

Florida Keys National Marine Sanctuary Revised Management Plan



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This document is the revised management plan for the Florida Keys National Marine Sanctuary. It replaces the management plan that was implemented in 1996 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) 809-4700 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 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 1996 *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 in 1996; 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 recreation and livelihoods for approximately 80,000 residents.

The Sanctuary is 2,900 square nautical miles of coastal waters, including the 2001 addition of the Tortugas Ecological Reserve. The Sanctuary overlaps four national wildlife refuges, six state parks, three state aquatic preserves and has incorporated two of the earliest national marine sanctuaries to be designated, Key Largo and Looe Key National Marine Sanctuaries. Three national parks have separate jurisdictions, and share a boundary with the Sanctuary. The region also 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 vessel groundings, pollution, and overfishing. Threats to the Sanctuary also include indirect human impacts, which are harder to identify but are 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.

Management Plan Organization

Within this document, the tools that the Sanctuary uses to achieve its goals are presented in 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 1996 *Management Plan* generally retain their designations in this document. As in the 1996 plan, two or more action plans may share a strategy where their goals and aims converge. The 1996 plan can be accessed on the Sanctuary's Web site floridakeys.noaa.gov

Accomplishments and Highlights

The Sanctuary's programs and projects have made significant progress since the original management plan was implemented 1996. An overview of these accomplishments is provided in the Introduction. In addition, each action plan contains bulleted lists of accomplishments since the 1996 management plan was adopted.

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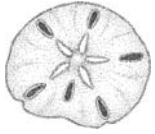
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Acronyms

ACHP	Advisory Council on Historic Preservation
AGRRA	Atlantic and Gulf Rapid Reef Assessment Program
ASA	Abandoned Shipwreck Act
ATBA	Areas to Be Avoided
AWT	Advanced Wastewater Treatment
CAD	Computer Automated Dispatch
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERP	Comprehensive Everglades Restoration Plan
CFR	Code of Federal Regulations
CRCP	Coral Reef Conservation Program
DARP	Damage Assessment and Restoration Program
DEP	Florida Department of Environmental Protection
DTNP	Dry Tortugas National Park
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
F.S.	Florida Statutes
FAC	Florida Administrative Code
FDACS	Florida Department of Agriculture and Consumer Services
FDCA	Florida Department of Community Affairs
FDHR	Florida Division of Historical Resources
FDOT	Florida Department of Transportation
FKNMS	Florida Keys National Marine Sanctuary
FKNMSPA	Florida Keys National Marine Sanctuary Protection Act
FPS	Florida Park Service
FR	Federal Register
FWC	Florida Fish and Wildlife Conservation Commission
FWRI	Fish and Wildlife Research Institute
FY	Federal Fiscal Year
GIS	Geographic Information System
GMD	Growth Management Division (Monroe County)
GMFMC	Gulf of Mexico Fishery Management Council
GPS	Global Positioning System
HAZMAT	Hazardous Materials
ICS	Incident Command Structure
ICW	Intra-coastal Waterway
IMO	International Maritime Organization
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

MRD	Marine Resources Division (Monroe County)
NCCOS	National Centers for Coastal Ocean Science
NEPA	National Environmental Policy Act
NGO	Non-governmental Organization
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NMSA	National Marine Sanctuary Act
NMSF	National Marine Sanctuary Foundation
NMSP	National Marine Sanctuary Program
NOAA	National Oceanic and Atmospheric Administration
NOAA/OLE	NOAA Office of Law Enforcement
NOS	National Ocean Service
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRDA	Natural Resource Damage Assessment Claims
NURC	National Undersea Research Center
OFW	Outstanding Florida Waters
OSDS	On-Site Disposal System
OSTDS	On-Site Sewage Treatment and Disposal System
PREP	National Prepared for Response Exercise Program
PSSA	Particularly Sensitive Sea Area
RECON	Reef Ecosystem Condition Program
REEF	Reef Environmental Education Foundation
RNA	Research Natural Area
RSMAS	University of Miami/Rosenstiel School of Marine and Atmospheric Science
SAFMC	South Atlantic Fishery Management Council
SAP	Science Advisory Panel
SAV	Submerged Aquatic Vegetation
SCR	Submerged Cultural Resources
SEFSC	Southeast Fisheries Science Center
SFWMD	South Florida Water Management District
SHIELDS	Sanctuary Hazardous Incident Emergency Logistics Database System
SPA	Sanctuary Preservation Area
SWIM	Surface Water Improvement and Management Act
SWM	Stormwater Management
TAC	Technical Advisory Committee
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
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAMS	Waterway Assessment and Marking System

WMA Wildlife Management Area
WQPP Water Quality Protection Program
WQSC Water Quality Steering Committee



3.1 Sanctuary Science

The Sanctuary Science management division consists of two action plans: 1) Science Management and Administration and 2) Research and Monitoring. An effective science program requires management and administration that focuses on coordinating research and monitoring projects, working with partners to secure funding and other support, communicating findings of the program, advising Sanctuary managers of relevant findings both by the program and from other sources, and engaging in other regional science efforts. This coordination role is substantial because of participation by a large number of governmental, academic and non-governmental scientists. Permitting is a component of this action plan, along with other critical aspects of administering an effective and comprehensive 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. Monitoring accrues value over time and requires long-term commitments of support. To improve our understanding of patterns and trends such as those documented by monitoring, 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 further; and,
- Validate models that guide management actions.

