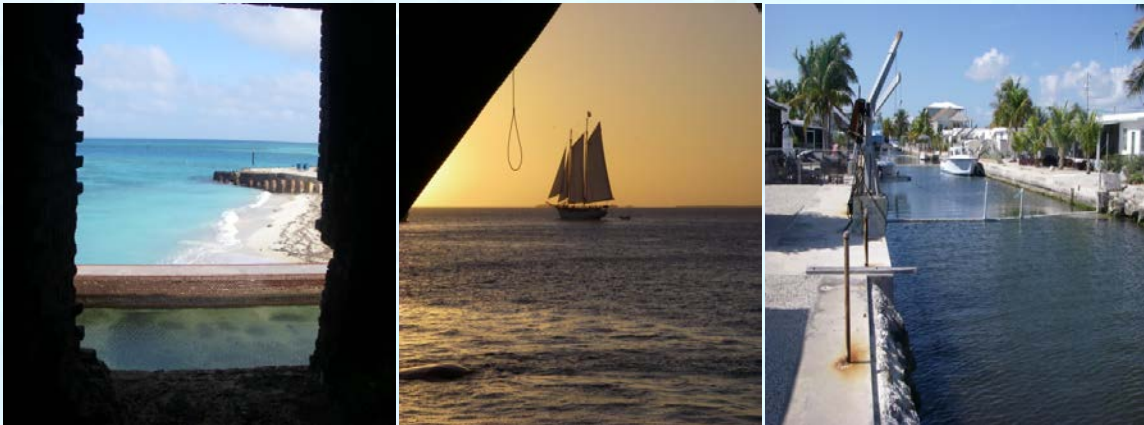


*in cooperation with the Florida Keys National Marine
Sanctuary Water Quality Protection Program Partners*

Florida Keys National Marine Sanctuary Water Quality Protection Program

Report to Congress



THE PURPOSE OF THE WATER QUALITY PROTECTION PROGRAM:

To identify and implement priority corrective actions within a compliance schedule to address point and nonpoint sources of pollution to maintain the chemical, physical, and biological integrity of the Sanctuary. The program is also to include the restoration and maintenance of a balanced, indigenous population of corals, shellfish, fish and wildlife, and recreational activities in and on the water.

Water Quality Protection Program Steering Committee

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Introduction

On behalf of the Water Quality Protection Program (WQPP) Steering Committee, the U.S. Environmental Protection Agency and the Florida Department of Environmental Protection are pleased to present this *Florida Keys National Marine Sanctuary Water Quality Protection Program Biennial Report* to Congress as directed by The Florida Keys National Marine Sanctuary Act amendment of 1992 (Public Law 102 – 587). The law directs the Steering Committee to issue a report summarizing the progress of the program, modifications to the program and recommendations for implementation of the WQPP.

The WQPP is managed by the Steering Committee, a collegial group composed of federal, state, and local officials, non-governmental organizations, and informed citizens that operates through consensus-building. The WQPP has been successful in meeting its goal of implementing the mandates specified in the Florida Keys National Marine Sanctuary and Protection Act that include the development of a program for the Sanctuary that would:

- ❖ reduce pollution from point and nonpoint sources
- ❖ ensure compliance with applicable federal and state laws
- ❖ adopt appropriate water quality standards
- ❖ create a comprehensive monitoring program
- ❖ identify funding for implementation of the program
- ❖ provide a mechanism for state and local government consultation and public participation

Much is being accomplished at the local level to address reduction of pollutants to the adjacent marine waters. Reduction of nutrient input will reduce algal growth and competition and increase water clarity by reducing the incidence and coverage of phytoplankton blooms. To date, more than 60% of the households in Monroe County are connected to improved sewage treatment facilities. Funding to complete the implementation of the Monroe County Sanitary Wastewater Master Plan is being pursued from federal, state, and local sources. Funding for increasing the number of sewage pump-out facilities for vessels has been made available from the Florida Clean Marina Program. Water quality standards are being developed for marine waters of the Florida Keys and completion of the Florida Keys Reasonable Assurance Document underscores the commitment of local partners in implementing improvements to wastewater treatment as specified in 99-395 Laws of Florida.

The monitoring program is the “glue” that holds the WQPP together and the Steering Committee recognizes the need for the continuation of the long-term monitoring and research programs to fulfill the mission of the WQPP. Data collected through the long-term monitoring program is essential in the effective, informed management of the Florida Keys National Marine Sanctuary (FKNMS). Long-term monitoring has demonstrated that the coral reef ecosystem is in decline and is a “shadow” of its former productivity and biodiversity. It has documented that many of the major predators have been removed through overfishing and have not recovered.

Evidence is mounting that nearshore seagrass beds are also in a state of decline. Members of the Steering Committee routinely use monitoring information to prioritize actions to remediate degraded water quality in the Florida Keys.

Although much is being accomplished at the local level, there is ample evidence that global climate change may be an overwhelming driving factor in the decline of the Florida Keys coastal ecosystem. The WQPP will direct future management actions to address the impacts of climate change on the Florida Keys ecosystem. Special studies are required to quantify, model and predict the effects of elevated sea surface temperatures, ocean acidification, and sea level rise on the Florida Keys ecosystem. The WQPP will lead the education of the public on these important concepts to garner their support for action.

The need for continued robust status and trends monitoring is underscored by activities associated with the Everglades restoration and oil and gas activities in the Gulf of Mexico and Cuba. Changes to the water delivery system through the Everglades into Florida Bay have the potential to affect water quality conditions of hardbottom habitats and coral communities throughout the FKNMS. The recent oil spill in the Gulf of Mexico also emphasizes the need for vigilant assessment of existing conditions of water quality and benthic communities.

The Steering Committee is committed to adaptive management of the FKNMS resources. It recognizes the need for an increased emphasis in monitoring the nearshore conditions to document impacts of improved wastewater and stormwater treatment on water quality and benthic communities. Also, there is a growing need to educate the public on the importance of reducing or eliminating the discharge of pharmaceuticals and personal care products to adjacent water because of adverse effects to the endocrine system of aquatic organisms. The Steering Committee recognizes the need to perform a pilot canal restoration project to improve canal water quality by remedying canal depth, geometry, seagrass wrack, and flushing characteristics. The program is committed to incorporate these additional charges through a balanced approach without decreasing the robust capacity to maintain the long-term mission of measuring the “pulse” of the Florida Keys ecosystem.

Florida Keys Water Quality Protection Program Steering Committee

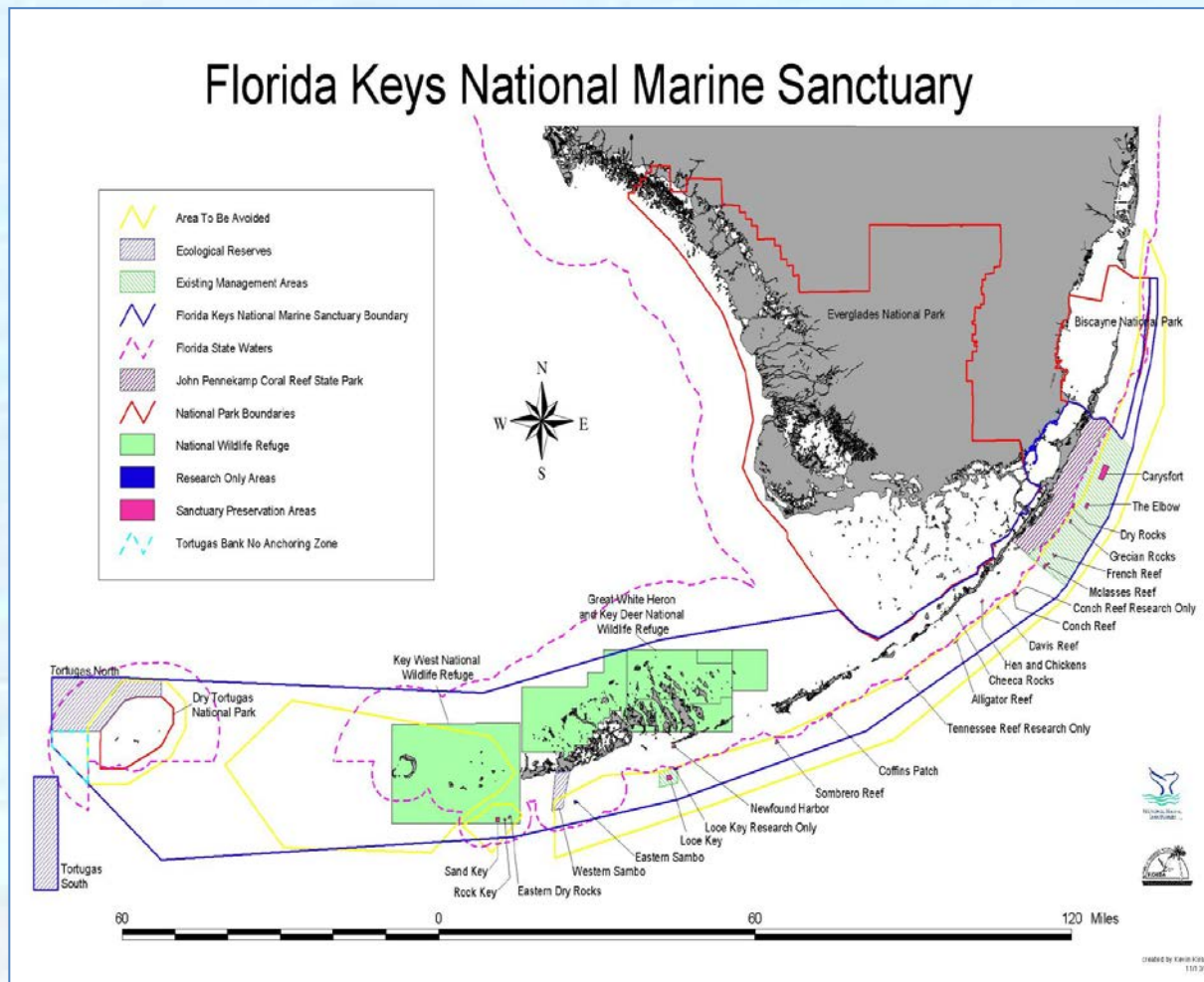
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Executive Summary

The Florida Keys

The Florida Keys are an archipelago of approximately 1700 islands that extend approximately 220 miles from the southeastern tip of the Florida peninsula to the Dry Tortugas. The Florida Keys form the western boundary of the Florida Straits which is the water body between the Florida Keys and Cuba that connects the Gulf of Mexico and the Atlantic Ocean. The natural features of the Florida Keys include mangrove islands, the largest documented seagrass meadow in the world, and North America’s only living coral barrier reef. Eco-tourism and commercial and recreational fishing are the main sources of income to the Florida Keys, evidence that a healthy economy is directly linked to a healthy marine ecosystem. For example, marine outdoor activities provide more than \$1 billion to the Monroe County economy and provide 58% of all jobs.

