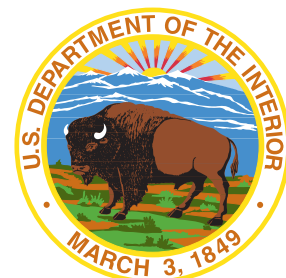
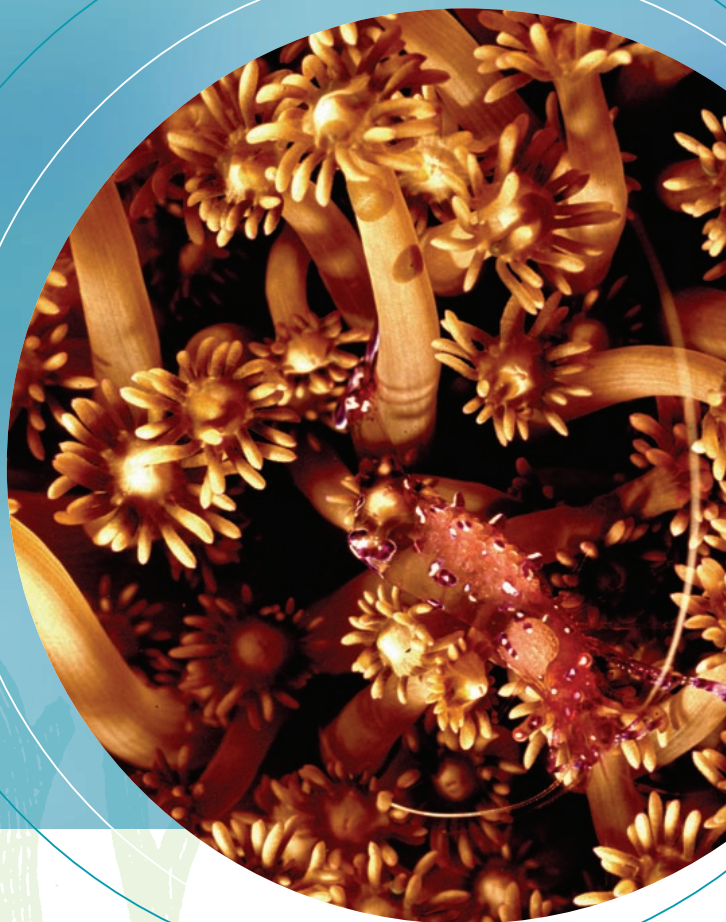


PROTECTING
THE NATION'S
coral reefs

U.S. DEPARTMENT
OF THE INTERIOR

2004





**The Mission of
the Department of the
Interior is to protect and
provide access to our
Nation's natural and cultural
heritage and honor our
trust responsibilities to
Indian Tribes and our
commitments to island
communities.**

Coral reefs are highly diverse, productive and complex ecosystems *that support fisheries of cultural and economic value, protect shorelines from coastal erosion and wave damage and are living museums of the world's tropical marine diversity.*



Jim Maragos/FWS



Karen Koltes/OIA

THE DEPARTMENT OF THE INTERIOR

Since its creation in 1849, the Department of the Interior (DOI) has become the Nation's principal conservation agency. DOI has jurisdiction over about 450 million acres of Federal lands and about 3 billion acres of the Outer Continental Shelf. DOI is also responsible for migratory wildlife conservation, historic preservation, water management, protection of endangered species, and providing the Nation with reliable, impartial scientific information for sound resource decisionmaking. DOI has trust responsibilities to American Indians and Alaska Natives; administrative responsibility for coordinating Federal policy in the territories of American Samoa, Guam, the U.S. Virgin Islands, and the Commonwealth of the Northern Mariana Islands; and oversight of Federal programs and funds in the freely associated states of the Federated States of Micronesia, the Republic of the Marshall Islands and the Republic of Palau. DOI's land management, resource protection, and trust responsibilities are met through hundreds of programs and activities conducted by its eight bureaus.

THE DEPARTMENT OF THE INTERIOR & CORAL REEFS

Coral reefs and associated seagrass and mangrove communities are among the most biologically complex and diverse ecosystems on Earth. They provide habitat to one-third of all marine fish species, build tropical islands, protect coasts from waves and storms, contain an array of potential pharmaceuticals, and support U.S. tourism and fishing industries worth billions of dollars. Coral reefs are also fundamental to the fabric of local communities, providing a source of food, materials and traditional activities.

Over the past few decades, public awareness of the outstanding yet fragile character of coral reef ecosystems has grown, prompting increased State and Federal efforts to protect and preserve the Nation's coral reefs. DOI protects these sensitive habitats at two dozen parks and refuges (fig. 1), collectively amounting to about 3.6 million acres of coral reefs and other submerged lands. In addition, DOI conducts pioneering scientific research to determine the structure, function, geologic history, status and condition of our Nation's coral reefs. However, most of the Nation's coral reefs have not been mapped nor have their conditions been assessed or characterized. Recent evidence indicates that coral reefs are deteriorating worldwide, and many are in crisis. Symptoms include loss of hard corals, increased abundance of algae, diminished recruitment of coral larvae, reduced biological diversity and a dramatic increase in bleaching episodes and disease outbreaks. Scientists and managers still lack critical information about the causes, but evidence suggests a variety of human forces, including population increases, shoreline development, increased sediments in the water, damage by tourists and divers, ship groundings, poor water quality from runoff and inadequate sewage treatment, overfishing, and fishing with poisons and explosives that destroy coral habitat. Elevated sea surface temperatures, especially during El Niño years, are now considered to be the primary stress triggering mass coral bleaching events, while the increasing frequency and severity of these events point to global warming as the underlying cause. These stresses act separately and in combination with natural factors, such as hurricanes and disease, to degrade reefs.



The Florida Keys Coral Story: Then and Now. In 1959, this large *Colpophyllia natans* (a type of brain coral) had a star coral attached at left and a species of *Diploria* (another type of brain coral) on the right. In 1988, the star coral was missing following Hurricane Donna in 1960 (note cavity in foreground), but the *Diploria* at right remained. By the summer of 1998, most of the coral head had died and is infested with algae and sea whips. This series of photographs, taken by USGS scientists, demonstrates the value of long-term monitoring to establish baselines and trends.



Gene Shimm/USGS

In an effort to prevent further loss of coral reef ecosystems, Executive Order No. 13089 on Coral Reef Protection was issued in June 1998. The Executive order directs the U.S. Coral Reef Task Force, co-chaired by the Secretaries of the Interior and Commerce, to develop and implement a comprehensive program of research and mapping to inventory, monitor, and “identify the major causes and consequences of degradation of coral reef ecosystems.” The order directs Federal agencies to use their authorities to protect coral reef

ecosystems and, to the extent permitted by law, prohibits them from authorizing funding or carrying out any actions that will degrade these ecosystems.

DOI also works with domestic and international partners through the Coral Reef Initiative. Launched in 1994, this initiative aims at concerted global action to protect and monitor coral reefs around the world by building and sustaining partnerships, programs, and institutional capacity at the local, national, regional and international level.

DOI conducts pioneering scientific research to determine the structure, function, geologic history, status and condition of our Nation’s coral reefs.

Protecting coral reefs. DOI is working nationally and internationally to protect coral reefs for present and future generations.



Jim Maragos/FWS

An unidentified nudibranch at Ailinginae Atoll, Marshall Islands—a possible new World Heritage Site.



Kevin Foster/FWS

The benefits of protection—a thriving coral reef.



Figure 1. DOI holdings with coral reefs; total area with coral reefs and other submerged lands is about 3,630,500 acres (ac).

