

Implementation of the National Coral Reef Action Strategy

REPORT TO CONGRESS

*Report on
U.S. Coral Reef
Task Force Agency
Activities From
2002 to 2003*



U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Produced in Cooperation with the U.S. Coral Reef Task Force



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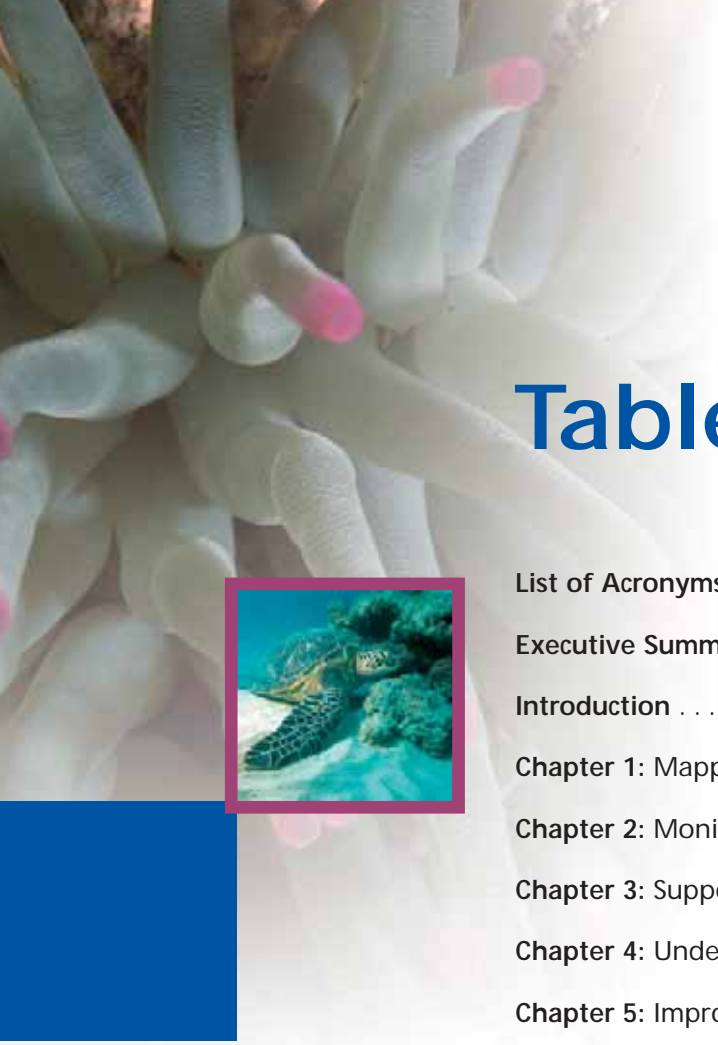


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Appendix B: Additional Coral Reef Task Force Activity Highlights

List of Acronyms

AIS	Aquatic Invasive Species	DNER	Department of Natural and Environmental Resources
AS	American Samoa	DOC	U.S. Department of Commerce
AGRRA	Atlantic and Gulf Rapid Reef Assessment	DoD	U.S. Department of Defense
APEC	Asia-Pacific Economic Cooperation	DOI	U.S. Department of the Interior
BUIS	Buck Island Reef National Monument	DOJ	U.S. Department of Justice
CBD	Convention on Biological Diversity	DOS	U.S. Department of State
CDHC	Coral Disease and Health Consortium	DOT	U.S. Department of Transportation
CDOM	Colored Dissolved Organic Matter	EFH	Essential Fish Habitats
CFMC	Caribbean Fishery Management Council	EIMS	Environmental Information Management System
CIRES	Cooperative Institute for Research in Environmental Sciences	EIS	Environmental Impact Statement
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora	EPA	U.S. Environmental Protection Agency
CNMI	Commonwealth of the Northern Mariana Islands	EEZ	Exclusive Economic Zone
CNP	Coastal Nonpoint Pollution Control Program	FGBNMS	Flower Garden Banks National Marine Sanctuary
COE	U.S. Army Corps of Engineers	FKNMS	Florida Keys National Marine Sanctuary
CoRIS	Coral Reef Information System (NOAA)	FAS	Freely Associated States (Republic of Palau, Republic of the Marshall Islands, Federated States of Micronesia)
CRCA	Coral Reef Conservation Act of 2000	FEMA	Federal Emergency Management Agency
CRED	Coral Reef Ecosystem Division	FMP	Fisheries Management Plan
CREMP	Coral Reef Evaluation and Monitoring Program	FMRI	Florida Marine Research Institute
CRES	Coral Reef Ecosystem Studies	FRA	Fisheries Replenishment Area
CREWS	Coral Reef Early Warning System	FWC	Fish and Wildlife Conservation Commission (Florida)
CRON	Coral Reef Outreach Network	FWRI	Fish and Wildlife Research Institute (Florida)
CRW	Coral Reef Watch	FY	Fiscal Year
CWA	Clean Water Act	GCRMN	Global Coral Reef Monitoring Network
CZMP	Coastal Zone Management Program	GIS	Geographic Information System
DAWR	Guam Division of Aquatic and Wildlife Resources	GPS	Geographic Positioning System
DHS	U.S. Department of Homeland Security	GU	Guam

HACCP	Hazard Analysis and Critical Control Point	NWR	National Wildlife Refuge
HCRI	Hawai'i Coral Reef Initiative	PR	Puerto Rico
HIWG	Hawai'i Interagency Coral Reef Mitigation Working Group	PRDENR	Puerto Rico Department of the Environment and Natural Resources
HOST	Hawai'i Ocean Safety Team	PSSA	Particularly Sensitive Sea Area
ICRI	International Coral Reef Initiative	RACE	Restoration and Assessment of Coral Ecosystems
IMO	International Maritime Organization	ROV	Remotely Operated Vehicle
LAS	Local Action Strategy	SeaWiFS	Sea-Viewing Wide Field-of-View Sensor
LIDAR	Light Intensity Detection and Ranging	SHARQ	Submersible Habitat for Analyzing Reef Quality
MIL	Mobile Irrigation Lab	SST	Sea Surface Temperature
MMA	Marine Managed Area	SPAW	Special Protected Areas Wildlife
MMS	Minerals Management Service	TNC	The Nature Conservancy
MOI	Memorandum of Intent	UNEP	United Nations Environment Programme
MPA	Marine Protected Area	UNESCO	United Nations Educational, Scientific and Cultural Organization
MPCD	Marine Pollution Control Device	USAID	U.S. Agency for International Development
NASA	National Aeronautics and Space Administration	USCG	U.S. Coast Guard
NCRI	National Coral Reef Initiative	USCRTF	U.S. Coral Reef Task Force
NEPA	National Environmental Policy Act	USDA	U.S. Department of Agriculture
NGO	Nongovernmental Organization	USFWS	U.S. Fish and Wildlife Service
NPS	National Park Service	USGS	U.S. Geological Survey
NOAA	National Oceanic and Atmospheric Administration	USVI	U.S. Virgin Islands
NOWRAMP	Northwestern Hawaiian Islands Reef Assessment and Monitoring Program	VIIS	Virgin Islands National Park
NRCS	Natural Resources Conservation Service	WRP	Wetland Reserve Program
NSF	National Science Foundation		
NWHI	Northwestern Hawaiian Islands		

Executive Summary



Coral reefs, often called the “rainforests of the sea,” are among the oldest and most diverse ecosystems on the planet. They provide resources and services worth billions of dollars each year to the United States and worldwide economies, a surprising amount considering that these ecosystems cover less than 1 percent of the Earth’s surface. With 10.5 million people living adjacent to a U.S. coral reef in mainland coastal communities or on islands (U.S. Census 2002), coral reefs have become an integral part of the culture, heritage, and economies of these regions.

Millions of people across the United States depend on coral reefs for food, protection from storms, and jobs. For example, South Florida’s coral reef ecosystems have a nonmarket value of \$228 million and support more than 44,500 jobs (Turgeon et al. 2002). U.S. coral reef fisheries alone support an ex-vessel landing (value of catch paid to fishermen) of more than \$137.1 million (Turgeon et al. 2002).

However, U.S. coral reef ecosystems and worldwide reefs are in danger. They are continuously damaged or destroyed by anthropogenic impacts such as pollution, overfishing, and coastal development, and by natural impacts such as tropical storms. The Global Coral Reef Monitoring Network (GCRMN) estimates 20 percent of the world’s coral reefs have been destroyed and predicts 24 percent are under pending destruction from adverse human impacts (Wilkinson 2004). In addition, GCRMN estimates another 26 percent of reefs are under a long-term decline (Wilkinson 2004). Compounding this problem is the lack of public awareness regarding the value and condition of U.S. coral reefs and the impact people upstream have on reef health.

Implementation of the National Coral Reef Action Strategy highlights the activities of the U.S. Coral Reef Task Force (USCRTF) in 2002–2003 to promote understanding of coral reefs and to reduce the threats to these valuable marine ecosystems. The report provides summaries and examples of many of the activities conducted by USCRTF members and their extramural partners to fulfill the goals and objectives of the *National Action Plan To Conserve Coral Reefs* (2000) (the Plan) and the *U.S. National Coral Reef Action Strategy* (2002) (the Strategy). This report is not intended to be a comprehensive list of agency programs and activities directly or indirectly affecting coral reefs. More comprehensive information on USCRTF accomplishments and future challenges can be found on the USCRTF website (<http://www.coralreef.gov>) or by contacting USCRTF members directly.



The report follows the 13 goals of the Plan and the Strategy to reduce threats to coral reef ecosystems worldwide:

- Create comprehensive maps of all U.S. coral reef habitats.
- Conduct long-term monitoring and assessments of reef ecosystem conditions.
- Support strategic research to address the major threats to reef ecosystems.
- Increase understanding of the social and economic factors of conserving coral reefs.
- Improve the use of marine protected areas to reduce threats.
- Reduce adverse impacts of fishing and other extractive uses.
- Reduce impacts of coastal uses.
- Reduce pollution.
- Restore damaged reefs.
- Improve education and outreach.
- Reduce threats to coral reef ecosystems internationally.
- Reduce impacts from international trade in coral reef species.
- Improve coordination and accountability.

As called for by the Coral Reef Conservation Act of 2000 (Pub. L. No. 106–562; 16 U.S.C. §6401 et seq.), the report addresses each goal and charts annual funding by federal agencies for activities directly related to the Strategy. It also presents a brief analysis of the future challenges facing coral reef ecosystems and the communities that depend on them. Appendix A lists federal obligations totaling \$177.29 million for coral reef conservation in 2002, \$163.59 million in 2003, and \$200.50 million in 2004. Appendix B (only available online at <http://www.coralreef.gov>) provides a more comprehensive list of USCRTF activity highlights.

Due to partnerships among USCRTF members and the involvement of nongovernmental organizations, much progress has been made to meet the Strategy’s goals and objectives. These partnerships have been successful at leveraging funding and resources to better understand and address threats to coral reef ecosystems, and thus partnerships are a major focus of this report and are included as highlights wherever possible.

Some highlights of USCRTF member activities in 2002–2003 include:

Mapping all shallow coral reefs. The USCRTF’s goal is to produce comprehensive digital maps of all U.S. shallow coral reefs (<30 m) by 2009. Between 2002 and 2004, the percentage of mapped areas increased from 35 to 66 percent. In addition,

new tools, including the Draft Northwestern Hawaiian Islands (NWHI) Atlas, are being created to give managers much needed habitat information for improved management.

Monitoring coral reef health. In 2002–2003, more than 50 monitoring activities were supported by USCRTF organizations and significant advances were made toward a national coral reef monitoring system. The National Oceanic and Atmospheric Administration (NOAA) partnered with other federal agencies to expand its Pacific coral reef ecosystem monitoring to American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI). The first *State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States* (Turgeon et al. 2002) assessed the condition of U.S. coral reefs, ranked threats in 13 geographic areas, detailed ongoing conservation actions taken by USCRTF agencies, and provided recommendations from coral reef managers to fill information gaps. The second biennial report, scheduled for publication in summer 2005, will reflect more quantitative data obtained through collaborative monitoring programs.

Research. USCRTF agencies and their partners have significantly expanded the understanding of processes affecting the structure, function, and health of coral reef ecosystems, which has improved coral reef ecosystem threat response and reduction. This increased understanding has improved the ability to respond to and reduce threats to coral reef ecosystems in some areas. For example, the Coral Disease and Health Consortium is coordinating scientific resources to investigate coral health, coral bleaching, and factors affecting the emergence, transmission, and impact of coral diseases.

Improving the use of coral reef-protected areas. New coral reef-protected areas were established or proposed in federal waters and several jurisdictions, including the U.S. Virgin Islands, Hawai'i, Puerto Rico, Florida, American Samoa, and the CNMI. In addition, management plan completion, regulation updates, and an increase in the capacity to implement enforcement and education efforts improved the effectiveness of existing coral reef-protected areas. NOAA, working with state and territory partners, is leading the first comprehensive, nationwide inventory and assessment of all U.S. coral reef-protected areas to identify key needs.

Reducing the adverse impacts of fishing. Since 2002, five of the seven U.S. states or territories with coral reefs have instituted new or revised fishery regulations to help restore and/or sustain coral reef fisheries. Actions were also taken to strengthen the management of coral reef fisheries in federal waters, including the implementation of the first Fishery Management Plan for Coral Reef Ecosystems of the Western Pacific Region and initiation of the process for establishing a new multi-jurisdictional fishery management plan in Biscayne Bay.

Reducing the impacts of coastal uses. Ship groundings and anchor damage continue to affect coral reef health throughout U.S. waters. USCRTF agencies have improved planning for and response to grounding events and implemented





measures to avoid vessel impacts by improving navigational aids and installing permanent moorings that obviate the need to anchor on coral reefs. For example, in 2002 and 2003, NOAA, the U.S. Coast Guard, and state and territory agencies completed an inventory of existing grounded vessels on U.S. coral reefs to help managers identify and prioritize vessels for removal.

Reducing the impacts of pollution on reefs. Land, sea, and air pollution continue to seriously affect coral reef ecosystems. Many actions have been taken to reduce these impacts, including removing more than 220 tons of fishing nets and other debris from the NWHI coral reef ecosystem and designating all state waters within the boundary of the Florida Keys National Marine Sanctuary as a no-discharge zone for vessel sewage.

Reducing the impacts from international trade. Since 2001, the United States has helped many countries address the adverse impacts of international trade on their coral reef ecosystems by assisting in identifying strategies to mitigate overfishing and destructive fishing and by collecting rare, threatened, or endangered species. These programs have strengthened implementation of sustainable management plans, enforcement of relevant laws and regulations, development of environmentally sound collection practices and alternatives, and implementation of other measures that protect and conserve the coral reef ecosystems outside U.S. control.

Improving coordination and accountability. State and territory members of the USCRTF, with assistance from federal agency members, developed 3-year local action strategies to identify and implement priority actions to reduce land-based sources of pollution, overfishing, recreational misuse and overuse, lack of public awareness, disease, and coral bleaching and climate change—six key threats to coral reefs. To improve coordination in the Pacific, the USCRTF invited the Republic of Palau, the Republic of the Marshall Islands, and the Federated States of Micronesia to be observers on the Task Force. These efforts have increased collaboration and cooperation among partners at all levels, resulting in improved local action to protect valuable coral reefs.

The activities summarized in this report represent significant achievements by government and nongovernmental partners to reduce threats to reefs and conserve healthy, resilient coral reef ecosystems and the human communities that depend on them. However, these accomplishments represent only intermediate steps toward achieving the goals of the Strategy. Much remains to be done to halt the degradation of coral reefs and to sustain these valuable marine ecosystems and the economies that depend on them. Building on this foundation of achievement and collaboration, NOAA and the USCRTF are committed to continuing efforts to protect the Nation's valuable coral reefs and working with international partners to protect coral reefs worldwide.

Introduction



In the United States, coral reef resources provide economic and environmental benefits to millions of people in the form of food, jobs, natural products, pharmaceuticals, and shoreline protection. They help communities prevent coastal erosion and the fish species they sustain are a critical source of revenue for the Nation's fishermen. The intrinsic beauty of coral reefs and their spectacular biodiversity, attract thousands of tourists each year, which makes tourism the top industry in many coral reef areas. Perhaps most important, the biodiversity found in the Nation's coral reef ecosystems may hold the key to significant medical discoveries.

Coral reef ecosystems have survived for millions of years despite an abundance of natural disturbances. However, natural stressors are now being compounded by impacts from people including pollution, overfishing, physical damage, and contributions to climate change. A combination of stressors has caused a rapid decline in the health of many coral reef ecosystems globally, and, left unchecked, this decline could lead to significant social, economic, and environmental consequences.

In response to this growing crisis, Executive Order 13089 (1998) established the United States Coral Reef Task Force (USCRTF) to coordinate efforts to protect, restore, and sustain coral reef ecosystems. The USCRTF—composed of 12 federal agencies, 7 state and territory partners, and 3 non-voting Freely Associated States—is directed to oversee implementation of the policy and federal agency responsibilities set forth in the Executive Order and to guide and support activities under the U.S. Coral Reef Initiative. USCRTF duties range from planning and priority setting to assisting and coordinating member activities.

Since its inception, the USCRTF has been an important catalyst for federal, state, territory, and local action. By increasing collaboration among federal, state, territory, and local agencies; nongovernmental institutes and organizations; and international partners, the USCRTF has maximized limited funding and resources through joint planning and priority setting, leading to many of the activities that have benefited coral reefs over the past few years. With input from a wide variety of groups and interests, the USCRTF has led efforts to identify key threats

The U.S. National Coral Reef Action Strategy's 13 Goals for Addressing Threats to Coral Reefs Worldwide

Theme 1: Understand Coral Reef Ecosystems—

Better understanding of complex coral reef ecosystems will improve management and conservation of these valuable resources. The Strategy outlines the following major goals to increase understanding of coral reef ecosystems:

Goal 1: Create comprehensive maps of all U.S. coral reef habitat.

Goal 2: Conduct long-term monitoring and assessments of reef ecosystem conditions.

Goal 3: Support strategic research to address the major threats to reef ecosystems.

Goal 4: Increase understanding of the social and economic factors of conserving coral reefs.

Theme 2: Reduce the Adverse Impacts of Human Activities—Reducing the impacts of human activities is essential to conserving coral reef ecosystems. The

Strategy outlines the following major goals to reduce the adverse impacts of human activities:

Goal 5: Improve the use of marine protected areas to reduce threats.

Goal 6: Reduce adverse impacts of fishing and other extractive uses.

Goal 7: Reduce impacts of coastal uses.

Goal 8: Reduce pollution.

Goal 9: Restore damaged reefs.

Goal 10: Improve education and outreach.

Goal 11: Reduce threats to coral reef ecosystems internationally.

Goal 12: Reduce impacts from international trade in coral reef species.

Goal 13: Improve coordination and accountability.



to U.S. coral reef ecosystems (see table 1) and to develop local and national action strategies addressing these threats. USCRTF member agencies and their partners have, in turn, coordinated efforts to carry out these actions.

USCRTF developed the *National Action Plan To Conserve Coral Reefs* (2000) in response to Executive Order 13089. The Plan serves as a blueprint to counteract the continued destruction of coral reef ecosystems and identifies 2 overarching themes and 13 goals with related objectives outlining the main threats to coral reef ecosystems and key actions to help reduce these threats. NOAA, in cooperation with the USCRTF, published *A National Coral Reef Action Strategy* (2002), as required by the Coral Reef Conservation Act

(CRCA), Pub. L. No. 106–562; 16 U.S.C. § 6401 *et seq.* The Strategy is based on the framework presented in the Plan and provides information on the major threats and needs in each jurisdiction, tracks progress in achieving USCRTF goals and objectives, and identifies priority actions needed to achieve the goals and objectives.

Starting two years after the publication of the Strategy and every 2 years thereafter, CRCA requires NOAA to submit a report describing all activities undertaken to implement the Strategy, including a description of the funds obligated each fiscal year to advance coral reef conservation. This report, *Implementation of the National Coral Reef Action Strategy*, fulfills this requirement and includes highlights of the full range of USCRTF

Table 1: Ranking of Major Threats to Coral Reef Ecosystems by Region

This table is a general summary of the relative impact of natural and human-related threats to coral reef ecosystems in the United States and Freely Associated States in 2002 and 2004, based on expert opinion of coastal managers within the jurisdictions. These threat levels may vary over time to reflect changes in natural and anthropogenic impacts or to incorporate new information about impacts.

Perceived Threat Level	Region																													
	U.S. Virgin Islands		Puerto Rico		Navassa		Florida		Flower Gardens NMS		Main Hawaiian Islands		Northwestern Hawaiian Islands		American Samoa		U.S. Remote Insular Areas		Republic of the Marshall Islands		Federated States of Micronesia		Northern Mariana Islands		Guam		Republic of Palau			
	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004	2002	2004
Climate change and coral bleaching	M	M	M	M	NA	L	H	H	L	L	L	M	L	M	M	H	M	M	H	H	M	L	M	M	L	H	H	H	H	
Diseases	H	H	H	M	NA	M	H	H	L	L	L	M	L	L	L	M	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Tropical storms	H	H	L	M	NA	M	M	M	L	L	L	L	L	L	M	M	L	L	M	M	L	L	M	M	M	M	L	L	L	L
Coastal development and runoff	H	H	H	H	NA	L	H	H	L	L	H	H	L	L	H	H	L	L	M	M	H	H	H	M	H	H	H	H	H	H
Coastal pollution	H	H	H	M	NA	L	H	H	L	L	H	H	L	L	H	M	L	L	L	L	M	L	H	M	H	H	H	H	L	L
Tourism and recreation	M	H	M	M	NA	L	M	M	L	L	H	H	M	L	L	L	L	L	L	L	L	L	M	L	M	H	M	M	M	M
Fishing	H	H	H	H	NA	H	H	H	L	M	H	H	M	M	H	H	M	M	M	M	H	H	M	M	M	H	M	M	M	M
Trade in coral and live reef species	L	L	H	M	NA	L	M	M	L	L	H	H	M	L	M	L	L	L	H	M	L	L	L	L	L	L	L	L	L	L
Ships, boats, and groundings	H	H	M	M	NA	L	H	H	M	M	H	M	H	M	M	L	M	M	L	L	H	H	M	M	M	M	M	M	M	L
Marine debris	L	M	M	L	NA	L	M	M	L	L	M	M	H	H	L	L	M	M	L	L	H	L	M	L	L	M	M	M	L	L
Aquatic invasive species	L	L	L	L	NA	L	M	M	M	M	H	H	H	L	M	L	M	L	M	M	L	L	L	L	L	L	L	M	L	L
Security training activities	L	L	H	L	NA	L	L	L	L	L	M	M	L	L	L	L	L	L	L	L	L	L	H	M	L	L	L	L	L	L
Offshore oil and gas exploration	L	L	L	L	NA	L	L	L	M	M	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Other	L	L	H	L	NA	L	L	M	L	L	M	L	L	L	L	M	H	M	L	L	M	L	H	H	L	L	L	L	L	L

H = High priority threat

M = Medium priority threat

L = Low priority threat

Source: Waddell 2005: *State of Coral Reef Ecosystems of the United States and the Pacific Freely Associated States: 2004*. NOAA/NCCOS



member activities addressing the threats to coral reef ecosystems.

This report is organized by the Strategy's 13 goals and their related objectives. Each chapter is arranged by the following framework:

- **Rationale for Action**—describes the justification for each goal.
- **Summary of Implementation**—provides an overview of the types of activities conducted by USCRTF members and partners during 2002–2003 to address each goal.
- **Highlights of Task Force Member Activities**—lists USCRTF members' major accomplishments by goal objectives. Many of the activities highlighted represent activities conducted in conjunction with other agencies at the federal, state, territory, and local levels; academic institutions; nongovernmental organizations; and others.
- **Future Challenges**—describes obstacles that need to be addressed and future activities required to better address the goals.

This report was produced in collaboration with members of the USCRTF and its partners to provide a summary of activities implemented in 2002–2003 that helped fulfill the goals and objectives of the Strategy. This report is not intended to be a comprehensive list of agency programs and activities directly or indirectly affecting coral reefs. More comprehensive information on USCRTF accomplishments and future challenges can be found on the USCRTF website (<http://www.coralreef.gov>) or by contacting USCRTF members directly. The vast majority of the activities outlined in this report have been accomplished through partnerships and have resulted in on-the-ground achievements in key issues such as capacity building, effective use of marine protected areas, and education and outreach.

Coral reef ecosystems face increasing pressures. However, as this report demonstrates, the USCRTF and its partners remain committed to identifying and reducing the threats to coral reefs and conserving healthy and resilient coral reef ecosystems for current and future generations.

Mapping U.S. Coral Reefs

GOAL: Produce comprehensive digital maps of all shallow coral reef ecosystems in the United States and characterize priority moderate-depth reef systems by 2009.



Rationale for Action

Accurate geo-referenced information on the location of specific natural resources and habitat types is important for effectively managing marine habitats. This need is particularly acute for coral reef ecosystems because the consequences of misinformed management decisions can have significant and lasting socioeconomic and ecological consequences. The USCRTF made mapping U.S. shallow-water

reefs a high priority, with a goal of producing comprehensive, digital maps of all U.S. shallow-water coral reefs by 2009. However, many coral reef ecosystems in U.S. waters, particularly in the Pacific Ocean and moderate-depth water (30–200 meters), still need to be accurately mapped and characterized using modern techniques at a scale useful to managers and the public addressing conservation issues. Current, accurate, and consistent maps will greatly enhance

OBJECTIVES

OBJECTIVE 1: Develop high-resolution benthic maps of local and regional coral reef ecosystems using imagery from satellites and aircraft and *in situ* surveys. The mapping activities include MPAs, reefs at risk of degradation due to human activities, and other priority sites identified by the U.S. Islands representatives.

OBJECTIVE 2: Develop large-scale, low-resolution maps of broad coral reef ecosystems throughout U.S. waters using satellites and other remote sensing assets for use in characterizing habitats, designing monitoring programs, and planning such regional conservation measures as MPAs.

OBJECTIVE 3: Develop and adapt new technologies and data sources to increase mapping efficiency while maintaining accuracy; enhance coral reef ecosystem mapping, survey, and assessment capabilities; and, if possible, detect important ecological changes and trends.

OBJECTIVE 4: Characterize priority deep-water reefs (moderate-depth reefs, 30–200 meters) and associated habitats.



efforts to conserve and manage coral reef ecosystems throughout the United States.

Comprehensive maps and habitat assessments assist a variety of conservation measures, including:

- Creation of accurate baselines for long-term monitoring;
- Characterization of habitats for place-based conservation measures (e.g., marine protected areas [MPAs]); and
- Enhancement of scientific understanding of the large-scale oceanographic and ecological processes affecting the health of reef ecosystems.

Comprehensive maps can also be used to illustrate trends in coral reef health over time by providing a geo-referenced tool to track disease and invasive species and documenting loss of habitat and reef-dependent species.

The USCRTF has committed to the production of comprehensive digital maps of all U.S. shallow (less than 30 meters) coral reefs and to the characterization of priority moderate-depth reef systems by 2009. Coral reef mapping efforts are coordinated through the USCRTF Mapping and Information Synthesis Working Group, which consists of representatives from NOAA, the U.S. Geological Survey (USGS), the National Aeronautics and Space

Table 2. Status of Shallow-Water Coral Reef Ecosystem Mapping Activities in Tropical and Subtropical U.S. Waters^a

	Total area mapped (km ²) ^b	Area mapped outside 10-fm depth curve (km ²) ^b	Area mapped inside 10-fm depth curve (km ²) ^b	Unmapped area inside 10-fm depth curve (km ²) ^b	Percentage of total estimated area mapped ^c
Puerto Rico	2,297	460	1,837	465	83
U.S. Virgin Islands	488	170	318	26	95
Southern Florida	0	0	0	0	–
Hawai'i (main islands)	812	131	681	551	60
Northwestern Hawaiian Islands	2,360	1,125	1,235	2,194	52
American Samoa	72	32	39	13	85
Guam	105	21	84	7	94
Northern Mariana Islands	204	93	111	12	94
U.S. Flag Islands (e.g., Palmyra, Navassa)	0	0	0	0	–
Republic of Palau	0	0	0	0	–
Federated States of Micronesia	0	0	0	0	–
Republic of the Marshall Islands	0	0	0	0	–
Total	6,338	2,032	4,305	3,268	66

^a Mapping activity refers to the transformation of data or imagery into a shallow-water benthic habitat map depicting geomorphology, zonation, biological cover, and associated assessments of the thematic accuracy of the map.

^b Depth-curve information derived from NOAA nautical charts. In clear water, seafloor features can be mapped in water up to 15 fm deep. Because of water quality, clouds, cloud shadows, and other factors, seafloor features in water less than 10 fm deep cannot always be mapped (10 fm is equivalent to 18.3 meters).

^c Percentage equals the area mapped divided by the sum of area mapped plus the unmapped area inside the 10-fm depth curve (10 fm = 18.3 m).

Administration (NASA), other federal and state agencies, and academic and nongovernmental organizations. Also, federal, state, and local agencies; universities; and the private sector continue to play an integral role in the production of both high- and low-resolution maps to meet management needs.

Summary of Implementation

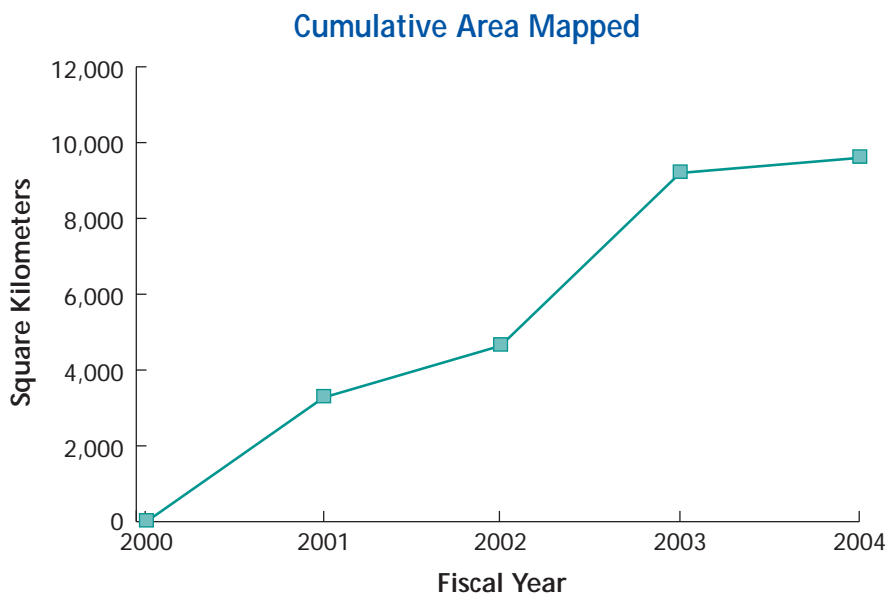
The comprehensive mapping program led by NOAA has used aerial photography and satellite images to create accurate benthic habitat maps that characterize more than 66 percent of the habitats of U.S. coral reef ecosystems in water less than 30 meters deep (see table 2 and figure 1). For some areas, shoreline maps, in addition to fine-scale maps

showing water depths (bathymetry), have been developed using light detection and ranging (LIDAR) technology.

As part of the mapping process, a habitat classification scheme is developed for each area, using similar classification schemes in different jurisdictions to allow for comparison. NOAA, in partnership with local management agencies and other partners, collects video imagery and diver ground-truthing of the shallow-water seafloor and uses them in the benthic habitat characterization process. For instance, scuba divers videotaped an estimated 8,000 linear kilometers of the seafloor around islands and atolls throughout the U.S. Pacific waters in 2002–2003. In southern Florida, more than 1,800 scuba dives have been performed along the reef tract. Examples of these classification schemes can be found online at <http://biogeo.nos.noaa.gov>.

Figure 1. Shallow-Water Coral Reef Area Mapped: 2000–2004

This graph shows the U.S. shallow-water coral reefs (less than 30 meters in depth) mapped since 2000. Currently, 9,598 square kilometers of U.S. coral reefs in shallow water have been mapped. Of this area, 6,338 square kilometers have been classified in habitat maps. The remainder is classified as unknown for various reasons.



Each map product is provided to the user community for evaluation and accuracy assessment. Independent contractors, such as the University of Hawai'i, evaluate the accuracy of the maps, while individuals from academia, state and territory management agencies, federal partners, and appropriate nongovernmental groups conduct user evaluations of the mapping products. Map products are generally 80 to 95 percent accurate, depending on the variety of benthic habitats found at each location.

In addition to efforts to map shallow-water coral ecosystems, NOAA, USGS, and academic partners are also mapping priority moderate-depth coral reef ecosystems identified by the fishery management councils as important habitat for many commercial reef fish species. Mapping moderate-depth reefs primarily involves using multibeam sonar technology in which sound waves emitted from a ship are reflected from the seafloor to provide information about the depth and character of the seafloor. A recent inventory indicates depth data have been collected for, at most, 20 percent of the moderate-depth areas in the U.S. Pacific waters, with emphasis on the Northwestern Hawaiian Islands (NWHI), Commonwealth of the Northern Mariana Islands (CNMI), and American Samoa (see table 3). Bathymetry data have also been collected around Florida in the U.S. Caribbean, but a similar inventory has not been completed for these regions. The collection of data for seafloor characterization requires ships capable of launching remotely operated vehicles (ROVs) and other advanced underwater technologies in combination with still and video

imagery. Due to specialized equipment requirements, the extent of seafloor characterization at these depths lags far behind bathymetry data collection. NOAA and USGS have generated benthic habitat maps of portions of the West Florida Shelf, the NWHI, Moloka'i, and O'ahu. NOAA and USGS are also undertaking an inventory of the distribution and status of known deep-water coral (cold-water coral) ecosystems occurring throughout the U.S. economic exclusive zone.

The shallow-water benthic habitat maps and their associated imagery and metadata are available to researchers and management agencies on CD-ROM and on the Internet at <http://biogeo.nos.noaa.gov> and <http://www.coris.noaa.gov>. These products are being used in a variety of ways to support coral reef management. For example, completed map atlases for Puerto Rico are helping researchers and resource managers study habitat suitability and MPA placement in southwestern Puerto Rico. Map atlases for the U.S. Virgin Islands (USVI) are being used to assess the impact of an expansion of the

Table 3. Status of Pacific Moderate-Depth Data Collection Efforts Using Ship-Based Technologies

	Area where bathymetry data have been collected (km ²) ^a	Potential coral ecosystem area inside 10-fm depth curve (km ²) ^b	Potential coral ecosystem area inside 100-fm depth curve (km ²) ^b
Hawai'i (main islands)	0	1,231	6,666
Northwestern Hawaiian Islands	70,019	1,595	13,771
American Samoa	271	55	464
Guam	26	108	276
Northern Mariana Islands	218	124	476
U.S. Pacific Flag Islands	0	252	436

^a Multibeam data provide important information about seafloor features. These data, in combination with such optical information as video or other imagery are used to develop benthic habitat maps.

^b Depth-curve information derived from NOAA nautical charts. Estimated coral ecosystem area for the Republic of Palau, the Federated States of Micronesia, and the Republic of the Marshall Islands derived from Landsat satellite imagery.

Buck Island Reef National Monument, assess the creation of the Virgin Islands Coral Reef National Monument and the Salt River National Park in St. Croix, and characterize the status of coral ecosystems and associated fisheries in the Virgin Islands National Park in St. John.

The map atlas covering 60 percent of the Main Hawaiian Islands is being used to assess the spatial characteristics and location of Marine Life Conservation Districts in Hawai'i and identify gaps in coral reef management areas. Moreover, USGS is using satellite imagery to map and study transport patterns of sediment in reef systems of some Hawaiian islands and to study potential impacts of these sediments on coral reef health.