3.1.1 Science Management & Administration Action Plan

Introduction

Scientific research and monitoring in the FKNMS involves dozens of projects conducted by a wide range of academic institutions, state and federal agencies, and other organizations. It is essential to maintain overall coordination and management of this complex set of activities and the information it generates to achieve science-based management of Sanctuary resources and to effectively communicate findings of the science program to interested parties. In addition, many scientific studies require Sanctuary permits in order to proceed as they involve temporarily placing sampling apparatus on the sea floor.

Sanctuary managers regularly require technical advice on best-management practices of natural resources and other issues, and obtain this advice from a Technical Advisory Committee (TAC) comprised mainly of scientists conducting projects in the FKNMS. This advice has been of great value to managers. For instance comments from the TAC were essential to Sanctuary managers as they developed the FKNMS *Comprehensive Science Plan* (see Research and Monitoring Action Plan).

The Florida Reef Tract is a nationally significant ecosystem that lies at the southernmost margin of the greater South Florida ecosystem. "Upstream" management actions may impact Sanctuary resources, and FKNMS staff is responsible for including such considerations at a host of meetings and discussions. These include several major efforts in South Florida that are highly relevant to Sanctuary management such as the South Florida Ecosystem Restoration Task Force, the Comprehensive Everglades Restoration Plan, and the Florida Bay and Adjacent Marine Systems Science Program, which require participation by Sanctuary staff.

Goals and Objectives

The goal of the Science Management and Administration Action Plan is to define the elements of a coordinated science program that meets management objectives, informs the public about the state of Sanctuary resources, and provides relevant information for regional efforts such as Everglades restoration.

The objectives of this action plan are to:

- Facilitate and manage scientific and educational projects that entail prohibited activities;
- Broadly disseminate findings of the science program and use this information in regional science efforts;
- Utilize the technical expertise of the regional scientific community in Sanctuary decision-making; and
- Define the elements of a distributed data management strategy.

Implementation

The Science Management and Administration Action Plan will be implemented by the FKNMS, EPA, FWC, and DEP.

Accomplishments

There have been substantive accomplishments in scientific coordination, data collection and dissemination of findings since the 1996 management plan. Examples include:

- An independent Science Advisory Panel, convened in December 2000, to review the science program and make recommendations about future directions.
- *Florida Keys National Marine Sanctuary Comprehensive Science Plan*, addressing the Science Advisory Panel's recommendations and identifying research and monitoring priorities in support of specific management objectives (posted at the FKNMS Web site floridakeys.noaa.gov).
- In January 1998, a workshop of 50 social scientists and stakeholders was held to design the Socioeconomic Research & Monitoring Program. Go to marineeconomics.noaa.gov/SocmonFK/keys.html for Goals and Objectives and products developed to date.
- The Tortugas 2000 process for designing the Tortugas Ecological Reserve relied heavily on compilation of existing research and new characterization studies in physical oceanography, natural resources, and human dimensions (floridakeys.noaa.gov/tortugas/welcome.html).
- A symposium at NOAA headquarters in 2001, conducted to present findings of the monitoring programs and associated projects to a broad audience of managers, scientists, and other interested parties.
- A session on marine ecosystems of the Florida Keys at the 2003 *Greater Everglades Ecosystem Restoration Science Conference*. The half-day session included 10 oral presentations covering a wide range of topics.
- A 2004 colloquium, "Connectivity: Science, People, and Policy in the Florida Keys National Marine Sanctuary," to engage the public about recent scientific findings regarding resource condition and linkages between natural resources, socio-economic use, and management challenges. A proceedings volume of presentations and panel discussions at the two-and-a-half-day meeting will be published in the National Marine Sanctuary Program's Conservation Series (sanctuaries.nos.noaa.gov/science/conservation/welcome.html).
- Staff helped organize a special symposium on Caribbean Connectivity at the 2006 annual meeting of the Gulf and Caribbean Fisheries Institute, which included a day of scientific presentations and a hands-on workshop on remote-sensing tools for managers. A set of papers will be published in the National Marine Sanctuary Program's Conservation Series (sanctuaries.nos.noaa.gov/science/conservation/welcome.html).
- Reports on findings of the Science Program including the Water Quality Protection and Marine Zone Monitoring Programs (posted at the FKNMS Web site floridakeys.noaa.gov). The 2002-03 report was published in the National Marine Sanctuary Program's Conservation Series (sanctuaries.nos.noaa.gov/science/conservation/welcome.html).
- Participation in South Florida, National, and International committees including the South Florida Ecosystem Restoration Task Force's Working Group, Florida Bay and Adjacent Marine Systems Program Management Committee, Southern Florida Shallow-Water Coral Ecosystem Mapping Implementation Team's Steering Committee, Comprehensive Everglades Restoration Plan Project Delivery Teams, Florida Reef Resilience Program's Steering Committee, Florida Oceans and Coastal Resources Council, Atlantic *Acropora* Biological Review Team and Recovery Team, U.S. Coral Reef Task Force, U.S. Climate Change Science Program's Synthesis and Assessment Product 4.4 (Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources), CORALINA International Advisory Board, and Organizing Committee for the 11th International Coral Reef Symposium.