DOI Holding	Area (ac) Emergent	Area (ac) Submerged	Area (ac) Total
National Wildlife Refuges (NWR); U.S. Fish and Wildlife Service			
1. Hawaiian Islands NWR	1,766	610,148	611,914
2. Midway Atoll NWR	1,549	296,820	298,369
3. Johnston Atoll NWR	681	118,656	119,337
4. Kingman Reef NWR	3	483,702	483,705
5. Palmyra Atoll NWR	680	515,232	515,912
6. Howland Island NWR	455	32,095	32,550
7. Baker Island NWR	405	31,332	31,736
8. Rose Atoll NWR	15	39,051	39,066
9. Jarvis Island NWR	1,086	36,433	37,519
10. Guam NWR (Ritidian Point only)	371	401	772
11. Key West NWR	2,019	206,289	208,308
12. Great White Heron NWR	6,501	186,287	192,788
13. Navassa Island NWR	1,285	363,665	364,950
National Parks (NP), National Historic Parks (NHP), and National Monuments (NM); National Park Service			
14. War-in-the-Pacific NHP	958	1,002	1,960
15. Kaloko-Honokohau NHP	661	500	1,161
16. Kalaupapa NHP	8,797	2,000	10,797
17. American Samoa NP	9,470	4,050	13,520
18. Biscayne NP	9,075	172,425	181,500
19. Dry Tortugas NP	39	64,661	64,700
20. Salt River Bay NHP	312	600	912
21. Virgin Islands NP	9,039	5,650	14,689
22. Buck Island Reef NM	176	18,839	19,015
23. Virgin Islands Coral Reef NM	0	12,708	12,708
Office of Insular Affairs			
24. Wake Atoll	1,600	428,000	429,600
Total	56,943	3,630,496	3,687,439

U.S. FISH AND WILDLIFE SERVICE

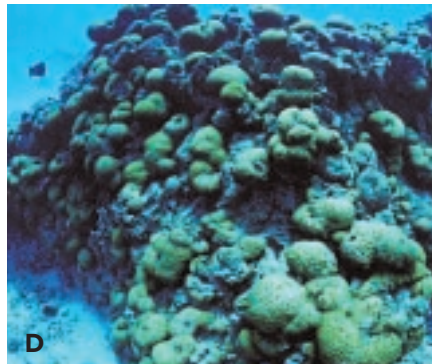
The mission of the U.S. Fish and Wildlife Service (FWS) is to work with others to conserve, protect and enhance fish and wildlife and their habitats for the continuing benefit of the American people. As threats mount to coral reefs worldwide, FWS is applying its unique expertise to protect these resources through a variety of management and operational programs. FWS manages 544 National Wildlife refuges covering more than 96 million acres of which 13 include significant coral reefs. FWS also protects and restores reefs and other species and habitats, enforces laws, and works with other countries to foster reef conservation worldwide. Virtually all of these approaches are founded upon partnerships—collaborative efforts with other Federal agencies, State, local and territorial governments, and concerned private groups. Together these dedicated partners can help reduce the threats to coral reefs and conserve these vital parts of our global heritage.

Programs & Recent Accomplishments Related to Coral Reefs

NATIONAL WILDLIFE REFUGES

The Refuge System administers a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife and plant resources and their habitats for the benefit of present and future generations. FWS manages 10 National Wildlife Refuges (NWR) in the Pacific which include approximately 2,164,000 acres of coral reefs and adjacent ocean habitat, and three refuges in South Florida and the Caribbean totaling more than about 756,000 acres (fig. 1). Among these are two of the System's newest refuges—Palmyra Atoll NWR and Kingman Reef NWR. Established in 2001, these refuges contain some of the most extensive and biologically important reefs in the Pacific.

To ensure that long-term conservation goals are achieved, the FWS is developing and implementing Comprehensive Conservation Management Plans for all of its refuges with coral reefs. Refuges are also developing and employing innovative tools for managing coral reefs, including marine zoning, habitat restoration, education and outreach, law enforcement, research and monitoring, and improving the public's enjoyment of the refuges.



Jim Maregos/FWS

Damage, Restoration and Recovery at Rose Atoll National Wildlife Refuge. Debris from a Taiwanese fishing vessel grounded in 1993 on coral reefs (A) is removed by a crew of American Samoan divers and salvors (B and C) in 1999–2000. The grounding caused extensive damage from the impact and spilled fuel. Later, leaching metals caused a bloom of bluegreen algae that killed corals over a wide area. Sponsored by FWS, the crew has removed 130 metric tons of debris through August 2004, allowing recovery of damaged areas (D). The remaining 30 metric tons will be removed in 2005.

ASSESSING PACIFIC REFUGES

Beginning in 2000, FWS and the National Marine Fisheries Service have co-sponsored 11 ship-based expeditions to assess the health and status of the coral reefs at nine NWRs in the Pacific. The first-ever scientific assessments of these remote refuges have included inventories of coral reef species, development of habitat maps, initiation of long-term monitoring, and in some cases, restoration of the coral reefs. Results of the surveys indicate that coral populations are healthy and currently affected primarily by climatic stresses including storms, wave action and coral bleaching during El Niño events. Derelict fishing gear and unauthorized harvesting or bio-prospecting for “valued” species are the major anthropogenic threats to these ecosystems. Assessment and monitoring surveys of Ritidian Point NWR in Guam initiated in 2004 for FWS by the University of Guam.

CORAL REEF CONSERVATION, RESTORATION AND PROTECTION

FWS programs for endangered species protection, coastal habitat restoration, fisheries management and review of Federal actions help to protect coral reefs and the species that depend on them. For example, millions of dollars provided to States and territories in direct assistance through the Sportfish Restoration Program are used to manage and protect coral reef fisheries and habitats. FWS works through the Endangered Species Act to ensure that human activities do not adversely affect listed, endangered or threatened species, such as sea turtles, Hawaiian monk seals, short-tailed albatross and manatees. The agency works closely



Associated Marine Habitats. Coral reefs have close ecological linkages to other shallow-water tropical marine systems. Some reef fish species range widely over seagrass beds for feeding and find shelter as juveniles in mangrove swamps. Reefs protect mangroves from wave action and mangroves, in turn, protect corals from siltation.

with States, commonwealths and territories to design sound development projects by integrating ecosystem (land-sea) approaches into project planning. By law, FWS must review and comment on Clean Water Act section 404 permits and other water-related development activities under Federal authorization or permit to ensure that these actions avoid, minimize and compensate for unavoidable impacts in the marine environment. Through the Fish and Wildlife Coordination Act, FWS works with other Federal partners to provide technical expertise and recommendations to reduce and avoid impacts to coral reefs. The Hawaii Working Group was recently created to streamline review of marine-related projects and ensure appropriate mitigation for lost coral reef habitats and/or ecological functions. FWS and its partners work proactively to protect coastal habitats by restoring watersheds and monitoring adjacent coral reefs to determine the effects of land-based activities on coral reef health, assessing potential impacts and developing recommendations to preserve the integrity of reefs, and deploying navigational aids in areas to prevent boat groundings and anchor damage. When accidents harm reefs, FWS works with partners to assess the damage and expedite reef recovery.



The United States is the largest importer of coral products to supply the aquarium, curio and jewelry trade (bottom). An FWS wildlife inspector examines a shipment of live coral specimens (top).

ENFORCING INTERNATIONAL TRADE LAWS

The United States is the largest importer of live coral and marine fishes for the aquarium trade, and coral skeletons and precious corals for the curio and jewelry trade. Hundreds of thousands of kilograms of hard corals and live rock, and over 1,000 coral reef species, are collected for the aquarium, curio and jewelry trade every year. Through its wildlife inspection program, FWS monitors and inspects wildlife imports and exports (including coral reef species), intercepts illegal shipments and collects and maintains U.S. trade data. FWS also is responsible for investigating import/export violations, assisting State and territorial governments when interstate commerce of illegally taken coral reef species occurs, and supporting investigations

of violations involving coral reef species on National Wildlife Refuges. In 1999 the U.S. Government successfully prosecuted illegal coral trafficking for the first time: a Florida man and his company were convicted of smuggling coral in violation of U.S. and Philippine laws and international trade restrictions.

INTERNATIONAL CONSERVATION OF CORAL REEFS

FWS is fostering the conservation of reefs in other countries through training and education programs, as well as projects that promote the conservation of species and habitats within a watershed framework. Among the important habitats linked to coral reefs and targeted for conservation are seagrass beds and mangrove forests. The Western Hemisphere



Jim Maragos/FWS

A Hawaiian monk seal, one of several reef-dependent endangered species managed by FWS.