Highlights of Task Force Member Activities

OBJECTIVES 1 & 2: Develop high-resolution benthic maps of local and regional coral reef ecosystems using imagery from satellites and aircraft and *in situ* surveys. The mapping activities include MPAs, reefs at risk of degradation due to human activities, and other priority sites identified by the U.S. Islands representatives. Develop large-scale, low-resolution maps of broad coral reef ecosystems throughout U.S. waters using satellites and other remote sensing assets for use in characterizing habitats, designing monitoring programs, and planning such regional conservation measures as MPAs.

Draft NWHI Atlas Is New Tool for Managers

In 2003, NOAA released the *Atlas of the Shallow-Water Benthic Habitats of the Northwestern Hawaiian Islands—Draft*, which provided baseline




Map products depict water depths and seafloor features in nearshore areas around the island of Ofu in American Samoa. Black areas indicate data "holidays" or areas for which no information was collected.

information on the locations and distributions of approximately 2,365 square kilometers of shallow-water reefs and other seabed features of the NWHI. The atlas is an integral tool in designing further research and management plans. The atlas and associated satellite imagery are being used to track marine debris deposition and removal, develop research mission plans, track the distribution of and gaps in tow-board data collection activities, monitor the impact of recent coral bleaching events, and provide an archive for future research and related activities. The benthic habitat maps and satellite imagery are being used to track and monitor the distribution and habitat use patterns of such protected species as the endangered Hawaiian monk seal and threatened sea turtles.

Revolutionary Map Helps Understanding of Global Coral Distribution

Through the joint efforts of NASA and NOAA, the first global map of tropical shallow water was created from nearly 44,000 SeaWiFS (Sea-viewing Wide Field-of-View Sensor) scenes. NOAA continues to work with the United Nations Environment Programme—World Conservation Monitoring



Centre to use these data to improve the ReefBase database of coral reefs. The maps are now available from the ReefBase website at <http://www.reefbase.org> and have been used to better understand the spatial distribution of coral reef ecosystems around the globe. These maps routinely appear in publications depicting the global distribution of coral ecosystems.

Data Provide Key Component of Southeast Florida Maps

The National Coral Reef Institute has produced detailed bathymetric data for a portion of southeast Florida reefs (up to 30.5 meters in depth) to serve as the base map for overlaying the results of biological and geological inventories, assessments, and monitoring. The maps integrate several available datasets, including aerial photography, LIDAR, and multibeam sonar, and will provide Florida with critical information to help it manage sensitive coral reef areas.

OBJECTIVE 3: Develop and adapt new technologies and data sources to increase mapping efficiency while maintaining accuracy; enhance coral reef ecosystem mapping, survey, and assessment capabilities; and, if possible, detect important ecological changes and trends.

New Airborne LIDAR Significantly Improves Capabilities

In September 2003, USGS tested a new underwater video system designed for rapid ground-truthing of habitat maps derived from remote sensing data. Using this new technology, USGS created fine-scale preliminary topographic maps for coral reefs in Biscayne National Park and portions of the northern Florida Keys. USGS scientists in collaboration with NASA are also mapping coral reef ecosystems using the Experimental Advanced Airborne Research LIDAR (EAARL). EAARL is a new

airborne LIDAR that provides unprecedented capabilities to survey coral reefs in water 10 meters or less in depth, nearshore benthic habitats, coastal vegetation, and sandy beaches.

New Index Provides Critical Habitat Information

NOAA has established an Acoustic Complexity Index for identifying essential fish habitats. When areas of Florida's reef tract were mapped using an advanced seabed classification system, results showed that areas with a moderate to high abundance of grouper were acoustically complex (i.e., they returned highly variable acoustic waveforms over short spatial scales). Few to no grouper were found in areas with low acoustic complexity; however, grouper were found in greater numbers in areas with high acoustic complexity. This "Acoustic Complexity Index" will help identify essential grouper habitats that need to be protected and conserved to address overfishing.

OBJECTIVE 4: Characterize priority deep-water reefs (moderate-depth reefs, 30–200 meters) and associated habitats.

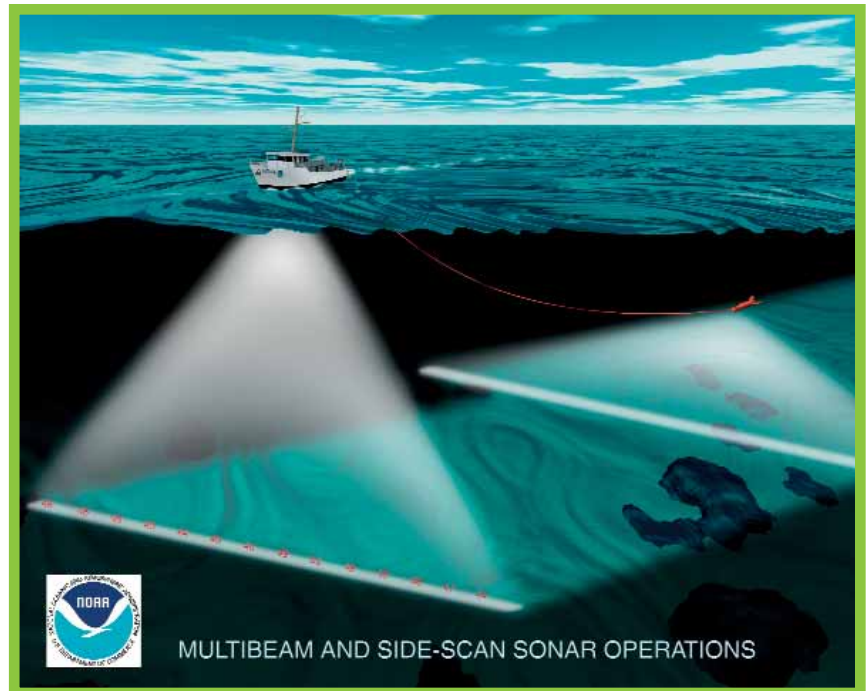
Discovery in Florida Leads to New Conservation

During a recent USGS/NOAA/University of South Florida multibeam cruise, scientists discovered and mapped approximately 16 square kilometers covered with 50 to 90 percent live coral in 70 to 80 meters of water on Pulley Ridge, an area on the southwest Florida shelf. Such extensive coral cover at these depths is unprecedented for hermatypic (reef-building) coral growth. (In comparison, Florida's shallow reefs typically have less than 10 percent live coral.) These moderate-depth corals may be key habitats for certain commercial fisheries and may seed the shallower reefs in the Florida

Keys. Sixty-six fish species have been identified, including deep-water and commercial species and those typical of shallow-water coral reefs. DNA testing is underway to determine the relationship between these moderate-depth corals and shallower corals of the Florida Keys. Initial results were presented to the Gulf of Mexico Fishery Management Council during July 2003. As a result, the 4,828-square-kilometer study area encompassing Pulley Ridge is being considered for designation as a fisheries Habitat Area of Particular Concern.

Study Offers New Information on Biology and Habitat in USVI Waters

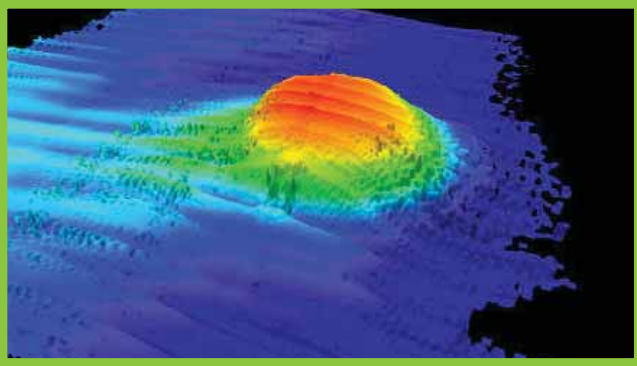
In March 2004, the National Park Service (NPS), NOAA, USGS, the USVI, and non-governmental organizations conducted moderate-depth biological and bathymetric characterizations of the Coral Reef National Monuments at Buck Island, St. Croix, and off the south shore of St. John. The study used ship-based multibeam and backscatter (a mapping technique that analyzes the strength of the echo once a sound wave hits a bottom surface) sonar technologies to identify benthic habitats. The associated biological resources were characterized using scuba-based visual census techniques and by trapping reef fish. The biological resource information will be combined with the seafloor characterization data to better understand the habitat use patterns and requirements of fish and other organisms found in these areas. A better understanding of these relationships will improve management and conservation efforts.



Several acoustic-based instruments mounted on NOAA vessels collect information about nearshore seafloor features and habitats.

Cruise of the NWHI Contributes to Atlas

NOAA and its partners, including Hawai'i and the U.S. Fish and Wildlife Service (USFWS), have released a plan to comprehensively map the moderate-depth coral reef ecosystems of the U.S. Pacific Ocean starting with the NWHI. In 2002, a 25-day cruise mapped critical boundaries in the area. Data collected were incorporated into the *Bathymetric Atlas of the Northwestern Hawaiian Islands: A Planning Document for Benthic Habitat Mapping* and are available online at <http://crei.nmfs.hawaii.edu/BathyAtlas>. Additional seafloor characterization imagery will be collected using various technologies, such as drop cameras, towed video cameras, ROVs, and other advanced underwater technologies. The data and additional imagery will be combined to create habitat maps that will then be used in coral reef fishery management plans.



A previously uncharted seafloor feature within the Midshelf Reef complex south of St. John, USVI was detected by a multibeam sonar instrument during a collaborative mapping expedition in early 2004.

Future Challenges

Shallow-water benthic habitat mapping. Over the next several years, USCRTF agencies plan to complete shallow-water maps of coral reef ecosystems in the United States, its territories and flag islands, and, possibly, the Freely Associated States (i.e., the Republic of Palau, the Republic of the Marshall Islands, and the Federated States of Micronesia) in the Pacific. Final benthic habitat maps for American Samoa, Guam, and the CNMI were completed in 2004. The Main Hawaiian Islands mapping project produced draft maps of 60 percent of

nearshore areas in 2003 and is expected to produce more complete draft habitat maps in 2006. In 2004, NOAA and its partners initiated a project to remap the coral reef ecosystems of southern Florida. The original maps were compiled using imagery collected in 1991–1992 and contain significant gaps. In 2005, NOAA and its partners plan to create a mapping implementation plan for southern Florida. In addition, a mapping effort may be initiated in the Freely Associated States. NOAA and its partners plan to map 40 percent of Palau and create a mapping implementation plan for the other Freely Associated States in 2005, contingent on funding.

Moderate-depth coral reef ecosystem mapping. The USCRTF has also set the goal of characterizing priority U.S. moderate-depth coral reef ecosystems by 2009. Mapping these ecosystems, especially those in remote locations, poses future challenges. New techniques will need to be developed to combine the moderate-depth bathymetry with moderate-depth seafloor characterization data to produce maps. The development of new technologies may help close gaps and provide managers with current, integrated data. At present, NOAA and its partners are working to map the moderate-depth reefs in the USVI National Monuments.

Monitoring Coral Reef Health



GOAL: *Establish a nationally coordinated, long-term monitoring program to assess the condition of U.S. coral reef ecosystems by linking new efforts to successful, ongoing programs.*

Rationale for Action

Successful coral reef ecosystem conservation calls for management that is responsive to changes in environmental, economic, and social conditions. Such management requires implementation of monitoring programs capable of measuring and tracking indicators of ecosystem conditions over time. Integrated monitoring programs will also help assess the efficacy of management actions (e.g., no-take reserves, fishing gear restrictions, habitat restoration efforts) and provide

comparable data sets and products that can be used to adapt these measures.

The USCRTF's *National Action Plan To Conserve Coral Reefs* (2000) recommended establishing a nationally coordinated, long-term monitoring program for all U.S. coral reef ecosystems and developing mechanisms to disseminate the information to all users. The USCRTF considered this a priority action because no such coordinated monitoring program existed at the time. Since 2000, many USCRTF members have been working to realize this

OBJECTIVES

OBJECTIVE 1: Working closely with partners and stakeholders, develop and implement a nationally coordinated, long-term program to inventory, assess, and monitor U.S. coral reef ecosystems.

OBJECTIVE 2: Develop a web-enabled data management and information system for U.S. reef monitoring and

data mapping with user-friendly GIS-based mapping and querying capability to present complex information in usable formats to all potential users while ensuring the security of sensitive place-based biological or cultural resource data.

OBJECTIVE 3: Develop and produce a biennial report on the state of U.S. coral reef ecosystems.



goal. Ultimately, this collaboration will allow the Nation to:

- Assess the current status of ecologically and economically important reef species and habitats;
- Track changes to species and habitats in response to environmental stressors and human activities;
- Evaluate the effectiveness of specific management strategies; and
- Forecast future conditions in a consistent manner to help design and evaluate effective management actions.

Summary of Implementation

USCRTF member organizations and their extramural partners have made progress in developing and

implementing a nationally coordinated, long-term monitoring program with emphasis on *in situ* monitoring conducted by the states and territories. The program aims to assist each jurisdiction in monitoring key parameters of water quality for benthic habitats and organisms (e.g., coral and algal cover), and associated biological communities (e.g., reef fish) identified as necessary for understanding the health of reef ecosystems (see table 4). Increasingly, these jurisdictions are also incorporating monitoring of meteorological and oceanographic variables. State agencies and academic partners have refined their monitoring approaches and increased the substantive and geographic coverage of these activities with grant and technical support from NOAA and the Environmental Protection Agency (EPA). Developed to meet the needs of local managers, these long-term monitoring efforts generally focus on populated coastlines where management is needed, and are

Table 4. Summary of Coral Reef Conservation Program State and Territory Coral Reef Ecosystem Monitoring Activities: 2000–2003

Overall program goals include support of water quality, benthic habitat, and associated biological community monitoring in all regions.

	2000			2001			2002			2003		
	Water quality	Habitat	Biological	Water quality	Habitat	Biological	Water quality	Habitat	Biological	Water quality	Habitat	Biological
American Samoa			X			X		X	X	X	X	X
Northern Mariana Islands		X		X	X		X	X	X	X	X	
Guam	X			X			X	X		X	X	X
Hawai'i		X	X		X	X		X	X		X	X
Florida								X	X		X	X
Puerto Rico		X	X		X	X		X	X		X	X
U.S. Virgin Islands		X	X		X	X		X	X		X	X
Freely Associated States									X	X	X	X

increasingly being refined to allow comparisons on a national level.

This baseline monitoring is complemented by a variety of other efforts including *in situ* monitoring in national parks, national wildlife refuges, and national marine sanctuaries by the U.S. Department of the Interior (DOI), NOAA, and their partners. These protected marine areas often provide key opportunities for more intensive monitoring and for investigating the results of management measures. For example, some of the longest coral reef monitoring data sets are from the Virgin Islands National Park. Recently, the National Park Service and NOAA have collaborated on expanding these monitoring efforts. The Florida Keys National Marine Sanctuary (FKNMS) Program, in partnership with EPA, NPS, the State of Florida, and numerous academic and nongovernmental partners, has perhaps the most intensive coral reef monitoring program in the United States. U.S. Department of Defense (DoD) monitoring of reef resources within its jurisdiction provides an additional complement that can be integrated into the national system.

NOAA, the U.S. Fish and Wildlife Service (USFWS), and states and territories have partnered to develop robust monitoring of remote reef areas. In the Pacific, NOAA leads annual monitoring cruises to the Northwestern Hawaiian Islands (NWHI) and biennial cruises to the Commonwealth of the Northern Mariana Islands (CNMI) and Guam (first cruise in 2003), American Samoa, the U.S. Line and Phoenix Islands (2002 and 2004), and Johnston Island (2004). In the Caribbean, NOAA and USFWS have collaborated on research and monitoring cruises to Navassa Island.


In 2002–2003, these collaborations covered a spectrum of monitoring and assessment activities ranging from the collection of large-scale, remotely sensed, near real-time measurements of oceanographic conditions to *in situ* monitoring of corals,



Scientists at work conducting multibeam mapping in the U.S. Virgin Islands in the dry lab of NOAA Ship *Nancy Foster*.

their associated biological communities, and the surrounding water quality. In 2002–2003, more than 50 complementary monitoring activities were supported by USCRTF organizations, including NOAA, DOI, DoD, EPA, states, territories, commonwealths, and the Freely Associated States. Furthermore, considerable support to monitor the Nation's coral reefs was made through contributions from nongovernmental organizations and private foundations (e.g., the Atlantic and Gulf Rapid Reef Assessment, Reef Environmental Education Foundation, and Reef Check Programs).

USCRTF satellite data collection monitoring is another source of critical information to coral reef managers in the United States and around the world. As part of the U.S. Integrated Earth Observation System, satellite remote-sensing technologies monitor sea surface temperatures and can therefore be used to help predict coral bleaching events on a global scale. These technologies are essential for monitoring on large spatial scales and for locations too remote to visit in a cost-effective manner. NOAA has partnered with other organizations to develop the Pathfinder Sea Surface Temperature project, a highly accurate record of



retrospective satellite-measured sea surface temperature being used to study subtle changes in ocean climate and reef conditions over time.

NOAA's Coral Reef Early Warning System (CREWS) deploys and maintains passive instrument arrays in domestic coral reef areas characterized by long-term monitoring and paleoclimatic information. CREWS instruments measure features of key coral reef areas to gain long-term, temporally intensive data coverage in near real-time. The developing and robust CREWS networks will establish long-term databases that coral reef marine protected area managers can use as tools in decision-making. Furthermore, data from these instruments can be used to validate satellite sea surface temperature products used for predicting coral bleaching.

Providing access to data is a key component of effective monitoring systems. To assist in delivery of this information, NOAA created the Coral Reef Information System (CoRIS), a web-enabled data and information access system for U.S. coral reef mapping, monitoring, and assessment. It will become the primary portal for NOAA coral reef information, and all programs that seek funding from NOAA's Coral Reef Conservation Program are obligated to provide data to CoRIS. CoRIS and the report on *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States* are, for the first time, providing a comprehensive outlook on U.S. coral reef ecosystems based on increasingly sophisticated monitoring programs.

Highlights of Task Force Member Activities

OBJECTIVE 1: Working closely with partners and stakeholders, develop and implement a nationally coordinated, long-term program to inventory, assess, and monitor U.S. coral reef ecosystems.

Long-Term Monitoring at the East and West Flower Garden Banks

In 1988, DOI's Minerals Management Service (MMS) initiated a monitoring program at the Flower Garden Banks, a coral reef area located approximately 100 miles southeast of Galveston, Texas. The monitoring program was designed to monitor the long-term general health of the banks and possible effects of offshore natural gas and oil operations. The Banks were designated a National Marine Sanctuary in 1992, and since then MMS has continued this monitoring as a cooperative effort with NOAA. To date, results show the reefs are healthy and growing. In 2002, the monitoring program was extended to deeper reefs, down to 130 feet, with results showing living coral cover averaging 70 percent. MMS uses the results of this monitoring for lease stipulations, protecting the coral from possible adverse impacts of nearby oil and gas developments.

Reef Assessment and Monitoring Program Links Efforts throughout the U.S. Pacific

Scientists from NOAA and USFWS have collaborated with other federal, state, and territory agencies; universities; and nongovernmental organizations to initiate a long-term, comprehensive program to assess and monitor the coral reef ecosystems of the

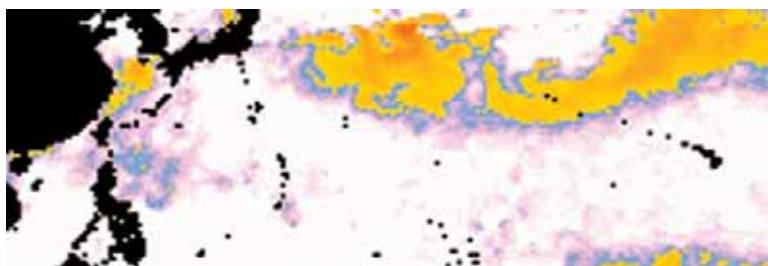
U.S. Pacific. Annual or biennial NOAA cruises have studied coral reef ecosystems of 42 islands, atolls, and reefs in the NWHI, American Samoa, Guam, the CNMI, and the remote National Wildlife Refuges in the Pacific, including sites explored for the first time, making this collaboration the most comprehensive, large-scale reef monitoring program in the world. Multidisciplinary monitoring efforts include detailed assessments of corals, other invertebrates, fish, and algae using a variety of methods.

Integration of concurrent observations of marine resources and their benthic and oceanographic habitats allows improved understanding of the spatial and temporal variability and complex biophysical linkages controlling these ecosystems. The program has greatly expanded the inventory of species known from these islands and discovered invertebrate and algae species new to science. Recent publications from the monitoring in the NWHI have quantified, for the first time, the high natural abundance of apex predators (and contrasted this with the depauperate state in the Main Hawaiian Islands) and their effects on prey fish; the importance of shallow, wave-protected microhabitats as nurseries for the juveniles of many species; and the relative importance of the three northernmost atolls as centers of endemism and recruitment sinks within the archipelago.

Over the past 4 years, these monitoring efforts have yielded 20 published manuscripts, 7 manuscripts in review, 13 manuscripts in preparation, 12 technical reports, and 61 oral presentations at scientific and resource management workshops and conferences. In October 2003, the USCRTF passed a resolution commending the Pacific monitoring program and calling for its continuation and expansion to the Freely Associated States.

Figure 2. Sea Surface Temperature Anomaly Map

An example of a sea surface temperature anomaly product used to convey potential bleaching events. This map of the Pacific Island region is a NOAA 50-kilometer HotSpot product for September 2002.



Near Real-Time Information Directs Field Monitoring Activities and Predicts Bleaching in the NWHI

In July 2002, NOAA's Coral Reef Watch (CRW) satellite and *in situ* sensors detected a sea surface temperature anomaly building in the central North Pacific Ocean (see figure 2). The anomaly grew as temperatures passed the threshold for coral bleaching at Midway Atoll National Wildlife Refuge on August 1 and remained above the threshold for more than a month. Based on the accumulated heat stress observed, CRW issued a coral bleaching warning on August 7. On September 8, NOAA, DOI, the State of Hawai'i, and other partners embarked on the fourth NWHI Reef Assessment and Monitoring Cruise. Although the CRW bleaching report did not instigate the cruise, the cruise plan was altered to focus attention on shallow reef habitats based on the reports. The fieldwork took place just 2 weeks after the thermal stress abated, and the scientists found evidence of extensive fresh coral bleaching at several atolls at the northwestern end of the island chain (Midway, Kure, and Pearl and Hermes). This first record of mass bleaching at these subtropical northerly reefs surprised many

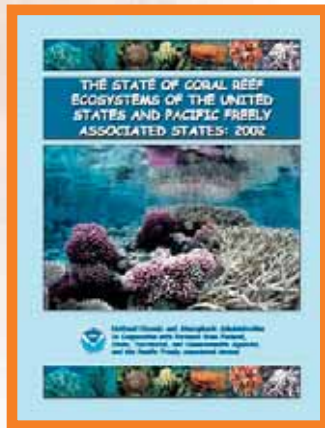
scientists although CRW had predicted the likelihood of the event. Documentation of this bleaching event has increased our knowledge of the resistance and resilience of different coral species and reef types in the NWHI and can assist in making management decisions as to which areas need increased protection.

FKNMS Zone Monitoring Program Completes Ecosystem Assessment

Data from the FKNMS Zone Monitoring Program, which is supported through NOAA and EPA, were used to complete an integrated assessment of the Florida Keys coral reef ecosystem in March 2003. This report presents results from 7 years of monitoring under EPA's Water

Quality Protection Program and 4 years of data from the FKNMS Zone Monitoring Program. The assessment addressed large-scale oceanographic processes, water quality trends, and the abundance, distribution, and community structure of coral, reef fish, and invertebrates. Additionally, the assessment included an analysis of long-term monitoring data collected in associated seagrass and other habitats. EPA and NOAA have also been collecting data on bleaching and disease through this program since 1997.

Much of the data was collected to assess the effects of zoning along the Florida Keys reef tract. For example, data collected on the density of yellow tail snapper showed that mean density of snapper was significantly higher in fully protected zones. This document stands as a model for collaborative integrated monitoring and its results will be used to compile the next biennial report on the state of



coral reef ecosystems. To view the full report, visit the FKNMS website at http://www.fknms.nos.noaa.gov/research_monitoring/welcome.html.

National Coral Reef Institute Expands Annual Monitoring in Florida

The National Coral Reef Institute, with funding from NOAA, is partnering with the State of Florida to conduct yearly monitoring at 10 permanent sites in Miami-Dade, Broward, and Palm Beach Counties. The monitoring follows the formal protocols developed by the Fish and Wildlife Research Institute (FWRI, formerly the Florida Marine Resource Institute) for the Coral Reef Evaluation and Monitoring Program (CREMP). The Florida Keys CREMP began in 1996 and is a cooperative program among NOAA, EPA, and FWRI. The expansion of CREMP to southeast Florida is closing monitoring gaps in Florida's coral reef ecosystems. NOAA has also expanded fish surveys to include these southeast Florida reefs. Data from the southeast CREMP will be incorporated into the current CREMP database, enabling reef researchers and state and county managers to better understand status and trends in Florida's coral reef system from the Dry Tortugas up to and including Palm Beach County.

OBJECTIVE 2: Develop a web-enabled data management and information system for U.S. reef monitoring and data mapping with user-friendly GIS-based mapping and querying capability to present complex information in usable formats to all potential users while ensuring the security of sensitive place-based biological or cultural resource data.

NOAA Unveils Comprehensive, Consolidated Website for Coral Reefs

In 2002, NOAA unveiled the Coral Reef Information System (CoRIS), a new data management system

and Internet site designed as a single access point for data and information on coral reefs. In the past, users faced a confusing array of more than 50 NOAA websites regarding coral reefs. Now all of the information is available on a single site. Backed by powerful search engines and keyword browse lists, CoRIS uses a GIS-enhanced information system to provide users with a single, easily accessible web portal to NOAA's coral reef resources. By cataloging and indexing metadata and summarizing data holdings, CoRIS guides users to the desired data and information and ensures the data will be available in the future.

The website provides access to more than 4,000 aerial photos of coral regions, bathymetric products, benthic habitat maps, fish census data, tide stations, paleoclimatological studies, photo mosaics, coral reef monitoring data, bleaching reports, and more, including links to non-NOAA information. Since CoRIS went online in late 2002, it has become a featured website in *Science* and was chosen as one of the December 2003 "Digital Dozen" (a list of 12 exemplary websites for educators selected by the Eisenhower National Clearinghouse). CoRIS can be accessed at <http://www.coris.noaa.gov>.



States and Pacific Freely Associated States, the first national assessment of the condition of U.S. coral reefs. The report identified increasing risks to reefs, particularly in certain hot spots located near population centers. In addition, the report indicated that every U.S. reef system suffers from both human and natural disturbances. Developed by 38 coral reef experts and 79 expert contributors, the report assessed the health of reef resources by ranking threats in 13 geographic areas and identifying ongoing management efforts. It established a baseline for subsequent biennial reports on the status of U.S. coral reefs, and the second biennial report is under development for release in summer 2005.

Future Challenges


Although implementing the Strategy has resulted in a wide range of monitoring activities conducive to integration (e.g., CoRIS, *The State of Coral Reef Ecosystems*), the degree to which these activities are unified is still relatively low. The many partners involved in coral monitoring are systematically working on remedies, including a measured and deliberate drive toward standardizing minimum parameters being measured by all programs in all locations.

Establish common monitoring parameters and indicators. To understand the status of coral reef resources on large spatial scales, track reef conditions over time and between sites and regions, and accurately forecast future conditions at an integrated nationwide level (e.g., U.S. coral reef ecosystems), it is necessary to conduct field monitoring in a consistent and comprehensive manner. This requires the use of monitoring protocols, parameters, and indicator species structured around methods that can be linked together to contribute to regional and global networks, while providing information needed for effective management at local levels. The actual protocols and methods depend on the information needed for the specific

OBJECTIVE 3: Develop and produce a biennial report on the state of U.S. coral reef ecosystems.

First National Assessment of U.S. Coral Reefs Released: Report Highlights Key Actions and Ranks Threats to Reefs

In 2002, NOAA and its USCRTF partners released *The State of Coral Reef Ecosystems of the United*



reef, size of the area, questions asked, and available financial and human resources. However, the protocols should include specific biological, physical, and socioeconomic indicators and data standards that can be easily monitored and reported in a national report on the state of U.S. coral reefs. The first step toward this goal requires multiagency roundtable discussions to develop a list of criteria, indicators, and an implementation plan. It is important to note that developing and implementing even a short list of standard protocols will require substantial investment.

Expand CoRIS. NOAA's CoRIS provides a powerful tool to access coral reef monitoring data. The value of this website will increase as it is expanded to include the full range of monitoring data and is linked to other data systems, including USGS's National Biological Information Infrastructure and the international ReefBase.

Integrate monitoring tools. Using available technologies is essential to integrating monitoring data

into a robust assessment of systemwide conditions. For example, NOAA, through its Coral Reef Ecosystem Integrated Observing System (CREIOS), which encompasses the CRW and CREWS initiatives, has developed software that links data from *in situ* platforms and satellites to provide information to coral reef management and research communities. CREIOS is working to integrate data from these instruments and field-based biological monitoring activities into an environmental decision support system. This collective monitoring network could be expanded beyond U.S. coral reefs to include stations in other countries, thereby making use of available cooperative instruments (e.g., World Bank/Global Environment Facility). Recognizing that the interconnectivity of reefs extends beyond mere political boundaries is an important step toward understanding the dynamics of coral systems and implementing effective management actions in the future.

Supporting Strategic Research

GOAL: *Provide coastal and ocean managers with scientific information and tools to help conserve, protect, restore, and sustain coral reef ecosystems.*



Rationale for Action

In general, coral reef and other natural resource managers are responsible for reducing or mitigating impacts of ecosystem stressors while balancing environmental, social, and economic goals. Achieving this balance requires an understanding of the stressors to coral reef ecosystems, the ability to predict how these systems will respond to natural and anthropogenic changes, the identification of possible management strategies to mitigate negative impacts, and an evaluation of the effectiveness of these strategies after

implementation. USCRTF research partners are committed to providing resource managers with science that is credible, relevant, and timely.

Strategic research enhances national, regional, and local capabilities to measure, understand, analyze, and forecast ecological change in response to natural and anthropogenic stressors. The goal of this research is to provide managers with tools to improve the integrity and sustainable use of the Nation's coral reef ecosystems. Such research requires a basic understanding of ecosystem structure, function,


OBJECTIVES

OBJECTIVE 1: Conduct a long-term regional and ecosystem-based research program to improve understanding of the processes that govern the structure, function, and health of coral reef ecosystems.

OBJECTIVE 2: Build capabilities to address such ecosystem-scale threats as disease, bleaching, and other sources of mass mortalities.

OBJECTIVE 3: Develop and transfer technology for faster and more accurate mapping, assessment, monitoring, and restoration.





productivity, and condition. It is also essential to understand the stressors contributing to declines in coral reef health and to analyze the social, economic, and institutional issues related to specific coral reef ecosystems.

Summary of Implementation

USCRTF members and partners, including NOAA, the U.S. Geological Survey (USGS), the National Park Service (NPS), the Environmental Protection Agency (EPA), the National Aeronautics and Space Administration (NASA), the U.S. Department of Defense (DoD), the National Science Foundation (NSF), and many partners at academic and private institutions are conducting short-term strategic and long-term ecosystem-based research to understand coral reef community dynamics, the impacts of anthropogenic and natural stressors, and effective management actions. Short-term research answers specific questions and provides coastal and resource managers with the tools to enhance their ability to effectively manage and protect local coral reef resources. USCRTF short-term research has contributed to:

- Improved understanding of direct and indirect causes of coral decline;
- Emphasis on process-oriented research to separate natural variation from anthropogenic changes;
- Identification of specific physiological parameters indicative of nonstressed and stressed coral conditions;
- Development of tools to predict bleaching and identify resilient sites; and
- Understanding of the genetic linkages among species and populations and their relationships with oceanographic processes.

Long-term studies enhance an understanding of linkages among species and habitats within coral

reef ecosystems, changes to these ecosystems resulting from natural and anthropogenic pressures, and the effects of management actions. Current efforts are providing the:

- Framework to determine the optimal placement, distribution, and size of marine protected areas (MPAs);
- Better understanding of the relationships between biodiversity and ecosystem function, including resistance and resilience to disturbances;
- Information on the processes affecting settlement and recruitment, growth and survival, movement patterns and ontogenetic shifts of ecologically and economically important coral reef organisms, and implications of management interventions; and
- Models to predict the cascading effects of zoning and other management measures on commercially and ecologically important reef fish and their habitats.

Highlights of Task Force Member Activities

OBJECTIVE 1: Conduct a long-term regional and ecosystem-based research program to improve understanding of the processes that govern the structure, function, and health of coral reef ecosystems.

Coral Reef Ecosystem Studies

In 2002, NOAA awarded grants to support two long-term regional Coral Reef Ecosystem Studies (CRES)—CRES Caribbean and CRES Micronesia. CRES Caribbean has begun to examine the effectiveness of MPAs, assess sedimentation and water

quality, and study reef demographics and community flux. Information from these studies will help local agencies develop and revise management efforts. CRES Micronesia (with a focus on Guam) is determining the classes and concentrations of coastal pollutants associated with watershed discharge of greatest concern to coral reef health. To develop integrated management schemes, this study is also collecting quantitative data on physical and chemical characteristics of coastal waters affected by watershed discharge.

USGS Tracks Sediment Movement on Reefs

As part of the Land-Based Sources of Pollution Local Action Strategy effort in Hawai'i, USGS is currently conducting studies to assess sediment movement from Maui and Moloka'i watersheds onto the surrounding reefs and to evaluate the impact this sediment has had on reef habitat. For example, results from the monitoring studies have established baseline rates at which sediment is transported during storm events. USGS researchers have found wave resuspension of sediment is a key process causing turbidity, which can be damaging to the reefs. USGS is also employing high-resolution mapping to provide baseline maps from which change over small areas (approximately 1 meter) and time frames (approximately 1 season) can be measured. Initial results suggest there is an extremely long residence time for sediment on the reefs. Even after implementation of conservation practices on land has decreased sediment delivery to surrounding reefs, reef recovery could take years.