- Presentations at regional, national and international conferences and workshops.
- Publications in peer-reviewed journals, books, and conference proceedings.

Strategies

There are five strategies in this Action Plan:

- B.11 Issuance of Sanctuary Research Permits
- W.29 Dissemination of Findings
- W.32 Maintaining a Technical Advisory Committee
- W.34 Regional Science Partnerships and Reviews
- W.35 Data Management

Each of these strategies is detailed below. Table 3.2 provides estimated costs for implementation of each strategy over the next five years.

Table 3.2 Estimated Costs of the Science Management and Administration Action Plan

Science Management and Administration Action Plan Strategies	Estimated Annual Cost (in thousands)*					Total Estimated 5 Year Cost
	YR 1	YR 2	YR 3	YR 4	YR 5	
B.11: Issuance of Sanctuary Research Permits	20	20	20	20	25	105
W.29: Dissemination of Findings	15	15	15	15	20	80
W.32: Maintaining a Technical Advisory Committee	10	10	10	10	15	55
W.34: Regional Science Partnerships and Reviews	60	60	65	65	70	320
W.35: Data Management	60	60	65	65	70	320
Total Estimated Annual Cost	<i>165</i>	<i>165</i>	<i>175</i>	<i>175</i>	<i>200</i>	880

* Contributions from outside funding sources also anticipated.

STRATEGY B.11 **ISSUANCE OF SANCTUARY RESEARCH PERMITS**

Strategy Summary

This strategy allows researchers to conduct prohibited activities if these activities further highly beneficial research and monitoring in the Sanctuary. Research activities that are not prohibited are maintained in a voluntary research registry. Permits are monitored and their provisions enforced (see also Strategy R.1 in the Regulatory Action Plan, 15 CFR 922.166, and the Sanctuary Web site floridakeys.noaa.gov/research_monitoring/permits.html).

Activities (1)

(1) Continue Research Permitting Program. Sanctuary staff continues to manage, authorize, and enforce the permitting program and review all permit applications. Strategy R.1 in the Regulatory Action Plan further describes the full permitting program. The FWC and Monroe County also issue permits for certain activities within their jurisdictions and staff coordinates with these programs.

Status: On-going.

Implementation: When determining whether to issue a research permit, the potential for damage is compared to expected benefits. Research that may result in resource alteration must be of the highest quality and be considered highly beneficial. Staff may request a committee of coral experts to review applications to collect live coral. Information and forms required for a research permit request are posted at the Sanctuary's Web site (floridakeys.noaa.gov/research_monitoring/permits.html). The results of permitted research are evaluated through a peer review. The Sanctuary is the lead agency, in collaboration with the DEP, FWC and Monroe County.

STRATEGY W.29 **DISSEMINATION OF FINDINGS**

Strategy Summary

This strategy will develop a program to synthesize and disseminate scientific research and monitoring results, including an information exchange network, conferences, and support for the publication of research findings in peer-reviewed scientific journals. It will help disseminate research findings among scientists, resource managers, and the general public.

Activities (5)

(1) Develop Periodic Reports on Sanctuary Health. This activity will create Florida Keys National Marine Sanctuary Condition reports for the general public. The reports will include up-to-date information on the status and trends of water quality, critical habitats, and species of particular interest. The reports will review the effectiveness of marine zoning in protecting biodiversity, sensitive habitats, fisheries resources and in modifying use patterns and user perceptions. The reports will also consider the state of the Sanctuary in the context of other tropical marine ecosystems at regional and global scales. Reports will be prepared periodically as the Science Program produces significant new information.

Status: Work on the first FKNMS Condition Report will begin in 2007. In addition, periodic science reports are posted on the Sanctuary's internet site.

Implementation: FKNMS is the lead agency.

(2) Continue to Communicate Findings of the Science Program. Staff conducts symposia and prepares newsletter articles, public presentations, annual reports, and other written and oral materials.

Status: On-going.

Implementation: FKNMS staff publish a newsletter (*Sounding Line*) (refer to the Outreach and Education Action Plan) and make frequent public presentations. Reports of findings of the science program are posted at the FKNMS Web site (floridakeys.noaa.gov). FKNMS is the lead agency. Collaborating organizations have primary roles.

(3) Establish an Information Exchange Network. This activity would develop a compendium of on-going and planned research to be updated periodically.

Status: No action has been taken to develop a compendium; however, a summary of on-going monitoring and research is posted at the FKNMS internet site.

Implementation: A FKNMS Science Advisory Panel (December 2000) reviewed existing science projects and recommended future action. Based on that review, a *Final Draft Comprehensive Science Plan* has been developed and the Technical Advisory Committee has provided further comment and review. The plan is posted at the FKNMS Web site (floridakeys.noaa.gov). A second review of the FKNMS science program will take place in 2007. FKNMS is the lead agency; the EPA has a primary role.

