

## CHAPTER 2

# 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.**

For successful conservation of coral reef ecosystems, management must be responsive to changes in environmental, economic, and social conditions. Monitoring programs must be implemented to measure, track, and report indicators of ecosystem condition over time. Monitoring allows managers and others to assess reef condition, diagnose reef problems, prioritize and implement solutions, evaluate the results of management decisions, and forecast future conditions.

The *National Action Plan* (USCRTF 2000) calls for an integrated, nationwide coral reef monitoring system to profile and track the health of U.S. coral reef ecosystems, with the results used to measure the effectiveness of management actions. When linked to comprehensive habitat mapping efforts, a rigorous monitoring and assessment program contributes to coral reef conservation by:

*Documenting the status of reef species of ecological and economic importance;*





*Tracking and assessing changes in reef communities in response to environmental stressors or human activities;*

*Evaluating the effectiveness of specific management strategies and identifying actions for future adaptive responses;*

*Evaluating the natural recovery and/or restoration of injured reefs;*

*Enabling informed decisions about the location of potentially harmful activities by providing baseline data on community composition and predicted ecosystem response;*

*Providing baselines for assessing catastrophic damage from natural or anthropogenic events such as storms, disease outbreaks, climate change, coral bleaching, vessel groundings, and toxic spills; and*

*Serving as an early warning system for identifying declines in coral reef ecosystem health.*

### Accomplishments by Objective

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

### Jurisdiction-Led Efforts

USCRTF member states, territories, and the FAS continued to develop long-term coral reef monitoring programs in 2004-2006 using

funding from NOAA's State and Territorial Coral Reef Ecosystem Monitoring Grant program and other partners. Cooperative agreements empower state and territorial agency partners in the jurisdictions to collect and share information about local coral reef ecosystems and the biological communities inhabiting them.

### Program highlights in 2004-2006 include:

*Placement of a monitoring coordinator in Guam, who helped develop a collaborative monitoring plan/strategy for the island;*

*Implementation of a comprehensive and coordinated long-term monitoring strategy in American Samoa; and*

*Completion of the fifth year of long-term monitoring for reefs in natural reserves throughout Puerto Rico.*

In 2006, the fourth consecutive year of the Southeast Florida Coral Reef Evaluation and Monitoring Project, three new sites were added and the project was completed through a continuing partnership between NCRI, FWC, and FDEP. Other jurisdiction-led achievements include the expansion of existing long-term monitoring programs to increase the number of surveys conducted through the program. For example, in the USVI, grantees expanded the number of monitoring locations from 12 to 19, and partners in Palau added seven new sites.

The results of these long-term monitoring activities form the backbone of a comprehensive, periodic monitoring report, *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States*. The second report in the series, released

in August 2005, characterized the condition of shallow-water coral reef ecosystems based on quantitative results of assessment and monitoring activities conducted by federal, state, territory, commonwealth, non-governmental, private, and academic partners. The report was produced in close collaboration with teams of experts who authored chapters on the condition of coral reef ecosystems in each of 14 jurisdictions. The report presents the contributions of over 160 scientists and managers working throughout the country as part of a growing coral reef integrated observing system. The report is available online at: [http://ccma.nos.noaa.gov/ecosystems/coralreef/coral\\_report\\_2005/](http://ccma.nos.noaa.gov/ecosystems/coralreef/coral_report_2005/). The third report is scheduled for publication in July 2008.

### **On-going Monitoring Activities in the Pacific**

USCRTF partners participate in biannual ecosystem monitoring cruises to Pacific Islands as part of the Pacific Reef Assessment and Monitoring Program (RAMP), coordinated by NOAA. These cruises use various standardized methodologies across all U.S. Pacific archipelagos to collect integrated ecosystem data on fish, coral, algae, marine invertebrates, oceanographic conditions, and sea-floor topography. In 2005, this program was expanded to include the Main Hawaiian Islands (MHI), bringing the Pacific-wide coverage to a total of 322 monitoring sites on 55 islands, banks, and atolls in the State of Hawai‘i, the Territories of Guam and American Samoa, CNMI, and the Pacific Remote Islands Areas (PRIAs). Also in 2005, coral health and disease surveys were initiated to characterize the incidence, prevalence, and abundance and distribution of coral disease at long-term monitoring stations.