Long-Term Studies on Ecosystem Dynamics

In 2002 and 2003, NOAA funded several multiyear research projects through its extramural partners



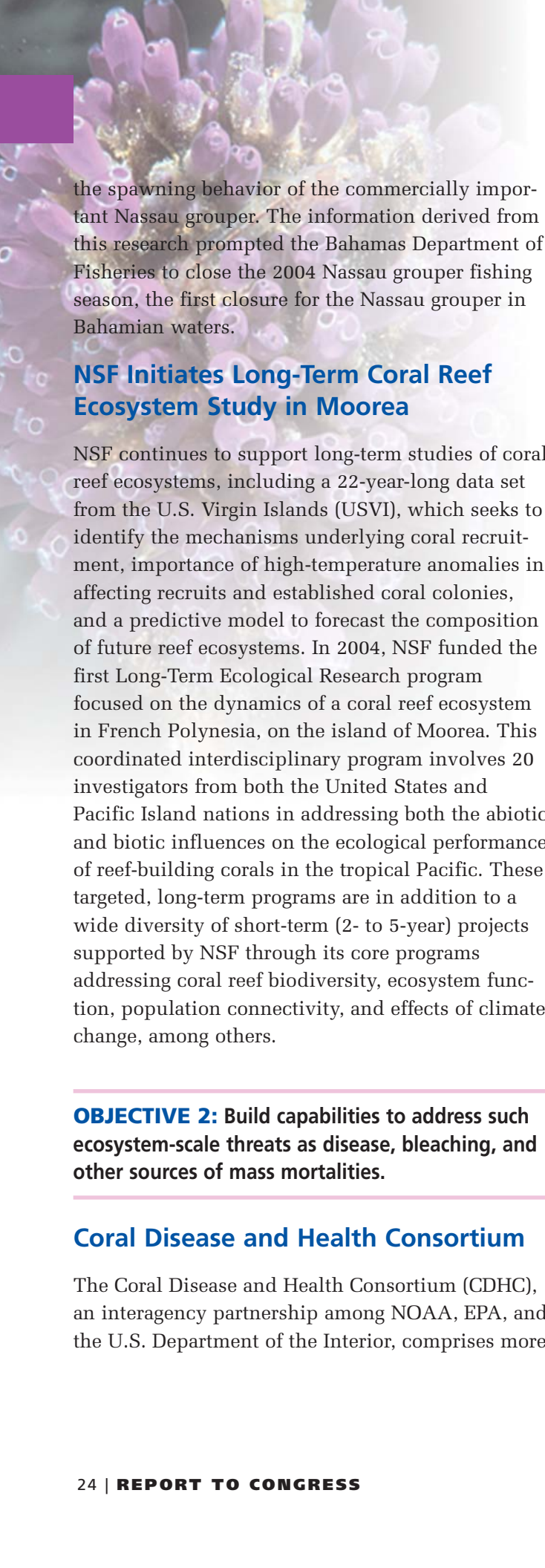
Students learn standardized approaches and techniques for laboratory studies on coral diseases at a molecular techniques workshop held in Hawai'i.

that focused on understanding coral ecosystem dynamics and the impacts of stressors, optimizing fish stocks, and designing and evaluating MPAs. Using NOAA's Aquarius operated by the University of North Carolina at Wilmington Undersea Research Program Center and located in the Florida Keys National Marine Sanctuary (FKNMS), scientists conducted research to:

- Determine whether recruitment and other demographic variables can help predict viability of coral populations;
- Understand the impact of currents on water quality and the degree to which nutrients and pollutants affect offshore coral reefs and seagrass beds; and
- Improve understanding of the effects of coral predation, bleaching, and disease on the condition of coral reef ecosystems.

In the waters surrounding the Caribbean Marine Research Center's Lee Stocking Island, Bahamas, scientists conducted long-term research focused on





the spawning behavior of the commercially important Nassau grouper. The information derived from this research prompted the Bahamas Department of Fisheries to close the 2004 Nassau grouper fishing season, the first closure for the Nassau grouper in Bahamian waters.

NSF Initiates Long-Term Coral Reef Ecosystem Study in Moorea

NSF continues to support long-term studies of coral reef ecosystems, including a 22-year-long data set from the U.S. Virgin Islands (USVI), which seeks to identify the mechanisms underlying coral recruitment, importance of high-temperature anomalies in affecting recruits and established coral colonies, and a predictive model to forecast the composition of future reef ecosystems. In 2004, NSF funded the first Long-Term Ecological Research program focused on the dynamics of a coral reef ecosystem in French Polynesia, on the island of Moorea. This coordinated interdisciplinary program involves 20 investigators from both the United States and Pacific Island nations in addressing both the abiotic and biotic influences on the ecological performance of reef-building corals in the tropical Pacific. These targeted, long-term programs are in addition to a wide diversity of short-term (2- to 5-year) projects supported by NSF through its core programs addressing coral reef biodiversity, ecosystem function, population connectivity, and effects of climate change, among others.

OBJECTIVE 2: Build capabilities to address such ecosystem-scale threats as disease, bleaching, and other sources of mass mortalities.

Coral Disease and Health Consortium

The Coral Disease and Health Consortium (CDHC), an interagency partnership among NOAA, EPA, and the U.S. Department of the Interior, comprises more

than 35 domestic and international partners. The partnership was formed at the recommendation of the USCRTF to organize and coordinate scientific resources and address ecosystem-scale threats to stony corals, such as disease and bleaching. NOAA convened the first CDHC workshop in January 2002 bringing together multidisciplinary field and laboratory scientists. At the workshop, scientists identified major gaps in the understanding of coral disease processes and identified and prioritized issue-driven research objectives to fill these gaps.

CDHC's *Coral Disease and Health: A National Research Plan* outlines strategic objectives, including:

- Creation of standardized terminology, methodology, and protocols;
- Research to define baseline measures of coral health, normal changes in physiology along environmental and physical gradients, and mechanisms of resistance and susceptibility to disease;
- Development of model coral species for controlled laboratory studies; and
- Development of diagnostic facilities, centralized data systems, and a website for information dissemination.

Implementation of the plan will improve understanding of the underlying mechanisms of coral pathologies. It will also increase the ability to manage coral diseases and bleaching by providing technical information on environmental and climatic stressors that may be mitigated through specific management actions and practical diagnostic tools. One example of a diagnostic tool is the *Field Guide to Western Atlantic Coral Diseases*, developed by NOAA to improve reporting of coral diseases by standardizing identification criteria and field nomenclature.

Rapid Response to Coral Disease Outbreak

A CDHC team, including ecologists and pathologists from DOI, EPA, NOAA, and the State of Florida, was mobilized in May 2003 in response to reports of a rapid die-off of *Acropora cervicornis*. Researchers conducted studies on the distribution and abundance of the event and its potential impacts on coral populations, collected samples for laboratory analysis, and recommended several potential management responses. The site was temporarily quarantined to reduce the potential for spread, and additional research is underway to understand the causes and consequences of the event.

Assessment of *Acropora* spp. Populations in the Caribbean

Populations of elkhorn coral (*Acropora palmata*) and staghorn coral (*A. cervicornis*) have declined drastically throughout the Caribbean region. In March 2005, these two species were proposed for listing as threatened under the Endangered Species Act. Ongoing monitoring efforts by USGS, NOAA, NPS, and other partners have documented losses of 80 to 98 percent of these species from a 1970s baseline. For instance, the aerial extent of elkhorn coral declined by 93 percent and staghorn coral declined by 98 percent between 1983 and 2000 within Looe Key National Marine Sanctuary, Florida. Although some areas in the USVI have experienced limited recovery since 2000 through sexual recruitment and the growth of fragments, others continue to show decline due to disease, predators, storms, and other factors. Between February 2003 and 2004, in the Virgin Islands National Park, 14 percent of monitored colonies died, 65 percent had disease, and 23 percent suffered broken branches. To assess potential recovery and population structure, NOAA scientists are examining genotypic diversity among

elkhorn stands throughout the Caribbean, and USGS and NOAA scientists and their partners continue to monitor *Acropora* spp. populations in Florida, Puerto Rico, and the USVI, with an emphasis on prevalence of disease and its cause.

Understanding Coral Resistance to Extreme Environmental Stress

USGS scientists are examining factors that enable corals to resist extreme environmental stress (e.g., temperature changes, wide ranges of dissolved oxygen, intense ultraviolet [UV] radiation) in the U.S. National Park in American Samoa. Examining corals transplanted into different stress conditions on the reef improves understanding of coral acclimatization, adaptation, and susceptibility to environmental stress, and the effects of water motion, dissolved oxygen, and habitat characteristics are being evaluated to help explain survival rates. The results of these studies may play an important role in designing coral reef protected areas to mitigate the effects of climate change on coral communities.

Statewide Resource Assessment and Monitoring Program for Alien Algae

The Hawai'i Coral Reef Initiative Research Program established a statewide resource assessment and monitoring program, completed the first assessments of alien algae, trained managers to identify problem species, and examined the relationship between water quality and the health of coral reef ecosystems. These efforts have resulted in an improved understanding of how nutrients and herbivorous fish affect the balance between algae and corals. To reduce the degradation of reef ecosystems, further work is needed to evaluate management measures that control land-based sources of pollution.





Atmospheric Dust Events Tied to Outbreaks of Disease

USGS scientists, along with their partners and collaborators, have been assessing the relationship between African dust storm events and the outbreaks of disease on reef systems in the Caribbean. A pathogenic strain of the fungus known to cause sea fan disease throughout the Caribbean region has been isolated from air samples collected in the USVI during African dust episodes. The fungus has also been isolated from lesions on diseased sea fans in the USVI and from soil in the Sahel, a region in Mali, Africa.

USGS has also been conducting studies that would ultimately enable researchers to hindcast global dust events by analyzing past coral skeleton growth. Overtime, seasonal fluctuations and specific environmental conditions are recorded in a coral's skeletal composition. USGS researchers have used high-resolution laser ablation techniques to measure up to 20 trace elements found in coral skeletons. These elements will help researchers determine past environmental events. USGS will continue to develop this technology and environmental interpretation over the next few years.

New Technology To Improve Scientific Modeling *In Situ*

The Submersible Habitat for Analyzing Reef Quality (SHARQ), developed and patented by USGS scientists, documents reef health. SHARQ helps quantify changes in water chemistry resulting from metabolism in the coral reef community. Researchers can change the environmental conditions of the submersible habitat to observe the response of the reef communities. Data from *in situ* experiments, combined with remotely sensed map data, are enabling scientists to model the effects of global climate change, turbidity, nutrients, temperature, and grazing on coral reefs.

Disease Prevalence Along South Florida

Since 1997, EPA with NOAA and Florida's FKNMS has surveyed coral bleaching and disease in the Florida Keys and Dry Tortugas. The assessments determine the frequency and distribution of coral disease, loss, and bleaching in the Florida Keys Reef Tract. Comparisons between different geographic zones and reef types have shown that back-reef corals near Key West and the Lower Keys have experienced the most serious declines. Since 2003, disease monitoring has included an assessment of coral size and the percent of partial mortality to better understand the ecological effects of disease. Continued assessments of coral health and prevailing physical, chemical, and biological parameters will help efforts to increase coral recovery and survival.

Understanding Coral Bleaching

EPA has initiated laboratory and field research to quantify the effects of temperature and solar radiation on coral physiology. Various coral species and coral symbionts are maintained in culture facilities and exposed to varying temperatures and doses of UV radiation. Research on coral symbionts demonstrates reduced growth rates at higher temperatures and an exacerbation of this effect by additional exposure to environmental levels of UV-B. This finding reveals an interactive effect of temperature and UV-B on coral symbionts that may lead to a bleaching response. UV-B attenuation in seawater is measured at various depths near coral reefs in the Florida Keys and has been found significantly altered by the amount of colored dissolved organic matter (CDOM) in the water column. This alteration in attenuation creates an added degree of vulnerability for corals exposed to UV-B because CDOM is derived from land (watershed) and seagrass sources. Information from these studies may be

used to justify management decisions to stop shoreline alterations and other deleterious activities that artificially modify the organic content in waters over reefs.

Basic Science of Coral Reef Diseases and Bleaching

NSF continues to fund a wide diversity of projects related to coral reef health through its core programs. In 2004, some of the new projects funded included:

- A study of the dynamics of the symbiosis between corals and their algal symbionts, including how this symbiosis is altered by stress;
- Biotic and abiotic factors influencing the establishment of fungal diseases of sea fans and sea whips;
- Research on the fine-scale flow of water through the branches of coral colonies;
- Emerging viral diseases in spiny lobsters on Florida coral reefs; and
- Mechanisms of dispersal, recruitment, and recolonization of coral larvae and coral reef fish larvae.

OBJECTIVE 3: Develop and transfer technology for faster and more accurate mapping, assessment, monitoring, and restoration.

Developing New Techniques To Rapidly Assess Coral Reef Health

DoD is developing advanced techniques to quickly and safely assess the viability and health of coral reef communities. DoD's Analysis of Biophysical, Optical, and Genetic Diversity of DoD Coral Reef

Communities Using Advanced Fluorescence and Molecular Biology Techniques project seeks to assess coral reef health by identifying and quantifying natural and anthropogenic stressors. It also seeks to assess coral reef health by collecting a library of baseline data on the physiological, biophysical, bio-optical, and genetic diversity of coral reef ecosystems near DoD installations. The non-destructive sampling technique will establish a relationship between the color proteins of coral and the physiological status of the reef to develop a spectroscopic index. The index will then be used to interpret spectral images collected by advanced fluorescence instruments mounted at permanent monitoring stations or adapted to remotely operated vehicles. By applying advanced technology to reduce the intrusiveness of data collection and improve collection speed, the project will lead to a better baseline understanding of coral reefs and enhance reef management by DoD personnel.

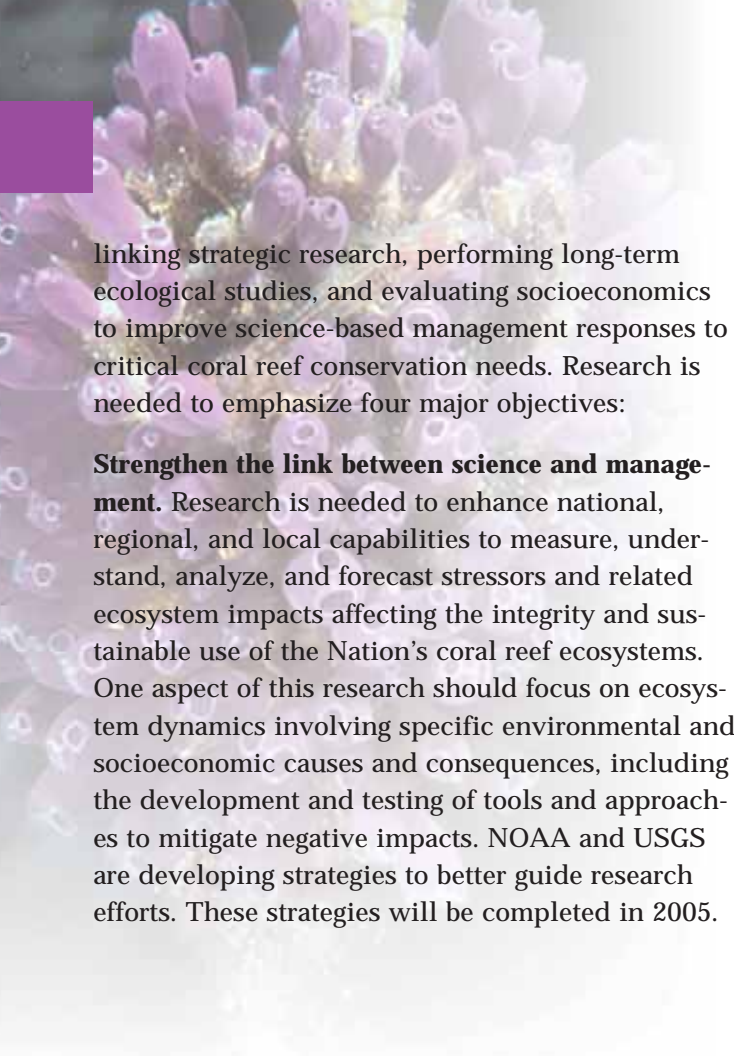
Ground Water and Surface Water Hydrologic and Circulation Models

Newly partnered multidisciplinary research teams from NPS and USGS are conducting a rigorous examination of environmental data. Using state-of-the-art ground water and surface water hydrologic and circulation models, the teams are documenting and mapping current reef conditions and quantifying and modeling threats to the reefs. These modeling tools will test hypotheses concerning the influence of pollutants on the health of Biscayne Bay, and decision support systems will integrate information from these models and ongoing experiments to guide decisionmaking by park managers.

Future Challenges

Future research activities are needed to focus on effectively responding to cumulative impacts,





linking strategic research, performing long-term ecological studies, and evaluating socioeconomics to improve science-based management responses to critical coral reef conservation needs. Research is needed to emphasize four major objectives:

Strengthen the link between science and management. Research is needed to enhance national, regional, and local capabilities to measure, understand, analyze, and forecast stressors and related ecosystem impacts affecting the integrity and sustainable use of the Nation's coral reef ecosystems. One aspect of this research should focus on ecosystem dynamics involving specific environmental and socioeconomic causes and consequences, including the development and testing of tools and approaches to mitigate negative impacts. NOAA and USGS are developing strategies to better guide research efforts. These strategies will be completed in 2005.

Integrate research and monitoring. Integration of research and monitoring is needed to conduct comprehensive assessments of coral reef ecosystem resources and cause-and-effect relationships. This approach is essential for differentiating between actual and perceived environmental issues.

Integrate socioeconomic research with biophysical science. Federal and state management agencies often face a lack of information on social, cultural, and economic issues. Research is needed to close these critical information gaps.

Evaluate the impacts of coral reef management decisions. Management can help sustain and restore the health of coral reef ecosystems and ensure their sustainable use. Research is needed on the effectiveness of management actions to determine their efficacy and to improve their benefits through an adaptive management process.

Understanding Social and Economic Factors



GOAL: *Assess the human dimension of coral reef resources and incorporate social, economic, and cultural values into conservation and management activities.*

Rationale for Action

Sustainable use and conservation of coral reefs require understanding the relationship between human behavior and human impacts to reef ecosystems. For effective management of human impacts, managers need to understand not only the natural science of coral reefs, but also the characteristics of the people who use the ecosystems. These characteristics include socioeconomic and demographic attributes, consumption and production patterns, the value placed on coral reefs as a usable resource (including passive

uses), and enthusiasm for alternative reef management strategies.

To date, the availability of information on the primary users of U.S. coral reefs and the value people place on the resources that reefs provide has lagged behind other areas. This is particularly true for such non-market-valued uses as recreation, preservation/existence, cultural, and spiritual uses. Because market-based prices are not available for these types of uses, assigning a monetary value to them is difficult and, consequently, little is known about the affects on reefs of changes in these attributes.

OBJECTIVES

OBJECTIVE 1: Assess the social and economic uses of coral reef systems and monitor human communities that use or depend on coral reef ecosystems.

OBJECTIVE 2: Assess the social and economic impacts of reef management on human communities.

OBJECTIVE 3: Assess the social, economic, and cultural value of reef resources.



Summary of Implementation

The National Park Service (NPS), NOAA, and state and territory governments are working together to implement research and monitoring programs that enhance understanding of the social and economic factors underlying the use and management of coral reef ecosystems. Since 2002, USCRTF members have implemented various research and monitoring projects, most of which are taking place in states and territories, resulting in the active collaboration of local agencies and researchers. For example, federal agency members of the USCRTF have supported projects to:

- Better understand the economic and cultural uses of coral reefs in Hawai'i, Puerto Rico, and the Pacific territories;
- Determine the economic and cultural importance and environmental impacts of commercial, subsistence, and recreational fisheries located in U.S. coral reef ecosystems;
- Monitor the human use of coral reef ecosystems domestically and internationally;
- Evaluate alternative management options in the United States and internationally; and
- Encourage local involvement in the decision-making and implementation processes.

The USCRTF is committed to understanding how humans use and value coral reefs. Recognizing the fundamental importance of this human dimension is critical to successful coral reef conservation and management. Therefore, the social, economic, and cultural dimensions of coral reef issues are also addressed in other goal areas.

Highlights of Task Force Member Activities

OBJECTIVE 1: Assess the social and economic uses of coral reef systems and monitor communities that use or depend on coral reef ecosystems.

Native Hawaiian Involvement in Managing the Northwestern Hawaiian Islands (NWHI) Coral Reef Ecosystem Reserve

The NWHI Coral Reef Ecosystem Reserve has taken steps to include native Hawaiians in the advice and decisionmaking processes for the Reserve and the proposed NWHI National Marine Sanctuary. Three seats on the Reserve Advisory Council are for native Hawaiian representatives. A cultural working group within the council involves a larger representation of the Hawaiian community, which is integral to the management and conservation of the Reserve and proposed Sanctuary. Various Hawaiian institutions are now studying traditional, cultural, and religious uses of the NWHI.

Cost and Earnings Study of the U.S. Caribbean Trap Fishery

Various studies have shown that a large percentage of trap fishing activities are done haphazardly on coral reefs. Such activities cause physical damage to the reef structure and target overexploited reef fish species, further threatening coral reef health and stability. To protect coral reef habitats and ensure the sustainable use of fish resources, the Caribbean Fishery Management Council (CFMC) plans to implement regulations for fish trapping. NOAA

collected socioeconomic information on the U.S. Caribbean trap fishery to support CFMC management and conservation efforts. Designed to complement ongoing coral reef biological research on trap and coral reef habitat interactions, information from the studies will be used to describe the socioeconomic condition of the fishery, establish socioeconomic baselines, and develop models to investigate the consequences of various management proposals.

Global Socioeconomic Monitoring Guidelines

The Global Socioeconomic Monitoring Initiative published region-specific socioeconomic monitoring guidelines to complement the *Socioeconomic Manual for Coral Reef Management* (2000). *SocMon Caribbean* (October 2003) and *SocMon Southeast Asia* (March 2003) (<http://ipo.nos.noaa.gov/socioeconomic/>) provide a standardized process by which to conduct socioeconomic monitoring specific to each region. They also provide the priority indicators to assess, questions to ask, and tables to analyze the data. The *Socioeconomic Manual for Coral Reef Management* explains how to implement the study. The manual and its companion regional publications were developed through substantial collaboration among social scientists and coastal managers in each region.

Global Socioeconomic Monitoring Initiative Training Opportunities

The Global Socioeconomic Monitoring Initiative has supported regional and national training workshops around the world to help reef managers incorporate

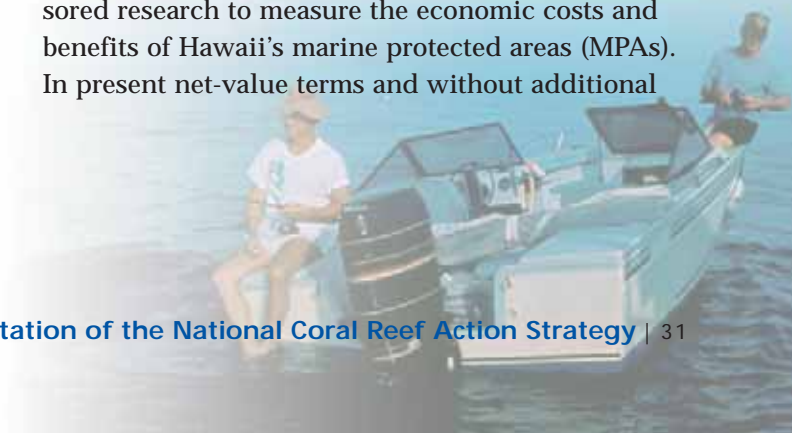


socioeconomic assessments and monitoring into their reef management programs. Workshops have been conducted in Barbados, the Philippines, Kenya, and the Maldives. The initiative has provided funds for individual sites to conduct socioeconomic monitoring after the workshops, including incorporating results into management actions.

OBJECTIVE 2: Assess the social and economic impacts of reef management on human communities.

Economic Costs and Benefits of Hawaii's Protected Areas

In 2003–2004, the Hawai'i Coral Reef Initiative Research Program and the State of Hawai'i sponsored research to measure the economic costs and benefits of Hawaii's marine protected areas (MPAs). In present net-value terms and without additional



management, the economic value of the MPAs ranges from \$6 million for Diamond Head to \$650 million for Hanauma Bay. In no case did the cost exceed the benefits and, in many cases, the economic benefit-to-cost ratio was high. To evaluate a system of user fees, financial benefit-cost ratios were also calculated.

Hawai'i Community-Based Management Planning Initiated

In 2002, NPS initiated community-based marine management planning at Kalaupapa National Historical Park, Hawai'i, which includes 2,000 acres (8 km²) of coral reefs in an adjacent marine area. Meetings were held in coordination with the Kalaupapa community to identify and prioritize options for a community-based approach to the park's marine management programs. These options include community participation in selecting monitoring programs, establishing special management areas in the park, and developing a legislative proposal for incorporating, in perpetuity, the fishing rules for residents into Hawai'i state law. NPS is participating with the local community and a multidisciplinary technical committee of partner

organizations, government agencies, and non-governmental organizations to propose fishing regulations and a monitoring plan for 2004.

Ecosystem Management of MPAs in the South Atlantic

To explore the possible use of MPAs in the South Atlantic (North Carolina to the east coast of Florida), NOAA and the University of Miami are developing an ecosystem-based model to assess the biological, economic, and social consequences of MPA implementation. The model will incorporate spatial and temporal information for both biological and economic dimensions. First, a conceptualized model describing the linkages among the various biological, fishery, and harvesting processes will be constructed. Then, stage-based biological models will be integrated with economic models of the harvesting sector. The resulting model will be used to evaluate a number of MPA proposals being considered by the South Atlantic Fishery Management Council to manage the snapper-grouper fishery. The model will help identify superior management alternatives that meet conservation goals while minimizing economic hardships.



OBJECTIVE 3: Assess the social, economic, and cultural value of reef resources.

Direct User Values for Hawai'i Coral Reefs

The Hawai'i Coral Reef Initiative Research Program sponsored an economic valuation study of Hawaii's nearshore coastal reefs in 2002–2003. Economists found Hawaii's nearshore reefs annually contribute nearly \$1 billion in gross revenues (\$364 million in value added) to the state's economy. The negative impacts

of algal blooms of invasive aquatic species—including significant depressions in property value and economic losses to the tourism industry—have prompted the private sector to play an active role in algal removal.

Hawai'i National Coral Reef Valuation Study

The Hawai'i National Coral Reef Valuation Study examines at a national level how people value the nonmarket resources (i.e., those that cannot be bought or sold) provided by the coral reefs of Hawai'i under alternative management approaches. Results of this study will help resource managers develop and implement policies that balance protection with multiple uses of reef resources and the value the public places on them. For example, total nonmarket resource values can be used to estimate the benefits and costs of alternative coral reef management strategies. The study is designed to complement recent studies of direct-user values for Hawaii's coral reefs.

Local Coral Reef and Coastal Resource Economic Valuation Initiative

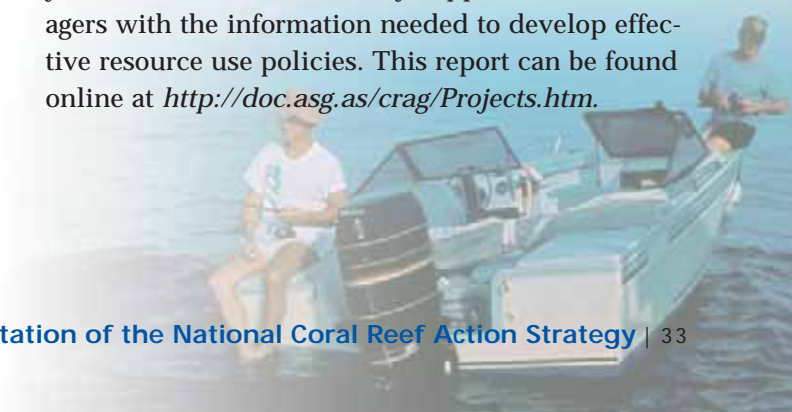
In August 2002, NOAA held a Coral Reef Economic Valuation Workshop in Honolulu, Hawai'i. The workshop brought together more than 50 state and territory coral reef and coastal managers, economists, international experts, and federal agency representatives. Workshop goals included assessing information on natural resource valuation in the jurisdictions, identifying priority information and study needs, and developing an implementation plan for filling the identified needs in each jurisdiction. Representatives prioritized information gaps, needs, and management applications for economic valuation studies. NOAA is helping support studies in each of these jurisdictions and is helping support the development of a coral reef manager's guide to economic valuation.

Determining the Value of Puerto Rican Reefs

NOAA, in cooperation with the Puerto Rico Department of the Environment and Natural Resources (PRDENR), has begun a project to estimate the economic value of coral reefs to recreational users and the economic impacts of recreational activities in and around Puerto Rico. During the first phase of the project, NOAA compiled rough estimates from existing Marine Recreational Fisheries Statistical Survey data, which are designed to estimate catch-per-unit effort and participation. The results indicate the relative importance of the angler fishing industry in Puerto Rico. During the second phase, started in 2003, NOAA and PRDENR started collecting more direct economic data from local anglers. By 2005, the agencies plan to create a valuation and economic impact model that will help evaluate costs and benefits of potential future policies.

American Samoa Coral Reef Economic Valuation Study

The Economic Valuation of Coral Reefs and Adjacent Habitats in American Samoa final report details the results of an economic valuation study examining the current and potential values for corals and mangroves. The report focuses on the value of the reefs to artisanal and subsistence fisheries, shoreline protection and recreation/tourism (ecotourism). The study estimates the territory's coral reefs provide US\$5 million in benefits to American Samoa residents and visitors per year. When potential nonuse benefits accruing to U.S. citizens are included, the territorial reefs are estimated to convey at least US\$10 million per year. The results of this study supplies local managers with the information needed to develop effective resource use policies. This report can be found online at <http://doc.asg.as/crag/Projects.htm>.





Future Challenges

Significant progress has been made on understanding the use and value of coral reef ecosystems in the United States and abroad, but additional

socioeconomic data are needed. The following are important components of future socioeconomic research:

Continuation of data collection. A continuous collection of data is needed on the preferences and perceived tradeoffs of those directly affected by changes in proposed coral reef management strategies. Increased collaboration among the USCRTF, local organizations, and interest groups can help set project priorities and improve the efficiency of project implementation by providing support, guidance, and oversight.

Development of socioeconomic tools. An expanded use of tools is needed to help improve the design and implementation of socioeconomic data collection, analyses, and interpretation (e.g., manuals, seminars, workshops).

Improving the Use of Marine Protected Areas



GOAL: *Improve management of coral reef resources through a strengthened and expanded network of coral reef marine protected areas.*

Rationale for Action

Marine protected areas¹ (MPAs) can be an important tool for protecting coral reefs from harmful activities. MPAs vary in size and can be designed to manage a multitude of activities.

Creating a network of well-managed MPAs helps protect the biodiversity and ecological integrity of coral reef resources. MPAs can also serve an integral role in an ecosystem approach to coral reef management and conservation.

¹ Marine protected area is used as defined in the MPA Executive Order 13158 as “any area of the marine environment that has been reserved by federal, state, territorial, tribal or local laws or regulations to provide lasting protection for part or all of the natural or cultural resources therein.”

OBJECTIVES

OBJECTIVE 1: Conduct and support national, state, and territory assessments of the effectiveness and gaps in the existing system of U.S. coral reef MPAs.

OBJECTIVE 2: Enhance the effectiveness of existing MPAs and strengthen their capabilities to protect coral reef resources through existing authorities, management plans, programs, and the involvement of all constituencies.

OBJECTIVE 3: Establish additional coral reef MPAs where needed, including the establishment of additional no-take ecological reserves in a balanced suite of representative

U.S. coral reefs and associated habitats, with the goal of protecting at least 5 percent of all coral reefs and associated habitat types in each major island group and Florida by 2002, at least 10 percent by 2005, and at least 20 percent by 2010.

OBJECTIVE 4: Strengthen and support cooperation with and among the Freely Associated States and international partners to establish networks of MPAs to protect and conserve reef ecosystems.



Like their terrestrial counterparts, MPAs can protect critical habitats and endangered species, enhance tourism and recreation, and serve important roles in public education and outreach on the social, economic, and ecological benefits of marine ecosystems and their protection. By providing a framework for the application of adaptive management, MPAs can establish and maintain feedback loops between science and policy. Multiple-use MPAs address the differing objectives of a wide variety of stakeholders, thereby helping to resolve conflicts between users of marine and coastal ecosystems, while providing conservation benefits to coral reef ecosystems.

Recognizing the urgent need to protect reef habitats from further decline, the USCRTF called for strengthening and expanding the Nation’s existing network of coral reef MPAs (USCRTF 2000). Based on a growing body of scientific information, the USCRTF recognized the special value of one type of MPAs—no-take ecological reserves² (reserves)—as a key tool to address the impacts of fishing on coral reef ecosystems (see also chapter 6). The USCRTF also called for designing coordinated networks of coral reef MPAs in U.S. waters and other areas to help ensure the long-term viability, ecological integrity, and sustainable use of coral reefs.

Summary of Implementation

Successful implementation of MPAs requires a science-based approach and the meaningful and sustained participation of stakeholders in all phases of system design, implementation, and evaluation. Since 2002, USCRTF members have made progress on many MPA-related objectives, underscoring the value of these tools in management of coral reef ecosystems.

A variety of coral reef protected areas are managed by federal agencies, such as NOAA’s national marine sanctuaries and fishery management zones

and the U.S. Department of the Interior’s (DOI’s) national parks and national fish and wildlife refuges. However, most shallow coral reefs occur in state waters where significant strides have been made in using protected areas as tools in reef management. Since 2002, USCRTF member agencies have worked to design and implement coral reef protected areas. For example, new MPAs and reserves were established in several jurisdictions, including the U.S. Virgin Islands (USVI), Hawai’i, Puerto Rico, American Samoa, and the Commonwealth of the Northern Mariana Islands (CNMI) (see table 5).

In addition to establishing new coral reef protected areas, USCRTF members have conducted a variety of activities to strengthen effectiveness of existing coral reef MPAs. Management plans and regulations have been developed or completed for several coral reef MPAs in Florida, Hawai’i, and Puerto Rico. These plans and regulations are essential to

Table 5. State, Territory, and Community Marine Protected Areas Established Between 2000 and 2003

The following table shows the number of new state, territory, and community marine protected areas (MPAs) designated between 2000 and 2003. This table is composed of preliminary data from the National Inventory of Marine Managed Areas being completed by the National MPA Center.

Jurisdiction	2000	2001	2002	2003
American Samoa		2		5
Commonwealth of the Northern Mariana Islands	3	2		
Florida	2		3	
Hawai’i				1
Puerto Rico	3		2	2
U.S. Virgin Islands	1			1

² Reserve in this case is defined in the *National Action Plan To Conserve Coral Reefs*. Ecological reserves are no-take zones used for maintaining biodiversity, productivity, and ecological integrity of coral reefs and other marine habitats.

effective implementation of existing protected areas, help agencies enforce and manage reef resources, and provide mechanisms for public involvement and evaluation of management efforts.

USCRTF members have mapped and monitored habitats and fish assemblages in MPAs throughout U.S. jurisdictions to gather critical baseline information. Through these efforts, managers tracked abundance and distribution of recreational and commercial fish species and, if populations were decreasing, identified when management action was needed. Florida, Puerto Rico, the USVI, and the CNMI developed stronger management regimes for MPAs through policies, legislation, and plans involving broad public input and stakeholder involvement. All of these actions enhanced the effectiveness of existing sites and strengthened their capabilities to protect coral reef resources.

USCRTF federal agencies also provided technical assistance and funding to states and territories to strengthen the management of MPAs. To enhance state and territory capacity, the USCRTF held several regional and local workshops that addressed the role of MPAs and reserve management in recreational overuse, lack of awareness, fisheries management, and climate change.

Highlights of Task Force Member Activities

OBJECTIVE 1: Conduct and support national, state, and territory assessments of the effectiveness and gaps in the existing system of U.S. coral reef MPAs.

National Inventory of MPAs Nearly Completed

In 2001, NOAA and DOI, in cooperation with other USCRTF members, began an extensive inventory of

coral reef protected areas in U.S. waters as part of a nationwide review of U.S. marine managed areas (MMAs). Data on the location and characteristics of federal, state, and territory coral reef protected areas will be collected and posted on the National Inventory's online database to help assess the current status of U.S. coral reef protected areas. Data for coral reef protected areas in Puerto Rico, Florida, Hawai'i, Guam, American Samoa, and the USVI have been collected and are under review. The CNMI has completed the data collection, and the data are available on the website. For more information on the MMA inventory and the MPA initiative, visit <http://www.mpa.gov>.