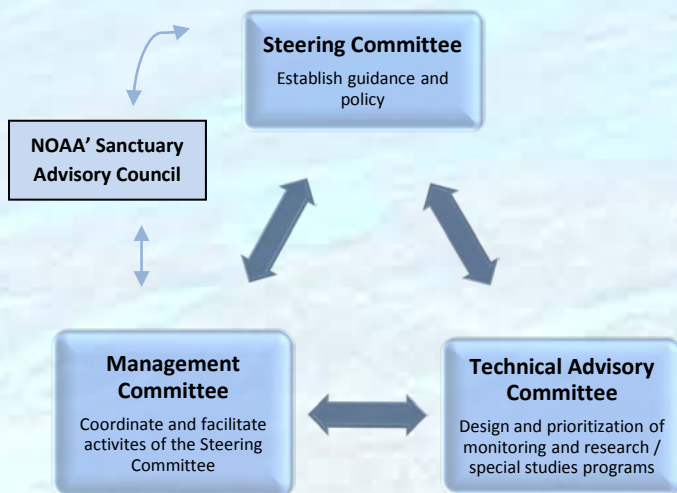


Overview of the Water Quality Protection Program

The Florida Keys National Marine Sanctuary (FKNMS) Water Quality Protection Program (WQPP) is a twenty year plus collaborative effort by federal, state and local governments, elected officials, non-governmental organizations, academics and local citizens dedicated to protecting and improving water quality, coral reefs, seagrasses, fisheries and recreational opportunities within the 2,900 square nautical miles of the FKNMS. In 1990, Congress formally recognized the uniqueness of the Florida Keys ecosystem with the signing of Public Law 101-605, the Florida Keys National Marine Sanctuary and Protection Act. A subsequent amendment in 1992 acknowledged the critical role of clean, clear water in maintaining marine resources within the FKNMS by directing the Administrator of the U.S. Environmental Protection Agency (EPA), the Governor of the State of Florida (Florida Department of Environmental Protection (FDEP)) and the Secretary of Commerce (National Oceanic and Atmospheric Administration, NOAA) to create a WQPP for the Sanctuary. This was the first such program for a marine sanctuary in the nation.

The purpose of the WQPP is to identify and implement priority corrective actions within a compliance schedule to address point and nonpoint sources of pollution to maintain the chemical, physical, and biological integrity of the Sanctuary. The program is also to include the restoration and maintenance of a balanced, indigenous population of corals, shellfish, fish and wildlife, and recreational activities in and on the water.

To ensure successful implementation of the program, the Act directed the EPA, FDEP, and NOAA to establish a Steering Committee charged with establishing guidance and policy for the development and implementation of the WQPP, oversees implementation of activities and reports progress to Congress through the biennial report.



The Act also requires the formation of a Technical Advisory Committee comprised of scientists from federal and state agencies, academic institutions, non-governmental organizations, and knowledgeable citizens to assist with prioritizing scientific research and design of an effective long-term monitoring program. The management committee, comprised of federal and state managers, coordinates and facilitates the activities of the Steering and Technical committees.

[Accomplishments of the Water Quality Protection Program](#)

The WQPP is a very successful program that has resulted in numerous significant accomplishments that have led to documentable improvements to the Florida Keys marine ecosystem. For nearly two decades, Steering Committee members have met semi-annually to identify and implement corrective actions, coordinate science and research activities and direct the monitoring programs as described in the WQPP.

❖ [Implementation of the Monroe County Sanitary Wastewater Master Plan](#)

In 1999, the Florida Legislature (Florida Statute 99.395) charged Monroe County with eliminating cesspools, traditional septic tanks, and noncompliant wastewater facilities by 2010. Monroe County completed the “Sanitary Wastewater Master Plan” in 2000 that provides an equitable, ecologically sound, and economical implementation strategy for managing wastewater and improving the water quality in the Florida Keys. While the deadline has been extended in 2015, significant progress has been made implementing the wastewater plan. In 2012, 49,317 of the 74,120 (67%) total equivalent dwelling units (a standardized measure of wastewater-producing structures) in the Keys are in compliance with advanced wastewater/ best available treatment regulations. To complete these upgrades, more than \$380 million has been invested in wastewater improvement. In May of 2012, the State of Florida provided a grant of \$50 million to provide funding for wastewater improvements to the Village of Islamorada and the Cudjoe Key Regional Service Area. A \$200 million funding deficit for improving all wastewater facilities is a potential obstacle for achieving complete compliance with wastewater regulations by 2015.

❖ [Implementation of the Monroe County Stormwater Management Master Plan](#)

This plan was completed in 2001 and includes an assessment of the adequacy of existing stormwater systems, prioritization of stormwater management needs for each developed island, identification of regulation and policy needs, and a plan to finance, construct, operate and maintain the required facilities. Implementation of the plan is ongoing and the City of Marathon has successfully combined stormwater collection and treatment with the construction of its wastewater collection system. The City of Key West has implemented its Stormwater Plan, eliminated inflow and infiltration into the wastewater collection system, and improved drainage in low-lying areas.

❖ [Florida Keys are a No Discharge Zone](#)

In 2002, with support from Monroe County and by request of the Governor of Florida, EPA, in accordance with Clean Water Act Section 312, designated all state waters within the Florida Keys National Marine Sanctuary a “no discharge zone.” This designation makes it illegal to dump boat sewage (treated or untreated) into state waters. In 2010, NOAA extended the coverage of the no discharge



zone to include all federal waters in the Sanctuary with a provision requiring all marine sanitation devices be secured to prevent intentional or accidental discharge.

❖ **Mooring Fields for Vessels**

The cities of Marathon and Key West now have in place comprehensive Mooring Field plans responsible for reducing approximately 100,000 gallons of sewage (nutrients and pathogens) annually to nearshore waters. Plan implementation includes anchoring, mooring and the disposal of vessel-generated wastewater through onshore facilities and mobile pump-out services to service the live-aboard and transient boating community. The successful implementation of these managed mooring fields and improved water quality (reduced bacteria numbers and improved oxygen conditions) have allowed return of porpoises, mullet, eagle rays and other marine organisms to the harbors.

❖ **Publication of *Tropical Connections – South Florida’s Marine Environment***

Dr. William Kruczynski and Pamela J. Fletcher co-edited and published *Tropical Connections* in 2012, a comprehensive book on South Florida’s marine environment designed to share with a general audience what has been learned about marine ecology during the past fifteen years. The book contains eight informative chapters written by 163 authors with each chapter recommending management priorities, identifying research gaps, and evaluating monitoring needs for each topic area that will greatly assist in directing the future activities of the Water Quality Protection Program.

Research and Monitoring Programs

Thirty special studies have been completed that provide information addressing specific management questions and concerns. Sixteen consecutive years of status and trends monitoring of water quality, coral reef, and seagrass have been completed. Monitoring data provide the scientific underpinnings for effective management of the Sanctuary and the Florida Keys marine ecosystem. Results from the monitoring project are entered into a publicly available database (STORET) and a comprehensive computer mapping data management system.

Significant findings of the monitoring program

- ❖ Overall water quality within the Sanctuary is good. However, the data shows elevated levels of nitrate nitrogen occurs nearshore and decreases with distance from land, suggesting a land-based source of nitrogen pollution.
- ❖ Incidence of human intestinal viruses in groundwater at the reef tract in Key Largo demonstrates that groundwater from the Keys that is contaminated by sewage is likely transported to the reef with movement of groundwater through the Key Largo Limestone.

- ❖ The seagrass/benthic habitat monitoring program has detected changes in seagrasses and macroalgae (seaweed) abundance between 1995 and 2010 that are consistent with increased nutrient availability in the water, especially nearshore. In several locales, these changes have resulted in the replacement of the dominant seagrass species (turtle grass) by species that are more tolerant of higher nutrient conditions.
- ❖ Coral reef monitoring has documented and quantified the decline of stony coral cover and species diversity within the Sanctuary. The incidence of soft corals is increasing in some locations where hard corals are dying. Although some local recovery of coral has been observed, the overall decline warrants significant concerns for the future of the coral ecosystem and the associated economic value to the Florida Keys.

Little Venice Special Study Project

- ❖ Little Venice is a canal neighborhood that was developed in the 1950s using cesspools as the primary means of wastewater disposal. A cesspool is an unlined excavated hole below a house and materials flushed into the hole are in direct contact with groundwater. The objective of the Little Venice project was to detect changes in water quality in residential canals due to implementation of improved wastewater collection and treatment. Phase I sampling (2001- 2003) was conducted prior to installation and operation of central collection and advanced wastewater treatment. Phase II (2005- 2007) was conducted after remediation.
 - ❖ Findings include a decrease in violations of water quality standards for bacteria and dissolved oxygen in canal waters after remediation. Also, the seagrass community at the mouths of the canals is recovering toward the historical natural levels of productivity and nutrient composition, a sign that excess nutrients from canals are decreasing as a result of the improved wastewater treatment.

Public Education and Outreach

Education and outreach play crucial roles in protecting the natural communities of the Florida Keys. Many residents and visitors are unaware that many of their actions can have a direct effect on the health of the Keys marine ecosystem and the plethora of plants and animals that live there. The WQPP and the FKNMS conduct numerous education and outreach efforts including: teacher training, Coral Reef Classroom, media campaigns (e.g., Water Quality Awareness Month), Team Ocean, Blue Star, lionfish derbies, and development and distribution of signs and brochures. A notable activity sponsored by the WQPP is the production of *Waterways*. The *Waterways* program is a successful television series that highlights the environmental and cultural resources of South Florida. With funding provided by the EPA, National Park Service, and the FKNMS, the first 26-minute episode of *Waterways* was in 1994

and broadcasts continue today. Over 100 episodes have been developed and are widely aired. Episodes currently under development will address invasive species, stewardship programs, effects of pharmaceuticals and personal care products that enter water, Everglades restoration, and the efficacy of marine zoning activities in the Sanctuary.

Budget Summary

The Sanctuary Act (1990) authorized funding to be appropriated to the EPA Administrator for implementation of the FKNMS WQPP. Appropriations from Congress to EPA Headquarters have averaged approximately \$2.1 million per year. Once established, annual monitoring costs were approximately \$1.05 million. A total of approximately \$15 million of EPA funds has been spent on monitoring since the inception of the program. Approximately \$1.5 million of EPA funds has been spent to fund special study projects. The remainder of the annually appropriated funds has been used by EPA Region 4 and the EPA South Florida Geographic Initiative to fund the EPA South Florida office and priority projects in south Florida. Federal and State agencies providing funds to the WQPP include: FDEP, South Florida Water Management District, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and NOAA.

There have been reductions in funding from other participating agencies since 2007, along with increased demands to use appropriated funds for additional projects in south Florida resulting in reduced funds available to the WQPP and lack of funding to support the WQPP special studies program. For example, in 2010 funds allocated to the WQPP were reduced approximately 40% which resulted in significant budget reductions to the water quality, seagrass and coral monitoring programs and no funding to the special studies programs.