(4) Sponsor Conferences. This activity involves sponsoring conferences to keep scientists and managers informed on research and monitoring results and existing or planned management actions.

Status: On-going.

Implementation: FKNMS and EPA staff convened a meeting in December 2000 at which principal investigators presented all elements of the science program to an independent panel for peer review. In December 2001, FKNMS, EPA, State of Florida, and other agency partners hosted a symposium in the NOAA Main Auditorium entitled "The Florida Keys National Marine Sanctuary: An Ecosystem Report Card." This one-day symposium presented results from status and trends monitoring of coral reefs, seagrasses, and water quality, and also reviewed performance of fully protected marine zones on benthic communities and fishery populations. Principal investigators from each monitoring project were present to discuss their findings and answer questions.

In August 2004, FKNMS hosted a colloquium in Key West entitled "Connectivity: Science, People and Policy in the Florida Keys National Marine Sanctuary." This two-and-a-half-day meeting included five plenary talks and panels on the topics of regional connections, connectivity between people and marine fishery resources, climate change, resource conditions, water quality, coral and seagrass habitats, human perspectives, and management tools. A proceedings volume will be published.

The FKNMS helped to organize a special symposium, "Caribbean Connectivity," at the annual meeting of the Gulf and Caribbean Fisheries Institute in November 2006. The special symposium included a full day of presentations and a day-long, hands-on workshop designed to train resource managers in the use of remote sensing tools.

FKNMS is the lead agency; the EPA and FWC have primary roles.

(5) Support Journal Publication. This activity involves funding the publication of research and monitoring findings in peer-reviewed scientific and management journals, as needed. Some publications have no associated fees.

Status: On-going.

Implementation: Recent publications have appeared in *Gulf and Caribbean Research*, *Marine Technology Society Journal*, *Proceedings of the 2003 Georgia Basin/Puget Sound Research Conference*, *Ecological Restoration*, a chapter in *Estuarine Indicators*, *Bulletin of Marine Science*, *Journal of Environmental Management*, *Journal of Leisure Research*, *New Zealand Journal of Marine and Freshwater Research* and *Ocean and Coastal Management*. NOAA is the lead agency; the EPA and FWC have primary roles.

STRATEGY W.32 MAINTAINING A TECHNICAL ADVISORY COMMITTEE

Strategy Summary

This strategy will maintain a previously established Technical Advisory Committee composed of scientists and other staff from federal agencies, state agencies, academic institutions, and private, non-profit organizations as well as knowledgeable citizens. Its purpose is to advise the EPA, DEP and the Sanctuary on the design and prioritization of water quality and ecological research and monitoring.

Activities (1)

(1) Convene Meetings of a Technical Advisory Committee. The Technical Advisory Committee meets once or twice per year to advise FKNMS managers. The EPA develops agendas in consultation with the FKNMS, DEP, South Florida Water Management District (SFWMD), Monroe County, and other members of the Water Quality Protection Program (WQPP) Management Team.

Status: On-going. Periodic meetings are held as the Committee determines a need or as requested by the WQPP Management Team. The most recent meeting was held in the summer of 2006.

Implementation: The EPA and DEP are the lead agencies; the FKNMS has a primary role.

STRATEGY W.34 REGIONAL SCIENCE PARTNERSHIPS AND REVIEWS

Strategy Summary

FKNMS staff actively participate in science-related committees, review panels, and other groups that collaborate on science issues pertaining to South Florida, coral reefs, resource management, and other topics. This strategy ensures that consideration of Sanctuary resources is included in regional

planning, that there is broad-based recognition of scientific findings concerning the Sanctuary, and that Sanctuary expertise is shared with partners.

Activities (1)

(1) Continue Regional Science Partnerships and Reviews. Several FKNMS staff are members of or participate in the U.S. Coral Reef Task Force, South Florida Ecosystem Restoration Task Force's Working Group, Comprehensive Everglades Restoration Plan Project Delivery Teams, Florida Bay and Adjacent Marine Systems Program Management Committee, Florida Reef Resilience Program Steering Committee, Southern Florida Shallow Water Coral Ecosystem Mapping Implementation Steering Committee, meetings of regional Coastal Ocean Observing Systems and their Regional Associations, the Florida Ocean and Coastal Resources Council, grant proposal review panels, and other committees and panels. In addition, staff review numerous permit proposals, management plans, science plans, etc such as the Everglades National Park General Management Plan.

Status: On-going.

Implementation: FKNMS staff regularly participate in meetings of various committees and panels and review various documents as noted above. NOAA and FWC are the lead agencies; the EPA and DEP have primary roles.

STRATEGY W.35 DATA MANAGEMENT

Strategy Summary

As technologies evolve, research and monitoring programs become more complex and the volume of information increases. It is clear that a distributed data management strategy is most appropriate. This strategy centers around an internet-based data search engine that points interested parties to Internet sites that serve the requested databases, maps, text files, etc. For the most part, these internet sites would be maintained by the information creators to ensure data currency and accuracy. This strategy is being carried out in accordance with recommendations of the Technical Advisory Committee, the Florida Oceans and Coastal Resources Council and FWC. It evolved from W.33: Ecological Research and Monitoring (Activity 2 - Establish an Ecological Information System) and W.28: Regional Database.