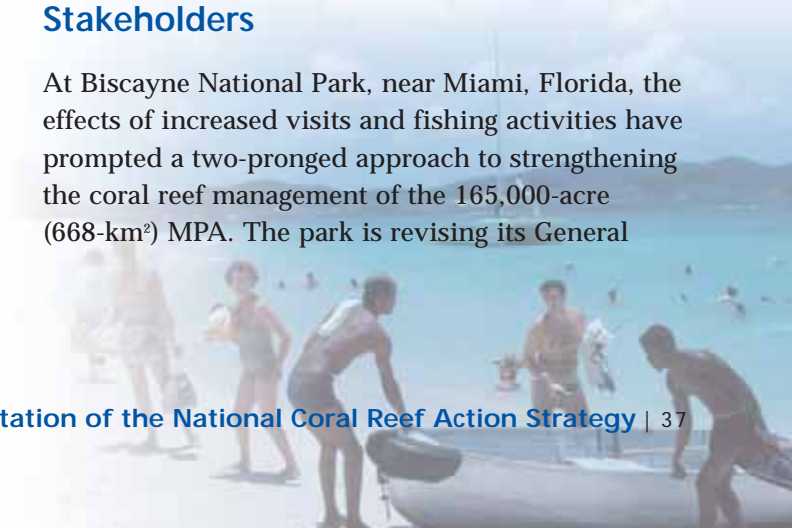
Recreational Use Study


The State of Hawai'i and the Hawai'i Institute of Marine Biology conducted a study of human use in four MPAs. Researchers found that despite high visitor numbers, diving and snorkeling activities have only minor impacts. Study findings suggested that boat-based snorkeling and diving tours with pre-dive briefings led to reduced impacts, so the report concludes that mandatory pre-diving briefings should be required for tours entering MPAs.

OBJECTIVE 2: Enhance the effectiveness of existing MPAs and strengthen their capabilities to protect coral reef resources through existing authorities, management plans, programs, and the involvement of all constituencies.

Biscayne National Park Embarks on Resource Management Plans With Stakeholders

At Biscayne National Park, near Miami, Florida, the effects of increased visits and fishing activities have prompted a two-pronged approach to strengthening the coral reef management of the 165,000-acre (668-km²) MPA. The park is revising its General





Management Plan (GMP) and creating a joint Fisheries Management Plan with the Florida State Fish and Wildlife Conservation Commission. Each planning process has benefited from extensive public input. In fall 2003, the park released preliminary draft alternatives for the GMP in which activities such as boating, scuba diving, snorkeling, and fishing would be zoned to reduce conflicts, enhance visitor experiences, and protect sensitive resources.

Northwestern Hawaiian Islands (NWHI) Coral Reef Ecosystem Reserve Implementation and National Marine Sanctuary Designation Process

Executive Order 13178 created the NWHI Coral Reef Ecosystem Reserve, the second largest marine conservation area in the world. The Order required development of a Reserve Operations Plan and mandated that a process be carried out to consider whether to establish a National Marine Sanctuary in the region. Reserve management efforts in close cooperation with the State of Hawai'i and the Hawaiian Islands Fish and Wildlife Refuge have included extensive marine debris clean-up operations (see chapter 8), research cruises (see chapter 2), and extensive outreach activities. *The Draft Final Reserve Operations Plan* was completed in early 2004.

In 2002, the Reserve held nine public meetings across Hawai'i and one in Washington, D.C., to solicit information and comments from stakeholders on the range and significance of issues related to the designation and management of a NWHI National Marine Sanctuary. More than 1,000 people attended the meetings, and more than 14,000 comments were received. Support for the conservation of the area was overwhelming. The process of collaborative input fostered the vision, mission, principles, goals, and objectives for the proposed sanctuary. Stakeholder comments and input will be

used to identify management issues for the proposed sanctuary management plan and environmental impact statement (EIS). NOAA is scheduled to release the draft EIS, draft management plan and proposed regulations for the proposed designation by January 2006. For more updated information, visit <http://www.hawaiiireef.noaa.gov>.

Culebra Management Plan Moves Forward

In 2003, Puerto Rico began a multistakeholder process to develop a management plan for Luis Peña Channel [Canal Luis Peña] No-Take Natural Reserve. The management plan will address enforcement, awareness and education, habitat protection and restoration, pollution, and other issues. The Authority for the Conservation and Development of Culebra and the Puerto Rico Department of Natural and Environmental Resources (PRDNER) are developing the plan with funding provided by NOAA and the National Fish and Wildlife Foundation (NFWF). The planning process, conducted with community stakeholders and a multidisciplinary working group, will provide a framework and action plan for managing the reserve.

American Samoa Creates New Territorywide MPA Program

American Samoa created a territory MPA program and hired an MPA coordinator to develop an MPA management plan. The plan seeks to protect 20 percent of the coral reef resources and coordinate all MPA efforts throughout the territory. In recognition that coral reef conservation issues extend beyond territorial boundaries, the newly hired MPA coordinator will work to establish a precedent-setting regional MPA program between American Samoa and the countries of Samoa and Fiji.

Community-Based Monitoring and Reef Watch Programs in Hawaii's Newest MPA

The Hawai'i Division of Aquatic Resources provided technical assistance to help a local community establish and develop a comprehensive monitoring program in a coral reef protected area. This locally driven program:

- Monitors coral reef resources, water quality, and human use patterns;
- Educates the public about new MPA rules and reports violations to the state; and
- Manages the removal of litter and marine debris through the Kapoho Reef Watch program at the Waiopae Tide Pools Marine Life Conservation District.

The Kapoho Reef Watch program is locally driven; the community that lives adjacent to the MPA provides all funding and staffing resources. Involving the community in the management of the area results in several benefits: The community members develop a sense of pride and stewardship over the resources; and they are more willing to call for enforcement when they see a violation, work with uninformed users to try to correct misuse, and educate users visiting the area on proper etiquette. These benefits lead to reduced violations and fewer negative impacts from recreational misuse of the reef.

Guam Continues as Leader in Use of Ecological Reserves for Reef Conservation

Guam has been a leader in developing a network of no-take ecological preserves³ to sustain coral reef ecosystems, including three areas with very limited

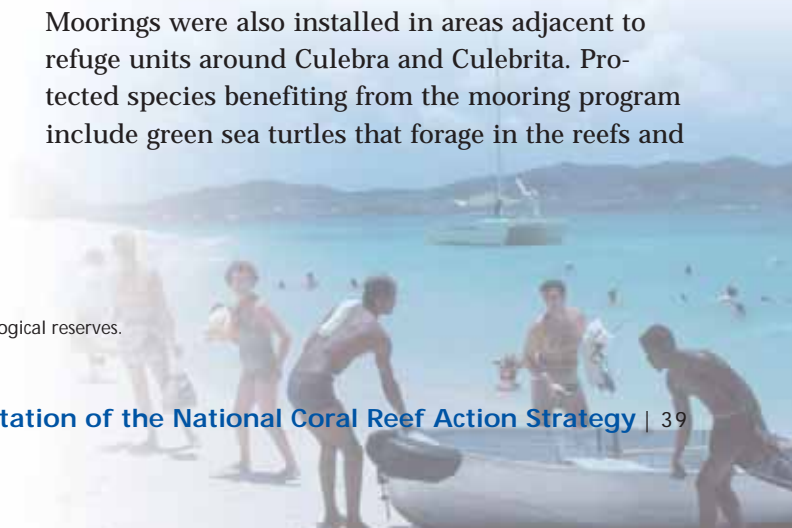
take of seasonal and culturally important species that still function biologically as no-take MPAs. In 1997, Guam established five marine preserves around the island, accounting for 11 percent of the shoreline and an estimated 28 percent of Guam's reef area. The Guam Department of Agriculture's Division of Aquatic and Wildlife Resources established baseline levels of fish populations in two preserve areas and suitable control sites prior to full enforcement on January 1, 2001. Data generated by continued monitoring of the fish communities at these sites will be compared with pre-implementation data to determine the long-term effectiveness of the preserve system. Compared with nonpreserve areas, preserve areas have shown increases in fish abundance, diversity, and spawning mass within 2 years after implementation.

Mooring Buoys Improve Habitat Protection in Puerto Rico Reserve

On holiday weekends, popular marine areas in Puerto Rico can have hundreds of vessels anchoring per day. In the areas of heaviest visitor use, PRDNER partnered with the U.S. Fish and Wildlife Service (USFWS) to install low-impact mooring buoys that reduce anchor damage to seagrass beds and coral reefs. The first buoys were installed in Puerto Rico's first no-take zone, the Luis Peña Channel [Canal Luis Peña] Natural Reserve. Reduced impacts because of significantly less anchor damage to seagrass meadows are evident with improved seagrass, coral, and associated hard-bottom habitats. In addition to protecting resources, mooring buoys provide a popular service to the boating community.

Moorings were also installed in areas adjacent to refuge units around Culebra and Culebrita. Protected species benefiting from the mooring program include green sea turtles that forage in the reefs and

³ The Government of Guam uses the term "preserves" to refer to no-take ecological reserves.



associated hard-bottom habitats such as sponge, soft coral, and algal areas. It is anticipated that, with improvements to turtle habitat, species recovery will be enhanced. The mooring buoy program and partnership between Puerto Rico and USFWS will eventually install 270 mooring buoys throughout Puerto Rico's high-traffic coastal waters.

OBJECTIVE 3: Establish additional coral reef MPAs where needed, including the establishment of additional no-take ecological reserves⁴ in a balanced suite of representative U.S. coral reefs and associated habitats, with the goal of protecting at least 5 percent of all coral reefs and associated habitat types in each major island group and Florida by 2002, at least 10 percent by 2005, and at least 20 percent by 2010.

East End Marine Park Established

In 2003, the USVI, with assistance from federal agencies, nongovernmental organizations, and community stakeholders, created the East End Marine Park at St. Croix. The 97-square-kilometer marine park contains beaches, mangroves, seagrass meadows, and coral reefs. A zoning plan protects the



park's sensitive resources while allowing for compatible recreational uses, including diving, snorkeling, boating, and swimming. Portions of the park are designated as no-take ecological reserves, while others are open to commercial and recreational fishing. Oil and gas extraction and commercial shipping are prohibited in the park.

U.S. Virgin Islands Monuments No-Take Prohibitions Implemented

In 2003, DOI implemented regulations to protect the new 12,708-acre (51-km²) U.S. Virgin Islands Coral Reef National Monument and the newly expanded 19,000-acre (77-km²) Buck Island Reef National Monument. These no-take marine reserves were created in 2001 to restore the coral reef ecosystem and replenish fish and shellfish populations. (Fishing for baitfish and blue runner is allowed at designated locations in the U.S. Virgin Islands Coral Reef National Monument.) The regulations had been delayed while the Government Accountability Office reviewed ownership claims to the area advanced by the territorial government.

The National Park Service (NPS) began developing general management plans to determine long-range (15–20 years) conservation efforts for the two national monuments in collaboration with various stakeholders, including local communities and the USVI territorial government. NPS and NOAA are collaborating on joint scientific surveys of fish and invertebrates, benthic mapping, and habitat characterizations at these two monuments (see chapter 1).

DoD Evaluates Johnston Atoll's Potential as a National Environmental Research Park

The U.S. Department of Defense (DoD) funded a study to evaluate whether Johnston Atoll has the potential to be a national environmental research

⁴ Reserve in this case is defined in the *National Action Plan To Conserve Coral Reefs*. Ecological reserves are no-take zones that are used for maintaining biodiversity, productivity, and ecological integrity of coral reefs and other marine habitats.

park and designated for the study of the environmental impacts of industrial byproducts and other human-related activities. As part of the base closure process, USFWS is coordinating with DoD for the contamination and hazardous waste cleanup activities necessary after several decades of military use and testing at Johnston Atoll.

Puerto Rico Designates Third No-Take MPA

In January 2004, the Tres Palmas Marine Reserve was designated as the third no-take reserve in Puerto Rico following a multistakeholder planning process. Long renowned for its beautiful beaches, excellent surfing, and abundant sea life, Tres Palmas also supports one of the best-preserved elkhorn coral patches (*Acropora palmata*) around the island; elkhorn coral is under consideration for potential listing as threatened under the U.S. Endangered Species Act. The reserve designation law mandates the development of a management plan and allows for the participation of stakeholders in its development and in the management of the reserve.

OBJECTIVE 4: Strengthen and support cooperation with and among the Freely Associated States and international partners to establish networks of MPAs to protect and conserve reef ecosystems.

USFWS Funds Studies of Endangered Species in Palau

In 2002, USFWS funded surveys of Palau's endangered dugongs and saltwater crocodiles, both of which are listed under the U.S. Endangered Species Act. The goal was to provide the Palau government with biological data needed to help expand an established national network of MPAs. In 2003, NOAA and USFWS co-funded a similar project to

gather information on nesting beaches for Palau's green and hawksbill sea turtles for consideration in enhancing the MPA network.


USFWS Leads Expedition—Results in Republic of the Marshall Islands' First National Park

In 2002, at the request of the people of Rongelap Atoll, USFWS led a multi-institutional expedition to assess conditions at the protected, uninhabited reef of Ailinginae Atoll in the Republic of the Marshall Islands and to evaluate its eligibility as a World Heritage Site. Participants included the College of the Marshall Islands, University of North Queensland, and University of California at Santa Cruz. State-of-the-art, high-resolution Quickbird satellite imagery assisted in the evaluation. Shortly after the expedition, the Republic of the Marshall Islands declared Ailinginae to be its first national park. A full report was due in 2004, and the United Nations Educational, Scientific, and Cultural Organization's World Heritage Centre is now beginning its evaluation of the atoll.

Future Challenges

While the members of the USCRTF have made progress towards strengthening and expanding the Nation's existing coral reef protected areas, significant challenges remain to fulfill this goal.

Complete the inventory and assessment of existing U.S. coral reef MPAs. Information on the location, distribution, purpose, and effectiveness of existing U.S. coral reef MPAs will allow coral reef managers, stakeholders, and others to assess the strengths and weaknesses of the current collection of sites. This information will also allow them to develop appropriate responses to improve effectiveness. Much of the information has been collected, and completing



the inventory and assessment will require continued commitment and cooperation by federal, state, and territory government agencies.

Increasing the effectiveness of current sites.

Although some progress has been made in increasing the effectiveness of existing coral reef MPAs, many sites lack the tools, resources, and capacity to meet their goals. Addressing these needs and increasing the effectiveness of all existing coral reef MPAs are critical steps to improving the resilience of coral reefs and the community economies that depend on them.

Increase public awareness and participation in coral reef MPAs.

Public awareness and participation in coral reef management are critical to the long-term success of these efforts. This is especially true with the use of MPAs as management tools. Increasing public awareness and participation in the design, creation, implementation, and evaluation of coral reef MPAs is essential for the effective management of these protected areas.

Conduct targeted research to design and implement coral reef MPA networks.

Effective management of coral reef ecosystems includes understanding how reef habitats are connected to each other across spatial scales and understanding how these linkages may change over time. Targeted research is

needed in a number of areas to improve the design and implementation of coral reef MPA networks. This includes research on such questions as:

- What is the flow and distribution of larvae, juveniles, and adults among reef systems (i.e., connectivity)?
- How would this connectivity affect the possible survival and recovery of reef habitats?
- Which reef habitats are most likely to survive current and possible adverse future conditions?
- What combination and design of coral reef MPAs would help provide the best possible chance for long-term sustainability of the reef ecosystem?

Evaluate Increased use of MPAs as coral reef management tools.

The implementation of coral reef MPA networks can help sustain the Nation's valuable reef ecosystems and the communities and economies that depend on them. Every jurisdiction has made progress in implementing ecological reserves, but only the NWHI and Guam have met (and exceeded) interim USCRTF goals. Open and participatory processes involving all stakeholders should be used in assessing gaps, needs, and possible alternatives for use of protected areas for effective sustainability of coral reef ecosystems.

Reducing the Adverse Impacts of Fishing



GOAL: Reduce the adverse impacts of fishing and other extractive uses to protect coral reef ecosystems and ensure sustainable fisheries.

Rationale for Action

More than 4,000 species of fish (25 percent of all marine fish) inhabit coral reefs and associated habitats

(Spaulding et al. 2001). These habitats support important commercial, artisanal, recreational, and subsistence fisheries in the United States and around the world. Coral reef fisheries

OBJECTIVES

OBJECTIVE 1: Identify, monitor, and protect critically important U.S. coral reef fisheries habitats and spawning populations through an expanded network of no-take ecological reserves; ensure effective enforcement of existing no-take fishery reserves; monitor reef fish stocks in no-take marine reserves and reference sites to evaluate the effectiveness of reserves; and identify and protect new areas necessary to ensure the integrity of fisheries and ecosystems.

OBJECTIVE 2: Reduce overfishing by monitoring coral reef fisheries, assessing the adequacy of current fishing regulations, revising regulations as needed (using existing statutory processes in the case of federal regulations), and providing enhanced enforcement and education.

OBJECTIVE 3: Enhance coordination on coral reef fishery issues with the U.S. territories in the Caribbean and Western Pacific.


OBJECTIVE 4: Reduce adverse environmental impacts of fishing by assessing essential fish habitat; identifying the effects of fishing and fishing gear; implementing actions or additional gear and fishing vessel anchoring restrictions to reduce habitat damage; eliminating destructive fishing practices; assessing and mapping deeper coral reefs, banks, and beds; and developing strategies to conserve these deeper ecosystems.

OBJECTIVE 5: Incorporate ecosystem-scale considerations into coral reef fishery management by performing targeted research, including the development of models, to understand the ecosystem effects of fishing and the socioeconomic impacts of fishery management.

OBJECTIVE 6: Reduce the overexploitation of reef organisms for the aquarium trade by banning the domestic commercial collection of coral and “live rock” and monitoring the collection of other species, developing new management measures or ecologically sound alternatives to wild collection, evaluating the effectiveness of existing legal authorities and policies governing the collection and importation of coral and other reef-dwelling species, and addressing inconsistencies among federal and state/territory regulations on collection and trade of ornamental coral reef species.

OBJECTIVE 7: Develop a process to evaluate issues and possibly develop guidance related to coral reef aquaculture in conjunction with stakeholders and relevant interagency groups, including the Aquatic Nuisance Species Task Force and the Invasive Species Council.





provide food and income and play a central social and cultural role in many island communities; however, human population growth, the emergence of export fisheries, and the use of more efficient fishing equipment have led to overfishing and degradation of the habitats upon which these fish depend.

Overfishing of high-value species has been documented on nearly all U.S. inshore reefs and contributes to localized depletions of key species. Increasing evidence shows overfishing significantly alters the ecological balance and contributes to the degradation of coral reef ecosystems. In particular, overfishing of herbivorous fish has been linked to phase shifts from high-diversity, coral-dominated systems to low-productivity, algal-dominated communities (Bellwood et al. 2004). Also, some fishing gear can damage reef habitats, and fishing pressure on predatory fish may accelerate bio-erosion of corals by their invertebrate prey. Overfishing has been identified as a major concern in all U.S. states and territories with coral reefs, and it was chosen in 2002 by the USCRTF as one of six priority areas for the development of local action strategies (LASs) to reduce this threat.

Summary of Implementation

USCRTF members and their partners are working together to implement programs that increase knowledge about coral reef fisheries and reduce the adverse impacts of fishing. Because most coral reef fisheries are located within state and territory waters, many programs are collaborative efforts among NOAA, the U.S. Department of the Interior (DOI), state and territory government agencies, fishery management councils, and nongovernmental and university partners. Since 2002, USCRTF agencies supported more than 57 federal management and research programs to understand and address coral reef fisheries. The programs emphasize efforts to:

- Assess the effectiveness of established marine protected areas (MPAs) in promoting the recovery of overfished stocks;

- Identify spawning aggregation sites and monitor the health of these aggregations and associated fishery resources;
- Understand habitat use patterns and linkages to identify key habitats that should be included within MPA networks; and
- Evaluate fishing efforts and the impacts of fishing gear on coral reef ecosystems.

This information is being provided to local, state, and territory resource agencies and regional fishery management councils to support ongoing evaluations of current regulations and the development of new regulations to enhance the sustainability of coral reef fisheries.

Successful efforts to reduce the impacts of fishing must include an integrated effort to protect, understand, and rebuild important coral reef fish populations. Assessments of fishery stocks are lacking for the majority of coral reef species (see table 6), hindering the establishment of a balance between resource protection and exploitation through ecosystem-based management approaches. To address this gap, NOAA and its partners have worked together to conduct detailed assessments of fish size, abundance, and diversity of selected coral reef fish populations throughout U.S. waters. These assessments help researchers evaluate the health of ecologically and economically important species and understand species interactions and the effect fishing has on these associations.

For example, comparative studies in the Hawaiian Island Archipelago found a large number of apex predators (primarily large jacks and reef sharks) throughout the entire Northwestern Hawaiian Islands (NWHI) chain. This is a stark contrast to the near absence of apex predators in the Main Hawaiian Islands. The difference in apex predator populations is likely a result of greater fishing pressure in the Main Hawaiian Islands, which emphasizes the need for better regulations to manage fishing and recover depleted populations (Friedlander and DeMartini 2002). In addition, the USCRTF and

Table 6. Overview of Coral Reef Species Stock Information Listed Under Fishery Management Plans for Federal Waters

Fishery management council/ jurisdiction	Fishery management plan	Number of stocks	Number of stocks overfished (biomass is below threshold)	Number of stocks not overfished (biomass is above threshold)	Number of stocks where fishing is closed in the EEZ	Stocks with no information about overfishing
South Atlantic	South Atlantic snapper-grouper	60	8	11	2	41
	South Atlantic spiny lobster	2	–	1	0	1
	Coral, coral reefs, and live/hard bottom habitats in the South Atlantic region	5	–	–	5	5
Caribbean	Puerto Rico and U.S. Virgin Islands reef fishery	140	2	–	2	138
	Puerto Rico and U.S. Virgin Islands spiny lobster fishery	1	0	1	0	0
	Puerto Rico and U.S. Virgin Islands queen conch resources	13	1	–	0	12
	Puerto Rico and U.S. Virgin Islands coral and reef associated invertebrates	25	–	–	6	25
Gulf of Mexico	Gulf of Mexico reef fish resources	42	5	3	2	34
	Gulf of Mexico spiny lobster	2	–	1	0	1
	Gulf of Mexico corals and coral reefs	5	–	–	5	5
Western Pacific	Western Pacific bottom fish and seamount groundfish	10	–	–	0	10
	Western Pacific coral reef ecosystem fishery management plan	146 ^a	–	–	0	146
	Western Pacific crustacean	6	–	–	5 ^b	6
	Western Pacific region precious corals fishery	12	–	–	12 ^b	12
Highly migratory species ^c	Highly migratory species	3 ^d	3	0	0	0

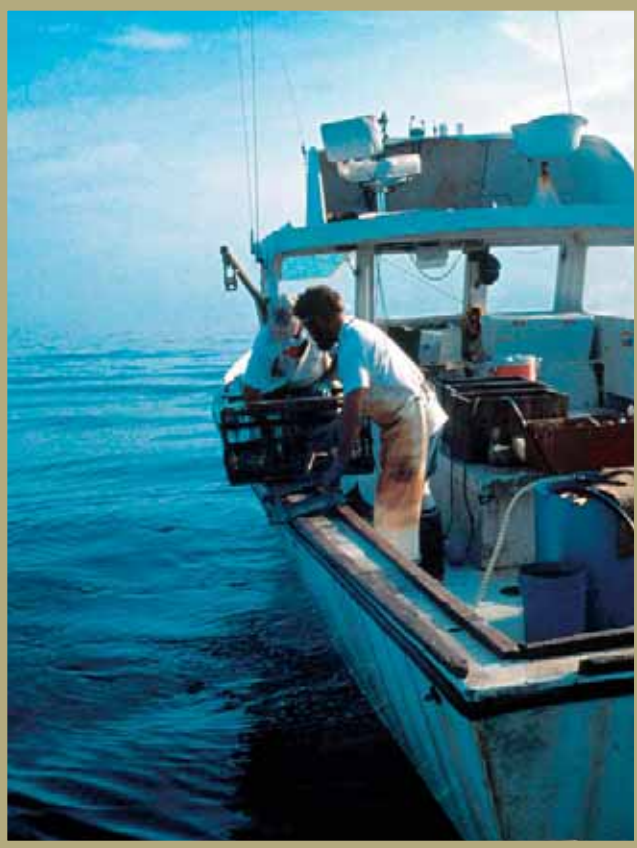
Information for this table was derived from the 2003 Status of U.S. Fisheries report, <http://www.nmfs.noaa.gov/sfa/reports.html>. The table includes only those coral reef-associated species that are listed on fishery management plans and does not reflect all known coral reef species.

^a This figure was taken directly from the Western Pacific Coral Reef Ecosystem Fishery Management Plan, <http://www.wpcouncil.org/coralreef.htm>, and includes only those species listed as currently harvested coral reef taxa.

^b The fishery is closed in the Northwestern Hawaiian Islands.

^c Highly migratory species are not under the jurisdiction of any one Fishery Management Council.

^d The three shark species include the Caribbean reef shark, tiger shark, and nurse shark.



its partners are identifying spawning aggregations, assessing temporal and spatial behaviors of groupers and snappers associated with these aggregations, and devising strategies to protect these aggregations in the Atlantic and Caribbean. Many of these commercially important species are slow growing and long lived, forming seasonal spawning aggregations that are easy for fishers to find and target, but that can be decimated within a few years by heavy fishing. Research illustrates that aggregations are vital to ensuring the successful reproduction and recruitment of these fish and their protection is critical to reef ecosystem health.

NOAA, DOI, state and territory agencies, and others are evaluating the effectiveness of established MPAs and developing new protected areas to enhance fishery resources. Effectiveness studies have centered on assessing changes in fish populations within established protected areas, relative to non-protected areas, and on determining if these protected areas act as sources or sinks for larvae and/or adults. For example, studies in Florida demonstrated the average size and density of exploitable (prey) species increased in no-take reserves and some spillover appeared to occur from reserves into the surrounding fished areas. Riley's Hump in the Tortugas South Ecological Reserve has shown significant increases in density of several snapper and grouper species since additional protections were implemented in 2001 (Burton et al. 2004), and scientists have observed an increase in spawning aggregations within coral reef reserves in Guam and other areas.

No-take ecological reserves (reserves) are increasingly important tools for coral reef fishery management (see also chapter 5). NOAA and its partners have initiated efforts to help local resource managers understand the importance of marine reserves and science-based decision-making processes in the effective design of MPAs. These efforts include:

- Workshops in Puerto Rico and the USVI for key stakeholders to improve their understanding of ecosystem impacts associated with overfishing and destructive fishing and the benefits of marine reserves in conserving biodiversity and enhancing fisheries;
- Socioeconomic evaluations to determine fishermen's perceptions and preferences about MPAs in the Caribbean;

- Development of models evaluating the effect of different management regimes on trophic dynamics (i.e., different levels of organization within the food chain), which can predict the rate of changes within a reserve, and assess its performance based on the types of habitats selected, patterns of use within these habitats, and fishing effort; and
- Research on connectivity and recruitment linkages between American marine reserves in Meso-American reef areas, the Dry Tortugas, and the Florida Keys.

Key elements for reducing the impacts of fishing include improved regulations, enhanced enforcement, and outreach and education efforts to inform stakeholders of new procedures and how to help sustain reef resources. Since 2002, five jurisdictions have instituted new or revised fishery regulations. In March 2004, Puerto Rico implemented comprehensive new fishing regulations, including ones compatible with federal regulations that established recreational and commercial fishing licenses by species.

For federal waters, final rules were published to implement the Fishery Management Plan for Coral Reef Ecosystems of the Western Pacific Region. This plan establishes a coral reef ecosystem regulatory area and complements four other fishery management plans to regulate fishing. Additional management measures were implemented in federal waters of the Gulf of Mexico and South Atlantic to help reduce overfishing and rebuild reef fish stocks. In Biscayne Bay, the National Park Service (NPS) established regulations related to lobster take. Beginning in 2003, USCRTF members initiated efforts to train local resource personnel in relevant laws, regulations, and related enforcement approaches. The USCRTF will continue to provide additional assistance in the area of enforcement.

Highlights of Task Force Member Activities

OBJECTIVE 1: Identify, monitor, and protect critically important U.S. coral reef fisheries habitats and spawning populations through an expanded network of no-take ecological reserves; ensure effective enforcement of existing no-take fishery reserves; monitor reef fish stocks in no-take marine reserves and reference sites to evaluate the effectiveness of reserves; and identify and protect new areas necessary to ensure the integrity of fisheries and ecosystems.

Gag Grouper MPAs Extended

Two MPAs were established in the northeastern Gulf of Mexico in 2000 to protect gag grouper (*Mycteroperca microlepis*) spawning grounds at the edge of the continental shelf in an effort to increase the stock biomass and, specifically, the percentage of males while protecting other species. NOAA supported efforts to map, characterize habitats, and evaluate changes in fish assemblages in the MPAs and an adjacent area of similar depth and habitat that is open to fishing. Efforts targeted the Madison-Swanson and Steamboat Lumps MPAs and the Twin Ridges control area. In all sites, reef fish abundance and distribution increased between 2001 and 2002, but declined by 2003. The recent decline may represent natural fluctuations; however, continued fishing activity in the MPAs aggravated the separation of natural and fishing mortality. In 2003, the Gulf of Mexico Fishery Management Council used the resulting data to extend the initial 4-year closure for an additional 6 years. NOAA proposed continued studies during the 10-year closure to evaluate the efficacy of area closures in the management of gag grouper resources.

More Effective Implementation of Marine Preserves in Guam

In 2002, Guam developed its Coral Reef Fisheries Management Local Action Strategy to increase and better assess the effectiveness of its five marine preserves at restoring reef fish stocks. The strategy focuses on increased law enforcement and prosecution, assessment of connectivity and spillover effects using larval tracking and reef fish assessments, and coordinated educational outreach, including program briefings to policymakers and the Guam legislature. Compared with data from the control sites, preliminary survey data show significant increases in fish density and species diversity within the preserves.

OBJECTIVE 2: Reduce overfishing by monitoring coral reef fisheries, assessing the adequacy of current fishing regulations, revising regulations as needed (using existing statutory processes in the case of federal regulations), and providing enhanced enforcement and education.

Enhanced Fishery Management in Biscayne National Park

A 2002 study of fish populations at Biscayne National Park conducted by the University of Miami and NOAA concluded that approximately 70 percent of commercial and recreational target species are overfished by federal standards and the number and size of key species are critically low. These findings led NPS to begin development of a groundbreaking Fisheries Management Plan (FMP) with the Florida Fish and Wildlife Conservation Commission (FWC). The joint FMP is a model effort to produce a management strategy transcending jurisdictions and boundaries to sustain fish stocks across their full range in and around Biscayne National Park. Scheduled for completion in late 2004, the FMP will be based on quantifiable,

desired future conditions for size and abundance of fishery populations to be met by reducing fishing gear impacts on habitat and bycatch, among other issues. NPS and FWC are incorporating input from the public and key stakeholders, including commercial and recreational fishers, divers, scientists, and conservationists, through the Florida Keys National Marine Sanctuary (FKNMS) Advisory Council to increase the effectiveness and facilitate implementation of the plan.

Training for Law Enforcement Officers

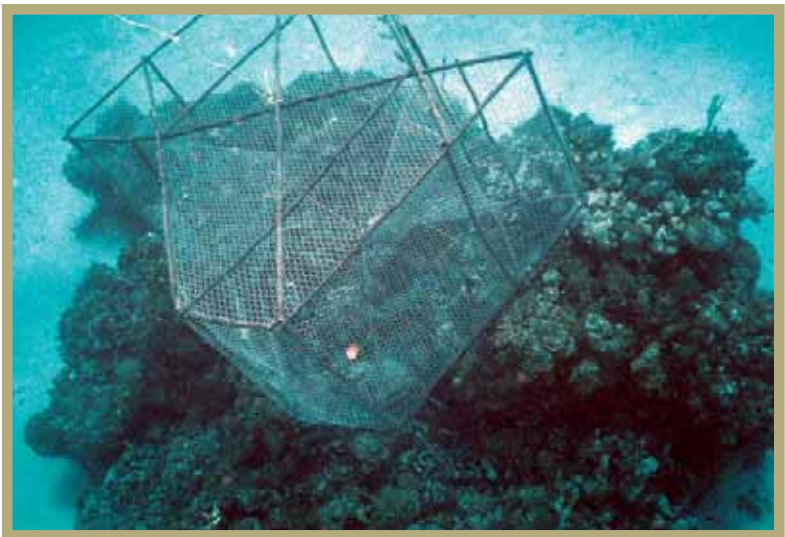
In 2003, the Puerto Rico Department of Natural and Environmental Resources selected eight rangers from six different regions to serve as members of a new Coral Reef Ranger Team in an effort to boost enforcement of coral reef and fisheries regulations. NOAA sponsored a training workshop for the rangers on the biology and identification of coral reef species, followed by a 2-week law enforcement training at FKNMS that emphasized topics in law enforcement, damage assessment, and coral and seagrass restoration.

OBJECTIVE 3: Enhance coordination on coral reef fishery issues with the U.S. territories in the Caribbean and Western Pacific.

LAS Implementation for Overfishing

In 2002, under the auspices of the USCRTE, state and territory partners began drafting LASs to address overfishing (or coral reef fishery management). These plans highlight ongoing conservation and management activities, identify gaps in local coral reef fishery management, and prioritize research and management needs for the next 3 years. Beginning in 2004, NOAA initiated support for new activities identified within the fishery management LASs, with an emphasis on supporting enforcement personnel and equipment.

OBJECTIVE 4: Reduce adverse environmental impacts of fishing by assessing essential fish habitat; identifying the effects of fishing and fishing gear; implementing actions or additional gear and fishing vessel anchoring restrictions to reduce habitat damage; eliminating destructive fishing practices; assessing and mapping deeper coral reefs, banks, and beds; and developing strategies to conserve these deeper ecosystems.



Antillean Z-trap dropped onto live coral in the Caribbean.

Understanding Trap Impacts

Certain types of fishing gear may damage coral reefs and seagrass beds. Managers need to understand the impacts of certain gear and the viable alternatives to those that are damaging. For example, fishers in the Atlantic, Caribbean, and Pacific commonly use traps to catch lobsters and fish, which have often been perceived as detrimental to coral reefs. Therefore, NOAA initiated an interdisciplinary effort in 2001 to analyze the placement and seasonality differences of trap usage, quantify damage to coral habitats, and examine the recovery rate of damaged organisms. Preliminary results from studies in Puerto Rico, the USVI, and Florida indicate that trap damage is not as high as anticipated because most fishers do not directly target hard coral areas.

OBJECTIVE 5: Incorporate ecosystem-scale considerations into coral reef fishery management by performing targeted research, including the development of models, to understand the ecosystem effects of fishing and the socioeconomic impacts of fishery management.


Western Pacific Coral Reef Ecosystem Fishery Management Plan

Early in 2004, NOAA published the final rule to implement the Western Pacific Region Fishery Management Council’s Coral Reef Ecosystem Fishery Management Plan—the first U.S. coral reef ecosystem-based management plan. The rule establishes a coral reef ecosystem regulatory area, MPAs, no-anchor zones, gear registrations, permitting and reporting requirements, and a framework for the regulatory process.

Hawai’i Marine Gap Program

The Hawai’i Marine Gap Program was established by the State of Hawai’i with support from NOAA to integrate available data on Hawaiian nearshore waters into a spatial database to provide a comprehensive ecosystem conservation and planning framework. The project’s primary objective is to conduct an analysis of current use and protection of habitat areas and species assemblages and to





help identify representative habitat types that should be considered for additional protection. To facilitate this work, a comprehensive database and geographic information system have been developed to better manage and visualize the vast amounts of data gathered in support of Hawaii's marine resources. The program is a central component of The Nature Conservancy of Hawaii's marine program.

OBJECTIVE 6: Reduce the overexploitation of reef organisms for the aquarium trade by banning the domestic commercial collection of coral and "live rock" and monitoring the collection of other species, developing new management measures or ecologically sound alternatives to wild collection, evaluating the effectiveness of existing legal authorities and policies governing the collection and importation of coral and other reef-dwelling species, and addressing inconsistencies among federal and state/territory regulations on collection and trade of ornamental coral reef species.

