of lowering and raising such a considerable number of traps, as well as additional impacts from “ghost traps” and entangled lines, require investigations.

### *Activities (3)*

**(1) Evaluate Impacts of Existing Fishing Gear and Methods on Habitats.** Research is needed to investigate impacts on habitats of commercial and recreational fishing gear and methods.

Status: Preliminary investigations have been conducted.

Implementation: The NOAA/NOS/NCCOS/Center for Coastal Fisheries and Habitat Research is investigating impacts of lobster traps on seagrass habitat and NOAA Fisheries is investigating coral reef impacts.

**(2) Conduct Research on Low-impact Fishing Gear and Methods.** This activity will facilitate research to develop gear designs and types that minimize impacts to corals, hard-bottom, seagrasses, and other habitat and species. Biodegradable fishing line, traps, and buoy lines are examples of gear types that would be studied. Modified trap designs would also be considered. Fishing methods, including resource handling and gear placement, would be examined to develop methods and gear that minimize impacts to resources while maintaining efficiency. Volunteers will provide assistance.

Status: No action has been taken.

Implementation: The FWC, SAFMC, and GMFMC will be the lead agencies.

**(3) Conduct Research on the Ecological Impacts on Sanctuary Preservation Areas of Bait Fishing and Catch-and-release Fishing by Trolling.** In order to make an informed decision about whether to maintain the catch-and-release fishing by trolling and bait-fishing provisions for some of the protected areas, it is necessary to assess the ecological effects of these limited consumptive activities.

Status: No action has been taken.

Implementation: NOAA will be the lead agency for organizing; partnerships, contracts, and agreements with other academic, agency, or non-governmental programs will likely be required for full implementation of this activity.

## STRATEGY F.15 ASSESSING SPONGE FISHERY IMPACTS

### *Strategy Summary*

The purpose of this strategy is to determine which sponge fishing methods have a low adverse impact on species and habitat and identify areas that exhibit low abundance, low recovery rates, and habitat damage. The strategy supports the development and implementation of regulations for the sponge fishery.

### *Activities (1)*

**(1) Assess Impacts of Sponge Fishery Methods.** Research is needed to compare impacts on resources and habitats of different sponge fishing methods.

*Status:* The SAC held two workshops in 2000 to gather information about commercial sponging and forwarded its recommendations to the FWC.

*Implementation:* The FWC is the lead agency for implementing this activity. Investigators at Old Dominion University have been awarded grants from the NOAA/NOS/NCCOS/ Coastal Ocean Program to investigate dynamics of hard-bottom communities, including commercially fished sponge species.

## STRATEGY W.18 CONDUCTING PESTICIDE RESEARCH

### *Strategy Summary*

This strategy will establish an independent research program to identify the impacts of spraying practices on Sanctuary resources and identify alternative means of mosquito control. Because pesticides used in mosquito control are nonspecific to the larval stages of crustaceans, fish and natural mosquito predators, the effects of the chemicals and all application methods need to be examined. In addition, the impacts of housing patterns, design, and landscaping need to be investigated as they affect the demand for mosquito control. This strategy is partnered with Strategy W.17 in the Water Quality Action Plan, which focuses on mosquito spraying.

### *Activities (3)*

**(1) *Research Impacts and Alternatives.*** Research the impacts of current spraying practices on Sanctuary resources and identify alternative means of mosquito control.

*Status:* A special study was funded in 1997 to investigate if aerial or truck-sprayed pesticides drift into nearshore surface waters. Dibrom and its breakdown product were found in some subsurface samples several hours after application in sufficient concentrations that represented an ecological hazard to sensitive marine organisms. More research is needed to quantify the risk of mosquito spraying and larvicide application on non-target organisms. The Monroe County Mosquito Control District asked USFWS for permission to aerially apply larvicides on refuge islands adjacent to population centers. USFWS approved limited use of ground application if it was part of a pilot project that included monitoring of impacts on target and non-target species. That alternative was supported by the Sanctuary's Technical Advisory Committee but rejected by the Monroe County Mosquito Control District.

*Implementation:* The lead agency will be the Florida Department of Agriculture and Consumer Services (FDACS). The FDEP will also have a primary role regarding evaluations of pesticide toxicity. The FDCA may also have an assisting role as the State land-planning agency for a designated Area of Critical State Concern, with oversight responsibility to ensure that local development regulations adequately protect the area's natural resources.

**(2) *Modify the Mosquito Control Program.*** The results of the pesticide research program will be used to modify the existing mosquito control program as necessary.

*Status:* No action has been taken.

*Implementation:* The lead agency will be the FDACS; the FDEP will also be a primary agency.

**(3) *Conduct a Field Survey of Household use of Pesticides and Herbicides and Develop a Plan to Minimize Their Impact on the Environment.*** This activity would involve a survey of pesticides, herbicides, and fungicides used in the Keys. The activity seeks to develop a plan, with a strong public education component, that will minimize the environmental impacts of household chemicals.