Program sponsors protected area manager training through two international programs, Mexico/RESERVA and Brazil/AMUC. The program also awards small grants to promote the involvement of local communities and organizations in coral reef conservation activities. FWS is also assisting the United Nations with the designation of coral reefs as World Heritage Sites.



Rachel Graham/WCS

Global change and coral bleaching. Coral bleaching, which results from loss of symbiotic algae when corals are stressed, is occurring with greater frequency and severity. Record high water temperatures during the 1998 El Niño triggered massive coral bleaching in many parts of the world, leading to widespread mortality. Taken



Robert Richmond/UH

along the Belize barrier reef in November 1998 ten days after Hurricane Mitch, the photo at left of bleached corals also shows the poor water quality from the massive runoff of fresh water laden with sediments and nutrients. Coral bleaching also devastated many Pacific reefs (at right).

NATIONAL PARK SERVICE

The National Park Service (NPS) is a world leader in the parks and preservation community, an environmental advocate, and a pioneer in protecting America's open spaces. NPS protects our diverse natural, cultural and recreational resources in 387 units of the National Park System, including 40 that contain marine and estuarine resources. Of these, a total of ten National Park units conserve more than 276,000 acres of coral reefs ranging from South Florida and the U.S. Virgin Islands to the Hawaiian Islands and the territories of Guam and American Samoa. These Parks are not only outstanding places to enjoy snorkeling, SCUBA diving, fishing and boating, they contain some of the most biologically rich and economically important coral reef resources in the world. For example, the reefs of War-in-the-Pacific National Historic Park (NHP), Guam, are home to an estimated 3,500 to 4,000 marine species, while the National Park of American Samoa contains over 890 species of fish alone.

Marine Protected Areas. DOI's coral reef parks and refuges provide unique opportunities for enjoying and studying coral reef ecosystems such as these in the National Park of American Samoa (top) and Palmyra Atoll National Wildlife Refuge (bottom).



Larry Basch/NPS



Jim Maragos/FWS

Established in 2001, the Virgin Islands Coral Reef National Monument is the most recently created coral reef unit in the National Park System. Originally reserved in 1935 as Fort Jefferson National Monument, the Dry Tortugas National Park in South Florida is among the first marine protected areas and includes more than 64,000 acres of coral reefs and seagrass beds. Biscayne National Park near Miami contains more than 165,000 acres of coral reefs and associated marine habitats.

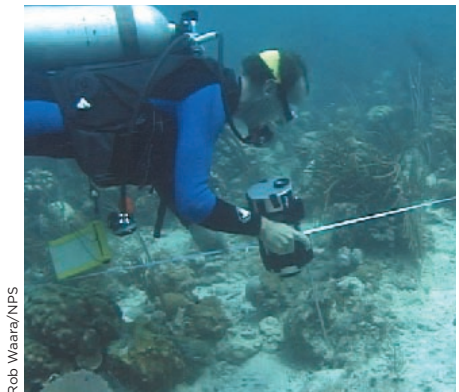
The mission and mandate of NPS are to conserve coral reefs unimpaired for future generations. NPS works cooperatively with Federal, State, territorial and local agencies, local communities, Native American authorities, user groups, and adjacent landowners to achieve these goals. As a global leader in the establishment and management of protected areas, NPS has long been involved in developing innovative and improved coral reef monitoring and management tools. NPS works internationally to share expertise and knowledge with others, and to improve the level of protection afforded coral reef parks in the United States and elsewhere.

Programs & Recent Accomplishments Related to Coral Reefs

RESOURCE MANAGEMENT

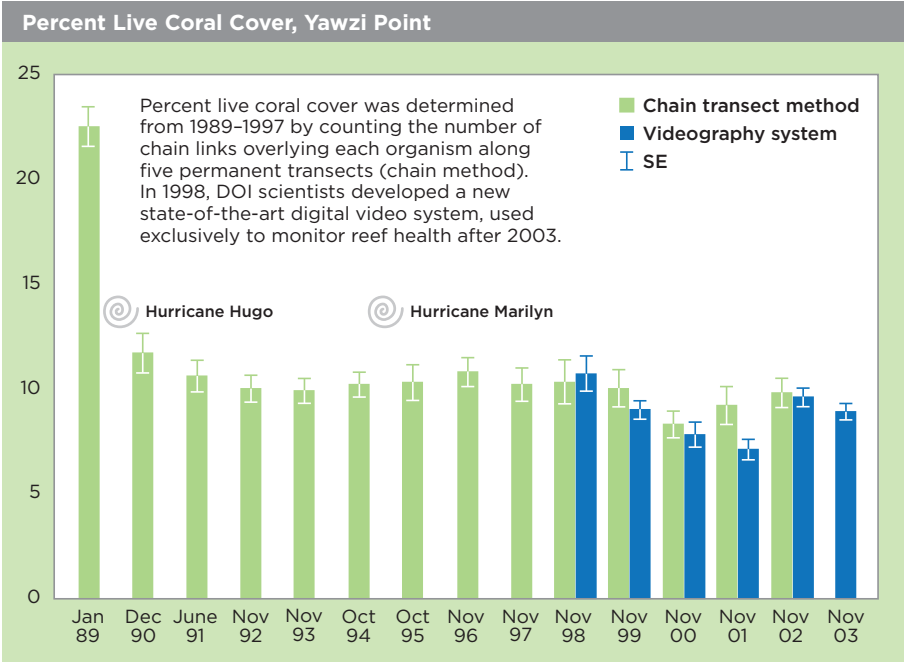
Although coral reef resources within the National Park System receive protection as national parks, they are continually subjected to damage from both natural events and human stresses such as fishing, recreational uses, environmental pollution, anchor damage, and ship and boat groundings. In 2003, the National

Park Service (NPS) promulgated regulations to implement no-take areas at the Virgin Islands Coral Reef National Monument on St. John, USVI, and the expansion of Buck Island Reef National Monument on St. Croix, USVI. These marine reserves were created by Presidential Proclamations in 2001 to restore coral reef ecosystems and replenish fish and shellfish populations in the Virgin Islands. Studies by NPS and U.S. Geological Survey (USGS) scientists revealed dramatic declines in reef fish assemblages due to overfishing, illegal harvest and ongoing mortality from discarded fish nets and traps. Implementation of these fully protected reserves marked a critical change in management of coral reef fisheries; all extractive uses in the two Monuments are prohibited except for fishing for blue runner and baitfish in limited portions of Virgin Islands Coral Reef National Monument. To reduce physical damage, anchoring is by permit only at Buck Island Reef National Monument and is prohibited at Virgin Islands Coral Reef National Monument. NPS and NOAA scientists are working together to evaluate coral habitat and assess populations of fish and shellfish to determine the effectiveness of these reserves in restoring reef health. In 2001, Dry Tortugas National Park created a 46 square mile no-take Research Natural Area in its General Management Plan, in concert with the Tortugas 2000 planning process. The multi-agency process included input from the Florida Keys National Marine Sanctuary, State of Florida, two Regional Fisheries Management Councils, and NPS as well as a diverse 25-member public Working Group.



Rob Waara/NPS

Monitoring Coral Reefs. In 1989, DOI scientists began monitoring coral reefs at Yawzi Point off the south coast of St. John, U.S. Virgin Islands, using percent live coral cover, a measure of reef health. Although the long-term data show that corals have not recovered to their pre-Hurricane Hugo levels, they do indicate that live coral cover has stabilized—an encouraging sign.



The result is the Tortugas Ecological Reserve, the largest fully protected underwater ecological reserve in North America (197 square miles). General Management Plans for the other coral reef parks are also being updated to provide a road map for each park to meet its resource protection and management goals.

MONITORING AND PROTECTION

The National Parks are monitoring the condition of coral reefs and working to reduce threats to reef resources. Kaloko Honokohau National Historical Park successfully intervened in a petition

before the State of Hawaii Land Use Commission (LUC) to change the land use classification for a 104-acre industrial park. As a result, 28 conditions requiring best management practices were imposed to prevent stormwater and wastewater pollutants from reaching the Park’s coral reefs. The Commission’s action was a landmark decision in Hawaii, setting a standard for future petitions before the Commission and enabling the Park to work with two other adjacent developers to implement the same conditions to protect the park’s water resources.