Closure of Live Rock Harvest in Western Pacific

One of the most significant actions within the Coral Reef Ecosystem Fishery Management Plan prohibited the harvest of live rock in federal waters. The plan defines live rock as "any natural, hard substrate, including dead coral and rock, to which is attached or which supports any living marine life-form associated with coral reefs." Along with American Samoa's ban on live rock collection in 2000, this prohibition closed the last loophole allowing the destructive collection of live rock in U.S. waters.

Managing Aquarium Collection in West Hawai'i

The Hawai'i Coral Reef Initiative Research Program has funded annual monitoring of the West Hawai'i

coastline. The 6-year program sought to investigate the status of aquarium fish populations along the west coast of Hawai'i and determine the effectiveness of the region's nine fisheries replenishment areas (FRAs). Although specific FRAs varied in their degree of effectiveness, overall study results demonstrate that MPAs can effectively promote the recovery of fish stocks depleted by fishing pressures in Hawai'i, at least for heavily exploited species. Overall, FRAs have successfully reduced conflicts between collectors and other resource users, promoted a sustainable fishery, and enhanced aquarium fish populations. The success of FRAs in West Hawai'i is likely to increase as aquarium fish grow and mature within these protected areas and further replenish nearshore reefs.

OBJECTIVE 7: Develop a process to evaluate issues and possibly develop guidance related to coral reef aquaculture in conjunction with stakeholders and relevant interagency groups, including the Aquatic Nuisance Species Task Force and the Invasive Species Council.

Aquaculture in waters adjacent to reefs has increased, and environmental issues have been dealt with on a case-by-case basis. USCRTF agencies have not yet developed national guidance specific to coral reefs and aquaculture.

Increase in the Number of Aquaculture Farms in the Hawaiian Islands

In 2002 and 2003, NOAA, through the University of Hawai'i Sea Grant College Program, has contributed to the founding and/or operation of 47 aquaculture farms in the Hawaiian Islands. This includes significant contributions to 8 pearl farms, 4 demonstration and training pearl hatcheries, 15 giant clam farms (including the largest commercial giant clam aquaculture venture in the Pacific), and 20 sponge farms. Overall, NOAA and its partners have helped

increase the number of aquaculture enterprises in the Hawaiian Islands to 126 farms valued at \$25.2 million and supplying approximately 630 jobs.

Offshore Aquaculture Technology Tested for Efficacy

NOAA and its partners have tested offshore aquaculture technology in such tropical locations as Hawai'i and Puerto Rico that have demonstrated the potential of this technology for coral reef fisheries management. This offshore aquaculture technology allows for the production of commercial reef fishes without depleting the natural population in coral reef ecosystems. For example, in Puerto Rico the cobia offshore pen produced 15 tons of marketable product in an 8-month period without depleting natural populations. Changes in benthic communities as a result of nutrient inputs in the surrounding area were found to be negligible.

Future Challenges

States, territories, and their federal partners have taken multiple steps to address the impacts of fishing on coral reefs; however, resource extraction still exceeds the limits of sustainability on most reefs near populated coastlines. Further progress will require a combination of enforcing existing regulations and exploring new alternatives for managing coral reef fisheries.

Enhance enforcement capabilities of state and territory agencies. The USCRF's state and territory members have identified lack of adequate enforcement as one of the major constraints to effectively



Example of traditional community fishing efforts using a non-selective seine net.

managing reef fisheries. In addition to environmental laws, officers in these regions are increasingly called on to enforce a variety of regulations, including customs efforts, drug interdiction, and immigration. These regions often do not have enough manpower, boats, or support to adequately enforce environmental laws and prosecute environmental crimes committed on their coral reefs. To address their pressing enforcement needs, DOI, the U.S. Department of Justice (DOJ), the U.S. Environmental Protection Agency (EPA), and NOAA have initiated a series of enforcement workshops to help support the individual needs of each jurisdiction and begin to provide additional training for both enforcement officers and legal personnel.

Increasingly, states and territories are experimenting with community-based approaches and enhanced education and outreach to improve coral reef fisheries compliance. These novel approaches, building on diverse models such as those pioneered in West Hawai'i and American Samoa, are among the most promising additions to the fisheries management toolkit.



Nassau Grouper is a candidate species for listing under the Endangered Species Act.

Continue support for implementing LASs. The USCRTF's state and territory partners have developed 3-year plans to address overfishing and coral reef fishery management issues in their jurisdictions. Additional support is needed from federal agencies and other partners to support the priority actions listed within these LASs.

Continue developing networks of no-take reserves. Combined with traditional fishery management efforts, no-take reserves can be effective tools for recovering and sustaining overfished species and protecting the habitats that sustain them. The USCRTF will continue to work with key stakeholder groups, including resource managers, recreational and commercial user groups, nongovernmental

organizations, and the public, in all phases of the design, implementation, and evaluation of MPAs. These efforts need to consider appropriate legislative and regulatory authorities; traditional, community-based, and subsistence uses; and the best available scientific data on the natural history of coral reef species, species associations, and habitat considerations.

Research coral reef fisheries. Research is needed in the area of ecosystem-level, multispecies stock assessments with an emphasis on nontraditional, poorly known species of increasing commercial importance (e.g., ornamentals, invertebrates, herbivorous fishes). Future research needs to examine the natural history of representative species from different trophic groups, including species interactions and the cascading effects of overfishing on target and associated nontarget species.

Characterize and protect essential fish habitats. Efforts need to focus on understanding the habitat requirements of commercially and ecologically important fish and invertebrates and the effects of habitat degradation on these species. Understanding the connectivity and linkages between adjacent habitats and their role as essential fish habitats (EFHs); the factors affecting recruitment, migration, and movement within and among habitats; and how to ensure appropriate habitats are delineated and protected as EFHs is also important.

Reducing the Impacts of Coastal Uses



GOAL: Reduce the impact of human coastal activities on coral reef ecosystems.

Rationale for Action

Coral reef ecosystems are being continually and, in some cases, irreparably damaged by a number of avoidable human activities. Dredging for navigation or marinas, beach renourishment, sand mining, pipeline and cable installation, and coastal development and modification projects can degrade water quality around reefs. Although reefs contribute to tourism revenues, a

boom in coastal tourism can lead to additional direct (e.g., from diving, snorkeling, and fishing) and indirect (e.g., through increasing demand for coastal development, sewage discharge, and vessel traffic) impacts on coral reef resources, compounding the adverse effects of coastal development.

As the number of people using and transiting coral reef areas has increased, so has the frequency of

OBJECTIVES

OBJECTIVE 1: Develop informal guidance, protocols, and technical assistance programs to reduce the risks of damage to coral reefs resulting from federal agency activities.

OBJECTIVE 2: Strengthen federal and state permitting and management programs for coastal development activities affecting coral reef habitats to minimize or prevent adverse impacts on coral reef ecosystems.

OBJECTIVE 3: Initiate actions at the national and international levels to prevent vessel groundings.

OBJECTIVE 4: Develop standard vessel grounding response, enforcement, and injury assessment guidance and improve the ability to remove grounded and abandoned vessels and restore damaged habitat.

OBJECTIVE 5: Strengthen existing and develop new resource management programs and protected areas to address the broad range of coastal activities.

OBJECTIVE 6: Develop mitigation guidelines for coastal development projects deemed essential by federal, state, and territory agencies.



vessel groundings in these areas. Vessels striking shallow coral reef resources cause localized damage to the habitat by crushing and fracturing the coral structures and displacing resident fishes. In addition, propeller scarring, anchoring, and other physical contacts cause damage to associated seagrass beds. Some affected habitats cannot recover without direct and often expensive human intervention, including direct removal of debris or vessels, emergency triage of injured animals, and long-term restoration of habitats and benthic communities.

Many of these growing pressures have resulted from rapid growth in coastal populations and tourism throughout the past few decades. One striking example of this pressure is the increasing amount of recreational boats registered in South Florida (see

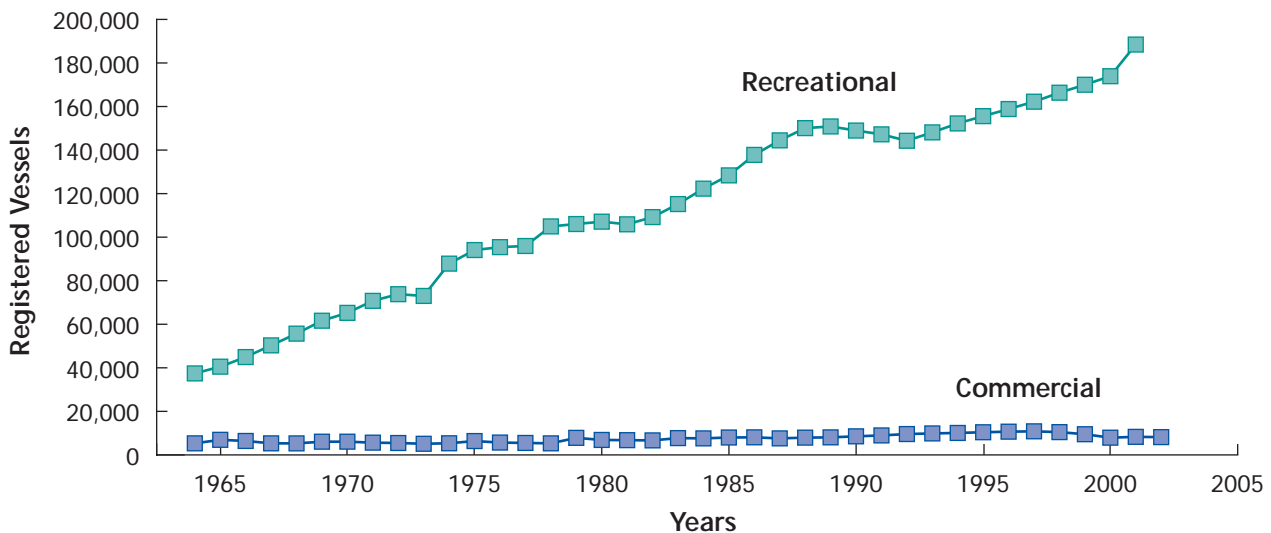
figure 3). Resources for the programs responsible for implementing and enforcing existing conservation authorities have not kept pace with growth, impeding conservation efforts. Adequate planning and the consistent and proactive application of existing federal and state authorities and programs can reduce the adverse impacts of coastal development, shoreline modification, and vessel groundings.

Summary of Implementation

The U.S. Coast Guard (USCG), the U.S. Department of the Interior (DOI), the U.S. Department of Defense (DoD), and NOAA have been working with state and territory governments to improve navigation through coral reef resources, examine

Figure 3. Increasing Trend in Recreational Vessel Registration in South Florida

The graph shows the increasing number of registered recreational vessels in South Florida (Broward, Collier, Miami-Dade, Monroe, and Palm Beach counties) compared to registered commercial fishing vessels. As of 2002, more than 191,000 recreational vessels were registered in these counties. Greater boat traffic reflects increased recreational fishing and increases the likelihood of groundings and other impacts on reefs.



Data Source: Ault et al. 2002.

the effectiveness of mitigation efforts, address coastal overuse and misuse, promote best practices, and protect important coastal areas. State and territory governments have taken legal steps to reduce the impacts to coral reef resources from overuse and misuse. For example, Puerto Rico passed Administrative Order (AO) 2003–25, which regulates recreational use in five natural reserves. This AO establishes a carrying capacity for each area, prohibits the anchoring of vessels in seagrasses and the tying of vessels to mangrove trees, and regulates other coastal activities. State and territory partners are also zoning coral reef areas to reduce user conflicts and abuse and increasing outreach and education.

Ship groundings and anchor damage continue to affect coral reef health throughout U.S. waters. USCRTF agencies have concentrated on improved planning for and response to ship groundings. The primary strategy has been to avoid vessel impacts by improving navigational aids and providing permanent moorings that obviate the need to anchor on coral reefs. Federal, state, and territory agencies are collaborating to develop rapid-response measures when groundings occur to remove vessels before irreparable harm is caused. Finally, NOAA and USCG have developed an inventory of existing grounded vessels to identify those that are appropriate for removal and other actions.

In addition to the damage caused by ship groundings, coral reef ecosystems are threatened by the recreational overuse and misuse associated with increased tourism. The USCRTF has identified this threat as one of six priority areas for action, and each state and territory, with assistance from federal agencies and nongovernmental partners, has developed local action strategies to address recreational impacts. Coastal zone management plans mandated by the Coastal Zone Management Act are additional mechanisms for coordinating these activities. States and territories are experimenting with novel approaches to improve incentives for coastal

development projects that avoid damaging sensitive habitats.

Many coastal activities that may impact coral reef ecosystems, including construction and dredging, require U.S. Army Corps of Engineers permits, environmental impact statements, and mitigation plans. Federal agencies have begun analyzing past mitigation activities to improve the permitting process and the success of mitigation efforts. Analysis conducted by the U.S. Fish and Wildlife Service (USFWS) has prompted the creation of interagency working groups in the Pacific and Atlantic/Caribbean region tasked with developing additional measures.

Highlights of Task Force Member Activities

OBJECTIVES 1 & 2: Develop informal guidance, protocols, and technical assistance programs to reduce the risks of damage to coral reefs resulting from federal agency activities. Strengthen federal and state permitting and management programs for coastal development activities affecting coral reef habitats to minimize or prevent adverse impacts on coral reef ecosystems.

Coral Damage and Enforcement Study

DoD sponsored a study to assess how enforced protection around military assets at Vieques Island and Culebra Island, Puerto Rico, affects nearshore marine ecosystems. Preliminary results show sites in former restricted military areas contain as much, if not more, coral cover, coral diversity, increased fish abundance, and increased biomass as nonrestricted sites. This finding indicates the importance of including *de facto* protected areas associated with military sites into coral reef planning. Some formerly restricted sites that are now open to the public show evidence of recreational anchor damage.



Grounded vessel off American Samoa. The U.S. Coral Reef Task Force members work to locate and prioritize removal of such vessels.

DoD Educates Personnel on Coral Reef Protection

DoD produced a brochure on coral reef protection for the military. The *Coral Reef Conservation Guide* provides an overview of DoD activities having the potential to adversely affect coral reef ecosystems and outlines DoD requirements and U.S. national laws and policies regarding coral reef protection. DoD continues to promote and distribute this brochure and other outreach material on coral reef protection.

Corps of Engineers Enhances Protection of Corals Through Its Regulatory Program

The Corps of Engineers has enhanced the protection of coral reefs through decisions under its regulatory program by stringently administering the avoidance, minimization, and compensatory mitigation provisions of its regulations in southeast Florida. Through its evaluation of alternatives for

bringing natural gas pipelines into southeast Florida from the Bahamas, the pipeline companies have changed from horizontal directional drilling (HDD) under the three reef tracts off the coast to using tunnel technology that results in essentially eliminating all impacts to the reef tracts in less than 120 feet of water. The HDD approach would have directly impacted acres of coral and involved very high risk for additional unintended impacts during construction. Those impacts and potential impacts are eliminated. On two beach projects, the Corps review resulted in reducing impacts to hard bottom

resources by more than half in each case, avoiding the most ecologically valuable resources, including coral resources. The permit decisions also require a much higher degree of care when removing the sand from offshore borrow areas by requiring specific operational constraints on the dredges. All unavoidable impacts will be fully offset by mitigation.

OBJECTIVES 3 & 4: Initiate actions at the national and international levels to prevent vessel groundings. Develop standard vessel grounding response, enforcement, and injury assessment guidance and improve the ability to remove grounded and abandoned vessels and restore damaged habitat.

Florida Keys National Marine Sanctuary Protected From Ship Damage by International Designation

On March 8, 2002, the International Maritime Organization (IMO) provided final approval for the

designation of the marine area around the Florida Keys National Marine Sanctuary (FKNMS) as a Particularly Sensitive Sea Area (PSSA) (the third such area designated in the world), in part through the efforts of USCG, NOAA, and the U.S. Department of State. FKNMS is highly valuable ecologically and economically. Since the area is vulnerable to damage from ships colliding and grounding on the reef, as well as damage from anchors and the dragging and swinging of anchor cables, IMO has designated four areas to be avoided by ships and three mandatory no-anchoring areas. By being designated as a PSSA, the marine area around the Florida Keys is one of the most protected areas in the world.

Hurricane Anchor System Protects Mangroves and Allows Boats To Take Shelter

The National Park Service (NPS) and the Friends of the Virgin Islands National Park, with assistance from NOAA, developed an anchoring system for Hurricane Hole, St. John, which is part of the new Virgin Islands Coral Reef National Monument. Hurricane Hole is one of the most significant, intact nursery areas in the U.S. Virgin Islands (USVI). NPS prohibits anchoring throughout the monument; however, Hurricane Hole has traditionally been an anchoring area during severe storm events. To protect important nursery and mangrove habitats and still allow the area to be used during emergencies, the park decided to install a hurricane anchor system. The park held multiple stakeholder meetings and engaged a nautical engineering firm to design an anchor system to protect vessels and the fragile shoreline environment. Research and public meetings led to a chain-system anchor design with a strong holding capacity. The permanent anchor system will be installed on the sea floor, preserving the area's natural beauty, and can be accessed only before a major storm.

Vessel Cited for Anchoring in the Tortugas Reserve

Through a joint effort of USCG and NOAA, a commercial vessel owner was cited in October 2002 for anchoring in the Tortugas North Ecological Reserve. For the first time, quick action identified the responsible party and resulted in the establishment of a restoration project. The citation put other vessel owners on notice that such activity will not be tolerated. The restoration project that followed reattached more than 1,100 coral colonies and fragments to the affected coral reef site.


Workshops Promote Interagency Response to Abandoned Vessels

NOAA, USCG, the U.S. Department of Justice, the Pacific Basin Development Council, and state and territory partners conducted two workshops on the issues associated with vessel groundings and abandoned vessels in the U.S. Flag Pacific Islands. The workshops were held in 2002 in Honolulu, Hawai'i, and in Tumon, Guam. More than 90 participants representing 4 U.S. Flag Island jurisdictions, the Federated States of Micronesia, and 5 federal agencies took part in the workshops. The workshops focused on the following four topics associated with vessel groundings:

- Magnitude of the issue;
- Legal frameworks;
- Response and enforcement; and
- Damage assessment and restoration.

Participants discussed how to further address and monitor the magnitude of the issues in each jurisdiction, including prevention measures, legal and technical assistance, and funding mechanisms. As a result of the workshops, participants from the





Commonwealth of the Northern Mariana Islands (CNMI) conducted an interagency meeting that determined jurisdiction, scope of duties, limitations, regulations, and other issues regarding grounding response and assessment, hazardous spill cleanup, vessel removal, and reef restoration.

Inventory of Abandoned Vessels Assesses Risk and Prioritizes Removal

During 2002 and 2003, NOAA's Abandoned Vessels Project, with the help of the USCG and local partners, conducted field surveys of 176 abandoned vessels in Guam, the CNMI, the USVI, and Puerto Rico. The surveys validate an online inventory database of existing abandoned vessels and assess the environmental, public safety, and navigational risks of each vessel. The inventory helps resource managers understand the threats posed by abandoned vessels, prioritize their removal, and update navigational charts. This effort has led to the removal of several vessels and improvements in capacity to prevent and respond to vessel groundings.

Navy Develops Operations Best Management Practices

The U.S. Navy continued development of best management practices for its installations and vessels operating in proximity to coral reefs and training protocols for personnel to implement such measures. This project will also develop checklists of recommended best management practices for application during facility construction or vessel operation to avoid potential degradation of coral reefs.

Impromptu Mapping in Saipan Harbor Reveals Danger to Navigation

During a monitoring cruise to Saipan, NOAA scientists were asked by the CNMI Port Authority to map the Saipan inner harbor area because of concerns about possible shoal soundings in or near the main shipping channel. After consulting with hydrographers, a reconnaissance survey was run and NOAA

presented a preliminary report to the harbormaster. The data were immediately sent for more detailed and rigorous analysis. From these data, NOAA issued a Danger to Navigation Report. As a result, the Saipan harbor is now restricted to vessels with less than 30 feet of draft until improvements to the channel can be made. Although the harbor survey was done primarily to define bathymetry and not specifically to assess benthic habitats, the data have aided in the protection of coral reefs around the Saipan harbor by averting potential damage caused by vessels grounding on shoals in the channel.

OBJECTIVE 5: Strengthen existing and develop new resource management programs and protected areas to address the broad range of coastal activities.

Easements Restore Coastal Wetlands and Reduce Runoff

In 2002, USFWS Partners for Fish and Wildlife Program provided technical assistance to the U.S. Department of Agriculture Natural Resources Conservation Service Wetland Reserve Program (WRP) to purchase 15,396 acres of conservation easements in coastal Martin County, Florida. In 2003, 12,936 acres of easements were purchased and restored to functioning wetlands to reduce land-based runoff in coastal lagoons containing dense seagrasses and the sabellariid reef ecosystem.

This Allapattah Ranch WRP project will improve and increase habitat coverage for a number of aquatic and terrestrial organisms by reducing sedimentation in nearshore waters, benefiting hawksbill, green, loggerhead, and leatherback sea turtles. A large number of state-listed and federal-listed species, including numerous migratory and wading birds, will also benefit. Since 1998, approximately 135,000 acres in Florida were enrolled in this cooperative agency program that highlights conservation partnerships with private landowners while allowing some sustainable uses of private lands.

Multiagency Partnership Results in Maui Land Trust

USFWS provided technical assistance to the Maui Coastal Land Trust, Ducks Unlimited, and the Hawai'i Division of Forestry and Wildlife in 2002 to help obtain \$2 million in federal assistance to purchase and protect a unique, 277-acre coastal ecosystem encompassing a wetland, riparian habitats, 1.2 miles of marine shoreline (including 8,000 feet fronting one of the most extensive coral reef systems on Maui), and one of the last intact sand dune complexes in the state. The funds, provided to the State of Hawai'i through the USFWS National Coastal Wetland Grant Program and Section 6 Recovery Land Acquisition Grant Program, were awarded to the Maui Coastal Land Trust to purchase, hold, and manage the property in perpetuity. In 2003, the USFWS Private Stewardship Grant Program awarded \$107,080 to the Maui Coastal Land Trust to initiate habitat restoration activities that will benefit not only the nearby coral reef system, but migratory bird species, sea turtle nests, rare coastal plants, and important archeological resources in the surrounding dunes as well.

DoD Develops Tools To Avoid Sensitive Marine Resources

DoD is collating environmental data in geographic information systems (GISs) to help resource managers more readily identify and avoid sensitive marine ecosystems. Coral reef assessment information is an integral part of the GIS tools. Using this marine resource assessment data and other



Guam's replanting efforts to combat erosion are conducted by the Guam Department of Agriculture.

available resources, the Environmental Information Management System (EIMS) has been assembled for marine areas in which the U.S. Navy routinely operates. EIMS will raise the environmental awareness of facility planners and ship operators and help ensure that training exercises can be better planned and timed to avoid sensitive marine resources.

Erosion Prevention on Offshore Islets in Hawai'i

USFWS funded the protection of fragile coral reefs from burial by rain-induced mudslides from the slopes of highly eroded islets near Oahu. Alien plants were removed and replaced with native species to stabilize the soils. This project served as a foundation to reach out to the local communities by creating educational opportunities for schools and fostering increased communication with such stakeholder groups as fishermen, kayakers, and hikers. In addition to protecting Hawaii's fragile



coral reefs, this project benefited the habitat of burrowing seabirds. Ongoing work on other Hawai'i islets will benefit multiple species of nesting birds and endangered coastal plants and arthropods. The State of Hawai'i, The Nature Conservancy, Bishop Museum, University of Hawai'i, and NPS continue their partnership with USFWS and work together to monitor and restore these islets.

OBJECTIVE 6: Develop mitigation guidelines for coastal development projects deemed essential by federal, state, and territory agencies.

Results From Mitigation Reports Trigger Federal Action

In 2002, USFWS, with additional funding from the U.S. Environmental Protection Agency (EPA), conducted an evaluation of compensatory mitigation (i.e., the restoration, creation, or preservation of coral reef resources as compensation for unavoidable impacts) for federally funded or per-

mitted coastal construction projects in the U.S. Pacific (<http://pacificislands.fws.gov/worg/pcrmreport.pdf>). The review showed limited implementation of such policies, which resulted in poor compensation for habitat loss. The reviewers examined past files for documenting the mitigation process, assessed the relative effectiveness of mitigation activities, and provided recommendations to improve future compensatory activities. Of the 11 projects evaluated, 9 implemented some form of compensatory mitigation. Of those nine, only four effectively

offset losses to the coral reef ecosystem. Therefore, the mitigation record in the Pacific was the successful mitigation of 116 acres and the loss of 62 acres.

Building on the Pacific report described above, USFWS released a draft report in 2003 of projects in South Florida and the U.S. Caribbean that had compensatory mitigation for impacts on coral reef resources (<http://www.fws.gov/southeast/es>). The review was completed in 2004. These Atlantic and Caribbean projects removed 264 acres of coral reef habitat with compensatory mitigation expected to be a total of 118 acres. The record in the Atlantic was similar to the results in the Pacific with successful mitigation of 5 acres and the loss of 76 acres.

Both studies pointed out large information gaps in the existing compensatory mitigation process. Both studies were also based on data over the last several years, including early years of limited success in mitigation. Mitigation approaches and mitigation success has substantially improved in the past 5 years, though further improvement is needed.

Recommendations made to improve mitigation activities include:

- Developing regional Interagency Coral Reef Mitigation Strategies;
- Identifying or creating a set of methodologies to adequately assess project impacts and appropriate mitigation measures;
- Developing a monitoring and tracking system for compensatory mitigation;
- Identifying and assessing additional mitigation approaches and activities; and
- Prioritizing compensatory mitigation activities in plans for large projects.

Implementing the recommendations should help federal agencies replace lost coral reef resources more efficiently and effectively.

Hawai'i Interagency Mitigation Working Group Formed

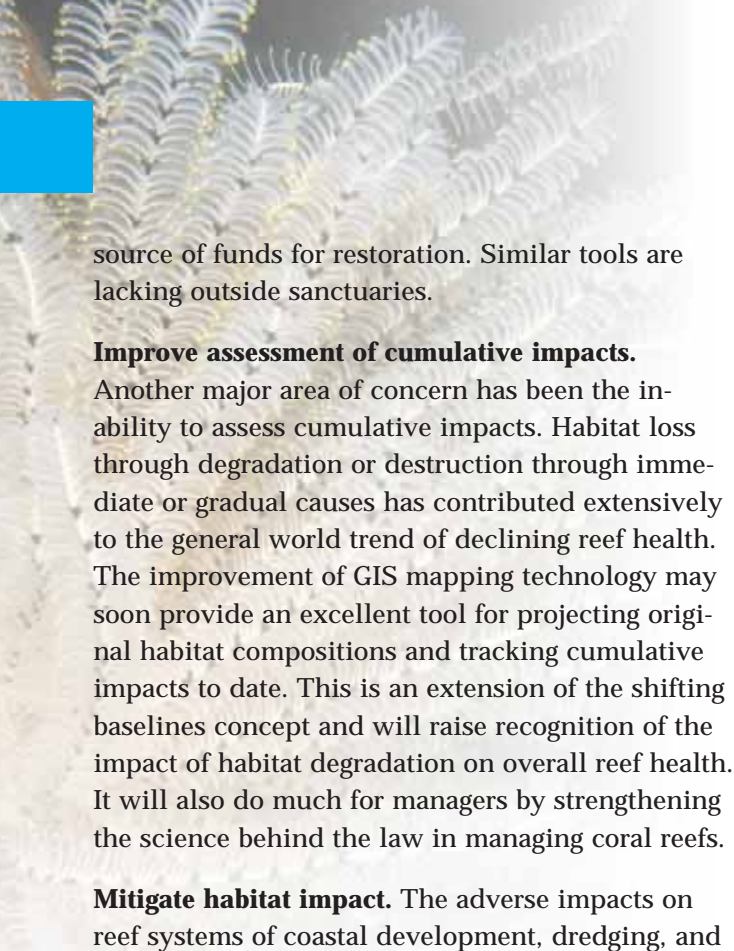
In 2002, as a result of the Pacific Compensatory Mitigation Report, the Hawai'i Interagency Coral Reef Mitigation Working Group (HIWG) was formed to improve the performance of natural resource agencies in providing recommendations for compensatory mitigation. The working group includes USFWS, EPA, NOAA, the Army Corps of Engineers (Regulatory and Civil Works), and Hawaii's Department of Land and Natural Resources and Department of Health. The group is working to address problems outlined in the Pacific Compensatory Mitigation Report and is meeting on a bimonthly basis to write an Interagency Coral Reef Mitigation Strategy. HIWG sponsored a resource assessment workshop to establish ecological criteria for assessing coral reef resource functions and biological values from which workshop proceedings were released in late 2004.

Future Challenges

The pressures of rapid growth of coastal populations and reef-related tourism over the past few decades have had a variety of adverse impacts on coastal coral reef habitats. In many areas, damage incurred as a result of coastal development, shoreline modification, and vessel groundings can be prevented or mitigated through consistent and proactive application of existing federal and state authorities and programs. However, lack of resources, information, and other tools have limited the ability of many programs to prevent impacts to valuable coral reef ecosystems.

There are a variety of challenges to reducing the impacts of coastal uses on reef habitats. In many areas, implementation of existing tools or development of new technologies is needed to help prevent damage by vessels to coral reef habitats. Improvements in mitigation measures and adherence to mitigation plans could help protect and restore sensitive coral reef resources. In addition, education and outreach continue to be priority needs to help reduce impacts on reefs from a variety of coastal activities.

Address damage by vessels. USCRTF members have initiated workshops and other management efforts to address the impacts of ships on coral reef ecosystems; however, increased efforts are required to fully address this issue. For example, collaborative initiatives among managers and vessel operators, including the establishment of additional safe harbor areas and no-anchoring zones, could provide viable alternatives to anchoring in sensitive reef habitats. The National Marine Sanctuaries Act (16 U.S.C. § 1431 *et seq.*) prohibits destruction, injury, or loss of sanctuary resources and establishes liability for response costs and natural resource damages for injury to these resources. These provisions have served as a powerful deterrent to damage and a



source of funds for restoration. Similar tools are lacking outside sanctuaries.

Improve assessment of cumulative impacts.

Another major area of concern has been the inability to assess cumulative impacts. Habitat loss through degradation or destruction through immediate or gradual causes has contributed extensively to the general world trend of declining reef health. The improvement of GIS mapping technology may soon provide an excellent tool for projecting original habitat compositions and tracking cumulative impacts to date. This is an extension of the shifting baselines concept and will raise recognition of the impact of habitat degradation on overall reef health. It will also do much for managers by strengthening the science behind the law in managing coral reefs.

Mitigate habitat impact. The adverse impacts on reef systems of coastal development, dredging, and

shoreline modification have been significant in many areas. To address this challenge, managers need an assessment of more effective options for mitigating impacts to reef ecosystems and better integration and accountability of compensatory mitigation in coral reef systems.

Provide education and outreach. Members of the USCRTF have made efforts in the previous 2 years to enhance education and outreach to improve understanding of the impacts of coastal uses on coral reefs and how to prevent or reduce these impacts. However, this issue requires increased commitment. To be successful in protecting fragile coral reef ecosystems, additional efforts are needed to help identify the causes of reef degradation and how to prevent them.

Reducing Pollution



GOAL: *Significantly reduce the amounts, sources, and cumulative impacts of pollution on coral reefs by fully implementing existing federal and state authorities.*

Rationale for Action

Healthy coral reefs require good water quality to grow, remain viable, and provide ecosystem benefits. Pollution can threaten reef ecosystems by harming sensitive species, altering species' compositions, disrupting critical ecological functions (e.g., photosynthesis), and impeding the normal settlement and growth of stony corals and other benthic invertebrates. Pollution enters reef ecosystems in many ways, ranging

from such specific point source discharges as sewage pipes and vessels to more diffuse sources such as runoff associated with agriculture, coastal development, road construction, and golf course irrigation. Land-based sources of pollution, including sedimentation, have been identified as top threats to coral reefs. In addition, marine debris has been identified as the primary anthropogenic impact to the otherwise relatively pristine Northwestern Hawaiian Islands (NWHI)

OBJECTIVES

OBJECTIVE 1: Reduce sedimentation and other land-based sources of pollution by implementing conservation management practices in coastal watersheds through public/private partnerships, incentive-based measures, regulatory measures, technical and financial assistance, habitat restoration, and other activities.

OBJECTIVE 2: Improve water quality by reducing nutrient discharges from wastewater treatment facilities, vessels, industrial sources, storm water, agricultural sources, and air deposition.

OBJECTIVE 3: Reduce chemical pollution (e.g., oil, toxins, hazardous materials) from land-based sources and vessel discharges.


OBJECTIVE 4: Reduce the flow of marine debris and remove existing marine debris from reef ecosystems.

OBJECTIVE 5: Prevent and control the spread of invasive species (e.g., non-native species) in coral reef ecosystems from ballast water and other mechanisms.

OBJECTIVE 6: Develop tools to assess and address the impacts of pollution on coral reefs.

OBJECTIVE 7: Increase awareness and understanding of the ecological health and socioeconomic impacts of land-based and marine pollution on reef ecosystems.





coral reef ecosystems. Invasive species⁵, which are considered a type of biological pollution, are increasingly impacting reef areas throughout Hawai'i and other jurisdictions.

Although the sources, characteristics, and impacts of pollution vary widely among U.S. jurisdictions, much of the pollution could be significantly reduced or potentially eliminated by fully implementing existing state and federal regulations and voluntary programs. The USCRTF identified land-based sources of pollution as a priority area for action and implementation of local action strategies (LASs) to address the problem in key watersheds.

Summary of Implementation

USCRTF member agencies address pollution by developing regulations to limit the types and amount of waste being discharged and by establishing federal/local partnerships to voluntarily implement best management practices within watershed areas. Increasingly, federal, state, and local agencies are using a ridge-to-reef approach to assess inputs from watersheds on reef habitats and evaluate the impact pollution has on reef ecosystems. In order to design management solutions, agencies are conducting multidisciplinary scientific research and developing tools to better identify origins of pollutants, track their movement, and understand their impacts on the environment.

Reduction of land-based sources of pollution is greatly affected by policies and regulations at the local level. Therefore, strategic partnerships among federal, state, and local agencies are important to addressing this problem. The U.S. Environmental Protection Agency (EPA), partnering with the states, implements programs under the Clean Water Act that regulate point source discharges polluting the Nation's waters. These programs address point source discharges from industrial facilities,

municipal wastewater treatment plants, certain agricultural operations, and storm water. In addition, EPA and other USCRTF federal agencies tackle nonpoint source pollution by partnering with states and territories and providing funding and technical assistance through a variety of programs and grant opportunities.

To address nonpoint source pollution, EPA partners with states and territories through voluntary programs like the Nonpoint Source Management Program (Section 319 of the Clean Water Act) to provide technical and financial assistance and educational training, initiate demonstration projects, and support monitoring efforts. NOAA's Coastal Zone Management Program funds projects that address polluted runoff threatening coral reefs and builds federal/state partnerships that encourage the restoration and sustainable development of coastal communities and resources nationwide.

In addition, EPA and NOAA partner with coastal states to tackle nonpoint source pollution through the Coastal Nonpoint Pollution Control Program (CNP). CNP differs from EPA's Section 319 voluntary nonpoint source program in that it establishes a consistent set of economically achievable management measures backed by enforceable state policies for controlling polluted runoff. Measures are designed to prevent pollution from agriculture, forestry, urban areas, marinas, and hydromodifications (i.e., channel modification) and to ensure environmentally sensitive management of wetlands and riparian areas. In 2002–2003, the U.S. Virgin Islands (USVI), American Samoa, and the Commonwealth of the Northern Mariana Islands (CNMI) received full approval of their CNPs from NOAA and the EPA. Puerto Rico has already received this designation.