*Status:* No action has been taken.

*Implementation:* The lead agency will be the FDACS; the FDEP will also be a primary agency.

## STRATEGY W.22 ASSESSING WASTEWATER POLLUTANTS IMPACTS

### *Strategy Summary*

The purpose of this strategy is to: 1) conduct special studies to establish pollutant-loading thresholds above which biotic communities are adversely affected; 2) detect the presence of wastewater pollutants from on-site sewage treatment and disposal systems (OSTDS), cesspits, package plant boreholes, and surface-water dischargers; 3) determine the relative pollution contribution of each method to surface waters, groundwaters, and sediments, document the transport of pollutants into the environment; and 4) describe the severity and extent of ecological impacts that can be linked to the pollutants.

### *Activities (1)*

**(1) Conduct Wastewater Pollutants and Ecological Impact Studies.** Potential approaches include experimental studies, eutrophication gradient studies; comparative studies of impacted and non-impacted sites; historical studies; geographic comparisons, use of biochemical and ecological indicators, use of sewage tracers; and high-frequency and spatially intensive water quality sampling.

*Status:* To date, six special studies have been completed. A comprehensive monitoring program has been initiated at Little Venice (Marathon, FL) to document conditions in canal and nearshore waters prior to and after construction of a central collection and treatment system for wastewater. This strategy is also included in the Water Quality Action Plan.

*Implementation:* EPA and FDEP are the lead agencies. The Sanctuary and Monroe County also have primary roles. The Water Quality Protection Program's Technical Advisory Committee and Steering Committee approve research topics and products.

## STRATEGY W.23 RESEARCHING OTHER POLLUTANTS AND WATER QUALITY ISSUES

### *Strategy Summary*

Conduct special studies to document the fate and ecological impacts of non-wastewater pollutants, develop innovative monitoring tools, and examine effects of global climate change on organisms and ecosystems of the Keys.

### *Activities (4)*

**(1) Estimate Other Pollutant Loadings.** This activity will document the locations and magnitudes of pollution impacts other than wastewater. Sources will include those both inside and outside of the Sanctuary (for example, permitted discharges, stormwater runoff, groundwater leachates, marinas, the C-111 canal, Biscayne Bay, Florida Bay, southwest Florida, oceanic fluxes, and gyre-induced upwellings). Pollutants will include hydrocarbons, heavy metals, and pesticides.

Status: Three special studies found that water movement through tidal passes is predominantly towards the Atlantic Ocean, and wind may be a controlling factor in speed and direction; pesticides used for mosquito control, or their toxic breakdown products are found in some canals in concentrations high enough to adversely affect marine organisms; and human pathogenic viruses were present in residential canals in the Keys, and these viruses were viable in cooler months.

Implementation: EPA and FDEP will be the lead agencies. Assistance may be provided by the Sanctuary, National Park Service (NPS), and South Florida Water Management District (SFWMD).

**(2) Identify Causal Linkages Between Pollutants and Ecological Impacts.** This activity will conduct research to identify and document causal linkages between non-wastewater pollutants and specific ecological problems.

Status: A special study demonstrated that corals exposed to water from Florida Bay grow more slowly than corals at control sites, probably in response to increased turbidity of Florida Bay waters. Current monitoring at the Little Venice site (Marathon, Florida) includes quantifying the structure of the seagrass community near the mouths of residential canals before and after improvements to wastewater treatment. Implementation: EPA and FDEP are the lead agencies. NOAA, NPS and SFWMD may provide assistance.

**(3) Develop and Evaluate Innovative Monitoring Tools.** This activity will identify and evaluate monitoring tools and methodologies used to detect pollutants and identify cause-and-effect relationships among water quality and biological resources.

Status: Special studies to date have found that coral growth rates and the concentration of zooxanthellae respond to environmental conditions; that the algal community changes in structure between Florida Bay and the Keys; and that chlorophyll in surface waters is a reliable and easily measured indicator of movements of water masses.

Implementation: EPA and FDEP are the lead agencies. NOAA also has a primary role.

**(4) Conduct Research on Global Change.** This activity will involve research to examine the effects of stresses associated with global change on the ecosystem. Examples of stresses include changes in temperature, salinity, frequency and intensity of storms, turbidity, sea level change, and ultraviolet and visible radiation.

Status: No action has been taken; several independently funded research projects have investigated some of the stresses listed above.

Implementation: The Sanctuary will be the lead agency. EPA, USFWS, and FDEP will assist. This activity is also included in the Water Quality Action Plan.

## STRATEGY W.24 RESEARCHING FLORIDA BAY INFLUENCES

### *Strategy Summary*

Conduct research to understand effects of water transported from Florida Bay on water quality in the Sanctuary.