War-in-the-Pacific National Historical Park initiated a unique project with the Territory of Guam and the University of Guam to address land-based sources of pollution. The project partners are working in island watersheds to assess the relationships among wildfires, upland erosion, and coral reef sedimentation at War-in-the-Pacific N.H.P. and other locations. The project will produce a set of best management practices for the park and island resource managers to reduce impacts on coral reefs and other terrestrial and marine ecosystems.

NPS and the USGS jointly conduct coral reef monitoring programs for the Atlantic-Caribbean and Pacific. Analyses of data collected since 1989 reveal disturbing patterns within the coral reef communities of the Virgin Islands, including a dramatic loss of live coral cover and decline in reef fish assemblages. USGS and the NPS Inventory & Monitoring Program developed an innovative, scientifically rigorous reef monitoring approach and protocols. The method combines a SONAR-based underwater positioning system with digital videotape recordings. Digital images are especially valuable in measuring coral cover and detecting and recording the effects of bleaching, disease, breakage and other changes in the appearance of coral colonies, as well as their recovery from these stressors. The technique is being adopted within the National Parks and broader resource management community.



Restoring elkhorn coral in the national park. Elkhorn coral, *Acropora palmata*, has suffered dramatic declines over the past few decades throughout the Caribbean. USGS and NPS worked with many partners, including these school children from St. John (top left), to restore elkhorn coral to the Virgin Islands National Park by transplanting coral fragments. A coral fragment transplanted in July 1999 to the Trunk Bay Underwater Trail (right) has grown into a thriving colony by 2004 (bottom left).

RESTORATION AND RECOVERY

NPS is responding to degradation or damage from impacts such as boat groundings. For example, Biscayne National Park suffers more than 200 reported boat and ship groundings yearly. To reverse widespread destruction of seagrass beds and coral reefs, NPS has taken the lead in applying National Park System Resource Protection Act authorities to recover damages from groundings. Since 2000, the NPS has collected more than \$3.3 million in damages to cover the costs of assessing, monitoring and restoring injuries to coral reef resources in the Florida Parks. Biscayne National Park was awarded \$2.1 million to recover damages from the groundings of two

ships within the park. NPS scientists also developed an innovative program to rebuild damaged coral reefs by growing corals in a nursery inside Biscayne National Park. Working with NOAA and the University of Miami, NPS scientists and volunteers rescue damaged coral fragments from vessel grounding sites and grow the colonies to restore damaged coral reef areas. Virgin Islands National Park completed implementation of a Resource Protection Plan. Under the plan, 211 moorings and 111 resource protection buoys were installed to allow access to natural areas while preventing anchor damage to benthic habitats.



Maintaining underwater trail signs at Buck Island National Monument, U.S.V.I.

EDUCATION AND OUTREACH

NPS recognizes that effective public education will enable communities and individuals to conserve and use coral reefs responsibly. Built on a theme of conservation through community outreach and partnerships, NPS conducts several education programs that empower recreational boaters, SCUBA divers and snorkelers to protect resources they enjoy in the National Parks.

For example, Biscayne National Park launched an intensive bilingual (English-Spanish) campaign, “Resource Protection through Boater Education.”

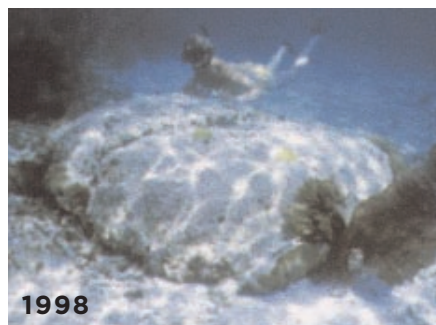
The campaign promotes responsible boating and navigation practices to avoid groundings on sensitive seagrass and coral reef areas. Biscayne National Park also conducts community-based volunteer programs, including the Great Annual Fish Count, an annual training seminar and underwater event that inspires recreational SCUBA divers and snorkelers to aid resource managers in monitoring fish populations.

Virgin Islands National Park established a touch-screen video program on

responsible snorkeling techniques at the Trunk Bay visitor kiosk to enable visitors to avoid impacting corals on the snorkel trail. The National Park of American Samoa worked with the Department of Marine and Wildlife Resources and American Samoa Community College to produce the *Natural History Guide of American Samoa* for use in the classroom and by the general public. The *Guide* describes the biology and ecology of coral reefs and a wide range of terrestrial and marine wildlife.



1988



1998



Peter Craig/NPS

An unidentified disease has killed most of this coral colony in the National Park of American Samoa. The purple band is all that remains alive, with algae already over-growing the dead coral at the back of the colony.

NATURAL LABORATORIES

National parks continue their long tradition of serving as coral reef research sites. Groundbreaking, innovative marine research was conducted from 1969–1971 during the Tektite I and II underwater habitat projects at the Virgin Islands National Park. Early research at both Biscayne and Dry Tortugas National Parks revealed the level of human impact to reefs due to recreational diving and fishing. This research led to pioneering use of reef mooring buoys and designated ship anchorages to reduce damage to reefs. NPS currently administers and coordinates research on coral reefs with other government agencies and universities on topics ranging from long-term ecosystem monitoring of water quality to fish landings and effects of hurricanes and coral diseases. Joint efforts with the NOAA and USGS re providing completed maps for the coral reefs ecosystems of the Hawaii, U.S. Virgin Islands and South Florida National Parks. Other continuing efforts include long-term studies of endangered sea turtles.

Coral disease. USGS scientists are monitoring reefs for disease such as black band. The disease that began at the top of the colony (top) has killed almost the entire colony by 1998. First identified in the Caribbean where they have devastated some species of coral, diseases are beginning to appear in Pacific corals (right).

Gene Shimm/USGS

U.S. GEOLOGICAL SURVEY

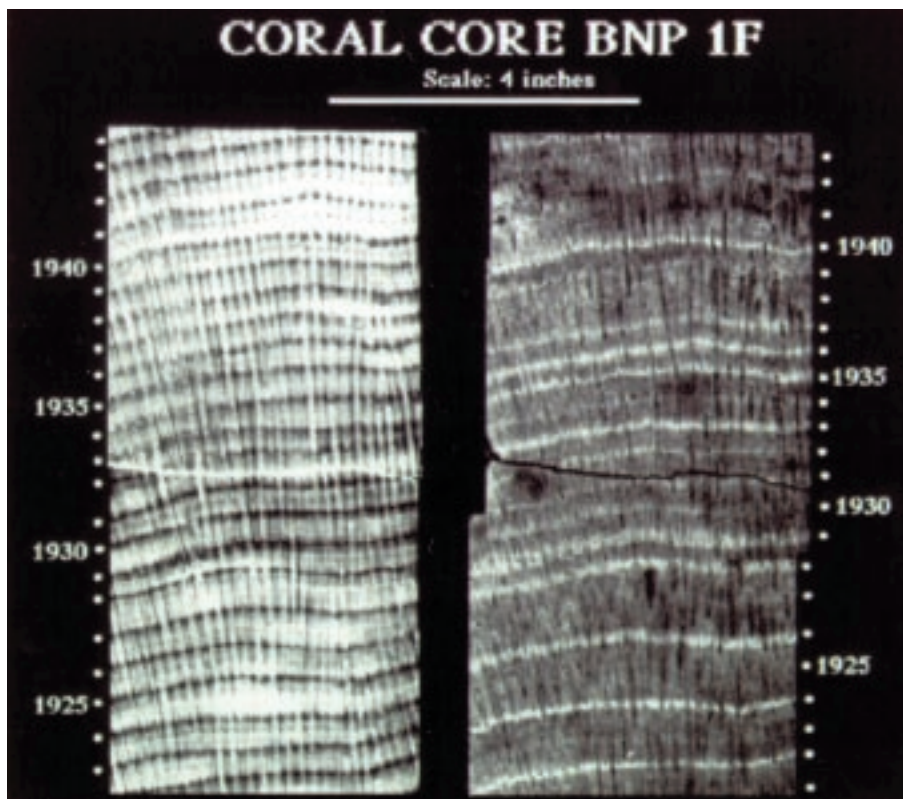
The U.S. Geological Survey (USGS), established in 1879, is the Nation's principal natural science and information agency, conducting research, monitoring and assessments to improve our understanding of the natural world—America's lands, water and biological resources. The USGS provides reliable, impartial information that is used by managers, planners and citizens to understand, assess and plan for changes in our environment. With research centers and field stations in Florida, the U.S. Virgin Islands, Hawaii and elsewhere across the Nation, USGS is providing resource managers with information critical to understanding the ecology, health, and management of coral reefs. USGS coral reef research focuses on understanding the structure and function of reef communities, high resolution thematic mapping and characterization to address reef health and change, geologic growth and development, the effects of sediment transport on reefs, and the interactions of groundwater and reef health. In addition, USGS scientists are investigating the relationships between water quality and coral health and disease; the effects of fishing and no take zones on coral reef resources; and developing new monitoring techniques.