Activities (3)

(1) Continue the Ecological Information System. Spatial and temporal information about ecological resources has been incorporated into an existing South Florida Geographic Information System (GIS). Information summarizing benthic habitats, species distributions and life histories, water quality, etc., is included. These are essential baseline data for effective ecological monitoring. Additionally, information will be derived from existing sources such as the Minerals Management Service / Marszalek / Dade Department of Environmental Resource Management maps and the NOAA/FWC benthic habitat maps, all of which have been digitized and incorporated into the FWC/Fish and Wildlife Research Institute's Marine Resources GIS.

Status: On-going.

Implementation: The FWC and other agencies, pending funding, have several separate but related projects underway that should meet this need. For example, the FWRI worked with the US Army Corps of Engineers (USACE) and Florida Department of Community Affairs (FDCA) on the Florida Keys Carrying Capacity Study, which generated new scenario-based

information. The carrying capacity project incorporated comprehensive growth plans, human-use, and environmental data into a model designed to facilitate growth management. Monroe County is also developing a GIS for land-use analysis, with some marine applications. Pending funding, the FWC would be the lead agency for integrating the data for easy access by FKNMS staff over the internet using map servers and internet-served databases.

(2) Establish a Data Management Protocol. This protocol will standardize the way investigators manage data by creating a single approach to maintaining, storing, and accessing digital data. For many years, researchers have maintained and analyzed their data as they saw fit. With research shifting focus from single organisms to ecosystems, the need arises to integrate multiple databases. In addition, a dynamic, distributed system is necessary for annual data gathering and archiving. A regional database and data management system will also be established for recording research results and the biological, physical, and chemical parameters associated with monitoring programs.

Status: No action has been taken to complete the protocol.

Implementation: Pending funding, the FWC will continue to produce annual CD-ROMs for the Water Quality Protection and Marine Zone Monitoring Programs. Some principal investigators are posting data and reports at individual Web sites. FKNMS will coordinate to the greatest extent possible with the NMSP IMAST group to ensure appropriate consistency with NMSP internal protocols. The FWC is the lead agency; the EPA and FKNMS have primary roles.

(3) Develop a Geographic Information System. This activity seeks to use photographs of sea bottom features near coral reefs to provide baseline data on coral cover at a particular time. The photographs provide information on the location of monitoring stations in relation to benthic cover and assist mooring-buoy specialists in pinpointing the location of buoy anchors. A comparison between 1995 and 1999 color infrared photographs shows seagrass damage over time, and turbidity increases caused by boats crossing over shallow areas. GIS analysis also shows the status of nearshore areas and details of the destruction caused by vessel groundings. A GIS will provide satellite views of the entire Florida Keys, showing areas of monitoring efforts, and nearshore aerial photographs of research areas where benthic habitat studies are being conducted.

Status: On-going.

Implementation: Staff and volunteers assist with GIS software and imagery. FKNMS has the lead for this activity and works with staff from other NOAA offices as well as partner agencies to develop layers as needed. Recent partnership discussions include potential projects with Monroe County Marine Resources Division.

3.1.2 Research and Monitoring Action Plan

Introduction

Overview

Congress mandates in the FKNMSPA 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 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 FKNMS Water Quality Protection Program (WQPP) 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 FKNMS 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 *1996 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; the 2002, 2004 and 2006 workshops of the Coral Disease and Health Consortium (Charleston, Key Largo, and Madison); and the 2005 International Marine Protected Areas Congress 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, FKNMS managers 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 FKNMS 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 FKNMS Research and Monitoring Action Plan will be implemented through 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 managers, DEP, and FWC, however, have the lead responsibility for overall program implementation. The EPA 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 1996 *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, FKNMS personnel assist in directing the activities. Researchers are registered (as appropriate) 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, DEP, or FWC personnel dedicated to research and monitoring activities direct the remaining activities.

Sanctuary Employees

Science activities require three full-time FKNMS employees: a science coordinator, a research interpreter, and an assistant. The Sanctuary Superintendent and the FKNMS Upper and Lower

Region Managers also are actively involved in these activities. Additional FKNMS, NOAA and DEP staff assist many science projects, including vessel and diving support.

Other NOS Support

The Socioeconomic Research & Monitoring Program for the FKNMS was initiated in 1998. The program is led by Dr. Vernon R. (Bob) Leeworthy, Leader of the Coastal and Ocean Resources Economics Program, located at the NOS Office of Management and Budget, Special Projects. Many academics, contractors, grantees and volunteers participated in this program. All program results are posted on the following Web site marineeconomics.noaa.gov/SocmonFK/keys.html

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 FKNMS volunteer coordinator is directing associated volunteer research and monitoring activities.