EPA Funding to the FKNMS Water Quality Protection Program

Program Activities	FY12	FY13 (projected)
Water Quality Monitoring	\$350,000	\$350,000
Coral Monitoring	\$250,000	\$250,000
Seagrass Monitoring	\$190,000	\$190,000
Data Management	\$45,000	\$45,000
Specials Studies		
Investigate Effects of Mosquito Control Pesticides on Non-Targeted Organisms in the FKNMS	\$100,000	\$0
Canal Management Master Plan to Improve Water Quality in the Florida Keys	\$100,000	\$0

In 2012, the WQPP Steering Committee elected to re-activate the Special Studies Program and provide funds for two projects: *Canal Management Master Plan to Improve Water Quality in the Florida Keys* and *Assessing the Effects of Mosquito Control Pesticides on Non-Targeted Organisms in the FKNMS*, as described in the WQPP Action Plan.

The Future

The completion of improvements to wastewater and stormwater remains the highest priority action item. Eliminating onsite systems and cesspits and upgrading wastewater facilities to advanced or best available treatment will reduce nutrients and bacteria to nearshore waters. This reduction will reduce algal growth and increase water clarity.

Long-term monitoring must be continued to measure the “pulse” of the Florida Keys ecosystem and **special studies must be performed** to determine cause-effect relationships among stressors and ecosystem structure and function. That need is underscored by activities associated with the Everglades restoration and oil and gas exploration in the Gulf of Mexico and Cuba. The Everglades restoration activities into Florida Bay are expected to affect water quality conditions of hardbottom habitats and coral communities throughout the FKNMS. The recent oil spill in the gulf emphasized the need for vigilant assessment of existing conditions of water quality and benthic habitat.

Several additional themes need to be added to the program.

- ❖ There is a need to educate the public on the **effects of pharmaceuticals and personal care products** on the health aquatic organisms and to organize the collection and disposal of unwanted drugs.
- ❖ There is ample evidence that **global climate change** is an overwhelming driving factor in the decline of the Florida Keys coastal ecosystem. The WQPP will lead the education of the public and implement monitoring and special studies to quantify impacts of climate change.
- ❖ Increased emphasis of **monitoring of nearshore waters**, including residential canals, is required to document impacts of improved wastewater and stormwater treatment and ensure that the restoration is successful.
- ❖ Completion of a **pilot canal restoration project to improve canal water quality** is essential to garner public support and identify sources of funding for wide-scale canal restoration efforts. Monroe County has authorized \$5 million to be put towards pilot demonstration projects to improve water quality in residential canals.
- ❖ Investigate effects of mosquito control practices on nontarget organisms.
- ❖ Investigate advanced tools for broad-scale monitoring to provide early warning of pollutants or harmful algal blooms.



Aerial view of Carysfort Reef - The Florida Keys contains the only living barrier coral reef in the continental United States. The reef consists of coral spurs separated by grooves of sand and rubble.

FLORIDA KEYS NATIONAL MARINE SANCTUARY

WATER QUALITY PROTECTION PROGRAM

"If you like nature how could you not love the Keys? And, if you like tourism, how could you not love the Keys? They are a vital part of Florida's economic engine and an ecological treasure."

Senator Alan Hays, Florida Senate Budget Subcommittee on General Government Appropriations

Background

The Florida Keys are a limestone archipelago that extends south and westward for over 220 miles from the southeast corner of the Florida peninsula to the islands of the Dry Tortugas. The islands were formed from material deposited approximately 125,000 years ago during a period of higher sea levels. The islands in the Upper Keys are the fossilized remains of ancient coral reefs (Key Largo Limestone) while the islands in the Lower Keys are the fossilized remains of sand bars (Miami Oolite Limestone). While the archipelago consists of approximately 1700 islands, only forty three of the islands are populated and connected by bridges and causeways. A popular tourist destination, the Florida Keys are home to approximately 73,000 permanent residents that doubles to twice that amount during the winter tourist season.

The City of Key West is the largest island and home to approximately 25,000 residents and is located at the end of the Overseas Highway (U.S. 1) in the Lower Keys. The outlying keys consist of islands that are only accessible by boat. Eco-tourism and commercial and recreational fishing are the main sources of income to the Florida Keys, and a healthy economy is directly linked to a healthy marine ecosystem.

Marine resources of the Florida Keys include extensive seagrass meadows, mangrove islands, and coral reefs. The Sanctuary is home to the largest documented seagrass meadow in the world, and the only living coral barrier reef in the continental United States. These environments support richly diverse biological communities possessing extensive conservation, recreational, commercial, ecological, historical, research, educational, and aesthetic values that result in the special national significance of the area. Coral reefs, mangrove forests, and seagrass meadows are the marine equivalents of tropical rain forests in that they support high levels of biodiversity, are relatively fragile and susceptible to damage from human activities, and possess high value to mankind when properly conserved.

Over 2.54 million tourists visit the Florida Keys each year. An economic survey on the reliance of the tourist industry on the marine resources of the Keys found that water-related recreational activities sustains the majority of \$1.3 billion spent by tourists annually in Monroe County and 46% of the employment in the Keys.



Seagrass is dependent upon clear water with low nutrients

Program Description

The Florida Keys National Marine Sanctuary (FKNMS) was created by Public Law 101-605, the Florida Keys National Marine Sanctuary and Protection Act (the Act) (November 1990). The Sanctuary covers approximately 2900 square nautical miles. The Sanctuary is managed by NOAA and the FKNMS Management Plan was implemented in July 1997, after a six-year planning process. The management plan was revised in December 2007 and described the accomplishments of successfully implemented strategies. It also provided useful information about the Sanctuary, its management strategies, activities, and products.

Recognizing the critical role of water quality in maintaining Sanctuary resources, Congress directed the U.S. Environmental Protection Agency (EPA) and the State of Florida, represented by the Florida Department of Environmental Protection (FDEP), to develop a Water Quality Protection Program for the Sanctuary (WQPP). This was the first such program developed for a marine sanctuary in the country.

The WQPP was finalized in 1996 and incorporated as the Water Quality Action Plan in the FKNMS Management Plan (1997). The WQPP recommends priority corrective actions and compliance schedules addressing point and nonpoint sources of pollution to restore and maintain the chemical, physical, and biological integrity of the Sanctuary. This includes restoration of a balanced, indigenous population of corals, shellfish, fish and wildlife, and recreational activities in and on the water.

The enabling legislation for the WQPP is notable for its specificity outlining the development of the program. The Act specified that the three agencies (EPA, FDEP and NOAA) develop a program for the Sanctuary to:

- ❖ reduce pollution from point and nonpoint sources
 - ❖ ensure compliance with applicable federal and state laws
 - ❖ adopt appropriate water quality standards
 - ❖ create a comprehensive monitoring program
 - ❖ identify funding for implementation of the program
 - ❖ provide a mechanism for state and local government consultation and public participation
-

The National Marine Sanctuaries Program Amendments Act (1992) specified the establishment of a Steering Committee, Technical Advisory Committee (TAC), and an EPA Liaison Office to support the implementation of the WQPP. The Management Committee was established to coordinate and facilitate the activities of the Steering Committee and Technical Advisory Committee.

Steering Committee

The WQPP is directed by the Steering Committee, a collegial group composed of representatives from federal, state, and local governments, non-governmental organizations, and informed citizens. The Steering Committee established guidance and policy for the development and implementation of the WQPP. The Steering Committee has met a minimum of two times per year since 1992 addressing difficult policy issues through a consensus-building and an adaptive management process.

Technical Advisory Committee (TAC)

The TAC advises the Steering Committee on scientific matters and assists in the design and prioritization of monitoring and research/special studies programs. The TAC is composed of scientists from federal and state agencies and academic institutions, non-profit organizations, and knowledgeable citizens. Concurrent with the adoption of the Comprehensive Science Plan (2002) for the FKNMS, the role of the TAC expanded from serving the WQPP to providing advice on the entire purview of scientific matters within the FKNMS. A primary function of the TAC is the development of research priorities and review of research proposals. The TAC meets on an “as- needed” basis, generally once or twice a year.

Management Committee

The Management Committee coordinates and facilitates activities of the Steering Committee and the TAC. In 2002, the role of the Management Committee was expanded to include all activities in the FKNMS. Responsibilities of the Management Committee include:

- ❖ Planning and preparing agendas for meetings of the Steering Committee and TAC
- ❖ Advising and making recommendations to the Steering Committee
- ❖ Development of budgets and schedules for program implementation
- ❖ Assessing progress of scientific activities, including long-term monitoring and special studies
- ❖ Advising Sanctuary managers on developing issues and future needs
- ❖ Development of the Biennial Report
- ❖ Advising Sanctuary managers on developing issues and future needs

The WQPP Consists of Four Components:

- ❖ **Corrective Actions** Reducing water pollution by using engineering methods, prohibiting or restricting certain activities, modifying existing regulations, and/or focusing enforcement to meet the objectives of the program. Other actions are designed to make the regulatory and management system work more efficiently.
- ❖ **Monitoring** A comprehensive long-term monitoring program designed to provide up-to-date information on the status and trends of water quality and biological resources (seagrasses and corals) in the Sanctuary. The monitoring program also provides information on the effectiveness of pollution reduction activities.
- ❖ **Research/Special Studies** To identify and understand cause-effect associations involving pollutants, transport pathways, and biological communities. Studies have also provided information required addressing specific management questions and concerns, improve our general understanding of the sanctuary ecosystem, develop predictive models, and develop monitoring tools and methodologies.
- ❖ **Public Education and Outreach** To increase public awareness of the Sanctuary and the role of the WQPP in reducing pollution sources and impacts on resources within the Sanctuary. It includes soliciting and incorporating public input in the design and implementation of the program. Successful implementation of corrective actions depends, to a large degree, on awareness, public participation and acceptance.

Florida Keys National Marine Sanctuary Water Quality Protection Program Steering Committee Membership

U.S Environmental Protection
Agency, Co-chair

Florida Department of
Environmental Regulation, Co-chair

National Oceanic and Atmospheric
Administration

U.S. National Park Service

U.S. Fish and Wildlife Service

U.S. Army Corps of Engineers

Florida Department of Economic
Opportunity

South Florida Water Management
District

Florida Keys Aqueduct Authority

Florida Fish and Wildlife
Conservation Commission

Local governments

Non-profit organizations

Knowledgeable citizens

Independent Reviews of the WQPP

Sound management must be based upon sound scientific information. Two objective external peer reviews of the WQPP have been performed to evaluate the WQPP's science program. Reviewers were asked to evaluate existing programs to provide recommendations to improve the long-term monitoring and special studies programs to assist program managers in decision making.

2000 Science Advisory Panel Review

In December 2000, the WQPP Management Committee convened a Science Advisory Review Panel, an independent group of scientists, to provide input and guidance on future special studies and monitoring to the FKNMS managers. Six scientists with excellent scientific credentials, including one with local knowledge, were selected as panel members. Presentations on all WQPP-funded monitoring and special studies were presented to the panel members. This included an overview of the coral, seagrass and water quality monitoring projects, the special studies projects, and the zone monitoring program. The Science Advisory Review Panel made the following observations and recommendations.