### *Activities (3)*

**(1) Conduct a Historical Assessment.** This activity will involve a historical assessment of the hydrology of the Everglades, Florida Bay, and Florida Keys water as it has affected water quality and biological communities in the Sanctuary. It will clarify the role of freshwater inflows and water quality from the Everglades and other freshwater discharges to the southwest shoreline of Florida, Florida Bay, and the Sanctuary. The activity will examine the effects of structural modifications and changes in quality, quantity, timing and distribution of freshwater releases from existing structures and will examine land-based practices affecting the water quality of runoff.

*Status:* Four Florida Bay Science Conferences have been successfully completed. A Paleoecology Report has been prepared for Florida Bay. ACOE has developed a Water Quality Model for Florida Bay. That model has not been implemented because it depends on an accurate hydrodynamic model that has not yet been prepared.

*Implementation:* SFWMD and NPS are the lead agencies. Assistance is provided by ACOE, which has historical data concerning water management activities affecting the Everglades and Florida Bay. A water quality monitoring network has been established in Florida Bay and surrounding coastal areas, including Biscayne Bay, Whitewater Bay, Ten Thousand Islands, the Southwest Florida Shelf, and waters of the Sanctuary. Historical salinity data for Florida Bay have been assembled and summarized.

**(2) Conduct Circulation Studies.** This activity will involve water circulation studies to estimate present-day, long-term net transport and episodic transport from Florida Bay to the Sanctuary. Studies of groundwater flow may also be included.

*Status:* A special study entitled "Hawk Channel Transport Study: Pathways and Processes" has been completed. A hydrodynamic model for Florida Bay has been developed by ACOE, but during testing it did not successfully duplicate known salinity patterns. Another hydrodynamic model for Florida Bay will be developed as part of the Florida Bay/Florida Keys Feasibility Study of the Comprehensive Everglades Restoration Plan. The University of Miami is conducting bimonthly cruises of Florida Bay and the west Florida shelf and continues to employ satellite-tracked drifters to study circulation patterns in Florida Bay and ocean currents.

*Implementation:* The EPA, FDEP, and NOAA are the lead agencies.

**(3) Conduct Ecological Studies.** This activity will involve studies to document any ecological impacts of Florida Bay waters on Sanctuary communities and potentially endangered or threatened species. Documentation of potential impacts could provide a stronger basis for action to restore historical freshwater flow to Florida Bay.



Status: Three special studies have been completed that address the impact of Florida Bay waters on Sanctuary resources. Findings include a demonstration that corals exposed to Florida Bay water grow at slower rates than those at a control site; that corals exposed to Florida Bay water had significantly higher zooxanthellae concentrations, probably in response to decreased light penetration in the more turbid water; and that differences in the algal community structure in waters surrounding the Florida Keys may, in part, be explained by the influence of Florida Bay waters. One study used carbon and nitrogen isotope ratios to attempt to determine sources of organic matter and nitrogen on the reef tract.

Implementation: EPA and the FDEP are the lead agencies.

## STRATEGY W.21 DEVELOPING PREDICTIVE MODELS

### *Strategy Summary*

This strategy will develop predictive models that, with appropriate scientific guidance, would help resource managers predict and evaluate the outcome of a particular strategy, such as engineering to reduce wastewater nutrient loadings. Initial conceptual models would be developed, information needs identified, environmental data gathered, and quantitative models developed and refined over the long-term and on a continuous basis.

### *Activities (2)*

**(1) Conduct a Modeling Workshop.** This activity will involve conducting a workshop to discuss modeling approaches, develop preliminary conceptual models, and define specific information needs for the models.

*Status:* The Florida Keys Carrying Capacity Study developed an Integrated Water Module for the Sanctuary that included stormwater and wastewater loading estimates for total nitrogen, total phosphorus, biochemical oxygen demand, and total suspended solids. A National Research Council Report (*A Review of the Florida Keys Carrying Capacity Study*) identified a number of deficiencies with this module.

*Implementation:* The lead agencies will be EPA, FKNMS, and FDEP.

**(2) Develop a Modeling Implementation Plan.** This activity will involve developing an overall plan for developing predictive models focused on management needs. The plan will include discussion of preliminary conceptual models, data needs, data gathering, and model development and refinement. The plan will also discuss mechanisms for ensuring that the modeling effort remains closely tied to management needs.

*Status:* No action has been taken. Hydrodynamic, water quality, and ecological modeling for Florida Bay is being conducted as part of the Florida Bay/Florida Keys Feasibility Study of the Comprehensive Everglades Restoration Plan.

*Implementation:* The lead agencies will be EPA, FKNMS, and FDEP. NPS, SFWMD, and ACOE will assist.

## PREVIOUS STRATEGIES

This review of the FKNMS Management Plan identified some Action Strategies that no longer warrant the low- or medium-priority attention they originally received in the *1997 Management Plan*. The following strategies are not included in this action plan because of the low likelihood of implementing low-priority strategies over the next five years:

- W.9 Laboratory Facilities
- F.4 Aquaculture Alternatives
- F.10 Bycatch
- F.14 Spearfishing
- R.5 Carrying Capacity