Evaluating Program Effectiveness

The FKNMS staff conducts periodic evaluations to determine the effectiveness of research and monitoring activities and prepares a *Comprehensive Science Plan*. Starting in 2007, FKNMS staff will prepare its first Condition report with support from NMSP, DEP and FWC as needed. The evaluations identify strategies and activities that are ineffective or inadequate; evaluations also suggest new activities. Evaluations involve two committees: 1) a Science Advisory Panel (SAP), which is an independent, peer-review panel comprised of scientists who are not actively engaged in research in the FKNMS and 2) a Technical Advisory Committee (TAC), which has direct knowledge of the FKNMS marine ecosystem through their research activities within the FKNMS. The SAP conducted a review in 2000 and a second review will be conducted 2007; the TAC generally is convened once or twice per year. In addition, the five-year reviews of the FKNMS Management Plan include evaluations of the Science Program by a Sanctuary Advisory Council working group.

Accomplishments

There have been substantive accomplishments in the FKNMS Science Program since implementation of the 1996 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.
- Collaboration with NOAA's Coral Reef Conservation Program
- On-going support of Keys-wide coral surveys and coral health expeditions

- On-going coordination and collaboration with the National Undersea Research Center (UNCW)
- Scientific and logistical support of the 5 year Sustainable Seas Expedition (1998-2002)
- On-going collaboration with the Florida Bay Science Managers
- Implementation of the Socioeconomic Research and Monitoring Program (1998-present, several baselines established in 1995-1996)

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	<i>550</i>
W.18: Conducting Pesticide Research	100	105	110	115	120	<i>550</i>
W.22: Assessing Wastewater Pollutants Impacts	200	210	220	230	240	<i>1,100</i>
W.23: Researching Other Pollutants and Water Quality Issues	250	250	275	275	300	<i>1,350</i>
W.24: Researching Florida Bay Influences	1,300	1,350	1,400	1,450	1,500	<i>7,000</i>
W.21: Developing Predictive Models	200	210	220	230	240	<i>1,100</i>
Total Estimated Annual Cost	<i>6,425</i>	<i>6,690</i>	<i>6,955</i>	<i>7,220</i>	<i>7,540</i>	<i>34,830</i>

* Contributions from outside funding sources also anticipated.

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.

FKNMS 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 Water Quality Protection Program 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 Fish and Wildlife Research Institute (FWRI) 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. A longer-term perspective on the health of marine ecosystems of the Florida Keys is being initiated in 2006 by Scripps Institution of Oceanography.

(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). Volunteers

in each of these programs undergo specific training to ensure the accuracy of the data collected for the programs.

Status: On-going.

Implementation: The Reef Environmental Education Foundation (REEF) 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. FKNMS 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 (NURC) at Key Largo and members of the research community. In addition to discussing the design of the project and initial findings, FKNMS 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 pending the identification of funding.

Implementation: FKNMS will be the lead agency for this activity; the FWC and DEP will have primary roles. FKNMS staff will include this activity in a request for proposals for funding.

(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 Reef Environmental Education Foundation conducts surveys that include small reef fishes that may be impacted by collections for the aquarium trade. FKNMS 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. FKNMS 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 32 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. FKNMS has begun to make data widely available to researchers and will work to ensure data format remains consistent with Integrated Ocean Observing System standards for metadata and data accessibility.

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*, the *Sanctuary Science Report 2001: An Ecosystem Report Card*, and the *Sanctuary Science Report 2002-03: An*

Ecosystem Report Card After Five Years of Marine Zoning (available at floridakeys.noaa.gov/research_monitoring/). The Strategy includes active participation and coordination with the U.S. Department of Interior/Dry Tortugas National Park (DTNP) and the FWC for implementation of the Memorandum of Understanding concerning research and monitoring of the Research Natural Area (RNA) established in 2007 and complimentary to the Tortugas Ecological Reserve.

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 current Sanctuary Preservation Areas and Special-use Areas were conducted prior to or soon after their implementation. FKNMS and partner agency staff have coordinated closely in development of the DTNP RNA research and monitoring plan through a series of workshops held between January and May 2007.

Implementation: The University of North Carolina at Wilmington/National Undersea Research Center (NURC) 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. FWRI conducts surveys of spiny lobster and queen conch. These same studies have collected baseline information for the DTNP RNA evaluation.

(2) Monitor Marine Zones and Utilize as Controls. Research and monitoring of the FKNMS 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 Sanctuary Advisory Council and the public.

Status: On-going.

Implementation: An interdisciplinary team (Florida Institute of Oceanography, Dauphin Island Sea Lab, Georgia State University, 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/NURC at Key Largo), reef fishes (NOAA Fisheries/Southeast Fisheries Science Center and the Reef Environmental Education Foundation), and spiny lobster and queen conch (FWRI). 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 Fully Protected 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/National Centers for Coastal Ocean Science (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 Sanctuary Advisory Council: "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. All the efforts here were identified as research priorities in NOAA's Coral Reef Ecosystem Research Plan for federal fiscal year (FY) 2005 - 2010, Part II: Regional Priorities and in the NOS Social Science Plan FY 2005-2010.

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 have been completed to establish baselines and several others are underway and planned.