Programs & Recent Accomplishments Related to Coral Reefs

DISEASES OF CORAL REEF ANIMALS

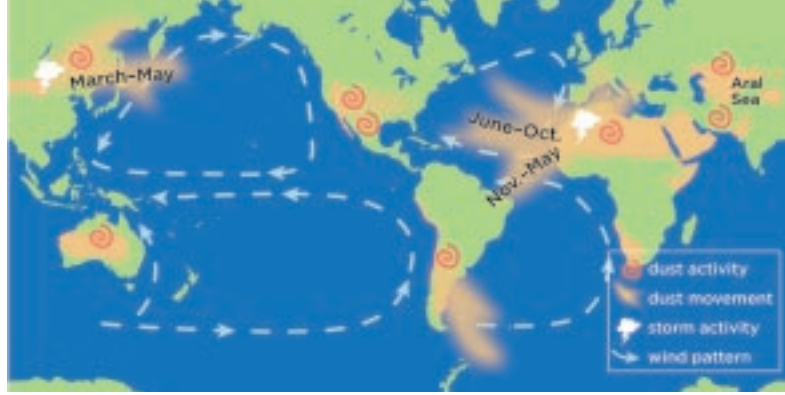
In the past two decades, diseases of hard corals, sea fans and sea urchins have caused massive mortalities in reef communities in the Caribbean, Florida and Gulf of Mexico and brought about significant changes in reef structure and biodiversity. In many cases, causative pathogens have not been identified because standardized approaches and case definitions of diseases are generally lacking. USGS scientists are working to strengthen multidisciplinary collaborations to determine the occurrence, causes, predisposing factors and effects of diseases of coral reef animals.

A member of the Coral Disease and Health Consortium, USGS recently conducted a workshop at its National Wildlife Health Center to discuss the diagnoses of coral diseases and develop guidelines for identifying and describing them. These efforts are expected to aid in the development of protocols to fully characterize disease syndromes using state-of-the-art techniques of histopathology, microbiology, biotechnology and toxicology. USGS scientists are also studying the health of coral reef communities in Hawaii, the Northwestern Hawaiian Islands, Johnston Atoll and American Samoa. They have determined that, in some cases, coral bleaching may be due to parasitic infections; that some corals

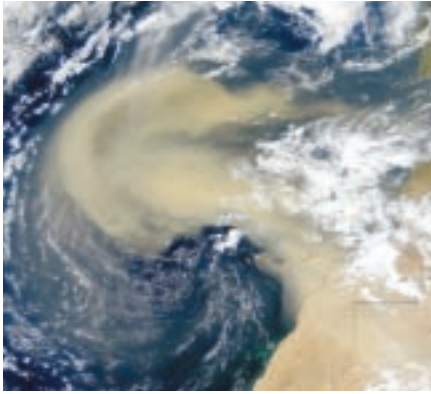


Charles Holmes/USGS

Coral Skeletons as Climate Records. Images of coral skeletons, like these of a core from Biscayne Bay National Park, allow USGS scientists to establish the age and climate history of coral colonies. An x-radiograph of the core (left), reveals annual growth bands, resembling tree rings, of the coral colony; the colony was found to be more than 350 years old. Variations in the growth bands reflect climate changes. For example, thick, dark bands correlate with very cold winter temperatures. Bright bands appear in the same core exposed to fluorescent light (right), recording years of heavy rainfall and hurricanes. For example, the bright band in 1928 records a hurricane in south Florida.



African Dust. A giant dust storm off the northwest coast of Africa is captured in this satellite image taken on October 30, 2001 (below left). Sediments are lifted by storm activity and carried thousands of miles across the Atlantic by the prevailing winds (left). Such dust storms carry infectious microbes and toxic chemicals and are now believed to pose a hazard to the ecosystems in the Caribbean. Droughts and agricultural practices in many regions have increased the size of the arid lands (in yellow) and aggravated the problem in recent decades.



are susceptible to infection by fungi and develop tumors; and that a die-off of sea urchins at Johnston Atoll may have been associated with a ciliate (a unicellular parasite). Recent evidence suggests that the tumor disease (fibropapillomatosis) that affects a large percentage of green sea turtles in Hawaii (and Florida) may be associated with a herpes virus. USGS scientists are currently working to develop tests to detect the virus in turtles and the environment.

INNOVATIVE RESEARCH TOOLS

The Submersible Habitat for Analyzing Reef Quality (SHARQ), developed and patented by USGS scientists, is being used in numerous locations in the Florida Keys, the Caribbean and Hawaiian Islands to document reef health in terms of fundamental metabolic processes. The SHARQ provides a mechanism for quantifying the impacts of physical factors such as temperature and light fluctuations on calcification, photosynthesis and respiration. Data from *in situ* experiments combined with remotely sensed map data is enabling scientists to model impacts

of global climate change, turbidity, nutrients, temperature and grazing on coral reefs.

ATMOSPHERIC DUST STUDIES

USGS scientists, along with their partners and collaborators, continue to assess the relationship between African and Asian dust storms and outbreaks of disease on reef systems in the Caribbean and Pacific Islands, as well as toxic algal blooms and effects on human health. A pilot study showed that dust collected in the Virgin Islands (VI) during African dust events was toxic to some marine organisms. A strain of the fungus known to cause disease and mortality of sea fans throughout the Caribbean region has been isolated from air samples collected in the VI during African dust events, soil from the Sahel, Mali, and sediment from the Gulf of Paria in the southeast Caribbean. A method has been developed to quantify particles as small as a micron incorporated into coral skeletons which will enable scientists to reconstruct the history of dust events.

GLOBAL CHANGE

USGS scientists and reef managers are advancing the science and management of coral reef systems affected by global change by examining the processes that control their resilience. Studies are underway in the National Park of American Samoa to determine the factors that enhance the ability of a diverse assemblage of corals to resist extreme environmental stress (e.g., increases in temperatures wide ranges of dissolved oxygen; and intense UV radiation). The lagoon includes species of *Acropora*, *Pocillopora*, and *Millepora* ordinarily prone to bleaching at high temperatures. Coral transplanted to different stress conditions on the reef are being evaluated for acclimatization, adaptation, and/or susceptibility to disease. The effects of water motion, dissolved oxygen, or habitat characteristics are also being evaluated to help explain different survival rates. The results of these studies may play an important role in establishing Marine Protected Areas to mitigate the effects of global warming on coral communities.



SHARQ is a large-scale underwater incubation chamber designed and patented (US6467424B1) by USGS scientists to isolate a water mass over a coral reef bottom. This tool enables scientists to measure changes in water chemistry resulting from the reef's metabolism as a result of changing environmental conditions. Data from SHARQ experiments are comparable from reef to reef from the Caribbean to the Hawaiian Islands.