- ❖ Water quality and benthic communities in canals and other nearshore areas are degraded and warrant immediate correction actions.
- ❖ The loss of coral reef habitat is proceeding at an alarming rate and requires immediate attention to determine causes of the decline.
- ❖ The monitoring and research programs that currently focus on status and trends should be reoriented to include identifying and quantifying causes of coral decline with sufficient monitoring left in place to evaluate corrective actions.
- ❖ Pollutant sources from land-based sources, including human-caused stressors (sewage, pathogens, and sediment) and their impacts on nearshore and offshore systems and human health should be quantified.

As a result of the 2000 review, a *Comprehensive Science Plan* (2002) was prepared for the FKNMS to identify and prioritize the science needs of the FKNMS. That document complements the Research and Monitoring Action Plan of the Sanctuary's Management Plan by assessing science needs at a more detailed level. The Action Plan establishes a framework – the Science Plan identifies management objectives and associated monitoring and research needs in a systematic fashion.

Panel Recommendations

Three coral monitoring sites were added at the Dry Tortugas to represent an area away from human influence.

Six sites at patch reefs were added to provide balanced representation of coral habitats throughout the Sanctuary.

Four hard bottom stations were dropped because they were superfluous.

Parameters added to coral monitoring including temperature, notation of disease, recruitment, and incidence of boring sponges.

Monitoring of coral sites after bleaching and hurricane events were added to the monitoring protocol.

The number of seagrass sites was adequate to provide benthic community composition. Seagrass sites were dropped and the sampling protocol revised to revisit sites every seven years.

Mid-depth samples for water quality were dropped.

Statistical analysis was performed and redundant stations were dropped. Number of stations was reduced from 202 to 155.

"Targeted" monitoring was performed at Little Venice to quantify conditions in residential canals before and after installation of improved wastewater treatment and disposal.

2007 Battelle and Science Advisory Panel Review

In 2007, EPA Region 4 requested Battelle Memorial Institute (Battelle) to perform an objective review of the comprehensive long-term monitoring and special studies projects associated with the WQPP for the Sanctuary, and to provide recommendations and next steps to EPA for future monitoring and special studies. As part of that review, Battelle was instructed to reconvene the independent Science Advisory Review Panel. The following is a summary of the recommendations that were made during that review.

General Recommendations

- Continue monitoring programs for water quality, seagrass, and coral reefs/hardbottoms to quantify and understand spatial and temporal changes to the Florida Keys ecosystem.
- Continue Special Studies Program to provide an understanding of the processes that drive changes and improved interpretation of monitoring data.
- Improve communication between scientists, managers, and the public.
- Develop conceptual models as effective communication tools.

Long-Term Monitoring Program

- Focus on integrating across monitoring programs.
- Add event-driven monitoring.
- Quantify more parameters in coral monitoring, such as size frequency.
- Synthesize long-term monitoring data sets and “mine” data to define mechanisms driving changes.
- Link water quality data with remote sensing capabilities.
- Investigate why patch reefs are responding to stressors differently than offshore reefs.
- Track pathogenic organisms.
- Develop hydrodynamic models.

The Management Committee, Technical Advisory Committee, and Steering Committee continue discussions on “streamlining” the long-term monitoring program. Reports from the three monitoring disciplines have been prepared that define and enumerate decrements to the rigor of the data set that would occur with forced reductions in sampling frequency and/or distribution due to budget cuts or other factors.

Funding for the WQPP

The Sanctuary Act (1990) authorized funding be appropriated to the EPA Administrator for implementation of the WQPP. Appropriations from Congress to EPA Headquarters have averaged approximately \$2.1 million per year. In the initial years of the Program, the funds were used to establish and implement the long-term monitoring programs and fund special studies projects. Once established, annual monitoring costs were approximately \$1.05 million (water quality \$480 K, coral reef \$320 K, seagrass \$250 K). A total of approximately \$15 million of EPA funds has been spent on monitoring since the inception of the program. Approximately \$1.5 million of EPA funds has been spent to fund 30 special study projects. The remainder of the annually appropriated funds has been used by EPA Region 4 and the EPA South Florida Geographic Initiative to cover infrastructure costs of the EPA South Florida Office and fund other priority projects in south Florida.

Additional funds have been provided to the WQPP from other agencies: FDEP (\$100 K annually), South Florida Water Management District (\$350 K), U.S. Fish and Wildlife Service (\$100 K), U.S. Army Corps of Engineers (\$100 K), and NOAA (\$200 K). Reduced funding from other participating agencies except FDEP since 2007 and increased demands to use appropriated funds for other projects in south Florida have resulted in reduced funds available for the WQPP and lack of EPA funds for the WQPP special studies program. In 2010, funds allocated to the WQPP were reduced approximately 40% which resulted in a significant reduction in monitoring activities.

The Steering Committee has been working with the principal investigators of the long-term monitoring programs to “streamline” the monitoring efforts. In addition, the Steering Committee elected to fund a pilot canal restoration project and mosquito control impact study in FY12 that continued the reduced level of funding to the monitoring programs. In January 2012, the Steering Committee unanimously agreed to work toward the development of a balanced approach that includes continuing the long-term monitoring program, re-establishment of the special studies program, a canal restoration project, and public outreach.

EPA Funding to the FKNMS Water Quality Protection Program

Program Activities	FY12	FY13
Water Quality Monitoring	\$350,000	\$350,000
Coral Monitoring	\$250,000	\$250,000
Seagrass Monitoring	\$190,000	\$190,000
Data Management	\$45,000	\$45,000
Specials Studies		
Investigate Effects of Mosquito Control Pesticides on Non-Targeted Organisms in the FKNMS	\$100,000	\$0
Canal Management Master Plan to Improve Water Quality in the Florida Keys	\$100,000	\$0
Pre and Post Monitoring of Canal Remediation Projects	\$0	\$300,000

Water Quality in the Florida Keys

The economy of the Florida Keys is based upon a thriving tourism industry and productive commercial and recreational fisheries. Healthy and productive seagrass and coral communities are the bases of the Florida Keys economy. Both require clean, clear, water that is low in nutrients. In 1985, Florida demonstrated its understanding of the importance of clean water to the Keys by designating the waters surrounding the Florida Keys “Outstanding Florida Waters”



Water Quality Monitoring

(OFW). Designation of OFW is intended to protect existing good water quality by eliminating the discharge of any pollutant that would result in a degradation of existing conditions.

In 1992, Congress required that the WQPP with establishing comprehensive long-term monitoring program for water quality and biological resources. The monitoring program was designed to quantify status and trends, answer resource management questions, and develop new scientific hypothesis for the Sanctuary. In 1995, the Water Quality Monitoring Network began collecting quarterly

monitoring data at 202 fixed stations within the Florida Keys National Marine Sanctuary. A statistical review of data was performed in 2002 and the number of stations was reduced to 155 by dropping redundant stations.

In general, water quality is good Sanctuary-wide. However, a consistent and significant finding from the monitoring program since 1995 is the detection of elevated nitrate levels occurring nearshore that gradually decrease with distance from shore. The presence of elevated nitrate concentrations in the near-shore waters of the highly populated Keys and its continued absence in the unpopulated Dry Tortugas region suggest that land-based pollutants, such as poorly treated sewage and stormwater runoff, are entering the nearshore waters of the Keys. Presence of a similar gradient in total organic carbon and a decreased variability in salinity from land to reef support this finding.

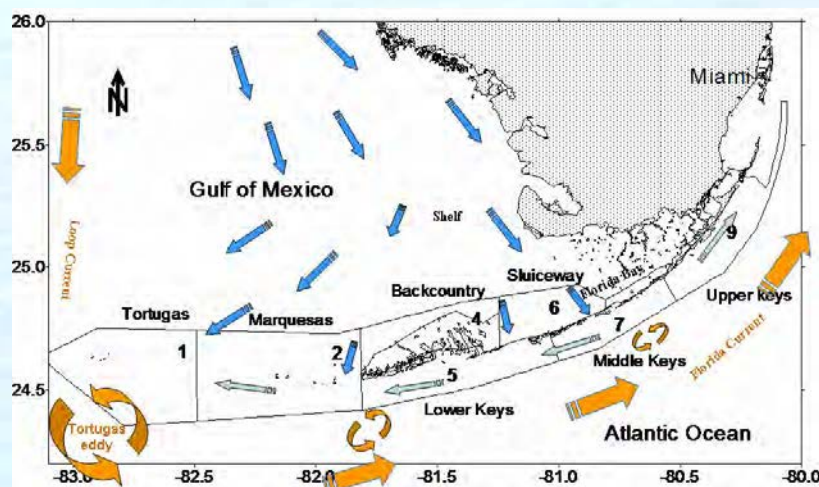
No regional or temporal trends have been observed in either total phosphorus or chlorophyll-*a*. There was a noteworthy elevation of dissolved inorganic nitrogen on the reef that was correlated to the highly active 2005 hurricane season, but by the end of 2008 water quality within the FKNMS returned to conditions prior to 2005.

Water quality data collected at the surface and at one meter above the bottom include: salinity, dissolved oxygen, temperature, turbidity, water clarity, nitrate, nitrite, ammonium, dissolved inorganic nitrogen, organic nitrogen, total nitrogen, soluble reactive phosphate, total phosphorus, organic carbon, silicate, and chlorophyll *a*.

Overall, dissolved oxygen and light penetration measurements are acceptable for marine waters. It is important to note that trend analysis of monitoring data from 1995 through 2008 indicates a statistically significant improvement in several parameters across large portions of the Sanctuary. For example, there has been a consistent downward trend in dissolved organic carbon, and the reasons for this trend are not clear.

Water Quality Surrounding the Florida Keys is Influenced by Far-Field Sources

The FKNMS is part of a complex hydrological system that includes the Everglades, Florida Bay, Biscayne Bay, and other adjacent and remote areas. Monitoring within and outside the Sanctuary boundary has demonstrated that some conditions observed within the Sanctuary may be strongly influenced by conditions occurring outside the Sanctuary. The Florida Current delivers water to the Florida Keys from the wider Caribbean and the Gulf of Mexico. Water from the Southwest Florida Shelf may flow through tidal passes in the Keys or be transported to the Atlantic Ocean south of the Keys. Runoff from the Everglades, tidal exchange from Florida Bay and Biscayne Bay, and atmospheric deposition are additional sources of nutrients and other pollutants to waters surrounding the Florida Keys.



Water Quality in the Florida Keys is influenced by external forces from the Caribbean and the Gulf of Mexico. Water from the Southwest Florida Shelf flows through and around the Keys. Long-term eddies and counter flows influence resident time of waters.