Implementation: Commercial Fisheries: 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 (RSMAS), 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, as well as spatial catch patterns. One panel consists of Keys-wide fishers who were not impacted by the areas. Panel data collection through year six has been completed and reports posted in pdf on the Web site. Panel data for years seven and eight will be completed in the summer of 2006. In addition, a panel was constructed of Tortugas fishers and three years of baseline data were obtained before creation of the Tortugas Ecological Reserve. New surveys have been conducted for the post-implementation assessment.

Tortugas Integrated Assessment (TIA): In FY 2005, NCCOS initiated an integrated assessment of the Tortugas Ecological Reserve. The purpose of the TIA is to evaluate the success or effectiveness of the reserve. The University of Massachusetts-Amherst, Human Dimensions Program was given the lead for the socioeconomic component of the assessment. The results of the Tortugas panel on commercial fisheries were incorporated into the effort. The UMASS-Amherst team is doing the follow-up activity for the recreation industry. The TIA is scheduled for completion in December 2006.

Knowledge, Attitudes and Perceptions of Sanctuary Management Strategies and Regulations; Commercial fishermen, Dive Shop Owners/Operators and Members of Local Environmental Groups: In 1995-96, researchers at RSMAS and the University of Florida through the Florida Sea Grant Program, established baseline measures for the knowledge, attitudes and perceptions of proposed management strategies and regulations, especially the no-take areas. In FY 2005, the socioeconomic research & monitoring program hired Thomas J. Murray & Associates and RSMAS to replicate the study. The study was completed in January 2007. This effort will also be extended to cover flats and backcountry fishing guides with special emphasis on new and possible expansion of no-motoring WMAs.

Recreation and Tourist Uses, Values, Attitudes and Perceptions. 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 (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 (marineeconomics.noaa.gov/SocmonFK/impsat.pdf). A multi-agency partnership is being formed to replicate and extend of this effort in FY 2007 and FY 2008.

Spatially Explicit Bioeconomic Models: Implementation will focus on building on the work of RSMAS and the NMFS Southeast Fishery Science Center for reef fish and flats/backcountry recreational fishing. Economists from NOS SP and NMFS Southeast Fishery Science Center and possibly Resources for the Future will be involved in this work. This work will support evaluation of various zoning strategies.

(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 all natural resources in the FKNMS with special emphasis on artificial and natural reefs by residents and visitors.

Status: On-going.

Implementation: Baseline data set 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. (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 (marineeconomics.noaa.gov/). In 2005 FKNMS began discussions to support an update of the 1995-96 socio-economic study of the Florida Keys. A partnership is being established between three elements of NOS (FKNMS, NCCOS and SP), the Monroe County Tourist Development Council and The Nature Conservancy to get updates on recreation-tourist activities. The previous efforts will also be extended to address the knowledge, attitudes and perceptions of Sanctuary management strategies and regulations for both residents and visitors to the Florida Keys/Key West and to evaluate how businesses use the fact that all the waters surrounding the Florida Keys/Key West are protected in the FKNMS to promote their businesses. In addition, the knowledge, attitudes and perceptions of Sanctuary management strategies and regulations will be extended to flats and backcountry fishing guides with a focus on the new WMAs. The project is also integrating efforts to estimate the socioeconomic impacts of climate change/coral bleaching by Australian economist Hans Hoegh-Guldberg. NOAA's CRCP is funding the extension of work done for Australia's Great Barrier Reef to the FKNMS with FY 2007 and FY 2008 funding. In addition, the project is integrating efforts sponsored by the Florida Reef Resiliency Program with the University of Massachusetts-Amherst, Human Dimensions Program.

Recreational Spiny Lobsters: The FWRI conducts annual surveys for the recreational spiny lobster fishery to estimate catch and effort. The FKNMS accounts for over half of the catch and effort. Socioeconomic add-ons were conducted in 1992 and 2001. The economic impact of both the two-day sport season and the regular season were estimated on the Monroe County economy in terms of expenditures, sales/output, income and employment for residents and visitors. Also, economic values or willingness to pay for increases in bag limits were also evaluated. Socioeconomic add-ons will be periodically updated in partnership with FWRI.

Water Quality and Economic Use Values: Develop models relating water quality to different economic uses (e.g. commercial fishing, recreational fishing, scuba diving, snorkeling,

swimming/beach use, and glass-bottom boat rides) and how changes in water quality may result in changes in economic values. Partnerships would be developed with EPA and DEP.

(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. For the *Spiegel Grove*, pre-sinking monitoring was conducted from August 2001 to May 2002 on the surrounding artificial and natural reef off Key Largo where the *Spiegel Grove* was to be sunk. Post-sinking monitoring was conducted from August 2002 to July 2003. To further monitor the *Spiegel Grove*, it is proposed that dive shop logbooks be collected monthly for a two-year period and the full methodology be implemented in year three. A third 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. Analysis would be done by SP economists.

Reef Permit Evaluation Tool: In 2000-2001, a study was conducted on the socioeconomics of the reefs in Southeast Florida in partnership with the State of Florida and the four counties of Monroe, Miami-Dade, Broward and Palm Beach. Estimates of use and economic value of both artificial and natural reefs were developed. As a follow-up, the partners discussed a future effort to develop economic models relating reef attributes to economic demand and value. Models would support assessments of introducing “new” artificial reefs into surrounding natural reef environments and/or restoration of damaged natural reefs. A key research product would be a reef permit evaluation tool.