Mike Field and Pat Chavez/USGS

STUDIES OF DEEP-SEA CORALS

The deepwater coral, *Lophelia pertusa*, has been discovered at sites in the Gulf of Mexico and off the coast of North Carolina where it forms dense colonies and extensive reef habitat for fishes and invertebrates. These deepwater patches of coral likely represent centuries of slow growth and are highly susceptible to disturbance. USGS has partnered with the Minerals Management Service (MMS), NOAA, and the University of North Carolina to determine the biology and ecology of these little known reefs. Using a submersible to collect samples and environmental data at depths to 800 meters, USGS scientists are determining the relationship between *Lophelia* and the reef's microbial flora; *Lophelia's* genetics, growth, metabolism, and reproduction; and food-web relationships of reef-associated organisms through the analysis of stable isotopes. Genetic techniques are uncovering geographic patterns of isolation and the metabolic functions that allow these corals to survive at depth. Recent studies of shallow water corals suggest that associated bacteria may benefit the corals by cycling carbon, fixing nitrogen, chelating iron and producing antibiotics that protect the coral from other microbes. The health of *Lophelia* and other deepwater corals likewise may be dependent upon symbiotic microbes.

Landsat™ image of Molokai, Hawaii. Red volcanic soil has run off the landscape in freshwater discharge; plumes of suspended sediment are clearly visible along the south shore, obscuring the underlying coral reefs and threatening their health.

PACIFIC ISLAND REEFS

The USGS is investigating the linkages among mountain, coastal and littoral ecosystems—the “ridge-to-reef” concept—Hawaii and at National Parks and National Wildlife Refuges in Polynesia and Micronesia. Increased sediments on the reef are often the result of land-based human activities, such as ranching, farming and construction. Sediments fill coastal wetlands, and once out over the reef, block light needed for photosynthesis, inhibiting coral growth and recruitment and smothering living corals. Waterborne pathogens from terrestrial sources also may infect reef organisms. USGS scientists are assessing the conditions that lead to high levels of sediment discharge from island watersheds, evaluating the effects of these sediments on reef habitat, and developing adaptive management strategies for resource managers and community stakeholders—all goals identified by Federal and local partners in their “local action strategies.” USGS’s multidisciplinary scientific approach has resulted in landscape-scale modeling of the origins and possible solutions to degradation of coral reefs in the Pacific.

WATER QUALITY STUDIES IN BISCAYNE BAY

The reefs of Biscayne National Park are part of the 150-mile-long chain of coral reefs that make up the Florida Keys Reef Tract. Reef health has decreased dramatically during the past 15 years, concurrent with declining water quality, loss of habitat from coastal development, increased incidence of disease, elevated water temperatures, storms and increased use of the Biscayne Bay by boats, divers, and fishers. Threatened are at least 50 species of corals and over 100 species of reef-associated fishes. The need to protect and restore the biological resources in the Park has prompted new, multidisciplinary research partnerships between NPS and USGS. During the past two years, teams of USGS biologists, geologists, hydrologists and geographers have begun to document and map the reef’s conditions through remote sensing and diver surveys. Causative agents and threats to the reefs are being quantified and modeled using environmental data coupled with state-of-the-art models of groundwater and surface water flow. Modeling tools now being developed will allow USGS scientists to test hypotheses concerning the influence of pollutants on the health of Biscayne Bay. One theory being tested is that contaminants pumped into freshwater coastal aquifers migrate through the region’s highly porous limestone, ultimately reaching the Bay’s reefs and contributing to their decline. Results from these studies will be integrated into decision support systems that will guide decision-making by Park managers.



Caroline Rogers/USGS

Research on an “endangered” coral. Once a dominant reef-building species in the Caribbean, elkhorn coral has suffered dramatic declines since the 1970s from white band disease and storm damage. USGS scientists and partners are investigating factors that may be preventing its recovery, including white pox disease shown here.

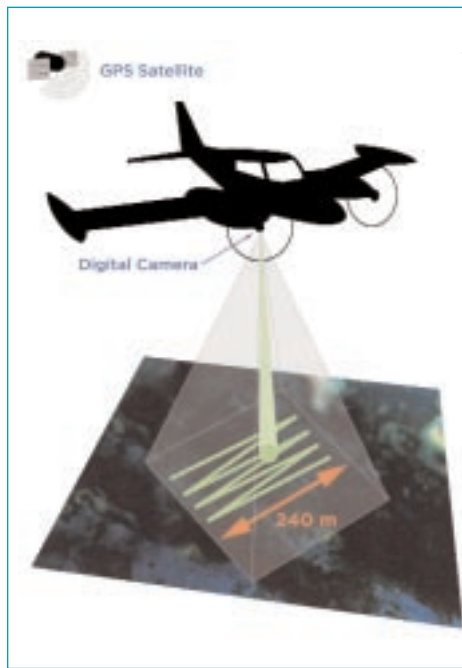
MONITORING REEF HEALTH

Over the past decade, USGS scientists have been developing innovative techniques for monitoring coral reefs in the Virgin Islands National Park, Buck Island Reef National Monument, and Dry Tortugas National Park. A new technique developed by USGS and the NPS, combining a SONAR-based underwater positioning system with digital imaging, is the most scientifically rigorous reef-monitoring protocol in the world. These methods are being used by USGS scientists to develop indicators of reef health, such as the amount of live coral versus algae on the reef and the abundance of juvenile and adult reef fish. Results indicate that the health of coral reefs in a number of areas has declined over the past decade. New protocols are also being used to map and assess the condition of elkhorn coral. Once a dominant Caribbean species, elkhorn coral has declined dramatically and is now being considered for listing under the Endangered Species Act. Collaborative studies by scientists from USGS, NPS and University of the Virgin Islands in Virgin Islands National Park (VINP), Buck Island Reef National Monument, and Biscayne National Park have determined that elkhorn coral is becoming more abundant at some sites; however, diseases, storms, predation, and physical damage from snorkelers and boats may be preventing its recovery. Monthly monitoring in 2003–2004 of 66 elkhorn corals in Haulover Bay (VINP) revealed that 17 percent died, 61 percent had white pox disease, 4.5 had white band disease and 74 percent suffered broken branches. USGS is sponsoring further research on prevalence and possible causes of these diseases.

MAPPING CORAL REEFS

In collaboration with NASA scientists, USGS scientists are mapping coral reef ecosystems in a number of areas using a newly developed lidar system. Called the Experimental Advanced Airborne Research Lidar (EAARL), this system is a temporal waveform-resolving, airborne green wavelength lidar. EAARL is designed to measure the complexity of shallow reef habitats and is being used to map submarine topography and coastal vegetation height and density.

EAARL is also being used to define the “optical rugosity”, analogous to the “topography” or “complexity,” of coral reef habitats. Rugosity is important to determining both the abundance and distribution of many reef organisms. An optical rugosity analysis of the northern Florida reef tract revealed that EAARL is able to distinguish the higher habitat complexity of inshore patch reefs from the lower complexity of outer bank reefs.



John Brock/USGS

This lidar (Light Detection and Ranging) image depicts the very fine detail of coral reef formations in Biscayne National Park off the southeastern coast of Florida. The images were generated by EAARL (Experimental Advanced Airborne Research Lidar), a new technology that provides unprecedented capabilities to survey coral reefs, shallow water habitats,

coastal vegetation, and sandy beaches. The EAARL system includes a water-penetrating lidar, a color digital camera, a hyperspectral scanner, and an array of precision GPS receivers mounted on the underside of an airplane. Blues depict lower elevations, while reds depict higher elevations.

OFFICE OF INSULAR AFFAIRS

The Office of Insular Affairs (OIA) carries out the Secretary of the Interior's responsibilities for the insular affairs. OIA coordinates Federal policy in the territories of American Samoa, Guam, the U.S. Virgin Islands and the Commonwealth of the Northern Mariana Islands. With the majority of U.S. coral reefs located in the insular areas, OIA plays an important role in improving the management and protection of the Nation's coral reefs. OIA also provides technical and financial assistance to the Federated States of Micronesia, the Republic of the Marshall Islands, and the Republic of Palau which share financial, diplomatic and military ties with the United States through a special relationship known as the Compact of Free Association. The freely associated states have some of the richest coral reef resources in the world and some of the oldest and most effective traditional management systems.

Traditional Fishing, American Samoa.