Regional measurements of chlorophyll-*a* concentration demonstrates that the most intense and persistent phytoplankton (algae) blooms originate outside of the Sanctuary on the Southwest Florida Shelf and are fueled by elevated phosphate levels. Phytoplankton blooms from the Southwest Florida Shelf or from nearby Florida Bay can be transported to Sanctuary waters and harm seagrasses and corals. Blooms reduce penetration of sunlight to benthic communities and can have detrimental impacts on seagrasses and corals.

In 2002, the Water Quality Monitoring Network provided agencies and researchers the data to assist in the interpretation of a dramatic algal bloom that occurred in an area southwest of the Everglades. The algal bloom called a “black water event” resulted in an unusually dark discoloration of the water over a sixty mile area. The black water event caused concern among fishermen, divers, and the public and resulted in the die-off of corals and sponges on the Gulf side of the Keys. Researchers attributed the black water event to a nutrient-driven phytoplankton bloom that began at the mouth of the Peace River and to winter storms. The black water traveled slowly southward through the Keys and persisted for approximately six months.

Florida Keys Residential Canals

Waterfront living is highly valued by Florida Keys residents. To accommodate this demand, developers created 111 miles of canals or 481 canal systems. The State of Florida issued a moratorium on new canal development in 1972 based in part on water quality degradation during canal construction. The moratorium halted dredging and filling to create finger canals until completion of a study that assessed the effects of the activity on marine habitat, plants



Construction of residential canals created waterfront property at the expense of habitat and water quality

and animals. That study found that canal development destroyed seagrass habitat, increased turbidity of adjacent waters, reduced the number of species and densities of marine organisms, and depressed oxygen levels. While the moratorium on canal construction was lifted upon completion of the study, the strict permit requirements and enforcement measures effectively stopped the excavation of canals in the Keys.

In 2002, the nearshore waters and canals of the Florida Keys were determined by the State of Florida to be impaired due to nutrients, and in violation of Chapter 62-302.530 Laws of Florida.

That statute states that “in no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of flora or fauna.”

Many of the canals in the Keys are not achieving the Class III designation – safe for swimming and fishing. The canals are deep, narrow, linear, many with dead-end configurations and are impaired due to low oxygen concentrations, high fecal coliform bacteria counts, and high concentrations of nutrients. In 2002, Monroe County funded the preparation of “*Monroe County Residential Canals: Inventory and Assessment.*” That report provided an inventory of the canals, a GIS database, a water quality classification methodology, and recommended remedial actions (weed gates, air curtains, backfilling and shallowing of canals, flushing, culverts, circulation devices, and nutrient removal) to improve water quality in the future.

The completion of the Little Venice Demonstration Project demonstrates that water quality within the canals will gradually show improvement as Monroe County implements improvements in wastewater and stormwater treatment. However, those improvements alone will not return many canals to Class III compliance.

Canal restoration is a high priority for the WQPP Steering Committee. A Canal Restoration Subcommittee is investigating methods to improve water quality in residential canals. The Subcommittee is tasked to develop a Canal Management Master Plan. Phase I of the Master Plan has been funded by FDEP and it will provide a list of the highest priority canal management and restoration issues, restoration options, and potential funding sources. Monroe County has dedicated personnel to apply for grants to implement canal restoration projects based upon information developed in the Master Plan. The Steering Committee will help streamline the permitting of restoration efforts.

Seagrass Monitoring Shows Trends Consistent With Increasing Nutrients

Since 1995, the Water Quality Protection Program has collected quantitative seagrass and benthic data within the largest documented seagrass bed on earth to quantify primary production; define baseline conditions; and, determine the relationships and trends between water quality and benthic communities. Covering nearly 80% of the benthic area of the FKNMS, seagrass plants stabilize benthic sediments, are highly productive, and provide habitat for many species of fish and invertebrates. Seagrasses absorb nutrients from sediments and water. Nutrient enrichment favors the growth of seaweeds in place of seagrasses. Reduced seagrass coverage can lead to degradation or loss of valuable nursery and foraging habitat for fish and shellfish, including queen conch, spiny lobster, and pink shrimp.



A boulder coral and soft corals in a turtle grass bed adjacent to the Florida Keys

Seagrass coverage throughout the Sanctuary was relatively stable 1995 - 2005. Since 2006, changes in seagrass coverage and macroalgae abundance have occurred in within the Sanctuary that is consistent with increased nutrient availability in the water column.

In several areas throughout the Sanctuary, turtle grass, the dominant seagrass species, is gradually being replaced by faster-growing macroalgae that are tolerant of higher nutrient conditions. Along with a shift towards an increase in macroalgae, the data demonstrate a long-term shift in the ratio of nitrogen to phosphorus in seagrass leaves that is consistent with increased nutrients.

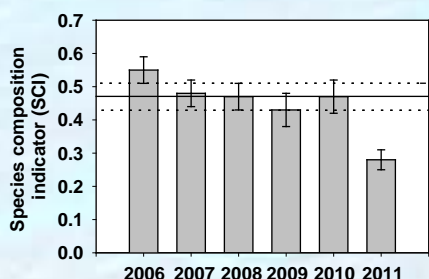


Figure 1. Trends in Species Composition Index, 2006-2011. This indicator shows that the species composition of the seagrass meadows of the FKNMS is changing towards faster-growing forms, and indicator of decreased water quality. The range indicated by horizontal lines is the 1995-2005 baseline and the 95% confidence interval for the baseline.

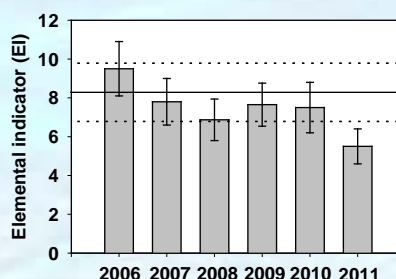


Figure 2. Trends in the Elemental Indicator, 2006-2011. This indicator shows that seagrass meadows of the FKNMS are becoming less nutrient limited. The range indicated by horizontal lines is the 1995-2005 baseline and the 95% confidence interval for the baseline.

Though the indicator trends are consistent with model predictions of nutrient-induced changes, they may be unrelated to man's activities in the region. However, the spatial pattern and agreement of the changes to models of the system suggest a regional-scale change in nutrient availability. The trend of these two independent indicators of seagrass health, SCI (Figure 1) and EI (Figure 2) suggests that water quality within the Sanctuary has declined.

Stony Corals in Decline and Soft Corals Increasing in the Florida Keys

Quantitative monitoring of coral reefs over the past sixteen years in the FKNMS has shown decline in stony coral cover and species diversity. Although some local recovery of stony coral has occurred, the overall decline warrants concerns for the future and health of the Florida Keys coral communities.



Bleached elkhorn corals are weakened, susceptible to diseases and may not recover from bleaching.

The Coral Reef Environmental Monitoring Project (CREMP) began in 1995. Shortly after, worldwide media attention was given to reefs because of global coral bleaching events due to high ocean temperatures from El Niño in 1997 and 1998. From 1996 to 2011, CREMP has recorded a 47% decline in stony coral from approximately 12% to approximately 6%. The decline has been attributed to coral bleaching due to thermal stress, coral disease, damage from hurricanes, and the 2010 winter cold snap. The most significant losses occurred between 1997 and 1999 (38%) following two consecutive years of widespread bleaching of corals. Since 1999, except for a small decrease the

percent cover of stony coral following the 2005 hurricane season, stony coral coverage Sanctuary-wide has been relatively stable.



Sponges have declined throughout the Florida Keys. Many such as this barrel sponge on Conch Reef are over 150 years old.

In 2009, monitoring showed a small, statistically significant, increase in total stony coral cover. However, corals at many shallow-water patch reefs were killed during the prolonged cold spell in January-February 2010. The latest monitoring data indicated that stony coral cover increased from 5.9% in 2010 to 6.6% in 2011. This is the second time in three years that coral cover has increased. Based on the results from two of the last three years, it is plausible that coral recruitment and recovery may be occurring. The monitoring program is conducting a targeted study at a select number of patch reefs to determine if the increase in stony coral cover is due to recruitment of new corals or by

recovery of surviving colonies after the cold water mortality of 2010.

Sponge coverage has also declined since 1996, suggesting that some factors driving the decline in corals are most likely impacting sponges as well (e.g., thermal stress events, disease). While conventional theory predicts an increase in macroalgae abundance with loss of coral and sponge cover, macroalgae coverage on reefs has not shown any significant increase.

For the past ten years, there has been an increase of octocorals (soft corals, sea fans, sea whips) in the Florida Keys concurrent with the decline of stony corals. Octocoral cover has been steadily increasing at shallow forereefs since 1999 by utilizing the available substrate left behind after the 1997/1998 mass coral bleaching event decimated the few, remaining stands of *Acropora palmata* (elkhorn) and large tracts of *Millepora complanata* (fire coral). These corals comprised the majority of coral cover at shallow forereefs prior to 1999. Like stony corals, octocorals are vulnerable to damage from hurricanes and thermal stress; however, they have demonstrated the ability to recover quickly.

The increase in octocorals is consistent with the time required for the growth of young octocoral colonies to become spatially dominant. Based upon the long-term monitoring, the trend of increasing octocoral coverage in the Keys should continue because of their ability to



The Florida Keys coral reef ecosystem may be entering a new alternative state dominated by octocorals that are growing in areas once dominated by hard corals such as elkhorn and staghorn.

recover after major disturbances and the likelihood that the frequency of major disturbances which are detrimental to stony corals will increase. The Florida Keys coral reef ecosystem may be entering into a new alternative state dominated by octocorals and the result of this change to ecosystem structure and function are not known.

Special Studies Program

The purpose of the Special Studies Program is to identify and understand cause-effect relationships involving pollutants, transport pathways, and biological communities of the sanctuary. A total of 30 special studies have been funded since the inception of the program. Funding sources include EPA, FDEP, NOAA, SFWMD, and Sanctuary Friends Foundation of the Florida Keys. Below is a summary of the major findings to date of the Special Studies Program, including the author and year of the study.

Injection Wells

Most groundwater in the Florida Keys is saline and flows predominantly toward the Atlantic Ocean. The flow rate is much higher in Key Largo Limestone (Upper Keys) than Miami Oolite (Lower Keys) (Shinn 1995). Wastewater (freshwater) injected into a Class V disposal well rises toward the surface. The wastewater plume enters nearshore waters (e.g., residential canal)

highly diluted (approximately 1 million to 1) by groundwater (Chanton/Kump 1995). As injected wastewater moves through the porous limestone, some denitrification occurs and sequestration of phosphate occurs until equilibrium is reached (Kump/Chanton 1997).