The U.S. Department of Agriculture (USDA) administers programs enabling many private landowners to receive technical and financial resources to apply conservation practices on their lands. The USDA's Natural Resources Conservation Service provides

⁵ An "invasive species" is defined as an alien (non-native species) whose introduction does or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112).

technical assistance to landowners who want to voluntarily develop individual farm and ranch plans and implement conservation measures that affect millions of acres. These efforts help reduce soil erosion and nutrient runoff, thereby enhancing water quality. The U.S. Fish and Wildlife Service (USFWS) also has a number of programs providing funds and technical assistance for projects that address erosion and coastal wetland loss. These include the Coastal Program, Partners for Fish and Wildlife, and the Coastal Wetlands Grant program.

The USCRTF also addresses other sources of pollution of major concern. This includes pollutions from vessels and marine debris and the introduction and spread of invasive species. NOAA has led a major interagency effort in the NWHI to remove existing accumulations of marine debris, mostly derelict fishing gear from distant water fisheries.

Highlights of Task Force Member Activities

OBJECTIVE 1: Reduce sedimentation and other land-based sources of pollution by implementing conservation management practices in coastal watersheds through public/private partnerships, incentive-based measures, regulatory measures, technical and financial assistance, habitat restoration, and other activities.

Collaborative Assessment of Land-Based Source Pollution in War-in-the-Pacific National Park, Guam

In 2002, the National Park Service (NPS) initiated a unique project with the government of Guam and

USDA/NRCS Programs Help Prevent Soil Loss

Sedimentation from land-based sources can impact coral reef ecosystems. Soil conservation efforts upstream can help reduce sediment transport from coastal watersheds to reef habitat.

In 2003, it is estimated that USDA/NRCS programs prevented:

52,417 dump truckloads of soil loss in the Caribbean.
5,542 dump truckloads of soil loss in the Pacific region.
12,816 dump truckloads of soil loss in Florida.

(Average dump truck volume is approximately 8 cubic yards.)

the University of Guam to assess the relationships among wildfires, upland erosion, and coral reef sedimentation in the War-in-the-Pacific National Historical Park and at other locations. Monitoring sites are yielding valuable information that will contribute to the development of best management practices to help resource managers address land-based threats to reef resources throughout Guam.

Using Partnerships and the Hawaiian Ahupua'a Concept To Reduce Land-Based Pollution

In Hawai'i, state, local, and private stakeholders and USFWS, USDA, and EPA formed watershed partnerships to implement landscape-scale conservation while reducing siltation on adjacent coral reefs. The ancient Hawaiian concept of the Ahupua'a recognizes the connectedness of the environment, from the mountains to the sea, and the importance of meeting community needs while respecting the vitality of the land. An intact forest absorbs, stores, and slowly releases rainwater much more efficiently than an ecosystem damaged by invasive species. Controlling habitat-altering factors in Hawai'i (e.g., invasive species, wildfires) while planting native



Sedimentation during high rainy season damages the southern coral reef ecosystems of Guam.

trees and understory species has proven effective in reducing the amount of sediment reaching adjacent marine ecosystems. In addition, in cooperation with the state, NPS, and the local community, USFWS funded removal of invasive plants and restoration of native plant species on several highly eroded islets near Oahu, which helped prevent reefs from being smothered by mudslides originating on these islets.

EPA Targeted Watershed Grants Program

In 2003, the Hanalei Heritage River Program received a \$700,000 grant from EPA's Targeted Watershed Grants program to reduce pollution and assess coral reef health in Hanalei, Kauai. The project funding will be used to upgrade antiquated cesspools, control sediment discharges from farms, reduce erosion in forests, monitor water quality, and assess changes in the structure and recruitment of reef ecosystems.

USDA and Local Partners Reforest Guam Watersheds

The USDA Natural Resources Conservation Service partnered with the Guam Division of Forestry and

Soil Resources, landowners, community members, and local businesses to implement the Guam Urban Forestry Project, which reforests watersheds and improves water quality in the Tumon Bay Marine Preserve. The community participated in all stages of the reforestation efforts, including installing vegetative barriers, filter strips, and tree plantings in the villages of Tumon and Harmon.

OBJECTIVE 2: Improve water quality by reducing nutrient discharges from wastewater treatment facilities, vessels, industrial sources, storm water, agricultural sources, and air deposition.

No-Discharge Zone in the Florida Keys National Marine Sanctuary

In 2002, EPA, acting on a recommendation by the Governor of Florida, the Monroe County Board of County Commissioners, and the Water Quality Protection Program Steering Committee, designated all state waters within the boundary of the Florida Keys National Marine Sanctuary (FKNMS) as a no-discharge zone for vessel sewage.

EPA Management Guidelines for Wastewater

The EPA released new guidelines in 2003 to help local governments strengthen their management of septic systems and other small, privately owned, decentralized wastewater treatment systems. These new guidelines are complemented by the Voluntary (National) Guidelines for Management of Onsite and Clustered Wastewater Treatment Systems. The guidelines seek to improve the performance of decentralized wastewater treatment systems. This objective is especially important in coastal areas with severely degraded or nonexistent wastewater treatment facilities.

Mobile Irrigation Labs in South Florida

To maximize the efficiency of irrigation water and nutrient usage in southern Florida, the USDA Natural Resources Conservation Service, in partnership with the South Florida Water Management District, Florida Department of Agriculture, and local soil and water conservation districts, is using mobile irrigation labs (MILs). These systems help reduce fertilizer and sediment losses that may affect coral reefs. In fiscal year 2002, in southern Florida alone, MILs resulted in an estimated savings of 3,478 million gallons of water.

OBJECTIVE 3: Reduce chemical pollution (e.g., oil, toxins, hazardous materials) from land-based sources and vessel discharges.

Contaminated Sediment/Debris Removed in South Florida

USDA's South Florida Resource Conservation and Development Area entered into a cooperative agreement with the Federal Emergency Management Agency (FEMA), Florida Department of Community Affairs, and Miami-Dade County to remove contaminated sediment and other debris from a 2.25-mile section of the secondary canal system. Removing the sediment eliminated its potential deposition and adverse impacts on associated coral reef ecosystems.

Uniform National Discharge Standards for Armed Forces Vessels

EPA and the U.S. Navy are working together to develop Uniform National Discharge standards to regulate discharges, other than sewage, which are incidental to the normal operation of Armed Forces vessels. Phase I of the rulemaking characterized the nature of the discharges (e.g., bilge water) and

determined which discharges will be subject to pollution-control measures. The Phase I rule identified 25 types of vessel discharges that would require control by a marine pollution control device (MPCD), and identified 14 vessel discharges that would not require pollution controls because of their low potential for causing adverse environmental impacts. Currently, the agencies are working on Phase II of the rule, which will establish 25 performance standards for MPCDs. Under this phase, EPA and the U.S. Navy are identifying and evaluating potential MPCDs for the 25 types of discharges in order to establish performance standards based on the environmental performance of feasible MPCDs. The agencies are promulgating discharge standards in "batches" and completed the Batch One technical analysis in August 2003. For more information, visit <http://www.epa.gov/waterscience/rules/UNDS/vessels.pdf>.

Ship Grounding Removal

The removal of a number of grounded and abandoned vessels threatening coral reef resources in Guam, Hawai'i, American Samoa, Puerto Rico, and southern Florida has prevented further impacts on coral reefs resulting from loose debris or cyanobacteria (*Lyngya spp.*) blooms, which have been linked to an increased presence of iron, phosphate, and nitrate.

U.S.S. *Mississinewa* Oil Removal

In 2002, the U.S. Navy offloaded nearly 2 million gallons of heavy fuel oil from the *U.S.S. Mississinewa*, a Navy oiler that sunk during WWII while anchored at Ulithi Atoll, Yap, in the Federated States of Micronesia. The Navy sent a salvage team to recover the fuel from the sunken vessel, eliminating the threat of oil releases that could have adversely affected the atoll environment and the health and safety of nearby residents.



Governor Felix P. Camacho during a Guam "Island Pride" coastal clean-up effort.

OBJECTIVE 4: Reduce the flow of marine debris and remove existing marine debris from reef ecosystems.

Derelict Fishing Gear, Marine Debris Removal Efforts in Hawai'i

The NWHI have one of the most pristine coral reef ecosystems in U.S. waters. Derelict fishing gear from distant water fisheries is the greatest anthropogenic impact to the NWHI. NOAA, the State of Hawai'i, the U.S. Department of the Interior, the U.S. Coast Guard (USCG), and many local partners continue to coordinate the removal of derelict fishing gear from the NWHI. They removed approximately 107 tons in 2002, 122 tons in 2003. Overall, they have removed a total of approximately 336

tons since 1996. It is estimated that 25–40 tons per year will continue to impact the NWHI.

Since derelict fishing gear continues to accumulate in the NWHI, a number of activities have been instituted to assess ways to reduce derelict fishing gear and its impacts to this coral reef ecosystem. These activities include:

- NOAA studies to detect and remove derelict fishing gear from the open ocean;
- An Asian Pacific Economic Cooperation workshop, in coordination with the U.S. Department of State, on the problems of derelict fishing gear that highlighted constructive information exchange, knowledge building, technical assistance, and capacity building; and
- Initiation of an interagency international working group to develop a strategy to address derelict fishing gear.

OBJECTIVE 5: Prevent and control the spread of invasive species (e.g., non-native species) in coral reef ecosystems from ballast water and other mechanisms.

Mandatory Ballast Water Management Program Established

USCG established a national mandatory ballast water management program requiring vessels entering the U.S. Exclusive Economic Zone intending to call at a U.S. port or place to manage their ballast water through such practices as mid-ocean exchange, retention of water onboard, and USCG-approved treatment methods. A follow-up regulation specifying the discharge standard to be met by ballast water treatment systems for use as an alternative to ballast water management practices is planned for late 2005. As part of this program, USCG is developing both an improved method

for verifying that ballast water was exchanged in mid-ocean and, in conjunction with the EPA, a process for testing and verifying the performance characteristics of technologies used to treat ballast water. The Armed Services Ballast Water Management Program also requires ballast water management practices for its vessels meeting the U.S. Department of Defense's policies and programs for ballast water exchange.

Volunteer Efforts of Invasive Species Control

In Hawai'i, volunteers removed an estimated 68 tons of invasive algae from Waikiki and Kaneohe Bay reefs. Though not significantly effective at relieving the threat of aquatic invasive species (AIS) in Hawai'i, events like this help increase awareness of the impacts of AIS in Hawai'i.

Hawai'i AIS Management Plan Approved

The Federal Aquatic Nuisance Species Task Force approved the State of Hawai'i Aquatic Invasive Species Management Plan in September 2003. The plan enhances the coordination of current management efforts, identifies remaining management gaps, and recommends additional actions needed to adequately address AIS. Such actions include minimizing the harmful ecological, economic, and human-health impacts of AIS through the prevention and management of their introduction, expansion, and dispersal into, within, and from Hawai'i.

OBJECTIVE 6: Develop tools to assess and address the impacts of pollution on coral reefs.

Coral Condition Indicators

EPA's Office of Research and Development, in collaboration with the Florida Keys National Marine Sanctuary and Dry Tortugas National Park, is


assessing coral condition within different geographic zones of South Florida. Coral condition indicators include coral composition and abundance, prevalence of bleaching and disease, total coral surface area, percent living coral, and living coral surface area. The approach allows composition-independent comparisons across reefs and geographic zones, information that will be used to investigate potential anthropogenic or natural stresses in areas of decline. Because measurements are made on each colony in the transect, the indicators can be analyzed at the population level. Populations in decline will be examined in the laboratory for sensitivity to suspected stressors.

Temporal Watershed Dynamics of the USVI and Puerto Rico Characterized With Geographic Information System

In 2002, NOAA began a project to characterize activities and changes in watersheds and to trace their potential impacts on shallow-water coral ecosystems in the USVI and Puerto Rico. The program will help managers understand the impacts of land use in coastal watersheds over time and identify and repair key watersheds that may most affect adjacent marine ecosystems. Other thematic data can be easily incorporated into the geographic information system to enhance the scope of the project.

National Coastal Condition Report

During 2003, EPA and its partner agencies conducted policy and technical reviews of a draft of the second National Coastal Condition Report (NCCR II); the final report has been released (<http://www.epa.gov/owow/oceans/nccr/2005/index.html>). NCCR II provides comprehensive, comparable, and nationally consistent ratings of several key ecological health indicators: water quality, coastal habitat loss, sediment quality, benthic community condition, and fish tissue contaminants, many of which may relate to the health of



coral reef ecosystems. Unlike the first NCCR issued in 2001, this updated version includes coastal condition information for Puerto Rico. During 2003, EPA and its partners also collected and analyzed data for the 2006 NCCR, which will be expanded to include indicator data for Hawai'i. Trends analysis gleaned from the NCCR II and future assessments will be used to help determine the effectiveness of coastal and estuarine protection programs.

OBJECTIVE 7: Increase awareness and understanding of the ecological health and socioeconomic impacts of land-based and marine pollution on reef ecosystems.

For the highlights under this objective, please see chapter 4: Understanding Social and Economic Factors and chapter 10: Improving Outreach and Education.

Future Challenges

Implementing voluntary and regulatory programs to address point and nonpoint pollution sources has helped improve water quality flowing into some coral reef areas; however, more work needs to be accomplished to reduce the sediment, nutrients, and other contaminants reaching coral reef ecosystems. To continue to address land-based sources of pollution, efforts need to address such activities as the following:

Resolve water quality issues. The U.S. state and territory islands have identified the need to update, repair, or expand current water treatment systems to accommodate increasing populations and avoid repeated incidents of sewage spills that can adversely impact coral reef and human health.

Support LASs. Federal agencies must continue to emphasize coral reef watersheds within their pollution-reduction programs and to implement LASs for land-based sources of pollution. At the local level, continued work is needed between states and territories and the local stakeholders to implement the actions contained in the LASs and adapt individual strategies to meet changing needs and objectives.

Restore watersheds. Federal agencies need to continue to implement land-based restoration programs to reduce nonpoint source pollution affecting coral reef ecosystems. One of the most critical improvements needed involves infrastructure related to sewage treatment and waste disposal.

Inventory invasive species and identify pathways for introductions. The introduction of non-native species to new areas has a devastating impact on native biota. In Hawai'i, invasive species are of particular concern to management agencies in areas where non-native algae have out-competed native corals and changed the structure of localized reef resources. To enhance knowledge about invasive species and their impact on coral reef ecosystems, inventories are needed of non-native species found in the Pacific Islands. Additionally, there is a need to identify pathways for invasive species introductions (e.g., hull fouling) in coral reef ecosystems in order to assist in prevention efforts.

Develop a program to monitor land-based pollution. Further work is needed to identify and measure the effectiveness of management activities to reduce the impacts of land-based pollution on the health of coral reef ecosystems. Specifically, effective and consistent monitoring programs are needed to establish baselines of coral reef health and to determine pollution status and trends.

Restoring Damaged Reefs



GOAL: Increase the capability of federal and nonfederal managers to efficiently and effectively restore injured or degraded coral reefs.

Rationale for Action

A well-developed coral reef can represent thousands of years of slow, incremental growth by resident stony corals. Consequently, many corals living today are centuries old. Despite the longevity and apparent natural resilience of corals and the reefs they construct, both are extremely vulnerable to destruction by human activities, either gradually through degraded

habitat quality, or suddenly through catastrophic damage from vessel groundings, toxic spills, or habitat destruction. The natural recovery of coral and fish populations can be slow in areas of degraded habitat and in the presence of other stressors, such as pollutants, climate change, high abundances of pest species, exotic species, or species that compete or inhibit the recruitment and growth of native fishes and corals and other

OBJECTIVES

OBJECTIVE 1: Review and evaluate existing reef restoration projects to quantify the benefits gained by the restoration effort and expenditure of the restoration compared to scenarios in which no restoration efforts were undertaken and make recommendations for improvements.

OBJECTIVE 2: Develop and test innovative methods and techniques to expedite reef restoration for all major categories of coral reef injury using a hypothesis-driven approach that involves rigorous, quantitative evaluation.

OBJECTIVE 3: Develop regional restoration plans that identify significant restoration alternatives and weigh the costs and benefits of natural recovery compared with restoration alternatives.

OBJECTIVE 4: Promote cost-effective pilot restoration of selected degraded U.S. reefs, focusing on habitats of high ecological, economic, and social or conservation value.

OBJECTIVE 5: Rehabilitate degraded fish habitat through the deployment of artificial structures and rapid, inexpensive transplant met

OBJECTIVE 6: Transfer proven restoration tools, techniques, and lessons learned to domestic and international partners.





Diadema (long-spined black urchin), an important herbivore, controls macroalgae in coral reef ecosystems.

benthic invertebrates. Natural recovery may never occur when the underlying habitat structure is destroyed or when the prevailing environmental conditions have been chronically degraded over time.

The *National Action Plan To Conserve Coral Reefs* (USCRTF 2000) recognizes that preventing the loss of coral reef habitat through proactive conservation measures is preferable to restoring coral reefs after they have already been damaged. However, when reefs have been damaged by human use or misuse, removing or mitigating the anthropogenic stressors responsible for their decline may enhance natural recovery. In specific situations, the USCRTF has facilitated recovery through active restoration efforts, which have shown some success. Most of these efforts have been limited to addressing physical damage to reefs at small spatial scales caused by vessel groundings. This typically involves repairing the reef structure to prevent further degradation or erosion with reattachment of benthic organisms being undertaken secondarily to speed up restoration of high-relief habitat.

Restoration efforts are also exploring the possibility of small-scale targeted efforts to enhance recovery

from hurricanes, experimental-scale removal of pest and exotic species, and enhancing recruitment of habitat-forming organisms. Since the practice of coral reef restoration is in its infancy, the USCRTF seeks to strengthen restoration science through the development, testing, and assessment of methods that repair damage caused by human impacts and assist in the natural recovery of coral reef ecosystem structure and function.

Summary of Implementation

As an important adjunct to reducing key threats to coral reef ecosystems, active restoration of coral reefs may help prevent further degradation and advance the natural recovery process in injured or damaged habitats. Through a better understanding of the extent and effects of human and natural disturbances to reefs and their potential to recover naturally, scientists are beginning to apply more practical restoration approaches including novel ecological restoration strategies under conditions where the natural system is out of balance. Critical aspects of the restoration process include building knowledge about possible restoration alternatives, developing effective restoration tools and approaches, and finding ways to gauge the success of restoration activities. The goal is to apply lessons learned toward simple and cost-effective techniques for enhancing restoration functions.

Most previous restoration projects in the United States were a response to ship groundings and efforts to mitigate coral losses due to harbor dredging and other discrete shoreline modification projects. Restoration efforts associated with vessel grounding involve the structural repair of damaged reef frameworks to avoid continued loss of habitat associated with erosion. They also may involve the transplantation of corals and other organisms to speed up ecological recovery. In 2002–2003,

USCRTF members developed guidelines to assess resource injuries, developed and implemented novel restoration projects, and evaluated and monitored existing restoration and mitigation projects in the Pacific and Atlantic. Since coral reef ecosystems are complex and the processes affecting recovery potential are varied (e.g., water quality, local disturbance, habitat structure), USCRTF members are undertaking a multifaceted, research-based approach to developing successful restoration tools and methodologies.

Highlights of Task Force Member Activities

OBJECTIVE 1: Review and evaluate existing reef restoration projects to quantify the benefits gained by the restoration effort and expenditure of the restoration compared to scenarios in which no restoration efforts were undertaken and make recommendations for improvements.

Assessment of Transplanted Corals as Part of a Mitigation Project

NOAA and the University of Hawai'i completed 6 years of monitoring a harbor mitigation project in Kāne'ōhe Bay. In the course of the project, all of the scleractinian corals from a small yacht harbor (an area of 38 square meters) were transplanted to a nearby reef that was dredged in 1939 for a seaplane runway. The reef had not recovered due to the persistence of a silt-sand substrate caused by the dredging that inhibited coral recruitment. Researchers found an initial decline in transplanted coral, followed by an average increase in coral cover of 40 percent over 6 years. Through this effort, colonies that would have died in the yacht harbor provided a low-impact source of coral to rehabilitate a

degraded reef, which provided habitat for 439 reef fish, with major benefits associated with increasing topographic complexity.

Assessment of Restoration Efforts at Ship Grounding Sites in Florida

The majority of coral reef restoration efforts by NOAA scientists have occurred in the Florida Keys over the past 15 years. A scientifically rigorous monitoring program was initiated at 10 restoration sites damaged by vessels aground or anchored on coral reefs in the Florida Keys National Marine Sanctuary (FKNMS). This restoration monitoring program was designed to evaluate the effects of restoration actions on an injured coral reef community by tracking the condition of key biological variables. Important indicators of reef habitat quality, coral cover, coral density, and coral colony size were compared among the restored sites and undisturbed reference sites. Preliminary results from the baseline monitoring conducted in 2004 showed coral recruitment and coral growth at most of the restoration sites. Other important reef community components such as octocorals, sponges, reef fish, and invertebrates were also observed among the restored reefs.

OBJECTIVE 2: Develop and test innovative methods and techniques to expedite reef restoration for all major categories of coral reef injury using a hypothesis-driven approach that involves rigorous, quantitative evaluation.

Ecological Approaches to Coral Restoration

NOAA scientists have been testing various novel, low-cost ecological approaches to coral restoration. To improve habitat quality and restore ecosystem functions, these approaches emphasize coral

recruitment, reduction of competing algae, and control of corallivorous predators. To evaluate the efficacy of removing targeted predators to mitigate tissue loss to elkhorn coral (*A. palmata*) populations, researchers conducted a pilot experiment in FKNMS involving the removal of coral-eating snails (*Coralliophila abbreviata*) from elkhorn coral colonies. Removing the corallivorous snails preserved 75 percent more live tissue than treatments leaving the snails in place, suggesting predator removal may be an effective conservation measure in situations where the natural system is out of balance.

The reintroduction of wild-caught and laboratory-cultured herbivorous long-spined black sea urchins (*Diadema antillarum*) to a wide variety of habitats in FKNMS is being tested by NOAA scientists and partners to control macroalgae that has proliferated since urchin die-off in 1983–1984. The primary factor limiting sea urchin reintroduction and recovery appears to be predation pressure by fish and large crabs with the laboratory-cultured urchins being more vulnerable. However, surviving urchins are contributing to the successful removal of algae through grazing pressure. Other research is evaluating the differences between structural restoration approaches in FKNMS and the ability to enhance recovery through the natural recruitment of corals, survival and growth of seeded coral larvae, and survival of transplanted fragments. These studies provide insight into factors controlling settlement and post-settlement survival, benefits and drawbacks of different structural restoration approaches, and optimal strategies for fragmenting and transplanting corals.

Coral Nursery Expanded at Biscayne National Park

In 2002, Biscayne National Park near Miami greatly expanded its coral nursery for future restoration

projects. Multiple impacts from vessel groundings, storms, coral diseases, and other stressors are requiring scientists and resource managers to develop innovative strategies to restore coral reefs. The coral nursery is a pioneering effort to rebuild damaged coral reefs by using new coral recruits grown in the nursery. Park scientists and volunteers populate the nursery by rescuing coral fragments from grounding sites that would die if not properly tended. They are first taken to the National Marine Fisheries Service Southeast Fisheries Center facility at Virginia Key to be stabilized and later transferred to nursery sites in the Park. The University of North Carolina, students from the University of Miami, and volunteers assist in research and nursery maintenance.

OBJECTIVE 3: Develop regional restoration plans that identify significant restoration alternatives and weigh the costs and benefits of natural recovery compared with restoration alternatives.

Restoration and Assessment of Coral Ecosystems

Recreational and commercial vessel groundings are a major cause of coral and seagrass habitat loss in FKNMS. More than 600 known vessel groundings occur every year within the sanctuary, with a likely equal number going unreported. In 2000, NOAA and the State of Florida began the Restoration and Assessment of Coral Ecosystems (RACE) Program to assess and restore coral resources damaged by small-vessel groundings within the sanctuary. Since its inception, the RACE Program has:

- Developed a set of rapid, cost-effective damage assessment methods using global positioning systems and bathymetric tools to accurately assess the extent of habitat damage;

- Created and calibrated a seagrass model capable of predicting time to recovery following restoration;
- Settled 19 seagrass cases totaling nearly \$600,000; and
- Streamlined communication and decisionmaking protocols between NOAA and Florida natural resource managers and law enforcement officers to ensure rapid assessment of injuries, effective case management, and successful restoration.



Juvenile *Diadema* (long-spined black urchin), with mixed coral species.

The successful application of the RACE Program has prompted NOAA and the State of Florida to modify the seagrass restoration process to aid coral reef restoration efforts in the sanctuary.

OBJECTIVE 4: Promote cost-effective pilot restoration of select degraded U.S. reefs, focusing on habitats of high ecological, economic, and social or conservation value.

Transplantation of Coral Fragments to Degraded Reefs

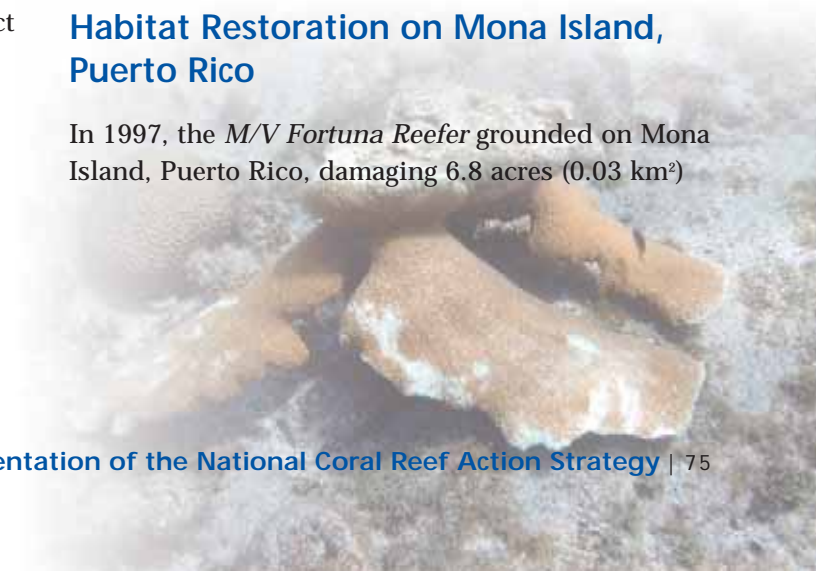
U.S. Geological Survey and National Park Service scientists conducted a small coral transplant project in the Virgin Islands National Park. The project reattached storm-generated *Acropora palmata*, *A. cervicornis*, and *Porites porites* fragments onto a degraded reef using plastic cable ties.

Approximately 20 percent of transplanted *A. palmata* fragments were alive after 4 years. Live fragments exhibited tissue growth over cable ties, fusion with the reef substrate, and growth in the form of new branches. The pilot project demonstrates the feasibility of a low-cost, low-impact method using naturally occurring, storm-generated fragments of fast-growing corals to help restore damaged reefs.

OBJECTIVE 5: Rehabilitate degraded fish habitat through the deployment of artificial structures and rapid, inexpensive transplant methods.

Habitat Restoration on Mona Island, Puerto Rico

In 1997, the *M/V Fortuna Reefer* grounded on Mona Island, Puerto Rico, damaging 6.8 acres (0.03 km²)





Elkhorn coral fragment seven years after restoration efforts. The coral has produced numerous branches and now has the typical adult morphology.

of shallow *Acropora*-dominated fore-reef habitat. Within 2 months, restoration experts stabilized 1,857 *A. palmata* coral fragments using stainless steel wire to secure fragments to the reef substrate and dead standing elkhorn coral skeletons. Six years after the restoration, 20.3 percent (377) of the restored fragments were living. Most live fragments were cemented to the reef and produced new branches, forming small colonies providing considerable structural relief. Reef fish communities have begun to shift from a dominance of roving herbivores to a more complex community associated with an increase in groupers and snappers. Given the large declines *Acropora* populations have sustained from disease, hurricanes, and other impacts, this restoration effort demonstrates reattaching

Acropora fragments may be a viable restoration tool in cases where remaining *Acropora* habitat is damaged by ship groundings and hurricanes.

Assessment of Artificial Structures as a Restoration Effort

Extending for more than 150 kilometers along the continental shelf off eastern Florida, *Oculina* Banks provides habitat for thousands of reef fish and invertebrates. It also provides spawning grounds for commercially important groupers. Although large portions of the area (*Oculina* Banks Habitat Area of Particular Concern) are protected from fishing, only an estimated 10 percent of the former live reef remains. Restoration efforts, started by NOAA and its partners in 1996 and expanded since 2000, involve deploying artificial structures seeded with fragments of the dominant coral, *Oculina varicosa*, into rubble habitats. Artificial structures appear to enhance the natural colonization of corals through recruitment, with high survivorship rates of transplanted fragments and increased densities of reef fish.

OBJECTIVE 6: Transfer proven restoration tools, techniques, and lessons learned to domestic and international partners.

USCRTF members have actively engaged the international community in the development, implementation, and evaluation of restoration efforts by:

- Convening sessions on coral reef restoration at major international symposia;
- Publishing peer-reviewed articles and technical documents and hosting websites on damage assessment, mitigation, and restoration approaches and the efficacy of various restoration projects; and

- Providing state and territory government partners and consultants with technical expertise to assist with damage assessment, resource valuation, and restoration planning and implementation.

Future Challenges

During the past several years, USCRTF members have improved the ability to conduct injury assessments, and calculate monetary damages; outline primary restoration alternatives; and implement emergency and compensatory restoration projects to mitigate damage, prevent further losses, and restore ecological functions of coral reefs. Efforts to address acute impacts on reefs, such as ship groundings, have exhibited engineering success with restoration structures remaining stable through subsequent disturbances and transplanted corals remaining attached with moderate to high rates of survival and growth. However, restoration efforts often lack rigorous evaluation, and few projects are designed to test how effectively different restoration approaches enhance biological performance or community function.

Future coral reef mitigation and restoration efforts are needed to preserve and restore critical ecological functions within regional ecosystem dynamics. Agencies need to continue to develop and evaluate inexpensive, effective restoration techniques to mitigate human impacts on reefs, including ship groundings, and to possibly address other disturbances. However, managers need to carefully analyze degraded sites before undertaking a restoration project, ensuring the causes of degradation are understood and have been eliminated or mitigated. Other considerations include the proper




Restoration scientists employ numerous mechanisms to ensure successful coral transplant efforts.

selection of species for transplantation, impacts on source populations of transplanted fragments, optimal sizes of transplants and methods of attachment, and other factors to enhance survival of corals, minimize damage to source reefs, and maximize rates of ecological recovery. Managers further need to recognize that each proposed restoration needs to be conducted on a case-by-case basis with consideration for variations in species life histories, environmental and physical parameters, and regional differences. The main objectives for future restoration and mitigation efforts include the following:

Continue to evaluate success of restoration projects. A rigorous evaluation of the success of existing reef restoration and mitigation projects should be conducted to identify site- and species-specific approaches that maximize transplant survival and effectively restore ecological function.

Continue to develop cost-effective, ecologically sound restoration methods. Broad, novel, cost-effective ecological restoration strategies are needed to enhance natural recovery and promote survival of critical habitat-forming organisms. Strategies are



needed to improve herbivory, coral recruitment, and coral growth; reduce pest or exotic species; and stabilize rubble and other unstable substrates.

Evaluate the benefits of using vessels as artificial reefs. To reduce diving pressure on natural reefs, the feasibility and ecological benefits of sinking decommissioned U.S. Navy vessels and other artificial substrates should be evaluated. Before vessels and other artificial substrates are sunk, it is critical for all steps to be taken to minimize ecological impacts associated with the sinking process.

Develop sources of coral fragments. Ready sources of coral fragments should be developed for immediate transplantation after ship groundings through

coral culture techniques, coral nurseries, and other low-impact coral sources in order to prevent harvesting of natural populations.

Enhance restoration research. Using adaptive management techniques to guide future restorations, a science-based, hypothesis-driven approach should be implemented for future restoration projects to answer questions on what works and why.

Increase community awareness. Local communities can be trained and involved in basic coral reef assessments and restoration techniques to raise awareness and increase the incidence of reporting coral injury to expedite reef recovery.

Improving Outreach and Education



GOAL: Increase awareness and understanding of the ecological, cultural, and socioeconomic importance of coral reef ecosystems among the widest possible audience.

Rationale for Action

Improving outreach and education is critical to helping people understand the value of coral reef ecosystems and ways to avoid damaging them. Reducing human impacts on coral reef ecosystems often requires changing behavior, beliefs, and decisionmaking criteria about conserving these vital ecosystems. An informed, engaged

public (including resource users, policymakers, industry representatives, nongovernmental organizations, and other stakeholders) is fundamental to achieving the goals of the *National Coral Reef Action Strategy*. People will be more likely to alter their actions and support conservation if they understand why coral reefs are important, realize how their actions affect the condition of the reefs, and are

OBJECTIVES

OBJECTIVE 1: Raise public awareness of and appreciation for coral reef ecosystems through targeted and focused communications campaigns.

OBJECTIVE 2: Incorporate coral reef ecosystem issues in education programs to promote understanding of marine conservation.

OBJECTIVE 3: Inform the public and policymakers about accomplishments and recommendations of the U.S. Coral Reef Task Force.

OBJECTIVE 4: Monitor coral reef ecosystems through monitoring and

OBJECTIVE 5: Monitor coral reef ecosystems through monitoring and





Outreach event at NOAA's Hawaiian Islands Humpback Whale National Marine Sanctuary.

aware of coral reef protection activities and how they benefit communities.

The need for effective outreach and education cuts across all goals of the *National Coral Reef Action Strategy*, and progress depends on fully integrating outreach and education into research and management initiatives. The USCRTF has identified lack of awareness as one of the priority issues for the development of local action strategies (LASs).

Summary of Implementation

The USCRTF, with the support of nongovernmental and academic partner organizations, has advanced public awareness activities throughout 2002–2003. USCRTF members reached out to stakeholders by creating and distributing educational materials and by funding outreach and education projects with a variety of partners. Agencies also collaborated to develop workshops and training modules to build the local conservation capacity, develop student education and career development programs, and promote local involvement in conservation management. In addition, both the National Park Service (NPS) and NOAA's National Marine Sanctuaries Program include major coral reef education efforts.

To expand outreach programs, many of the USCRTF members have created and distributed a variety of multilanguage publications, videos, posters, bibliographies, virtual libraries, and public service announcements targeted to reach vast numbers of stakeholders. To complement these broadly focused resources, agencies also developed materials specifically designed for key user groups. For example, the U.S. Department of Defense developed materials for military personnel that outline the crucial role the Armed Forces play in successful conservation efforts. The Virgin Islands National Park also delivered targeted materials on such subjects as the impacts of fishing gear on reef health, illegal removal of corals, and the effects of driving on beaches.

Beyond information dissemination, agencies have conducted community meetings and other initiatives to improve two-way communication and foster community involvement. These activities have allowed managers to better understand stakeholder

motivations and develop educational programs addressing concerns specific to each group. For example, NOAA held a series of workshops with fishermen in Puerto Rico and the U.S. Virgin Islands to discuss community values and the importance of reefs to fishing livelihoods. Also, the U.S. Fish and Wildlife Service (USFWS) documented traditional marine conservation practices at a community-managed reef in Hawai'i and established statewide exchange programs to share the information.

To strengthen local initiatives, the USCRTF increased technical assistance for local capacity building through workshops and training programs. Agencies have supported training programs for local scientists and managers in the application of field and laboratory research tools and methodologies geared toward an improved understanding of coral reef processes, threats, and impacts. Many states and territories funded education and outreach specialist positions to coordinate their outreach efforts, allowing resource management agencies to significantly increase the reach of their activities.