The insular areas are developing and adopting comprehensive management strategies to protect and sustainably manage their coral reefs, ensuring that present and future generations will continue to enjoy the beauty and abundant resources of these unique ecosystems.



Programs & Recent Accomplishments Related to Coral Reefs

U.S. ISLANDS PLAN OF ACTION

The majority of coral reefs under U.S. jurisdiction are located in the insular areas. OIA has worked closely with insular governments and local stakeholders to identify local and regional priorities for the protection and sustainable use of their coral reefs. The priorities of the insular areas are summarized in the *U.S. All Islands Coral Reef Initiative Strategy*, a cornerstone of the *National Action Plan to Conserve Coral Reefs (2000)*, and their Local Action Strategies and regional planning efforts such as the *National Biodiversity Strategy and Action Plan for the Federated States of Micronesia*. These strategies and plans provide vision and a broad scope of action, from education and outreach to the establishment of marine protected areas and increased local enforcement, designed to improve the management and protection of coral reefs.

PARTNERSHIPS AND ASSISTANCE

OIA, in cooperation with the National Oceanic and Atmospheric Administration (NOAA), annually provides technical and financial assistance to the insular areas to improve the management and protection of their marine resources. Grants support a broad range of projects designed to fill gaps in management capacity and to develop a comprehensive resource management program within each of the jurisdictions. Notable accomplishments include the declaration of new protected areas, status reports on reef health, the establishment of local coral reef advisory groups, the development of community-based management plans, expanded research on coral health and restoration, the development of GIS

information and management tools, the development of culturally appropriate education materials, and increased public awareness and community support for the sustainable use and conservation of coral reefs. Recognizing that overfishing poses a particularly serious threat to their local reef fish stocks, American Samoa recently banned SCUBA-assisted fishing as well as the harvest of live rock. With support from OIA and NOAA, the first territorial parks have been established in the Commonwealth of the Northern Mariana Islands and the U.S. Virgin Islands.

REGIONAL COOPERATION

The Marine Resources Pacific Consortium (MAREPAC) was established in December 1999 with funding from OIA. MAREPAC is a model program that promotes regional cooperation on marine resource use, management, and preservation among the Pacific Islands of American Samoa, the Federated States of Micronesia, the Commonwealth of the Northern Marianas, the Republic of Palau, Guam, and the Republic of the Marshall Islands. MAREPAC now serves as the advisory group to the Association of Pacific Island Legislatures and is helping them craft effective legislation on the conservation and sustainable use of their marine resources.

WORKING WITH THE FREELY ASSOCIATED STATES

The freely associated states total fewer than 2,000 square miles of land in aggregate but are distributed over more than 3,000,000 square miles of ocean—an area equivalent to the conterminous United States. These waters are home to some of the most extensive and biologically diverse coral reef ecosystems in the world. Islanders have depended on these resources for a wide range of utilitarian, symbolic, and ornamental functions since prehistoric times.



With funding from OIA, several new initiatives have been launched to improve the management and use of their marine resources. Among these is development of the *National Biodiversity Strategic Action Plan for the Federated States of Micronesia* (FSM). Led by the Micronesian Chapter of The Nature Conservancy, this blueprint for conservation and management is the first effort of its kind for the region. The Plan identifies prioritized areas for biodiversity protection based on the collective biological knowledge of regional scientists and local experts. OIA has supported workshops to train resource managers from around the region to recognize, assess and protect spawning grounds of reef fish, and to monitor reef health. OIA and other partners are also supporting the Natural Resource Assessment Surveys in the Marshall Islands. The surveys have provided information on the health of the marine resources of several atolls, trained local managers and students in field techniques, and provided recommendations to the communities for improving the management and protection of their

A blueprint for conserving the biodiversity of the Federated States of Micronesia.

OIA, in cooperation with other Federal, local and international partners, supported development of the *National Biodiversity Strategic Action Plan*. In the first effort of its kind for the region, the blueprint lays out the vision and framework for creating the first national system of protected areas for the Federated States of Micronesia.

coral reefs. The assessment of Ailinginae Atoll is expected to lead to the atoll being declared a World Heritage Site.

A PARTNERSHIP FOR A NEW MARINE RESEARCH AND EDUCATION CENTER

OIA is working with the National Park Service and a consortium of universities known as the Joint Institute for Caribbean Marine Studies to establish a new marine research and education in St. Croix, USVI. Located at Salt River Bay National Historical Park and Ecological Reserve, the “Salt River Bay Marine Research and Education Center” will be dedicated to research on the health and sustainability of coral reef and other tropical marine systems, student education, and public awareness of the economical and cultural heritage associated with the tropical oceans.

REEF RECOVERY

OIA worked with other Federal and local partners to remove nine abandoned fishing vessels grounded by a storm on coral reefs in Pago Pago Harbor, American Samoa. Monitoring of the area indicates that some of the coral reefs are recovering.



OIA's programs are helping the freely associated states improve management and protection of their rich biological resources such as these recently documented at Ailinginae Atoll, Marshall Islands.

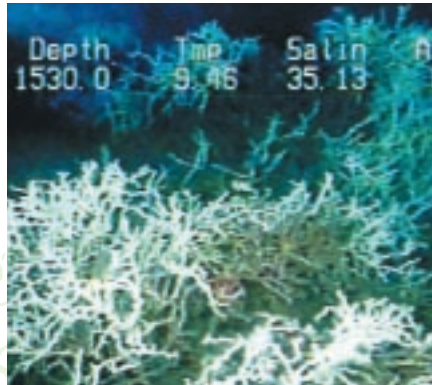
MINERALS MANAGEMENT SERVICE

As steward of our Federal offshore lands known as the Outer Continental Shelf, the DOI is responsible for balancing the Nation's search for petroleum energy and marine minerals with the protection of the human, marine and coastal environments. The Minerals Management Service's (MMS) environmental programs serve this important mission by providing the information necessary for informed decisions regarding energy and non-energy mineral planning and development activities on the Outer Continental Shelf.

Deepwater Coral Discoveries. A conger eel rises from its protective burrow in a *Lophelia* colony (top). Dense assemblages of this deep-sea coral have been found by DOI scientists and partners on the Outer Continental Shelf off North Carolina. Recent surveys by MMS have also found dense assemblages of *Lophelia* in the Northern Gulf of Mexico (bottom) such as these captured from the Johnson Seal Link at 1,529 ft. offshore Alabama. DOI scientists will continue to assess the extent and distribution of these little known coral communities.



Steve Ross/Ken Suljak/USGS



G.S. Boland

Programs & Recent Accomplishments Related to Coral Reefs

PROTECTION OF THE FLOWER GARDEN BANKS

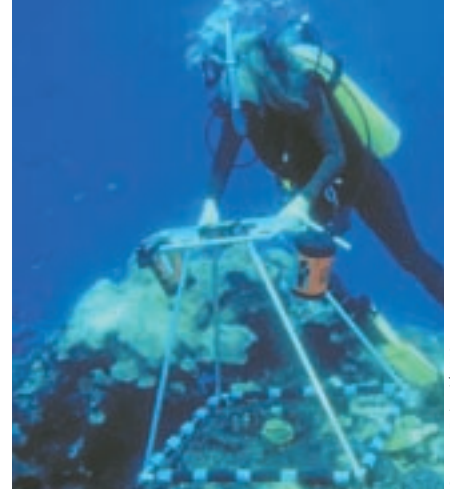
Since the early 1970s, MMS has supported a comprehensive program of mapping and multidisciplinary study of the East and West Flower Garden Banks in a petroleum-rich area of the Gulf of Mexico approximately 110 miles south-east of Galveston, Texas. The Flower Garden Banks are a pair of salt dome features that rise to within 60 feet of the surface from water depths of over 400 feet. These banks, with caps covered by an assemblage of reef-building corals and associated tropical and sub-tropical organisms, represent the northernmost coral reef system on the continental shelf of North America. The cover of live coral on both Flower Garden Banks rivals any coral reef in the western hemisphere. The MMS studies have provided information essential to the environmentally sound management of these sensitive and important coral reef habitats that have been designated as a National Marine Sanctuary. The MMS has used this information in developing lease stipulations that have permitted natural gas and oil exploration, development, and production to proceed in the vicinity of the banks with no detrimental environmental effects. Continuous, long-term monitoring of the health of the banks and possible effects of offshore natural gas and oil operations was initiated by the MMS in 1988. Since 1994, the Flower Garden Banks Monitoring Program has continued as a cooperative effort jointly

funded by MMS and the NOAA's National Marine Sanctuary Program. Monitoring was extended to deeper reefs in water depths to 130 feet on the East Flower Garden Bank during 2002 where initial results have shown living coral cover of nearly 70 percent. Information from this ongoing monitoring program is used by MMS analysts to evaluate the adequacy and effectiveness of current lease stipulations designed to protect the important biological resources of the Flower Garden Banks. Results from the monitoring studies show that the corals of the Flower Garden Banks are healthy and growing. The MMS also supported the deployment and analysis of satellite-tracked ocean surface drifter buoys to study dispersal of coral larvae originating from the synchronous spawning of corals on the Flower Garden Banks. The MMS received the Federal Environmental Quality Award from the Council on Environmental Quality and the National Association of Environmental Professionals for its environmental monitoring and research programs in the Flower Garden Banks National Marine Sanctuary.