Septic Tanks

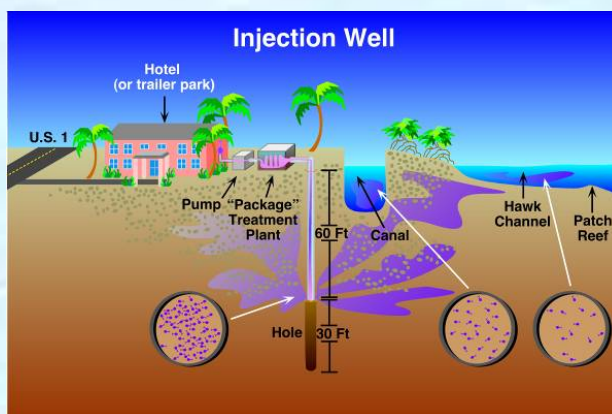
Heavy rains drive wastewater from septic tank drainfields to surface waters and the benthic community at the mouths of residential canals may be degraded (Lapointe 1995).

Public Health

Human fecal bacteria and viruses were found in 18 of 19 nearshore sites in the Florida Keys and are indicative of sewage contamination of surface waters (Rose 1997). Viruses were alive and infectious during winter months (Rose 1998). Young and old and people that are immunocompromised are advised to avoid contact with water from residential canals (Rose 1998; Lipp 2003). Human fecal bacteria and viruses are found in the mucus of living hard corals at the reef tract and their incidence is correlated with human population density (Lipp 2003).

Tracers of Land-Based Sources of Pollution

An analysis of nitrogen isotope ratios in the water column along transects from the Keys to the reef tract demonstrate that either nitrogen from land is not reaching the reef tract or that the technique is not sensitive enough to detect the sources of nitrogen (Swart 2006). However, human intestinal viruses have been detected in the groundwater at the reef tract that support the conclusion that groundwater from the Florida Keys that is contaminated by sewage can be transported to the reef through Key Largo Limestone (Lipp 2007; Futch 2010).



Wastewater disposed into a shallow injection well can rise toward the surface and contaminate residential canals and other nearshore waters as shown in this experiment using viral particles as tracers (Paul 1997).

Coral Diseases

Coral diseases are found throughout the Florida Keys and the incidence is highest in the Lower Keys (Mueller 1997). The incidence of Black-band Disease is highest in the Upper Keys



White-pox disease of elkhorn coral is caused by a human intestinal bacteria that is found in sewage.

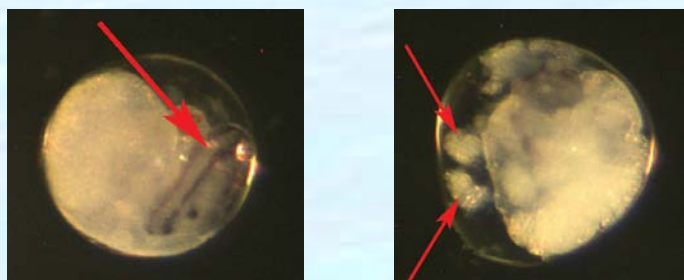
(Richardson 1997). Easily measured indices can assess the condition of corals and distinguish between local and global stressors (Mueller 1997). Aspergillosis, a fungal infection of sea fans, is caused by a terrestrial fungus that has invaded the marine environment (Harvell 2003).

A bacteria commonly found in the human intestine (*Serratia marcescens*) is the causative agent of White-band Disease, a lethal disease of the threatened elkhorn coral (Lipp 2004). The strain of the bacteria that causes the coral disease is identical to that found in untreated wastewater (Patterson 2002, 2010).

Effects of Mosquito Spraying

Pesticides sprayed from airplane and truck reach surface waters in canals adjacent to residential developments. Toxicity of one of the chemicals is high in surface waters adjacent to a sprayed area (Pierce 1997).

Queen conch larvae exposed to field concentrations of mosquito pesticides had marked abnormalities in larval development and high mortality (Glazer 2003; Delgado 2004). Zinc and/or copper in sediments may be partially responsible for lack of reproductive success in nearshore conch (Glazer 2010).



Four-day-old queen conch embryos in normal seawater (left) and exposed to a mosquito pesticide (Naled) (right). Arrow on the left points to eye spots, arrows on right point to abnormal cells.

Marine Protected Areas

Spiny lobsters are larger and more abundant in a Marine Protected Area than in adjacent areas where fishing is allowed. Gravid female lobsters migrate from nearshore patch reefs to the bank reef to spawn (Bertelsen 2003). Baseline data for benthic taxa have been obtained for modeling the effect of Marine Protected Areas on growth and survival of hard corals, soft corals, and sponges (Smith 2003).

Centralized Data Management

The WQPP has recognized the importance of long-term data sets and has a regional database and data management system for recording the biological, physical, and chemical results from the comprehensive monitoring and research programs. In 1993, EPA contracted with the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute to develop a data management plan and prototype data management system.

All original and synthesized data sets are stored in a centralized location at FWRI in the original formats as submitted by the individual projects. For data security, data are stored in fireproof and waterproof safes within the FWRI and at an offsite location. Access to these data, in their original form and content, is provided upon request and approval to researchers, managers, and the general public.

The data management program also enters data generated in the WQPP into EPA's STORET database. STORET is a national database and a tool for providing researchers, managers and the public site-specific sampling results. STORET has evolved from a simple data repository for water quality data to one that can also accept biological, chemical, and physical data. A website has been created that contains annual reports, executive summaries, original data, and synthesized data (GIS shapefiles and Goggle Earth files). This information is also available annually on a CD-ROM data disk.



http://ocean.floridamarine.org/FKNMS_WQPP/index.html

Wastewater Improvements by 2015

Historically, wastewater disposal for residences in the Florida Keys consisted of cesspools (an unlined hole in the ground). Cesspools provide no treatment of wastewater. In the early 1970s, the Florida Department of Pollution Control required installation of septic tanks for onsite treatment. However, septic tanks do not function well in areas with porous limestone substrates and high water tables, such as the Florida Keys. Scientific studies demonstrated that nutrients, bacteria, and viruses from onsite treatment systems were rapidly found in adjacent residential canals. Inflow and infiltration problems with the antiquated central collection and treatment system in Key West was responsible for discharge of untreated wastewater to adjacent surface waters resulting in closure of nearby beaches due to bacteria contamination.

In 1999, the WQPP Program Document reported that approximately 80% of nitrogen and 55% of phosphorus in nearshore surface waters originated from wastewater. The report also identified that septic tanks and cesspools contributed approximately 50% of the nutrient loading while package plants, central treatment plants, and live-aboard boats contributed the remaining 50%.

In 1999, the Florida Legislature established new treatment and disposal requirements for all wastewater facilities in Monroe County. Chapter 99.395 Laws of Florida required all new sewage treatment facilities and onsite systems permitted after June 18, 1999, to comply with the advanced wastewater treatment or best available technology standards and all existing systems to meet those requirements by 2010. Facilities with a capacity of less than 100,000 gallons per day (gpd) must meet BAT standards and facilities over 100,000 gpd must meet AWT standards.

(Chapter 99.395, Laws of Florida)

BOD = Biochemical Oxygen Demand; TSS = Total suspended solids; TN = Total nitrogen; TP = Total phosphorus. Effluent (treated wastewater) concentration standards are in milligrams per liter (mg/L) as annual average (mg/L is equivalent to "part per million").	
BAT standards apply to facilities with design capacities less than 100,000 gallons/day (generally, OSTDS and "package plants")	10 BOD 10 TSS 10 TN 1 TP
AWT standards apply to facilities with design capacities equal to or greater than 100,000 gallons/day (community and central wastewater treatment systems)	5 BOD 5 TSS 3 TN 1 TP
Best Available Technology and Advanced Water Treatment Standards	

The law also requires that wastewater treatment plants with design capacities under 1 million gpd discharge treated effluent to Class V injection wells (drilled to 90 ft (18 m), cased to 60 ft (27 m)). Wastewater facilities with a design capacity equal to or greater than 1 million gpd are required to discharge treated effluent into deep injection wells with a minimum depth of 2000 ft (610 m). In addition to the new treatment standards, the law prohibited new surface water discharges of wastewater and required elimination of all existing surface water discharges by 2006.

Equivalent Dwelling Unit” or “EDU” is equal to one household, or an average of one hundred and sixty-seven (167) gallons/day. This unit is established for the purpose of assessing rates, fees, charges and assessing progress towards implementing advanced wastewater treatment or best available technology.

In 2013, 49,317 of the 74,120 (67%) EDUs have been connected to advanced wastewater treatment or best available technology in the Florida Keys.

The 2010 deadline has been extended by the Florida Legislature until December 31, 2015, to allow those facilities that are behind schedule to come into compliance with the law. The law assigns responsibility for meeting these requirements to the owners of the systems, whether local governments or private entities. However, local governments in the Florida Keys are responsible for building and operating appropriate wastewater facilities, connecting package plants and onsite systems, and helping homeowners who remain on onsite systems comply with the new, more stringent requirements.

The state continues work with local governments and wastewater plant owners to promote completion of facilities and allow timely connection of package plants and onsite systems to prevent non-compliance with the law. The state is also helping local governments identify and generate the necessary financial resources to implement the Monroe County Wastewater Plan by the 2015 deadline.

The current estimated cost to implement the Monroe County Sanitary Wastewater Master Plan and comply with the wastewater regulations is \$725 million. To date, local funds from sales tax revenue, capital development fees/assessments, ad valorem tax and rates have generated \$382 million - nearly half of the project costs. Federal and state grants have contributed \$55 million and \$51 million, respectively. The difference between the project costs and available funding equals a shortfall of \$238.8 million that remains to be procured. To date, over 60% of equivalent dwelling units in Monroe County have been connected to improved wastewater treatment facilities. An EPA Region 4 grant was given to the University of North Carolina Environmental Finance Center (EFC) to work with local governments and communities on identifying, securing, and managing funds for improvements to wastewater infrastructure. The EFC provided direct support and helped develop sustainable and equitable revenue resources and user fees, prepared capital investment plans, and cash flow plans, and established rates and fees.

Little Venice Water Quality - Environmental Success Story

The Little Venice neighborhood in Marathon, FL, was identified by the *Monroe County Sanitary Wastewater Master Plan* as the number one priority for receiving improved wastewater treatment because of high estimated nutrient loading to surface waters. The neighborhood is characterized by a large number of homes with cesspools and antiquated septic systems. The lot sizes are small and the density of homes is high.



Typical residential canal in the Florida Keys

Water quality of the residential canals was monitored in 1984–1985 by the Florida Department of Environmental Regulation and showed significant nutrient enrichment in the canals, high chlorophyll-*a* concentrations indicative of algal blooms, and high coprostanol concentrations in sediments. Coprostanol is a breakdown product of cholesterol and is an indicator of fecal contamination.

Improvements to sewage treatment in Little Venice were first approved by the Monroe County Board of County Commissions in 1997 as an advanced wastewater treatment pilot project. The project was financed in part by a \$4.3 million Construction Grant from EPA. In 1998, the BOCC asked the FCAA to take over the project. The original project consisted of 697 EDU's and was built for about \$9 million. A second phase was added with FDEP grant money and included another 270 EDU's. The total cost of the Little Venice collection and treatment system, which is complete, is about \$14.6 million. The system became operational in 2004. Wastewater is treated to advanced wastewater treatment standards of 5:5:3:1 (BOD₅, TSS, TN, TP) and utilizes Class V injection wells for disposal of treated wastewater.