Although formal educational programs for students lag behind informal education and training programs, progress has been made in creating curricula from coral reef research. Activities primarily focus on providing resources and training to teachers, distributing materials, delivering presentations to classrooms, and developing exhibits and displays in museums and aquariums. For example, American Samoa incorporated the ecology and cultural importance of coral reefs into education programs, trained teachers, developed environmental workshops, and participated in a program providing small grants to help teachers design hands-on coral reef projects.

Biannual USCRTF meetings are an important venue for improving local outreach and education.

By increasing the visibility of national, regional, and local efforts to protect coral reefs, the 2002–2003 meetings in Puerto Rico, Guam, and the Commonwealth of the Northern Mariana Islands provided important opportunities to share information and resources and to transfer tools and expertise to local entities.

Highlights of Task Force Member Activities

OBJECTIVE 1: Raise public awareness of and appreciation for coral reef ecosystems through targeted and focused communications campaigns.

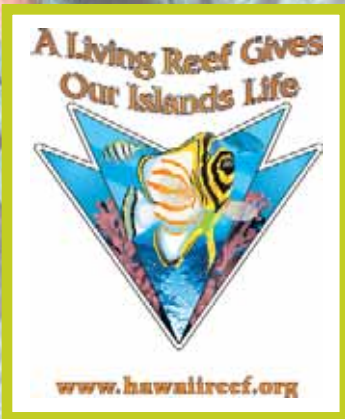
Guam Launched Multimedia Coral Reef Awareness Campaign

In 2003, as part of its Education and Outreach Local Action Strategy, the Guam Coral Reef Initiative Coordinating Committee launched a multimedia coral reef awareness campaign. A unique clownfish character



serves as the campaign mascot and the “teacher” in an educational video for use on incoming flights, movie theater slides, hotel room tent cards, coloring books, advertisements, and streetside banners. In conjunction with Earthweek activities, the campaign sponsored an islandwide children’s contest to name the clownfish character, which was named Professor Kika Clearwater.





Living Reef Program in Hawai'i Raises Reef Awareness

In 2002–2003, more than 40 agencies, nonprofit organizations, and community groups joined together to create the Coral Reef Outreach

Network (CRON)—an organization that worked to launch the Living Reef Program. The goals of the Living Reef Program are to raise awareness about the importance of reefs to communities and what actions individuals can take to minimize harmful impacts. To jump-start the program, a logo and the slogan “A Living Reef Gives Our Islands Life” were created. CRON held several planning meetings and made progress toward a website, an online game for children, and a video starring Alexander Gould (the voice of Nemo in the movie *Finding Nemo*) demonstrating how children can minimize their impacts on coral reefs. In addition, the Living Reef Awards Program was created with sponsor Tiffany & Co. Jewelers, and CRON is hiring a public relations firm to create public service announcements. Hawai'i officially launched the Living Reef Program at a June 2004 ceremony in the Governor's chambers.

OBJECTIVE 2: Incorporate coral reef ecosystem issues in education programs to promote understanding of marine conservation.

USFWS Funds Hawaiian Traditional Knowledge Education

In 2003, USFWS funded a program for high school students in O'ahu's Ewa Beach community to learn

traditional Hawaiian knowledge about the ecology and human uses of local marine algae. The students integrated this information into such scientific techniques as water quality testing. As a result of the program, the community is working with the state to consider establishing a nearshore marine protected area (MPA) at Ewa Beach. USFWS provided funding in 2004 to begin a similar high school program in the predominantly native Hawaiian community of Nanakuli, O'ahu.

NPS Outreach Empowers Boaters To Protect Resources

In 2002–2003, NPS conducted outreach programs to help recreational boaters protect the resources they enjoy in Biscayne National Park. Through partnerships with the Florida Fish and Wildlife Conservation Commission, the U.S. Coast Guard (USCG), and the Miami-Dade Marine Patrol, NPS launched an intensive bilingual Resource Protection Through Boater Education campaign. Park-specific educational programs encouraged responsible boating and navigation, which should reduce groundings on seagrass and coral reefs in the park's 165,000-acre (668-km²) marine area. Exhibits with messages targeted to visitors to the Keys (e.g., “Protect Your Keys,” “Be Safe, Not Sorry”) were installed at two public harbors in the park.

NOAA Develops Curricula Targeted at K–12 Schools

NOAA, through the Sea Grant College Program, has developed multiple curricula for K–12 schools in Puerto Rico, including bilingual textbooks, targeted specifically to coral reefs. In addition, NOAA funded a full-time Sea Grant extension agent in American Samoa. Extension agents are hired by the local community to teach, develop curricula, and build capacity as needed in the region and are helping build a stronger presence for NOAA in the Western Pacific.

Northwestern Hawaiian Islands Discovery Visitor Center Opens

In May 2003, the Northwestern Hawaiian Islands (NWHI) Coral Reef Ecosystem Reserve opened the NWHI Discovery Center in Hilo, Hawai'i. The center raises awareness of the special nature of the NWHI and illustrates why NOAA is working to conserve the area. The center, named "Mokupapapa" after the low-lying coral islets found in the NWHI, interprets the natural science, culture, and history of the NWHI and the surrounding marine environment. Interactive displays, three-dimensional models, and a theater allow visitors to experience the wonder of this unique ocean region. In its first year of operation, the center attracted more than 50,000 visitors, exceeding the projections of a study conducted before the center was opened. School groups regularly visit the center, which has broad community support.



The U.S. Department of the Interior National Park Service works in the communities to promote greater understanding of coral reef ecosystems.

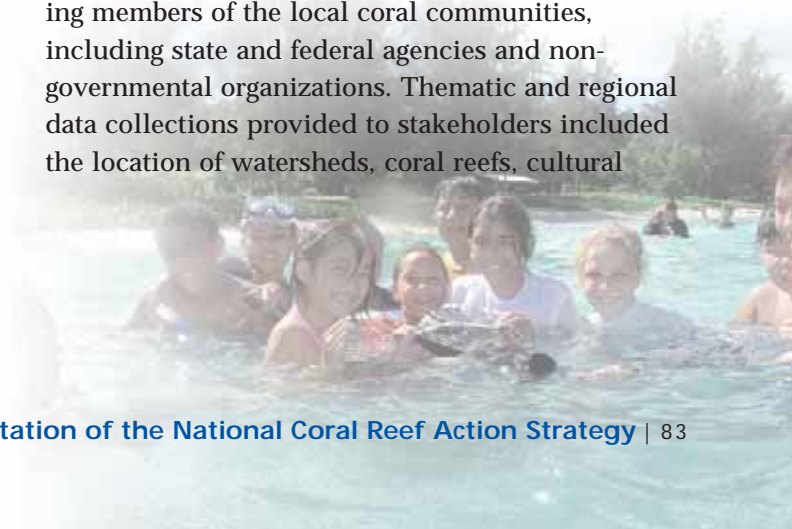
coral reef stakeholders and constituents to provide them with access to CoRIS data sets and to make these data more accessible and understandable. A virtual library was developed to provide online access to coral literature to enhance public knowledge about coral reefs. The Data Outreach pilot project included the University of Hawai'i Sea Grant College Program, University of Hawai'i, American Samoa, Cooperative Institute for Research in Environmental Sciences, The Nature Conservancy, the U.S. Geological Survey, the U.S. Environmental Protection Agency, and NPS.


The project consisted of a series of small-scale meetings in American Samoa and Hawai'i involving members of the local coral communities, including state and federal agencies and non-governmental organizations. Thematic and regional data collections provided to stakeholders included the location of watersheds, coral reefs, cultural

OBJECTIVE 3: Inform the public and policymakers about accomplishments and recommendations of the U.S. Coral Reef Task Force.

NOAA's Coral Reef Information System Team Shares Reef Data

In 2003, NOAA's Coral Reef Information System (CoRIS) team conducted regional meetings with





resources, sea turtle populations, and MPA information. The meetings gave database managers critical feedback and insights from current and potential users of the CoRIS website and generated a dialogue between NOAA scientists and constituent groups. The project served as a model for future NOAA efforts to engage, advise, and inform data-user communities through increased awareness and appreciation of agency science.

OBJECTIVE 4: Increase understanding of coral reef ecosystems through conducting comprehensive assessments of monitoring and coral reef habitats.

Multiagency Educational Partnership Formed for the NWHI

In 2002, NOAA, USFWS, and state and local Hawaiian partners formed a NWHI multiagency education partnership. The partnership focused on education and outreach activities associated with the 2002 NWHI Reef Assessment and Monitoring Program expedition. An education and documentation team, organized by the NWHI Coral Reef Ecosystem Reserve, aboard the *R/V Rapture* posted daily reports, journals, science pieces, video reports, and images from the NWHI to the website <http://www.hawaiianatolls.org> during the voyage. Across the country and internationally, thousands of people followed the voyage and learned about the NWHI. Questions about the voyage were routed through the website and answered by the team aboard the *R/V Rapture*. The video segments were shown to scheduled school groups visiting the NWHI exhibit at the Hawai'i Maritime Center.

The educational partnership continued through 2002–2003 when the Navigating Change project with the Polynesian Voyaging Society began.

Navigating Change seeks to motivate, encourage, and challenge people to take action and improve Hawaii's environmental conditions, especially coral reef ecosystems. In 2003, the partners conducted teacher workshops across Hawai'i in concert with a statewide sailing journey of the famed Polynesian voyaging canoe *Hokule'a*. The canoe traveled around the state and then made a historical voyage to the NWHI in May 2004.

OBJECTIVE 5: Support outreach and education initiatives in states and territories and initiate grants to local community groups.

Supporting Safe and Secure Waterways in Hawai'i

A safe and secure business environment is vital to Hawaii's more than \$3 billion maritime and ocean industry. NOAA has been working through the University of Hawai'i Sea Grant College Program in collaboration with the Hawai'i Ocean Safety Team (HOST), a nonprofit organization formed in 1998. HOST represents commercial and recreational waterfront users with its mission to promote the safe and pollution-free use of Hawaii's waters and provides an open forum to discuss issues related to ocean safety and the ocean environment. Together, NOAA, the University of Hawai'i Sea Grant College Program, HOST, and USCG have been addressing issues related to the establishment of updated port, harbor, and waterway security zones implemented since September 11, 2001. These zones have changed the way maritime and ocean users conduct their businesses in Hawai'i and the Nation.

Grants for Local Conservation Projects

Financial and programmatic partnerships are central to reaching diverse audiences and involving a

range of stakeholders in conservation efforts. To build on these partnerships and support local conservation initiatives, federal, state, and territory agencies and nongovernmental partners funded grant programs aimed at increasing community awareness. Since 2001, the Coral Reef Conservation Fund, operated by the National Fish and Wildlife Foundation, has leveraged \$1.21 million in NOAA funds with \$1.69 million in matching funds for a total of \$2.90 million to support 34 outreach- and education-focused coral reef conservation projects. These projects seek to increase community awareness through the support of public/private partnerships that solve specific outreach and education problems.

Future Challenges

Federal, state, and territory agencies have increasingly taken steps toward creating outreach and education programs that build support for coral reef conservation; however, a widespread lack of public awareness regarding the importance and decline of coral reef ecosystems still exists. Accordingly, many management efforts lack support from communities that could work with agencies to advance reef protection and restoration.

For conservation efforts to succeed, outreach and education programs need to be more strategically planned, involve sustained and direct contact with users of coral reef ecosystems, and be fully integrated into the management process. The activity highlights described above demonstrate positive trends and examples of effective initiatives. Further progress could be realized through USCRTF involvement in the following efforts:

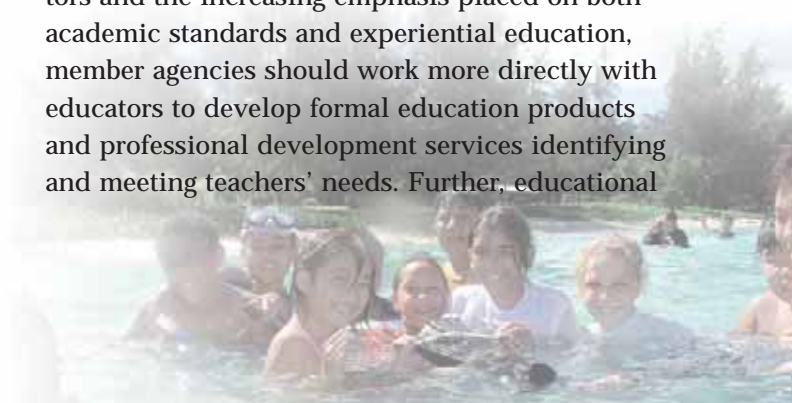
Continue the trend toward interactive, hands-on outreach. Information alone is not sufficient to change behavior. Stakeholders and constituents

may become more aware of the importance and value of coral reef ecosystems, but increased awareness does not automatically result in improved behaviors. Outreach that includes constituent meetings, training workshops, and capacity-building technical assistance will better identify barriers to change, promote increased agency transparency, improve stakeholder buy-in, and ultimately support more sustainable, community-based conservation initiatives.

Strategically plan key messages, identify intended audiences, and develop appropriate communications vehicles. A more targeted communications and outreach approach using focus groups and other planning tools will improve the effectiveness of communications campaigns.

Improve coordination between resource management and outreach goals. Coral reef scientists, managers, outreach coordinators, and educators should work together to translate scientific findings and management goals into specific outreach initiatives that build public support for achieving those goals. At the same time, outreach specialists should help resource managers better understand potential barriers to sustainable reef use, develop culturally sensitive communications, solicit meaningful and sustained feedback, and create incentives for sustainable behavior.

Focus more resources on educational programs for students, particularly formal curriculum development. Youth education builds a foundation for future reef management and stewardship. Recognizing the limited resources of many educators and the increasing emphasis placed on both academic standards and experiential education, member agencies should work more directly with educators to develop formal education products and professional development services identifying and meeting teachers' needs. Further, educational





Students at the Saipan International School in the Northern Mariana Islands learn about water quality testing as part of a volunteer marine monitoring program with the Coastal Resources Management Agency and the Division of Environmental Quality.

activities should focus on effectively translating agency science and management directives into creative activities that build wider public support for conservation and service-learning projects that simultaneously serve educational and community purposes.

Prioritize outreach efforts that explicitly address LASs, in particular the Lack of Awareness Local Action Strategy. In addition to the *National Coral Reef Action Strategy* goals outlined above, LASs have been developed for each state and territory to guide coral reef conservation efforts. Additional focus is needed for outreach projects that explicitly address the goals outlined in both the national strategies and LASs.

Reducing Threats to Reefs Internationally



GOAL: Exercise global leadership through commitment to and collaboration with domestic and international partners to protect and conserve coral reefs and associated ecosystems globally.

Rationale for Action

Coral reefs are found in more than 90 countries, and the United States has political and economic interests in helping these nations protect their ecosystems. Healthy marine ecosystems are critical to U.S. diplomatic and development strategies in many countries to promote economic and food security, social stability,

improved human health, natural disaster and climate change mitigation, and biodiversity conservation. Coral reef ecosystems are economically, socially, and culturally important, constituting the economic base in many countries, particularly small island nations.

Although the report *Status of Coral Reefs of the World* (Wilkinson 2002) found that coral reefs have continued

OBJECTIVES

OBJECTIVE 1: Exercise global leadership in the international arena in shaping and developing environmentally sound and comprehensive ocean and coral reef policy.

OBJECTIVE 2: Build human and institutional capacity to manage and conserve reef ecosystems and coastal watersheds through integrated coastal management.

OBJECTIVE 3: Promote efforts to prevent, reduce, and control land-based sources of pollution and their effects on coral reef ecosystems, including beaches, lagoons, seagrass beds, mangrove forests, shallow reefs, deep reefs, and submerged-bank reefs.

OBJECTIVE 4: Support the creation and effective management of coral reef MPAs, particularly those that contain substantial ecological (i.e., no-take) reserves.

OBJECTIVE 5: Address the impact of global change, coral bleaching, and reef health on reefs and people.

OBJECTIVE 6: Address unsustainable and destructive fishing practices and the U.S. role in and impact on international trade in coral reef species.



to decline from direct and indirect anthropogenic impacts, new conservation and management initiatives at international, national, and local levels are showing considerable success in mitigating the declines. More and more, these activities are addressing direct human impacts and protecting coral reef areas. To build on these localized successes, more work is needed to assist countries in replicating small-scale successes on national and regional scales.

Summary of Implementation

In response to the continuing global decline in coral reef health, USCRTF member agencies have substantially increased their efforts and leadership roles to address the pressures facing the world's reefs. The U.S. Agency for International Development (USAID), the U.S. Department of State (DOS), NOAA, and the U.S. Department of the Interior (DOI) have engaged domestic and international partners to increase the prominence of coral reefs and associated ecosystems in various international forums. Internationally, the United States promotes environmentally sound policies and decisions, improved human and institutional capacity to manage and conserve coral reefs, and proactive strategies to address impacts of global change by enhancing the resistance and resilience of coral reef ecosystems. For example, the United States:

- Supports the International Coral Reef Initiative, the nonbinding global forum of choice to discuss coral reef conservation and related activities;
- Continues to play a critical role in the Convention on International Trade in Endangered Species to ensure the sustainable management of coral reef resources (see chapter 12);
- Is the largest pledged contributor to the Global Environment Facility, the major multilateral organization supporting coral reef conservation activities in developing countries; and

- Supports such key United Nations (UN) programs as the UN Environment Programme's (UNEP's) Regional Seas Programs, which foster regional cooperation among governments. Funding from DOS has been key to ensuring UNEP's Regional Seas Programs and other such regional environmental programs as the South Pacific Regional Environment Program focus on controlling land-based sources of pollution affecting coral reef ecosystems.

USAID provides the principal U.S. bilateral support for coral reef conservation overseas. The agency has projects in more than 20 countries in Latin America, the Caribbean, Southeast Asia, the Middle East, and East Africa. Activities range from field programs promoting improved management practices and the establishment of marine parks and reserves to the promotion of sustainable tourism and fisheries. For example, in Jamaica, USAID's Ridge-to-Reef Program helps reduce the adverse impacts of agricultural runoff and decreases nutrient-rich sewage flowing from settlements into watersheds and along rivers.

NOAA, DOI, the U.S. Environmental Protection Agency, and other USCRTF agencies primarily provide technical assistance, small grants, and support for targeted workshops and symposiums. These activities create strategic partnerships with other governments, international institutions, nongovernmental organizations, and the private sector in support of conservation. The partnerships have enabled the USCRTF to extend its outreach, leverage funds, and add value to its efforts. For example, NOAA and the Coral Reef Fund (a partnership with the National Fish and Wildlife Foundation) have supported 63 small matching grants in 30 countries between 2002 and 2004. These activities enhance community-based conservation, promote watershed management, improve the effectiveness of marine protected areas (MPAs), promote socioeconomic assessments in management plans, and develop regional MPA systems.

DOS continues to provide substantial financial support to the International Coral Reef Initiative (ICRI) and such ICRI-related activities as development of the biennial *Status of Coral Reefs of the World* (Wilkinson 2002, 2004). USCRTF agencies also provide financial and technical support to international coral reef meetings such as the International Tropical Marine Ecosystem Symposium held in the Philippines in 2003, which brought together more than 200 managers and scientists from around the world to identify and address priority issues in the conservation of coral reef resources.



Local Jamaican fishing community weaving fishnets and traps.

Highlights of Task Force Member Activities

The following activities exemplify how the Task Force addresses international threats to coral reefs. Other international activity highlights can be found under other pertinent chapters.

OBJECTIVE 1: Exercise global leadership in the international arena in shaping and developing environmentally sound and comprehensive ocean and coral reef policy.

Coral Reef Issues Included in World Summit on Sustainable Development Johannesburg Plan of Implementation

At the World Summit on Sustainable Development (WSSD), U.S. efforts stressing the importance of coral reef resources led to the inclusion of coral reef issues in the WSSD Johannesburg Plan of

Implementation. This implementation plan includes actions to change unsustainable patterns of consumption and production and to protect and manage the natural resource base of economic and social development.

White Water to Blue Water: A New Initiative for Integrated Coastal Management

At WSSD, the U.S. government launched the White Water to Blue Water Initiative, which involves U.S. agencies, other governments, nongovernmental organizations, and the private sector in a cross-sectoral approach to improving integrated ecosystem management from the watershed extending into the ocean. To execute this new initiative, an international steering committee was formed to identify existing programs and develop new partnerships that enhance integrated approaches in such areas as wastewater and sanitation, sustainable agricultural practices, integrated coastal management, sustainable tourism, and environmentally sound marine transportation in the Caribbean. In March 2004, a weeklong conference and training institute was held

in Miami, Florida, to facilitate partnerships, exchange best practices, and encourage innovation.

OBJECTIVE 2: Build human and institutional capacity to manage and conserve reef ecosystems and coastal watersheds through integrated coastal management.

Capacity Building for Improved Resource Management

USAID's Coastal Resource Management Program in the Philippines has successfully improved coastal governance, built capacity, and empowered local communities to stop and reduce destructive fishing practices and overfishing. During the 7-year life of the project, 110 communities established, monitored, and protected 83 marine sanctuaries covering more than 9,900 acres (40 km²) of coral reefs, seagrass, and mangroves. According to project findings, coral cover within the marine sanctuaries increased by 46 percent. Community-managed sanctuaries are helping to regenerate depleted fish populations and act as biodiversity corridors or protected areas to expand the protected habitat for vulnerable plants and animals. These sanctuaries are just part of more than 741,000 acres (3,000 km²) of coastal resources now under improved management in the Philippines as a result of this project.

OBJECTIVE 3: Promote efforts to prevent, reduce, and control land-based sources of pollution and their effects on coral reef ecosystems, including beaches, lagoons, seagrass beds, mangrove forests, shallow reefs, deep reefs, and submerged-bank reefs.

USAID Program Improves Environmental Management in Central America

The USAID Guatemala/Central America Regional Environmental Program supports improved

environmental management (including disaster mitigation) in the Mesoamerican Biological Corridor through training and technical assistance. In 2003, 138,000 acres (560 km²) of agricultural land met certification and market requirements, reducing the environmental pollution from coffee and banana production. In addition, 35 private industries in the Mesoamerican Biological Corridor implemented low-cost, best management practices in their production processes. Three municipalities improved their solid-waste and wastewater management by introducing low-cost technology in municipal services, leading to improved water quality in regional watersheds affecting the Mesoamerican Coral Reef and other coastal systems.

Watershed Conservation Plans Developed in Palau

In 2002–2003, the U.S. Fish and Wildlife Service funded a private, nonprofit environmental group in Palau to work with government agencies and communities to develop watershed conservation plans benefiting native forests, mangroves, and coral reefs. The watershed advisor provided technical advice and coordination and has made substantial progress in establishing national policies and planning documents that will reduce soil erosion affecting Palau's spectacularly diverse coral reefs.

OBJECTIVE 4: Support the creation and effective management of coral reef MPAs, particularly those that contain substantial ecological (i.e., no-take) reserves.

Improving MPA Management

In Bunaken National Marine Park in Indonesia, USAID supported the development and implementation of a sustainable finance plan. A management board now raises and retains sufficient funds through visitor fees to fund park enforcement. Enforcement patrols have stopped blast and cyanide fishing, and, inside the marine park, coral coverage increased by 10 percent in 2002. As a

result of this project, the national government is using Bunaken as a model for drafting national policy guidance authorizing local co-management of all national parks.

Guidebook Helps Managers Assess MPA Effectiveness

MPA managers and practitioners have a new guidebook to measure management effectiveness of their MPAs, *How Is Your MPA Doing? A Guidebook of Natural and Social Indicators for Evaluating Marine Protected Area Management Effectiveness*. In 2002, NOAA and DOS, in partnership with the World Wildlife Fund and the World Commission on Protected Areas, prepared a draft guidebook providing a framework linking MPA goals and objectives with indicators that measure management effectiveness. The framework was developed by MPA specialists and reviewed by an extensive team of international MPA experts. The framework and indicators were developed over a 4-year period and included field-testing in 20 sites around the world. The guidebook was released in September 2003 at the World Park's Congress in Durban, South Africa, and can be adapted by an individual MPA for its specific needs. Electronic copies are available at <http://www.effectivempa.noaa.gov/guidebook/guidebook.html>.

OBJECTIVE 5: Address the impact of global change, coral bleaching, and reef health on reefs and people.

First Annual Earth Observation Summit Convened

In 2003, the United States convened the first Earth Observation Summit at which 33 nations and the European Commission began to develop comprehensive, coordinated, and sustained Earth observation systems. This coordinated effort will increase observation coverage, improve data sets, and lead to



a greater understanding of weather and climate as they relate to coral bleaching and global change.

Coral Reef Watch Satellite-Based Products Operational

As part of NOAA's Coral Reef Watch (CRW) Program, two satellite-based, web-accessible products became operational in 2003. Hot Spots and Degree Heating Weeks (<http://coralreefwatch.noaa.gov/satellite/index.html>) increase the reliability of monitoring and forecasting data on coral reef bleaching for CRW users. These products, which provide stakeholders with current conditions of local and remote reefs, enabled near real-time warnings of several coral reef bleaching events worldwide, including events affecting the Great Barrier Reef in Australia, American Samoa, and the Northwestern Hawaiian Islands. Management practices (e.g., to alleviate additional anthropogenic stressors) or scientific studies may be undertaken in response to information received. Field observations provided by users aid in the continued development of CRW products.

Research and Development Initiated for CRW Risk Maps

NOAA's CRW program initiated research to develop risk maps—forecasting tools incorporating multiple

data sets to increase short- and long-term forecasting of the location and severity of coral bleaching events. In 2003, NOAA partnered with The Nature Conservancy (TNC) and the Australian Institute of Marine Science to develop a risk map for the MPA network being developed by the Palau government with the assistance of TNC.

OBJECTIVE 6: Address unsustainable and destructive fishing practices and the U.S. role in and impact on international trade in coral reef species.

Improved Environmental Law Enforcement in the Philippines

USAID/Philippines Coastal Resources Management Program helped establish three coastal law enforcement councils in the province of Bohol. Training, which included building general capacities and enhancing global positioning system skills and other basic investigative techniques, increased the confidence of officers from councils and other local maritime and fishery enforcement groups. In 2003, the enforcement councils reported a 95-percent success rate in prosecuting cases filed in court against illegal fishing methods. The councils have also helped municipal governments standardize laws and fines related to coastal resource management and launched information campaigns in popular illegal fishing hotspots.

Future Challenges

The major factors contributing to the declining health of coral reefs are increased sediments and pollution, overexploitation and destructive fishing, and global climate change. Although many different projects are reducing the damage from human impacts, these efforts are often at a small scale. Many coral reef countries do not have the capacity to implement coral reef conservation programs, and some are unaware of the extent of damage to their

reefs. An urgent need exists for greater U.S. leadership on international coral reef issues and for providing technical assistance to developing countries, large and small.

Since the development of the *National Coral Reef Action Strategy* (NOAA 2002), several emerging issues have been identified, including:

- Identifying new approaches to increase the resilience of coral reefs in the face of global climate change;
- Understanding the role of environmental and anthropogenic stressors in the recent worldwide occurrence of increased coral diseases with emphasis on development of strategies to mitigate disease impacts;
- Linking freshwater and marine issues and recognizing the need to maintain the quantity, quality, and timing of freshwater inflows into coastal estuaries and their importance to healthy reefs and fisheries;
- Implementing socioeconomic assessment protocols to link ecological monitoring to human activities on coral reefs; and
- Developing alternatives to reduce human pressures on coral reef ecosystems and promote economic and ecological sustainability, including novel financing mechanisms, aquaculture, and sustainable tourism.

Past successes in integrated coastal management and MPAs underscore the need for consistent funding for technical assistance and for a constant exchange of information. Continued success depends on long-term support of and commitment to capacity building that combines large-scale, integrated coastal management approaches with networks of MPAs to maintain resource productivity, enhance resiliency, and protect marine and coastal habitats. Integrated coastal management can provide a framework for more effective site-based management. Focus is needed on train-the-trainer activities to disseminate information over time.

Reducing Impacts From International Trade



GOAL: Reduce the adverse impacts of the collection of and trade in coral reef animals, encourage more responsible trade, and encourage the conservation and management of coral reef ecosystem, both domestically and internationally.

Rationale for Action

Coral reefs face increasing pressure from commercial harvesting for export to supply the world's growing demand for food, aquarium organisms, live reef food fish, curios, jewelry, pharmaceuticals, and traditional medicines. In many cases, collection occurs at unsustainable levels leading to a reduction in the abundance and biomass of targeted species, a shift in

species composition, potential large-scale ecosystem degradation, and diminished long-term benefits to local communities. In addition to overfishing and overexploitation, destructive fishing practices (e.g., cyanide use to capture aquarium and live reef food fish) and unsafe diving practices are becoming more widespread as fishermen must access more remote and deeper locations to collect target species.

OBJECTIVES

OBJECTIVE 1: Assess the nature and extent of trade in coral reef species and both positive and negative impacts associated with the trade.

OBJECTIVE 2: Evaluate and implement approaches to mitigate negative impacts associated with trade.

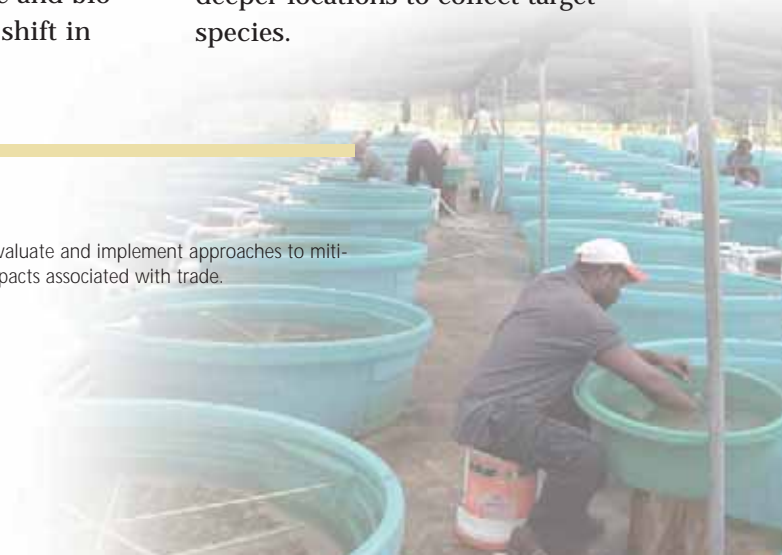
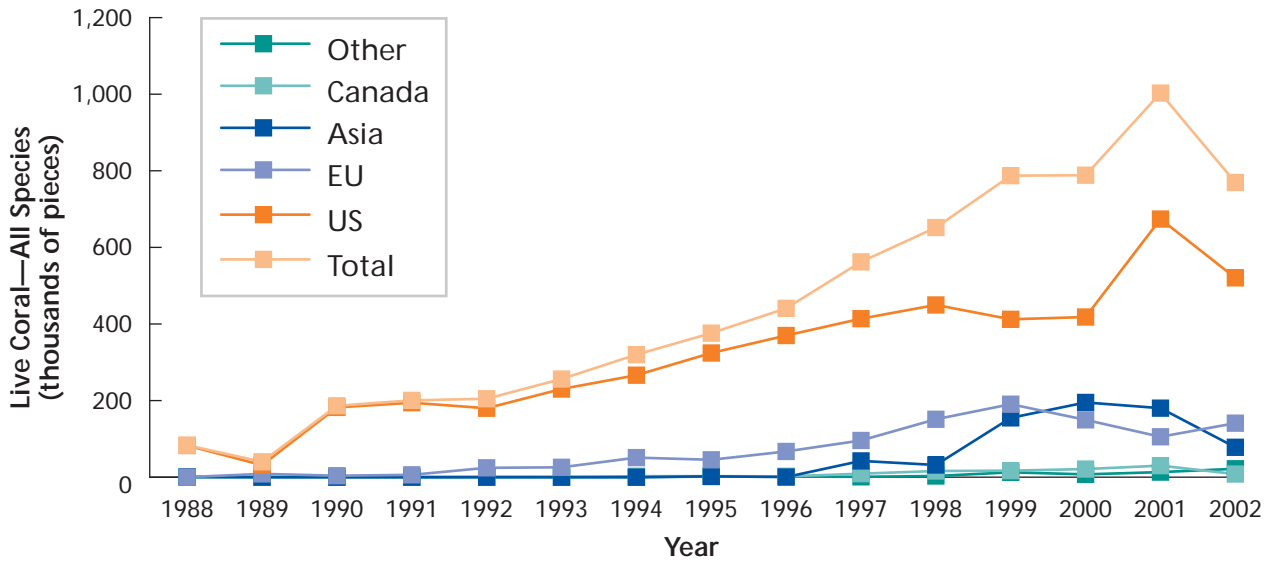


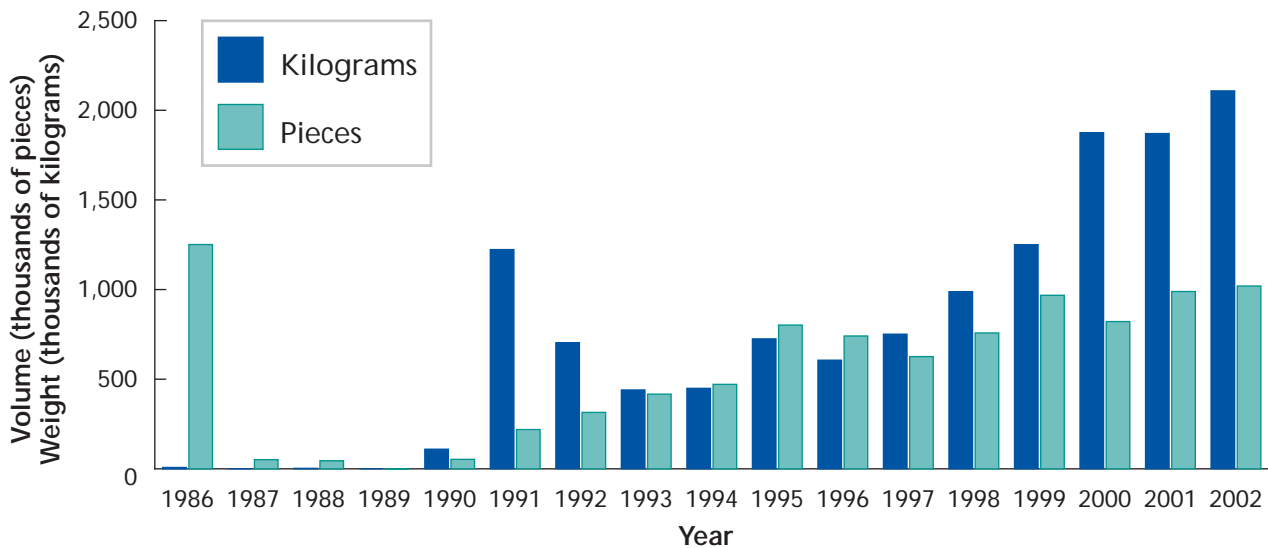
Figure 4. Total International Trade in Stony Coral: 1986–2002

Figure 4-A shows the number of colonies of live stony corals, reported by genus or species, imported by the United States, European Union, Asia, Canada, and all other countries. The trade has increased by 500 percent over a 10-year period with a temporary decline in 2002 due to a reduction in exports from Indonesia. Figure 4-B shows the number of pieces of reef substrate and kilograms of live rock exported for use in home aquariums. Most of this material is from Fiji, Indonesia, and Vietnam, with 80–95 percent imported into the United States. For trade records prior to 1993, countries often reported unidentified stony corals as *Scleractinia*.