CORALS ON GULF OF MEXICO DRILLING PLATFORMS

A multi-year study funded by MMS, initiated during 2001, is examining the patterns of coral community development and structure on oil and gas platforms. The first phase of the project completed in 2004 has had great success discovering wide-spread distribution of reef-building corals on platforms throughout a region within 40 miles of the Flower Garden Banks. Corals were found in abundance on most of the

Research diver taking fixed-dimension photographs to determine changes in percent cover of corals and other components of the coral reef community to monitor the health of the Flower Garden Banks over time.



Gregory Boland/MMS

study platforms, particularly those greater than 15 yrs old. In all, eleven species of corals were found, encompassing eight hermatypic scleractinians. A second phase of the study, starting in 2004, is designed to determine the maximum ranges for coral development on older structures including variables of latitude, longitude and water depth. Significant progress has been made in understanding the distribution of reef-building corals inhabiting the hard substrate provided by offshore platforms and how their distribution is related to the proximity of the Flower Garden Banks coral reefs.

DEEPWATER CORALS

Recent surveys on the Gulf of Mexico continental slope have discovered significant assemblages of the deepwater coral, *Lophelia*. The distribution and extent of these remarkable coral habitats in the northern Gulf of Mexico are being investigated for the first time in 2004 and 2005 by MMS using the Johnson Sea Link Submersible. Assemblages of corals such as *Lophelia* have been recognized recently as an important community in deep water throughout the world with levels of biological diversity rivaling those of shallow-water coral reefs. The need to protect these fragile communities has been recognized by the U.S. Commission on Ocean Policy in its

2004 report. The new MMS studies are intended to provide the fine-scale observations and sample collections required to describe these communities and provide input to resource managers for implementing protective measures directed at deepwater oil and gas operations. Additionally, in support of MMS information needs, USGS scientists are conducting studies of the microbial ecology and genetics of *Lophelia* and species composition, diversity, abundance and trophic relationships of fishes and invertebrates associated with deep-sea corals, as described in the USGS section of this report.

OTHER CORAL REEF RESEARCH

The MMS has sponsored several additional coral reef projects, including a five-year study of the effects of a major oil spill at Bahia las Minas, Panama, on coral reefs, mangroves, and seagrasses; the development of a community profile for south Florida coral reefs; a mapping inventory of Florida Keys seagrasses and coral reefs; and impact assessment of exploration wells offshore south Florida. MMS is also co-sponsoring the Third International Deep-Sea Coral Symposium to be held in November 2005 and the symposium, "Global Aspects of Coral Reefs: Health, Hazards and History."

CONCLUSION

As the Nation's primary steward of natural resources, DOI has responsibility for the well-being of the coral reef resources under its jurisdiction. The Department also has legal and enforcement authorities used in protection of these important ecosystems. Through its science and resource management bureaus, DOI conducts a wide variety of programs that directly or indirectly protect coral reefs for the benefit and enjoyment of the public. Coral reef habitats and their astounding biological diversity appear to be in decline worldwide, even in many protected areas. In some instances, protection could be made more effective with better understanding of how factors interact to degrade these complex systems. In others, we are doing the right things, but compartmentalization and fragmentation of actions have led to less than full effectiveness.



Jim Maragos/FWS

In response to Executive Order 13089, DOI is redoubling its efforts to protect coral reefs. DOI will inventory, map, and assess the condition of its coral reef resources. DOI will support directed research that will give our managers the knowledge and tools they need to protect coral reefs effectively. DOI will move forward with actions needed for conservation, mitigation, and restoration of these fragile ecosystems. As co-chair of the Coral Reef Task Force, DOI will be a leader in establishing linkages with other Federal and State agencies and other nations. Through these linkages, we hope to share information and technologies and ensure that protection efforts are coordinated to provide the maximum benefit for our world and for future generations.

INFORMATION

For additional information, visit our website at coralreef.gov or contact the following.

Office of the Assistant Secretary for Fish and Wildlife and Parks

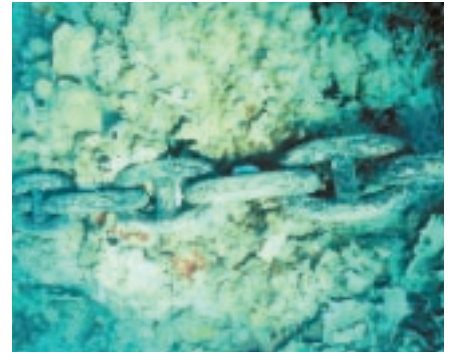
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Robert Richmond/UH

Human effects. A carelessly placed anchor chain crushes corals (top); a derelict fish net is entangled in coral (bottom). DOI is working to reduce these and other threats to coral reefs.

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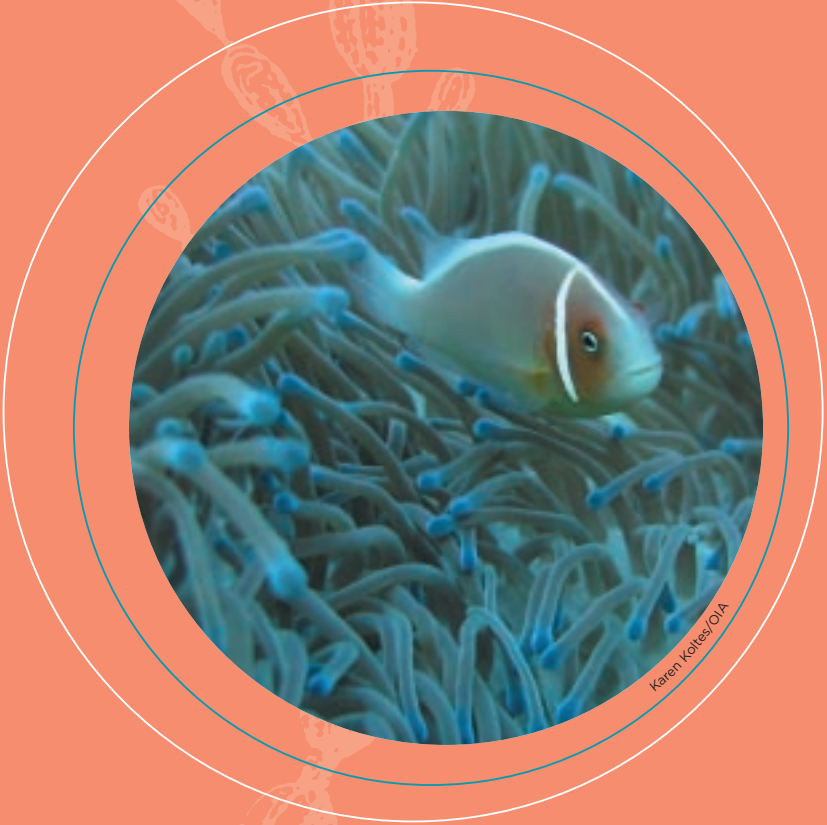
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