From 2001-2003, canal water quality at the head and mouth of canals was monitored weekly and seagrass communities were monitored at permanent stations at 0, 50, 100 and 200 meters offshore from the mouths of four canals to establish baseline conditions. Monitoring resumed from 2005-2007 after the treatment plant became operational. Follow-up monitoring of offshore seagrass communities continued through September 2010. Canal water quality improved after implementation of improved wastewater treatment. After remediation, canals had significantly fewer violations of the dissolved oxygen standard and significantly fewer violations of the fecal coliform standard. Significantly less concentrations of enterococci bacteria (intestinal bacteria) were also observed after remediation. Seagrass communities off the mouths of the canals showed evidence of increased water clarity and reduced epiphyte loads following remediation. Thus, monitoring data support that advanced wastewater treatment is having a positive impact on the water quality in the Little Venice area.

Florida Keys National Marine Sanctuary is a No Discharge Zone for Boater Sewage

There is a large community in the Florida Keys that live on boats. Although nutrient loading into surface waters from vessels may be a relatively minor contribution to the total loading, loadings from vessels are a significant source to harbors and marinas. The result is nutrient enrichment of waters that typically have poor circulation and flushing characteristics.

Every winter, approximately 400 live-aboard and touring vessels congregate in Boot Key Harbor, Marathon, Florida. Water quality monitoring detected repeated violations of standards for fecal coliform and dissolved oxygen due to untreated or poorly treated wastewater from vessels in Boot Key Harbor and other marinas and harbors throughout the Florida Keys. Monitoring data provided the scientific justification for designating state waters within the Sanctuary a “no discharge zone.” With support from Monroe County, and at request of the Governor of Florida, EPA, in accordance with Clean Water Act Section 312, designated all state waters within the FKNMS a “no discharge zone.” That designation became effective in 2002 and made it illegal to discharge boat sewage (treated or untreated) into state waters.

In Boot Key Harbor, 226 mooring balls were installed, and pump out facilities for vessel holding tanks were made available onshore and through mobile pump out boats. A dock master was hired to oversee activities in the harbor.

In 2004 – 2005, the first year of operation of the completed facilities and management of Boot Key Harbor, 6568 vessels were pumped out, removing approximately 99,000 gallons of sewage that would have been discharged into the harbor. In 2007 – 2008, approximately 156,000 gal of wastewater was properly disposed from vessels by City of Marathon facilities at Boot Key Harbor and private marinas in Marathon.

Through the diligence of Monroe County and the City of Marathon, Boot Key Harbor is now well managed and has improving water quality. It is reported that

porpoises, mullet, eagle rays, and other marine organisms that had not been seen for many years within the harbor are now commonly sighted. Also, fecal bacteria levels have been greatly reduced in surface waters and regularly meet state standards. This is truly a success story. In 2010, the NOAA extended the no discharge zone regulation to include federal waters within the FKNMS. The new regulation also requires that all marine sanitation devices be locked to prevent any wastewater discharge, intentional or accidental while boating within the sanctuary.



Sewage pump-out vessel in Boot Key Harbor, Marathon, FL

Designation of all state and federal waters within the Sanctuary will reduce nutrients capable of stimulating algal growth that is harmful to seagrass and coral reef communities. In addition, it will eliminate a source of bacterial and viral pathogens that may pose a public health concern.

To help boaters comply with the regulation and achieve the desired effect of reducing pollution into the Sanctuary, a successful interagency education and outreach campaign – “Pump It, Don’t Dump It” – was initiated in 2003. This program distributes education flyers to marinas throughout the Florida Keys and provides public service announcements that air regularly on local radio and television. A working group comprised of state, federal and local governments, and the environmental organization Reef Relief are updating the “The Pump It, Don’t Dump It” campaign to include a current list of pump-out facilities available in the Keys and toll-free numbers for the public to call for additional information.



The Florida Keys are a No-Discharge Zone

Clean Marinas in the Florida Keys

Addressing pollution from boats, marinas, and boatyards is a priority action item for the WQPP. While establishing stormwater regulations and designating the FKNMS as a “no-discharge zone” provided an enforcement mechanism to address boater pollution, it is important that the boating community be made aware of the requirements (Clean Marina Programs) and complies with the regulations.

Funding for the construction of pump-out facilities and pump-out vessels at marinas can be sought through the Clean Vessel Act Grant Program. The Clean Vessel Act is a federally funded program administered through the Florida *Clean Marina Program*.

Priorities for improving marina infrastructure

- ❖ *Increase availability of pump-out facilities at marinas*
- ❖ *Increase mobile pump-out services*
- ❖ *Implement best management practices for stormwater*
- ❖ *Establish mooring fields*

Centralize Management of Decentralized Wastewater Treatment Systems

Sparsely populated islands of the Lower Keys will not be connected to central wastewater collection and treatment facilities, but are required to comply with the mandated wastewater treatment requirements by 2015 (Chapter 99.395, Laws of Florida). In 2010, the EPA provided a \$3.6 million grant to the Florida Keys Aqueduct Authority (FKAA) to test centralized management of decentralized onsite wastewater systems in unincorporated Monroe County in the Lower Florida Keys. The FKAA will manage the project, provide information to home owners, and demonstrate the capabilities and advantages of decentralized treatment systems with centralized management. The project will utilize onsite/decentralized treatment technologies designed to achieve the high levels of treatment required, including nutrient removal. The project will be implemented in several phases including planning, construction, monitoring, and reporting of results. FKAA is currently evaluating possible locations for systems, identifying appropriate technologies, and developing public outreach activities.

Development of Numeric Nutrient Criteria for the Florida Keys

In July 2008, several environmental groups sued EPA for failing to promulgate numeric nutrient criteria for State of Florida waters. In January 2009, EPA determined that Florida's existing narrative standards were insufficient to protect water quality and agreed with the plaintiffs that numeric nutrient criteria were required to meet the requirements of Clean Water Act Section 303(d). In August 2009, EPA entered into a Consent Decree with the environmental groups to settle the litigation and establish a timeline for establishing final standards.

EPA's deadline for proposing numeric nutrient water quality standards for estuaries and coastal waters was November 30, 2012, with finalization of the standards to occur by September 30, 2013. In order to comply with these deadlines, EPA and FDEP are working with local governments, non-governmental organizations, universities, and knowledgeable stakeholders within coastal communities throughout the state to develop appropriate numeric nutrient (total nitrogen and total phosphorus) criteria for Florida's estuaries and coastal waters.

One of the purposes of the WQPP is: "Adoption or revision, under applicable Federal and State laws, by the State and the Administrator of applicable water quality standards for the Sanctuary, based on water quality criteria which may utilize biological monitoring or assessment methods, to assure protection and restoration of the water quality, coral reefs, and other living marine resources of the Sanctuary" *Florida Keys National Marine Sanctuary and Protection Act*

The EPA and FDEP have hosted a series of workshops and public meetings to identify and compile the best available monitoring data and scientific literature that will direct the development of scientifically defensible nutrient water quality standards that are protective and restorative of coastal waters and marine resources. Data from the long-term monitoring program of the WQPP have provided the scientific underpinnings for the establishment of appropriate nutrient water quality standards for the Florida Keys.

Florida Keys Reasonable Assurance Document

Residential canals were excavated to maximize the amount of fill material required to raise the elevation of adjacent lands for development. Many canal systems in the Florida Keys are long, dead end systems with little tidal exchange. Also, many canals are deep which prevents vertical mixing of waters within the canal. Many canals have dissolved oxygen levels that are below the Florida standard. The nearshore waters in the Florida Keys, including canals, are classified as Class III (Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife). For these waters, the applicable water quality standard is Chapter 62-302.530(30), F.A.C., which states that DO in Class III marine waters: "Shall not average less than 5.0 milligrams/liter in a 24-hour period and shall never be less than 4.0 milligrams/liter. Normal daily and seasonal fluctuations above these levels shall be maintained."

In 2002, the nearshore waters and canals of the Florida Keys were determined by the State of Florida to be impaired due to nutrients, and in violation of Chapter 62-302.530 Laws of Florida that states that "in no case shall nutrient concentrations of body of water be altered so as to cause an imbalance in natural populations of flora or fauna." Once a waterbody is determined to be in violation, the State must add the waterbody to the state's list of impaired surface waters as required by the Clean Water Act Section 303(d). Once listed, the State is required to develop a Total Daily Maximum Load model that allocates the amount of pollutant discharged into a water body while still maintaining water quality standards, or develop a Reasonable Assurance Document that certifies that pollution controls are in place to return the impaired waterbody into compliance. To comply with the requirements of the Clean Water Act, Florida submitted the Florida Keys Reasonable Assurance Document (FKRAD) to EPA.

The FKRAD was developed by a technical review committee composed of local, regional, state, and federal agency staff was convened to provide guidance and local knowledge. The FKRAD is divided into four geographic reports (Northern, Central, South Central, and Southern areas) and identifies management actions that have been taken, or those that are planned, to reduce nutrient loadings to achieve water quality standards and obtain beneficial uses. While the existing and proposed management activities are expected to result in achieving water quality targets for nutrients, there is general agreement by all parties that the management activities will not fully address the low dissolved oxygen levels occurring within residential canals of the Keys. FDEP adopted the Reasonable Assurance Plans on February 7, 2012 and submitted to EPA for concurrence. The Reasonable Assurance Plans includes FDEP working with the FKNMS to identify potential improvements to the canals and evaluate whether reclassification of the canals to Class III - Limited is appropriate. Class III - Limited is restricted to waters with human-induced physical or habitat conditions that, because of those conditions, have limited aquatic life support and habitat that prevent attainment of Class III uses.

Outreach and Education

Education and outreach is an important feature of the Water Quality Protection Program. Educators, scientists and managers collaborate on outreach projects designed to promote environmental education and garner support for environmental conservation and stewardship, as well as water quality improvement projects in the Florida Keys. Generally, the outreach campaigns have been multi-agency efforts targeting residents, visitors, the media, and community leaders. Three of the successful outreach efforts are presented here: the *Waterways* program, Water Quality Awareness Month, and Sanctuary Science Summaries.

The *Waterways* program is a successful television series that highlights the environmental and cultural resources of south Florida's natural areas, including national parks, marine sanctuaries, and wildlife refuges. With funding from the EPA, National Park Service, and the FKNMS, the first *Waterways* was broadcast in 1994, and to date over 100 episodes have been produced. Each 26-minute episode promotes an understanding of the south Florida's ecosystem, inspires curiosity, and encourages conservation. Episodes that are currently under development will address invasive species, stewardship programs, Ft. Jefferson in the Dry Tortugas, Everglades restoration, and the effectiveness of marine zoning.

Water Quality Awareness Month is an outreach campaign held annually in March that has received strong support by county and local governments. Monroe County, Marathon, Key West, Key Colony Beach, Islamorada, and the Key Largo have issued proclamations recognizing Water Quality Awareness Month and have declared the importance of water quality to protecting the coral reef ecosystem, the Keys economy, and quality of life. For this campaign, local experts appear on radio programs to describe ways to reduce water use and pollution from boats, homes, and offices.