A. Live Coral Reported by Genus or Species



B. Live Rock and Reef Substrate Reported as *Scleractinia*



Although trade-driven damage to reef ecosystem is generally less than that associated with dynamite fishing, overfishing for local consumption, and collection of corals for building materials, it is an issue of importance to the United States—the world’s largest consumer of coral reef animals and products for the marine ornamental trade (see figure 4). Domestically, the United States prohibits the use of most destructive fishing practices and the commercial collection of stony corals and live rock in federal, state, and territory waters. Although the United States promotes sustainable management and conservation efforts for domestic coral reef fisheries, many coral reef species and products collected using destructive practices and removed from reefs in an unsustainable fashion in other nations continue to be imported into the country. The United States can help encourage exporting countries to manage coral reef fisheries to ensure they are sustainable, trade is equitable, resource conflicts between users are minimized, and post-harvesting mortalities are minimal. If managed sustainably, trade in coral reef species could provide jobs in predominantly rural, low-income coastal communities, thereby providing strong economic incentives for coral reef conservation in regions with few alternative sources of revenue.

Summary of Implementation

To respond to the threats to coral reefs from unsustainable harvest and destructive fishing practices to supply international markets, the USCRTF developed the comprehensive trade strategy *International Trade in Coral and Coral Reef Species: The Role of the United States* (<http://www.coralreef.gov>). USCRTF agencies have implemented various components of this trade strategy in partnership with other governments, international organizations, non-governmental organizations, and the private sector.

The Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) provides a particularly valuable forum for addressing unsustainable trade. The United States promotes sustainable international trade through CITES by:

- Working to improve compliance with existing listings;
- Participating in CITES Animals Committee working groups and meetings to advance coral reef conservation efforts;
- Implementing notifications, decisions, and policies adopted by the CITES Secretariat and member countries;
- Evaluating the need for additional species listings; and
- Developing listing proposals to protect species from overexploitation.

The United States also works with partners in other multilateral forums (e.g., Asia Pacific Economic Cooperation) and bilateral negotiations that have proved useful in addressing coral reef trade issues.

The U.S. Agency for International Development (USAID), NOAA, the U.S. Department of the Interior, and the U.S. Department of State (DOS) provide assistance to many coral reef countries to address the adverse impacts from international trade. These programs strengthen human and institutional capacity to develop and implement sustainable management plans, enforce relevant laws and regulations, develop environmentally sound collection practices and alternatives, and implement other measures that protect and conserve coral reef ecosystem. USCRTF agencies have also supported voluntary, private sector approaches (e.g., through the Marine Aquarium Council) that engage industry and conservation groups in setting standards for improved management, collection, and handling practices.



Stony corals from Southeast Asia for sale as curios in Hawai'i.

of reef substrate were traded in 2002 with the United States importing 67 percent of all live coral and 89 percent of all live rock. An analysis of coral composition indicates the majority of the corals traded for use as curios are such branching corals as *Acropora*, *Pocillopora*, and *Stylophora*, which tend to be the most common and fastest growing taxa. More than 60 percent of live corals consist of a small number of large polyp taxa, which tend to be less common and exhibit slow growth and low rates of recruitment.

U.S. Imports of Ornamental Coral Reef Species

The United States imports nearly 50 percent of all marine aquarium fish in international trade, but few data are available to determine specific species or the sustainability of the harvests. In 2002, NOAA supported an analysis of 1 month's data (October 2000) from U.S. Fish and Wildlife Service (USFWS) importation and exportation forms to better characterize the trade. During the 1-month project period, 1,185 shipments contained 1,038 marine fish species from 95 families, representing a dramatic increase over the same period in 1971 (200 species) and 1992 (809 species). Although extrapolating the total annual imports captured by the study is difficult, the report provides a glimpse into the importance of various traded species and the source countries involved.

Improving the Declaration Process To Promote Compliance With CITES and U.S. Wildlife Laws

Due to the large volume of species of ornamental tropical fish imported by the United States, imports have traditionally been pooled into one category—ornamental fish. Such categorization, however, cannot identify levels of trade in individual species or separate fish according to marine and freshwater

Highlights of Task Force Member Activities

OBJECTIVE 1: Assess the nature and extent of trade in coral reef species and both positive and negative impacts associated with the trade.

Extent of Trade in CITES Appendix II: Listed Stony Corals

Stony corals harvested from reefs around the world supply international markets with live aquarium animals, curios, jewelry, and other products. All stony corals were added to Appendix II of CITES in 1990. As a result, corals could still be traded internationally, and trade levels were regulated through a system of permits issued by the exporting country based on a finding of nondetriment and legal acquisition. Although stony corals are regulated through CITES, the United States and other countries have expressed concern about the impacts associated with increasing levels of trade. NOAA completed an updated analysis of CITES data on global trade and found that more than 750,000 live corals, 2.1 million kilograms of live rock, and 1 million pieces

taxa. In spring 2003, USFWS introduced a voluntary Internet-based system (eDecs) for declaring wildlife imports and exports, including coral reef species. The system expedites shipment declaration and clearance, improving communication between the import/export community and USFWS enforcement staff, promoting compliance with CITES and U.S. wildlife laws, and facilitating a thorough analysis of trends in the trade of ornamental coral reef fish.

OBJECTIVE 2: Evaluate and implement approaches to mitigate negative impacts associated with trade.

Protecting Species Through CITES Appendix II Listings

In a trade involving at least 75 countries, 26 of the 33 known seahorse species are being collected through target fisheries or as bycatch to supply an annual demand for more than 25 million animals for traditional medicines and hundreds of thousands for aquarium pets. Rapid declines in catch reported from the major exporting countries and concerns about a rapidly increasing trade prompted the United States to propose listing all 33 species of seahorses (genus *Hippocampus*) in Appendix II of CITES. All species were successfully added to Appendix II at the 12th Conference of the Parties (COP12) to CITES in November 2002. The United States is committed to providing exporting countries with technical assistance to develop adaptive management measures that will help ensure sustainable harvests and funded an initial workshop on seahorse management in 2004.

Evaluation of the Need for Additional CITES Listings

Sea cucumbers (also known as beche-de-mer) are an important component of the coral reef fauna and

are under considerable harvest pressure to supply a growing international demand for seafood. As a result, populations of high-value species are being overexploited and fisheries continue to expand into new locations. COP12 adopted the U.S. recommendations to convene a technical workshop to evaluate the status of sea cucumbers and consider appropriate conservation measures, including regional management, domestic fisheries controls, and possible future CITES listings.

Improvement of Reporting Requirements for CITES-Listed Corals

NOAA and USFWS participated in the Coral Working Group of the CITES Animals Committee to improve reporting requirements for corals in international trade. New definitions were adopted by CITES to distinguish live coral, dead coral, and coral rock (reef substrate and live rock) in trade, and a list was developed of corals that must be reported to the species and corals that can be identified to the genus on CITES export permits. The working group is also evaluating possible codes to differentiate wild harvested corals from those produced through mariculture (pen-type enclosures within open bodies of water) and aquaculture (pond or confinement systems) and whether non-detriment findings must be based on the impacts to the species in trade or its role in the ecosystem.

Significant Trade Review for Queen Conch Through CITES

As part of the CITES process to review and enforce sustainable trade measures, the United States funded a Caribbean-wide workshop on the trade of queen conch to evaluate the recommendations and develop regional strategies to improve management of queen conch (*Strombus gigas*) resources. The workshop produced the following suite of recommendations for countries:

- Study the status of queen conch stocks in commercial fishing areas;



Adult Queen Conch (*Strombus gigas*).

- Promote regional management planning;
- Develop standardized trade terminology; and
- Cooperate with law enforcement activities.

The United States also imposed trade restrictions recommended by CITES on queen conch imports from a number of countries. Before trade can resume, each country must implement long-term conservation measures, including scientifically sound species management programs.

Support for Private Sector Initiatives of the Marine Aquarium Council

The Marine Aquarium Council (MAC) is an international nonprofit organization that brings marine aquarium animal collectors, exporters, importers, and retailers together with aquarium keepers, public aquariums, conservation organizations, and government agencies to promote best management, collection, and handling practices for ornamental coral reef species. NOAA, USAID, DOS, and their partners, in coordination with other USCRTF members, have provided technical assistance in the development of MAC certification standards, funding for training of fishers in the Philippines and elsewhere in environmentally friendly collection practices, and support for outreach efforts by MAC

that were instrumental in these efforts. In October 2002, the first importer was certified in compliance with the MAC standards for trade in marine aquarium organisms, and the first certified reef aquarium organisms were imported to the United States in 2003. There are now certified collectors and sites in the Philippines and Fiji, and certified importers and retailers in the United States, Canada, and Europe are providing certified products.

Free Trade Agreements

Singapore is one of the largest transshipment centers for coral reef-associated species. In association with the U.S./Singapore Free Trade Agreement, the two countries signed a Memorandum of Intent (MOI) on Cooperation in Environmental Matters (June 13, 2003). The MOI calls for strengthening relationships through compliance, enforcement, and performance cooperation, and improving the environmental protection of endangered species. Increasing cooperation through the MOI will help improve enforcement of CITES commitments.

Asia-Pacific Economic Cooperation Forum

The United States has been working with the Asia-Pacific Economic Cooperation (APEC) to design a multiyear implementation program to address over-exploitation and destructive fishing practices associated with the live reef food fish trade, an industry involving annual exports of more than 30,000 metric tons of grouper, humphead wrasse, and other vulnerable, long-lived reef fish. Through the creation of a regional research network, the United States, Chinese Taipei, Hong Kong, and Australia developed the capacity to establish a sustainable grouper (*Seranidae*) aquaculture industry that benefits all APEC economies. The effort is reducing destructive fishing practices by providing an alternative source of income and employment to people currently engaged in dangerous and illegal fishing practices.

Encouraging Sustainable, Environmentally Sound Mariculture To Reduce Wild Harvest

In Komodo National Park in Indonesia, USAID supports efforts to develop environmentally friendly mariculture of grouper and wrasse (*Labridae*) for the live reef food fish trade. The program has developed completely closed mariculture techniques using local species of fish. Once the young fish reach sufficient size in the mariculture facility, they are distributed to local fishers to be raised in fish pens. In 2004, the program expects to produce up to 125 tons of fish for the market.



Live reef food fish trade in Hong Kong.

Future Challenges

Despite strong U.S. efforts, the adverse impacts of international trade continue to increase, along with U.S. consumer demand for coral reef animals. The United States needs to strengthen its role as an international leader in the development of sound coral reef policy and to provide guidance and technical assistance to exporting countries. Continued implementation of the recommendations of the USCRTF trade strategy is needed with an emphasis on capacity building in countries with coral reefs, domestic enforcement, public education and awareness, and active participation in such international and regional programs as the International Coral Reef Initiative to highlight concerns and promote conservation initiatives. Future efforts can be summarized by the following four key objectives:

Strengthen CITES protection of coral reef animals.

Consideration of additional listing proposals and strengthened management strategies are needed for listed coral reef species. The United States needs to support the implementation of CITES requirements for listed species, including technical assistance to exporting countries to:

- Monitor resource trends and harvests;
- Develop management measures to ensure sustainable harvest through an adaptive management process; and
- Devise practical means for addressing bycatch and habitat loss associated with the nonselective harvest of certain species (e.g., seahorses).

The United States also needs to evaluate whether other such species as sea cucumbers, precious corals⁶, mollusks, and coral reef fish qualify for and could benefit from additional protection through CITES.

⁶ Species of precious corals include pink coral, *Corallium secundum*, the gold coral, *Geradria* (formally *Parazoanthus*) sp., bamboo coral, *Lepidisis Olapa* (formally *Keratoisis nuda*), and shallow water black coral species including *Antipathes dichotoma*, *Antipathes grandis*, and *Antipathes ulex*.



Examples of coral species produced using environmentally friendly mariculture practices.

Analyze the trade in coral reef species. A detailed analysis of trade in coral reef species not currently regulated through CITES is needed to assess future need for management actions. A thorough review and analysis of U.S. imports of non-CITES-listed species are critical to identifying species of concern traded at unsustainable levels that may be inappropriate for trade. The analysis would provide data on trends in exports for individual species by the exporting countries. When combined with data on the natural history and threats, the analysis would help identify potential species needing regional and international protection.

provide more environmentally friendly and stable livelihoods for local communities.

Evaluate additional measures to help ensure sustainable harvest of coral reef species in trade.

Evaluation and development of measures to help ensure that coral reef species imported by the United States are harvested sustainably and transported using best management practices is needed. USCRTF members would work with source countries, the aquarium trade industry, and other interested partners to evaluate and develop these measures.

Develop environmentally friendly mariculture and aquaculture techniques.

Technical assistance to exporting countries is needed to reduce wild harvest through the development of environmentally friendly mariculture and aquaculture approaches. Currently, 98 percent of traded marine aquarium reef fish come from the wild (Moe 1999), whereas 98 percent of the freshwater aquarium species come from aquaculture facilities. Establishing appropriate and ecologically sound mariculture in developing coral reef countries could help relieve the pressure on reefs and pro-

Improving Coordination and Accountability



GOAL: Increase communication, collaboration, and accountability in and among Task Force members.

Rationale for Action

Effective communication and collaboration are essential for successfully implementing the coral reef conservation efforts recommended in the *National Coral Reef Action Strategy* (NOAA 2002) and *National Action Plan To Conserve Coral Reefs* (USCRTF 2000). Because threats to

coral reef ecosystems frequently span a broad range of geographical and organizational jurisdictions, coordination across federal, state, and local governments and with nongovernmental organizations is essential for designing and implementing effective solutions.

Executive Order 13089 on Coral Reef Protection recognizes the value of

OBJECTIVES

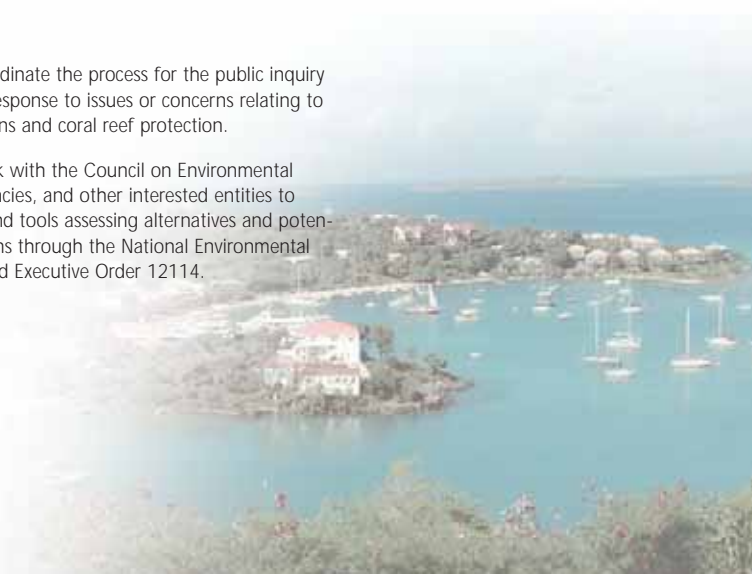
OBJECTIVE 1: Coordinate the submission of coral reef protection implementation plans, annual reports, and other documents by USCRTF member agencies.

OBJECTIVE 2: Coordinate planning and development of crosscutting initiatives; promote exchange of information on activities, needs, and concerns; and facilitate resolution of issues related to coral reef conservation.

OBJECTIVE 3: Coordinate the annual submission of agency reports of programs, policies, and actions.

OBJECTIVE 4: Coordinate the process for the public inquiry about and agency response to issues or concerns relating to federal agency actions and coral reef protection.

OBJECTIVE 5: Work with the Council on Environmental Quality, federal agencies, and other interested entities to develop guidance and tools assessing alternatives and potential impacts of actions through the National Environmental Policy Act (NEPA) and Executive Order 12114.





U.S. Coral Reef Task Force meetings provide a forum for scientific information exchange and discussion.

coral reef ecosystems and directs U.S. government agencies to work independently “to ensure actions they authorize, fund, or carry out will not degrade the conditions of such ecosystems.” Federal agencies are also directed to work together through the USCRTF to collectively and strategically address the threats to coral reef ecosystems. Among its first actions to further enhance coordination, the USCRTF expanded its membership to include the governors of the seven states and territories with coral reefs. In 2002, the presidents of the Freely Associated States (the Republic of Palau, Republic of the Marshall Islands, and Federated States of Micronesia) were included in the USCRTF as non-voting members.

Summary of Implementation

The USCRTF uses a variety of mechanisms, including the *National Action Plan to Conserve Coral Reefs* and the *National Coral Reef Action Strategy*, to promote planning, priority setting, coordination, and partnership building. The Strategy, prepared by the USCRTF and NOAA, respectively, with input from federal agencies and state and territory partners, identifies the key threats to coral reef ecosystems, ranks high-priority threats in each region, sets objectives to address key threats, and creates implementation plans to attain the objectives.

The USCRTF provides several venues to promote coordination at the federal, regional, and state levels to support stewardship of coral reef resources. The USCRTF steering committee brings together representatives from each of the participating federal agencies, states, and territories to highlight new and existing opportunities for collaboration. USCRTF meetings are held twice a year and provide an opportunity for members to discuss key issues, propose new actions, present progress reports, and update the coral community on past accomplishments and future plans. The meetings provide a valuable venue for the exchange of information in which members can voice concerns and issues about their coral reef conservation efforts and collaborate to find more effective alternatives. Intergovernmental collaboration allows members to match resources with opportunities and to leverage funding and other resources for interagency efforts. Through these biannual meetings and working groups, the USCRTF provides opportunities for public input and inquiry about coral reef conservation efforts.

USCRTF members have passed multiple resolutions and launched a variety of initiatives to advance U.S. efforts to protect and sustain coral reef ecosystems. These initiatives have enhanced partnerships that

produce new information, tools, and actions to reduce threats to coral reefs. Most significant among these was the USCRTF's commitment to develop 3-year local action strategies (LASs) in each jurisdiction to address the major threats of overfishing, land-based sources of pollution, climate change, coral bleaching, disease, recreational overuse and misuse, and lack of public awareness. These bottom-up strategies have directly involved stakeholders in the development of state-level action plans to address these issues and are significantly:

- Improving coordination between federal and state/territory priorities;
- Raising the profile of coral reef issues and concerns in related projects (e.g., nonpoint source pollution, coastal zone management initiatives); and
- Strengthening national policy and support for coral reef conservation by updating national goals for reef management.

Highlights of Task Force Member Activities

OBJECTIVE 1: Coordinate the submission of coral reef protection implementation plans, annual reports, and other documents by USCRTF member agencies.

Biennial Report Identifies Monitoring Gaps

The second biennial *State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2004* details the current condition of reef ecosystems in seven states and territories, numerous remote islands under U.S. jurisdiction, and the

three Micronesian countries in free association with the United States. Written in collaboration with interagency working groups in each jurisdiction, the report describes the results of national monitoring efforts and helps decision-makers by identifying gaps in current monitoring activities. The report will be available online in 2005 at <http://www.coris.noaa.gov>.

OBJECTIVE 2: Coordinate planning and development of crosscutting initiatives; promote exchange of information on activities, needs, and concerns; and facilitate resolution of issues related to coral reef conservation.

States and Territories Develop Participatory LASs

Each of the seven states and territories with coral reefs has implemented a process of stakeholder meetings and workshops to develop LASs. These LASs are 3-year, locally driven roadmaps for collaborative and cooperative action among federal, state, territory, and nongovernmental partners that identify and implement priority actions needed to reduce key threats to valuable coral reef resources. Through extensive workshops, briefings, and public meetings involving a variety of different local interest groups, including the tourism industry, fishermen, and nongovernmental organizations, each jurisdiction developed strategies containing a variety of projects designed for implementation over a 3-year period (FY 2005–2007). These efforts were led by state management agencies with the assistance of federal partners, including NOAA, the U.S. Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA), and the U.S. Department of the Interior (DOI). Presently, most jurisdictions have final-draft 3-year LASs and began implementing first-year projects in 2004 (see table 7).

Expert Workshop Targets Responses to Climate Change

In 2002, the USCRTF passed two resolutions highlighting the impacts of climate change and coral bleaching on coral reefs. In response, NOAA, EPA, and DOI organized an expert workshop in June 2003 to explore collaborative approaches to better understand and address the threats to coral reefs associated with climate variability and change. More than 100 U.S. and international coral reef management and science representatives shared information on the science, modeling, monitoring, and management of coral bleaching and identified specific actions and new research priorities to help reduce impacts and increase the resiliency of these valuable ecosystems. As a result of the meeting, NOAA, the Great Barrier Reef Marine Park Authority, the Nature Conservancy, and other partners are developing *A Coral Reef Manager's Guide to Coral Bleaching*.

Regional Technical Workshops Address Land-Based Sources of Pollution

Land-based sources of pollution are perhaps the biggest direct threat to coral reefs and addressing this threat is central to effective LASs. In 2003, EPA and USDA's Natural Resources Conservation Service hosted a workshop to further the development and implementation of LASs addressing land-based sources of pollution in the Pacific Islands. More than 100 managers and scientists participated; reviewed draft versions of their LASs for land-based sources of pollution in Hawai'i, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands; and highlighted further development and implementation needs. In May 2004, NOAA, EPA, and USDA hosted a similar workshop to further the development and implementation of LASs addressing land-based sources of pollution in Florida, Puerto Rico, and the U.S. Virgin Islands.

Table 7. Local Action Strategy (LAS) Completion Status by Jurisdiction

Information in this table represents LAS status as of October 2004.

LAS Threat Area	American Samoa	Northern Mariana Islands	Florida	Guam	Hawaii	Puerto Rico	U.S. Virgin Islands
Land pollution	●	●	○	●	●	●	●
Fishing	●	●	○ ^a	●	●	●	●
Recreational overuse		●		●	▲	●	●
Lack of awareness		●	○	●	●	●	●
Climate change	●						
Disease							
Other	● ^b		○ ^c		● ^d		

● Final document available. ○ Development phase complete; final document available in 2005. ▲ Development in progress.

^a Strategy addresses fishing, diving, and other uses.

^b Strategy addresses population density.

^c Strategy addresses maritime industry and coastal construction impacts.

^d Strategy addresses invasive species.

OBJECTIVE 3: Coordinate the annual submission of agency reports of programs, policies, and actions.

Mapping Plans Keep Public and Decisionmakers Abreast of Progress and Needs

The USCRTF's Mapping and Information Synthesis Working Group developed several regional mapping implementation plans—used to identify high-priority mapping sites—and status reports in collaboration with federal, state, and local stakeholders.

For instance, the *Status of Coral Reef Ecosystem Mapping Activities* (August 2003) outlines activities conducted by NOAA, the National Aeronautics and Space Administration, and the U.S. Geological Survey and, where applicable, describes how the resulting data were applied.



Regional U.S. Coral Reef Task Force meetings provide a venue to highlight accomplishments and challenges for coral reef ecosystem conservation in the jurisdictions.

OBJECTIVE 4: Coordinate the process for the public inquiry about and agency response to issues or concerns relating to federal agency actions and coral reef protection.

Website Source of Information and Exchange

The USCRTF website (<http://www.coralreef.gov/index.cfm>) provides the public with an opportunity to learn about the USCRTF and its coral reef conservation efforts. Users who submit comments and inquiries receive responses from USCRTF representatives.

Public Participation Critical to USCRTF Success

In 2003, the USCRTF passed a resolution emphasizing the important role of public participation in its efforts. The resolution recognized that it is vital to

make the public aware of and involve them in coral reef protection and preservation to ensure the long-term survival of coral reefs. As a result, the USCRTF established a mechanism for responding to concerns raised in public-comment sessions at USCRTF meetings. While the USCRTF receives many requests for general information, there have been fewer than five formal petitions to the USCRTF questioning the consistency of federal action with the Executive Order Policy (Section 2) to “ensure that any actions they authorize, fund, or carry out will not degrade the conditions of such ecosystems.”

OBJECTIVE 5: Work with the Council on Environmental Quality, federal agencies, and other interested entities to develop guidance and tools assessing alternatives and potential impacts of actions through the National Environmental Policy Act (NEPA) and Executive Order 12114.

Interagency Team Established on Impacts to Palau Reefs

The U.S. Army Corps of Engineers led an inter-agency National Environmental Policy Act Cooperating Agency Team that provided environmental oversight of the Palau Compact Road project



U.S. Coral Reef Task Force member agencies, for example, the National Park Service and NOAA, collaborate and share resources on many initiatives to better understand and conserve our coral reef ecosystems.

to reduce project-related impacts on coral reefs. This project is being built under a treaty between Palau and the United States and is the largest project ever undertaken in Micronesia. The Team, including NOAA, DOI, and EPA, developed the Federal Environmental Impact Statement for the project and is now involved in the environmental oversight of the actual construction. Two large protected areas have been designated as compensatory mitigation for the project, including a 30,000-acre (121-km²) marine protected area (Ngaremeduu Conservation Area).

Future Challenges

The USCRTF has brought federal, state, and local agencies together to address the threats facing coral reef ecosystems. By leveraging funds and resources, exchanging ideas, and seizing opportunities, the USCRTF has raised awareness of coral reef conservation issues and, through the combined efforts of its members, spearheaded U.S. efforts to protect, restore, and sustain the Nation's valuable coral reef ecosystems. However, a number of challenges remain regarding increased coordination and effectiveness, including the following:

Implement LASs. States and territories have drafted their LASs and prioritized certain needs, but implementation requires commitment from USCRTF members and other organizations. LAS implementation also requires funding and capacity building at the local level. States and territories need to work closely with federal government and nongovernmental partners to ensure high-priority needs are met.

Coordinate funding requests at the federal level. At present, no effort to coordinate budget planning across federal agencies exists to ensure agencies leverage their budgets and collectively address high-priority state and territory needs. Developing interagency budget

requests could improve agency planning efforts by highlighting joint priorities, goals, performance indicators, and implementation plans.

Improve planning and performance tracking. While USCRTF members have conducted a wide range of conservation activities, no centralized system exists to assist in planning, track progress, and report accomplishments. In addition, no standardized set of performance measures exists to ensure federal, state, and local agencies identically measure their levels of success. The USCRTF is examining development of a centralized database to achieve these goals, but is still considering the manner in which to proceed.

Increase opportunities for agency and nongovernmental participation. The USCRTF has sought input on how best to engage organizations and the public in USCRTF efforts and coral reef conservation activities. The USCRTF is committed to continuing and expanding engagement in these activities. In addition, while most federal agencies have been active in conservation efforts, participation could be improved by more active involvement of several important agencies.

Federal Expenditures for U.S. Coral Reef Task Force Conservation Activities (2002–2004)

Federal Agency Funding Directly Related to Coral Reef Conservation by Agency (2002–2004)

This table shows estimates of federal agency funding directly related to coral reef conservation activities for fiscal years 2002–2004, by agency. Figures in the table include funding directly related to major categories of coral reef conservation activities defined by the USCRTF in the National Action Strategy. In general, estimates do not include funding for activities indirectly related to coral reefs and funding used to fulfill basic mission functions of member agencies. Federal agency representatives provided funding estimates to the USCRTF for use in this report. Funding totals do not include the U.S. Department of the Treasury Global Environmental Facility, but the USCRTF considers its support significant to coral reef conservation activities.

Agency	2002	2003	2004
Estimated Funding (\$ Millions)			
DOC ^a	48.14	47.48	56.96
DOI	9.93	12.22	15.84
EPA	1.69	1.92	1.23
DOJ ^b	—	—	—
USCG (DHS) ^c	8.69	7.94	13.43
DOT ^d	0.00	0.00	0.00
DOS	1.40	1.55	1.58
USAID	43.21	40.02	25.7 ^e
DoD ^f	—	—	—
NSF ^g	—	—	—
NASA ^h	0.63	1.06	1.26
Subtotal	113.69	112.19	116.00
USDA ⁱ	63.60	51.40	84.50
Total	177.29	163.59	200.50

^a The U.S. Department of Commerce (DOC) budget figures reflect funding for NOAA's Coral Reef Conservation Program and other NOAA programs directly related to coral reef conservation activities.

^b The U.S. Department of Justice (DOJ) engages in actions in this area as part of the normal course of its work, but does not specifically allocate funds for coral reef habitats.

^c The U.S. Coast Guard (USCG) does not have any explicit line items in its budget for coral reef activities. Figures in this table represent funds expended or projected to be expended by various USCG components in support of coral reef protection. Normally, the USCG support involves law enforcement efforts and response to marine pollution incidents.

^d U.S. Department of Transportation (DOT) Federal Highway Funding does not directly fund coral reef conservation activities; however, specific road projects funded through this program are required to have water quality protection measures in areas where it is a possible threat.

^e This is only a partial estimate of funds. Not all funds have been obligated.

^f The U.S. Department of Defense (DoD) does not have explicit Congressional authorization line item funding in its budget for coral reef activities. However, as part of mission-related activities, DoD funds projects and programs to conserve and protect coral reefs in proximity to DoD installations and activities.

^g The National Science Foundation (NSF) has no programs specifically targeted to coral reef research; however, NSF awards funding to projects that deal with aspects of coral reef research and conservation. As of July 2004, the award total for current active awards related to any aspect of coral reefs (socioeconomic, paleoecology, deep-water reefs, etc.) across the agency is more than \$48M.

^h The National Aeronautics and Space Administration (NASA) funds research competed for by the science community through NASA Research Announcements.

ⁱ U.S. Department of Agriculture (USDA) programs and activities are not authorized for the sole purpose of providing direct beneficial impacts to coral reef ecosystems. The budget numbers represent spending for specific conservation programs that have impacts on water quality in the seven coral reef jurisdictions. These programs provide benefits to aquatic ecosystems through nonpoint source, nutrient, and sediment reduction from land-based sources. Activities take place in watersheds that outlet into estuaries linked to coral reef ecosystems or into waters where coral reefs are directly located.

Federal Agency Funding Directly Related to Coral Reef Conservation by Goal Area (2002–2004)

This table shows estimates of federal agency funding directly related to coral reef conservation activities for fiscal years 2002–2004. The data are organized by the major goal or coral reef conservation activity areas defined by the USCRTF in the *National Action Strategy*. Agency funding estimates are shown under each goal or activity area. In general, estimates do not include funding for activities indirectly related to coral reefs and funding used to fulfill basic mission functions of member agencies. Funding estimates were provided by federal agency representatives to the USCRTF for use in this report. As all agencies do not track expenditures by the following 13 categories, they are not represented in this table and, therefore, total expenditures are much lower than shown in the previous table.

Goal	2002	2003	2004
Estimated Funding (\$ Millions)			
1. Map All U.S. Coral Reefs			
DOC ^a	5.28	2.42	1.88
DOI ^b	NA	NA	0.53
NASA ^c	0.10	0.10	0.10
Subtotal	5.38	2.52	2.51
2. Assess and Monitor Reef Health			
DOC ^a	8.45	7.64	7.81
DOI ^b	NA	NA	2.77
EPA	0.92	0.76	0.82
NASA ^c	0.10	0.15	0.15
Subtotal	9.47	8.55	11.55
3. Conduct Strategic Research			
DOC ^a	9.02	8.65	15.26
DOI ^b	NA	NA	4.97
EPA	0.37	0.23	0.21
NASA ^c	0.23	0.61	0.81
Subtotal	9.62	9.49	21.25
4. Understand Social and Economic Factors			
DOC ^a	0.42	0.46	1.27
DOI ^b	NA	NA	0.40
Subtotal	0.42	0.46	1.67
5. Improve Use of Marine Protected Areas			
DOC ^a	12.57	10.62	12.59
DOI ^b	NA	NA	2.75
Subtotal	12.57	10.62	15.34

continued

Goal	2002	2003	2004
6. Reduce Impacts of Fishing and Other Extractive Uses			
DOC ^a	3.40	5.83	5.38
DOI ^b	NA	NA	0.57
USCG ^d	3.41	3.64	6.53
Subtotal	6.81	9.47	12.48
7. Reduce Impacts of Coastal Uses			
DOC ^a	0.09	1.39	1.04
DOI ^b	NA	NA	0.32
EPA	0.02	—	0.02
USCG ^d	4.35	3.92	6.53
Subtotal	4.46	5.31	7.91
8. Reduce Pollution			
DOC ^a	3.87	3.92	4.05
DOI ^b	NA	NA	0.34
USDA ^e	63.60	51.40	84.50
EPA	0.25	0.77	0.12
USCG ^d	0.89	0.35	0.35
Subtotal	68.61	56.44	89.36
9. Restore Damaged Reefs			
DOC ^a	0.50	0.58	0.94
DOI ^b	NA	NA	0.18
Subtotal	0.50	0.58	1.12
10. Improve Education and Outreach			
DOC ^a	0.28	0.33	1.49
DOI ^b	NA	NA	0.45
EPA	0.13	0.03	0.06
USCG ^d	0.04	0.03	0.02
NASA ^c	0.20	0.20	0.20
Subtotal	0.65	0.59	2.22
11. Reduce Threats to International Coral Reefs			
DOC ^a	1.10	1.04	0.88
DOI ^b	NA	NA	0.96
EPA	—	0.13	—
DOS	1.40	1.55	1.58
Subtotal	2.50	2.72	3.42

continued

Goal	2002	2003	2004
12. Reduce Impacts From International Trade			
DOC ^a	0.13	0.17	0.29
DOI ^b	NA	NA	—
Subtotal	0.13	0.17	0.29
13. Improve Coordination and Accountability			
DOC ^a	0.28	0.58	1.15
DOI ^b	NA	NA	0.18
Subtotal	0.28	0.58	1.33
14. Other			
DOC ^a	2.75 ^f	3.85 ^g	2.93
Subtotal	2.75	3.85	2.93
TOTAL^h	124.15	111.35	173.38

^a U.S. Department of Commerce (DOC) budget figures reflect funding for NOAA's Coral Reef Conservation Program and other NOAA programs directly related to coral reef conservation activities.

^b U.S. Department of the Interior (DOI) budget figures were not tracked by the 13 categories until FY 04.

^c The National Aeronautics and Space Administration (NASA) funds research competed for by the science community through NASA Research Announcements.

^d The U.S. Coast Guard (USCG) does not have any explicit line items in its budget for coral reef activities. Figures in this table represent funds expended or projected to be expended by various USCG components in support of coral reef protection. Normally, USCG support involves law enforcement efforts and response to marine pollution incidents.

^e U.S. Department of Agriculture (USDA) programs and activities are not authorized for the sole purpose of providing direct beneficial impacts to coral reef ecosystems. The above budget numbers represent spending for specific conservation programs that have impacts on water quality in the seven coral reef jurisdictions. These programs provide benefits to aquatic ecosystems through nonpoint source, nutrient, and sediment reduction from land-based sources. Activities take place in watersheds that outlet into estuaries linked to coral reef ecosystems or into waters where coral reefs are directly located.


^f Funding includes overarching management grants.

^g Funding includes overarching management grants and capacity building initiatives.

^h Total funding does not include USAID funds, which are not distributed by Goal.

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Side view of orange tube coral: Photo by Andy Bruckner

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Scientists on the NOAA Ship *Nancy Foster*: Photo from NOAA's Biogeography Program

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Top view of orange tube coral: Photo by Andy Bruckner

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Snorkeler inspecting coral: Photo by NPS Submerged Resources Center

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Coral: Photo by Andy Bruckner

Individual casting a net: Image Courtesy Guam Coral Reef Initiative Coordinating Committee

Grunts: Photo by Andy Bruckner

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Fish pot: Photo by Andy Bruckner

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Guam replanting: Photo Courtesy of Guam Dept. of Agriculture — Division of Aquatic & Wildlife Resources

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St. Croix beach: Image Courtesy of NPS-Harpers Ferry Center

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Sun anemone (*Stichodactyla helianthus*): Photo by John Brooks, NPS image

USDA staff at work: Photo by Bob Nichols, USDA NRCS

Sediment plume: Photo Courtesy of Guam Department of Agriculture, Division of Aquatic and Wildlife

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Soil conservation efforts: Photodisc

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Overtaken coral: Photo by Andy Bruckner

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