(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 1999 and 2000, the socioeconomic research & monitoring program funded the Gulf and Caribbean Fisheries Institute to hold special sessions on the socioeconomics of marine protected areas. A set of papers were published in the Proceedings of the 52nd and 53rd Annual Conferences of the Institute. In 2000 and 2001, the program partnered with NOAA/NOS/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

Scientists have investigated optimal approaches to increasing queen conch populations through release of aquaculture-reared juveniles. Research to date has allowed scientists to determine 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. Research to investigate possible endocrine disruption of queen conch near shore is on-going.

Activities (2)

(1) *Transplant Queen Conch from Inshore to Offshore Environments.* Scientists have 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 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 FWRI, in collaboration with the University of Florida, has obtained a grant from the NOAA/NOS/NCCOS/Coastal Ocean Program and EPA/Special Studies to investigate anthropogenic effects on queen conch reproductive development.

STRATEGY F.7 RESEARCHING IMPACTS FROM ARTIFICIAL REEFS

Strategy Summary

A number of artificial reefs (primarily 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 FKNMS 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: On-going.

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

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

Status: On-going.

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 National Marine Fisheries Service (NMFS)/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 NMFS are the lead agencies for implementing this activity. The National Park Service (NPS), the South Atlantic Fishery Management Council (SAFMC), and the Gulf of Mexico Fishery Management Councils (GMFMC) provide primary support. NMFS/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 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 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: This activity is dependent upon the availability of sufficient funding.

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 derelict fishing gear such as lost or abandoned crab and lobster 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. This activity is dependent upon the availability of sufficient funding

Implementation: The NOAA/NOS/NCCOS/Center for Coastal Fisheries and Habitat Research is investigating impacts of lobster traps on seagrass habitat and NMFS 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: This activity is dependent upon the availability of sufficient funding.

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: This activity is dependent upon the availability of sufficient funding.

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 Sanctuary Advisory Council 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 DEP will also have a primary role regarding evaluations of pesticide toxicity. The FDACS 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 DEP 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 DEP 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 DEP are the lead agencies. FKNMS 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: This activity is an on-going focus of the FKNMS WQPP and will be addressed upon recommendation of the FKNMS Water Quality Steering Committee (WQSC) and the TAC. 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. An independent investigation has determined that transport of nutrients by upwelling is the major source of nitrogen and phosphorus along the outer bank-barrier reef system of the Florida Reef Tract.

Implementation: EPA and DEP will be the lead agencies. Assistance may be provided by FKNMS, NPS, and 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 DEP 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. An on-going special study is examining possible endocrine disruption of nearshore queen conch and effects of mosquito-control compounds on larval development of queen conch.

Implementation: EPA and DEP 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: On-going; several independently funded research projects have investigated some of the stresses listed above.

Implementation: FKNMS personnel have been involved in monitoring and tracking changes in the coral community of the Keys due to elevated sea surface temperatures and other perturbations since 1976. The anecdotal observations and monitoring data (Looe Key Reef 1990) have been reported in Sanctuary status reports and published in various publications since 1983. The Sanctuary is the lead agency. EPA, USFWS, and DEP 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: Six Florida Bay Science Conferences have been successfully completed. A Synthesis Report on research in the system has been prepared for Florida Bay and will be published by the FWC in 2006. The report includes a section that reviews knowledge of the paleoecology of the Bay. The USACE has developed a Water Quality Model for Florida Bay. Modeling efforts (hydrodynamic, water quality, and ecological) are being conducted by several teams as part of the Florida Bay/Florida Keys Feasibility Study of the Comprehensive Everglades Restoration Plan.

Implementation: SFWMD and NPS are the lead agencies. Assistance is provided by USACE, 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 USACE, 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, DEP, 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: This activity is an on-going focus of the FKNMS WQPP and will be addressed upon recommendation of the FKNMS WQSC and the TAC. Three special studies have been completed that address the impact of Florida Bay waters on FKNMS 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 DEP 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. The Florida Bay/Florida Keys Feasibility Study of the Comprehensive Everglades Restoration Plan (CERP) has held a number of meetings of its Project Delivery Team and sub-committees in support of model development for Florida Bay (hydrodynamics, water quality and ecological). To read more about this ongoing effort www.evergladesplan.org/pm/studies/fl_bay.aspx.

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

(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: This is an on-going activity under the CERP with three predictive models in various states of development. Models include Physical, Water Quality, and Ecological variables. FKNMS scientific staff serve an advisory role on the Project Delivery Team for this effort.

Implementation: 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. The National Center for Coral Reef Research (NCORE) has been utilizing data from various sources to develop a data navigation interface for the FKNMS. Researchers at the University of Miami/Rosenstiel School of Marine and Atmospheric Science (RSMAS) have been developing oceanic and coastal circulation and larval dispersal models as several spatial scales relevant to the FKNMS. The lead agencies are EPA, FKNMS, and DEP. NPS, SFWMD, and USACE 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 *1996 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