Over one hundred half-hour episodes of *Waterways* have been produced. Each episode explores the natural treasures of south Florida and includes interviews with local experts who explain efforts that are underway to protect this unique ecosystem.

Sanctuary Science Summaries are two-page documents highlighting various aspects of the scientific findings of the monitoring and research programs in the sanctuary. An overview summary describes current findings from the coral, seagrass and water quality monitoring programs. Additional summaries describe research programs and activities to reduce pollution in the Keys. These summaries, developed by Sanctuary staff and researchers, are available on the sanctuary's website: <http://floridakeys.noaa.gov/>.

EPA Strategic Goals

EPA's *National Water Program Guidance* identifies five indicators to assess the condition of the resources in the FKNMS. The indicators depend upon WQPP's monitoring and implementation activities to assess water quality, biological resources, and progress toward improving wastewater treatment within the Sanctuary. The WQPP annually reports the status of meeting the indicators to EPA. Results are published in the EPA National Water Program's *Best Practices and End of the Year Performance Report*. The measures are reviewed by the Office of Management and Budget (OMB) for program effectiveness and performance.

Water Quality: In FY12, water quality targets were achieved for SP47-b, nitrogen and phosphorus. For the first time in five years, SP47-a, chlorophyll *a* and water clarity failed to meet the targets.

Stony coral coverage: Coral coverage rebounded in 2009 to achieve SP-45 for the first time in five years. The rebound may have occurred due to improved water quality, reduced sedimentation as a result of low storm activity or may be due to natural variation with the system. In 2010, an unprecedented cold snap occurred in the Keys killing massive amounts of stony corals in shallow reefs. The 2011 monitoring data showed stony coral coverage increasing from 5.9% in 2010 to 6.6% in 2011. Stony coral coverage has now increased two of the last three years. Targeted monitoring is being initiated to help discern if this is a true recovery or merely noise in the data.

Seagrass and Benthic Habitat: The 2011 monitoring data showed that the overall health and functionality of seagrass were not maintained. The two independent metrics of the health of seagrasses suggest that there were significant water-quality degradation at the seagrass monitoring stations. Both metrics have been trending lower since 2006 suggesting that water quality within the Sanctuary has declined in that last five years.

Five measures of ecosystem health:

1. SP47-a Water Quality. At least 75% of the monitored stations on the reefs of the FKNMS will maintain chlorophyll *a* levels at less than or equal to 0.35 ug/L and light clarity (Kd) levels at less than or equal to 0.20 per meter.
2. SP47-b Water Quality. At least 75% of the all monitored stations in the near shore and coastal waters of the FKNMS will maintain dissolved inorganic nitrogen (DIN) levels at less than or equal to 0.75 uM and total phosphorus (TP) levels at less than or equal to 0.25 uM.
3. SP45 Stony Coral Coverage. Achieve "no net loss" of stony coral cover (mean percent stony coral cover) in the FKNMS and in the coastal waters of Dade, Broward, and Palm Beach Counties, Florida, working with all stakeholders (federal, state, regional, tribal, and local).
4. SP46 Seagrass and Benthic Habitat. Annually maintain the overall health and functionality of seagrass beds in the FKNMS as measured by the long-term seagrass monitoring project that addresses composition and abundance, productivity, and nutrient availability.
5. SFL1 Wastewater Treatment. Increase percentage of sewage treatment facilities and onsite sewage treatment receiving advanced wastewater treatment or best available technology as recorded by equivalent dwelling units (EDU) in Florida Keys by 2% (1500 EDUs) annually.

The Future

Completion of improvements to wastewater and stormwater infrastructure is a high priority action item. Reduction of nutrient input to nearshore waters due to improved wastewater and stormwater treatment will reduce algal growth and competition and increase water clarity by reducing the incidence and extent of phytoplankton blooms.

An essential activity for the future is continuing the robust status and trends monitoring program. That need is underscored by activities associated with the restoration of the Everglades and continuing oil and gas activities in the Gulf of Mexico and Cuba. Changes to the water delivery system through the Everglades into Florida Bay are expected to affect water quality conditions of hardbottom habitats and coral communities throughout the FKNMS. The recent oil spill in the gulf also emphasizes the need for vigilant assessment of existing conditions of water quality and benthic communities. For example, the status and trends monitoring program served as the basis for pre-spill monitoring that was conducted in preparation for the possible arrival of oil from the Deepwater Horizon spill. The Steering Committee is committed to “streamlining” the long-term monitoring program while still maintaining the rigor required for informed management.

There is a need to locate additional monitoring stations to evaluate nearshore conditions, including residential canals, to document changes to nearshore water quality and benthic communities due to improved wastewater and stormwater treatment. Also, the WQPP will take the lead in educating the public on the importance of reducing or eliminating the discharge of pharmaceuticals and personal care products to adjacent water because of adverse effects to the endocrine system of aquatic organisms.

Additionally, there is ample evidence that global climate change is an important driving factor in the decline of the Florida Keys coastal ecosystem. The WQPP will direct future activities to address the impacts of climate change on the Florida Keys ecosystem. Special studies are required to quantify, model, and predict the effects of elevated sea surface temperatures, ocean acidification, and sea-level rise on the Florida Keys ecosystem. The WQPP will lead the education of the public on these important concepts to garner their support for action.

Addressing the complexities canal restoration is a high priority future activity. Planning has been initiated to develop a Canal Management Master Plan that will provide an ecologically sound and economically feasible implementation strategy for improving and managing the environmental quality of canal systems in the Florida Keys. Once completed, funding for a pilot canal restoration project will be sought to demonstrate methods to improve canal water quality by remedying canal depth, geometry, seagrass wrack, and flushing characteristics.

Conclusion

The WQPP has been successful in meeting the mandates specified in the Florida Keys National Marine Sanctuary and Protection Act that include the development of a program for the Sanctuary that would:

- ❖ reduce pollution from point and nonpoint sources
- ❖ ensure compliance with applicable federal and state laws
- ❖ adopt appropriate water quality standards
- ❖ create a comprehensive monitoring program
- ❖ identify funding for implementation of the program
- ❖ provide a mechanism for state and local government consultation and public participation

Much has been accomplished at the local level to address reduction of pollutants to the adjacent marine waters. To date, more than 60% of the households in Monroe County are connected to improved sewage treatment facilities. Improvements to nearshore water quality as a result of improved treatment of wastewater have been demonstrated. Funding to complete the implementation of the Monroe County Sanitary Wastewater Master Plan is being pursued from federal, state, and local sources. Completion of the Florida Keys Reasonable Assurance Document underscores the commitment of local partners in implementing improvements to wastewater treatment as specified in 99-395 Laws of Florida. Funding for increasing the number of sewage pumpout facilities for vessels is available from the Florida Clean Marina Program.

Long-term monitoring has demonstrated that the coral reef ecosystem is in decline and is a “shadow” of its former productivity and biodiversity. It has documented that many of the major predators have been removed through overfishing and have not recovered. Evidence is mounting that nearshore seagrasses are also in a state of decline. Members of the Steering Committee routinely use information from monitoring and special studies to prioritize actions to remediate degraded water quality in the Florida Keys.

The Steering Committee is committed to adaptive management of the FKNMS resources. Future activities have been identified and prioritized and are consistent with the Water Quality Action Plan (Appendix 1). The WQPP will incorporate these future activities through a balanced approach without decreasing the capacity to maintain the long-term mission of measuring the “pulse” of the Florida Keys ecosystem.

Appendix 1

The following is a list of the current status of high priority activities contained in the FKNMS WQPP Action Plan. Implementation Key: ● Substantial, ◐ Moderate, ○ Minimal

STRATEGY	ACTIVITY	STATUS
Domestic Wastewater (AWT for facilities > 100,000 gpd, BAT for facilities <100,000 gpd)	W.3 Implement Monroe County Wastewater Plan	◐
	W.2 Conduct Little Venice AWT demonstration project	●
Water Quality Standards Development	W.5 Support ongoing WQS development and the development of biocriteria	◐
Stormwater	W.11 Implement stricter stormwater permitting	◐
	W.12 Implement stricter stormwater management	◐
	W.14 BMP development and education programs	◐
Canals (residential)	W.10 Improve water quality in residential canals	○
Monitoring Program	W.20 Implement water quality monitoring	●
	W.33 Implement ecological monitoring (coral/seagrass)	●
Marinas/Live-aboards	B.7 Strengthen regulations to reduce marina and boater pollution – designate Sanctuary no discharge zone	●
	L.1 Ensure adequate marine pump-out facilities to eliminate discharge of waste from vessels into Sanctuary	◐
	L.6 Establish mobile pump-out services	◐
	L.2 Develop marina siting plans	◐
	L.3 Reduce marina pollution through appropriate infrastructure and education programs	○

STRATEGY	ACTIVITY	STATUS
Florida Bay / External Influences	W.19 Restoring freshwater flow to Florida Bay from the Everglades	○
	W.24 Research the effects of Florida Bay on the Sanctuary	●
Mosquito Spraying	W.18 Pesticide research on impacts of mosquito control	●
	W.17 Reduce aerial spraying within the Sanctuary	●
Research / Special Studies	W.21 Develop aquatic resource predictive models for the Sanctuary; contribution from nearshore / farfield sources	●
	W.22 Detect and identify wastewater / stormwater pollutant sources and ecological impacts	●
	W.23 Develop tools for pollutants and water quality problems such as loading models and innovative monitoring tools	●

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Additional Resources

To find out more about the Florida Keys National Marine Sanctuary and the Water Quality Protection Program, please visit us on the web at:

Florida Keys National Marine Sanctuary Water Quality Protection Program

http://ocean.floridamarine.org/fknms_wqpp/

Florida Keys National Marine Sanctuary

<http://floridakeys.noaa.gov/wqpp/>

Southeast Environmental Research Center

<http://serc.fiu.edu/wqmnetwork/>

EPA South Florida Geographic Initiative

<http://www.epa.gov/region4/water/southflorida/index.html>

Florida Keys National Marine Sanctuary Water Quality

<http://myfwc.com/research/gis/projects/biogeographic/fl-keys-nms-water-quality/>

Monroe Canal Restoration

<http://www.monroecounty-fl.gov/index.aspx?NID=598>

Monroe County RESTORE Funding

<http://www.monroecounty-fl.gov/index.aspx?NID=432>

Water Quality Concerns in the Florida Keys; Sources, Effects, and Solutions

<http://academic.research.microsoft.com/Paper/5557616.aspx>

Florida Keys Basin Water Quality Reports

<http://www.dep.state.fl.us/water/basin411/keys/status.htm>

Florida Keys Reasonable Assurance Plans

<http://www.dep.state.fl.us/water/watersheds/rap.htm>



City of Key Colony Beach



US Army Corps of Engineers