### **Main Hawaiian and Northwestern Hawaiian Islands**

Following three years of baseline surveys of approximately 400 sites annual monitoring cruises targeting a subset of approximately 73 sites have been conducted in the NWHI since 2003. In addition to the standard survey methods, cruise leaders collaborated with partners to conduct monitoring projects for nesting sea turtles, Hawaiian monk seals, and cetaceans. Coral disease surveys conducted in the NWHI since 2003 provide researchers with spatial-temporal appraisals of coral reef health and disease dynamics in the region. In 2005, the NWHI Coral Reef Ecosystem Reserve (now Papahānaumokuākea Marine National Monument) organized two research cruises; in addition to bathymetric surveys, scientists performed Rapid Ecological Assessments, set up and surveyed permanent coral disease monitoring transects, tagged and tracked over 100 large predators (primarily sharks and giant trevally), and researched genetic connectivity among fish and invertebrate species.

Management concerns and approaches for the NWHI shifted following the first-ever discovery and documentation of massive coral bleaching in the NWHI in 2002 and again in 2004 (Aeby et al., 2003; Kenyon et al., 2006; Kenyon and Brainard, 2006). In addition to documenting massive coral bleaching, the ecosystem/oceanographic approach of the Pacific RAMP allowed for an understanding of the causes of these bleaching events (Hoeke et al. 2006). Spatial patterns of bleaching during both recorded massive bleaching events in the NWHI were well correlated to high water temperatures. Maximum surface water temperature anomalies in 2002 and 2004 towards the northern end of the NWHI appear to have been the warmest in 30 years, and appear to be trending upwards. On the large scale, these temperature anomalies were associated with a series of atmospheric high-pressure ridges, which kept surface solar radiation high and winds light, causing



Porites coral heads of exceptional size (~8-10 meters high) thought to be among the largest and oldest ever were observed around Ta'u Island in American Samoa

rapid warming of the surface waters. These atmospheric features were centered over the northwestern end of the island chain, where the greatest temperature anomalies occurred. On a smaller scale, reef morphology further restricted water mixing, further elevating water temperatures by as much as 3°C in protected backreef and lagoon areas, particularly at the three northernmost atolls (Kure, Midway, and Pearl and Hermes), where the most severe bleaching was documented. Prior to these findings, coral bleaching was considered a low probability in the NWHI (Turgeon et al., 2002) and thus received minimal management concern and strategic planning.

The first biennial RAMP cruises spanning the entire Hawaiian Archipelago, including the populated MHI and uninhabited NWHI, were conducted in 2006. These ecosystem assessment and monitoring surveys made spatial comparisons across all 18 major islands and reefs of the Archipelago examining fish, coral, macroinvertebrates, and algae at the

species level at 117 sites.

The 2005/2006 MHI RAMP cruises found significantly higher coral cover than expected at many of the windward survey sites around the islands. These data surprised managers and scientists, and support a re-evaluation of management strategies, including potential enhanced protection through the establishment of new MPAs in some of these areas, such as the Ka'u coast of Hawai'i and portions of the north sides of Maui and Lanai. NOAA's development of bottom camera technology ("BOTCAM") and spatial analysis of bottomfish communities in the MHI resulted in significant alterations to the management strategies planned to recover these populations in the MHI by the State of Hawai'i, the Western Pacific Fishery Management Council, and NOAA.

### Guam, CNMI, and American Samoa

Guam and CNMI were surveyed in 2005 as

part of the biennial Marianas Archipelago RAMP cruise program. Building on the first cruise in fall 2003, the team collected a variety of ecological data at 14 islands and 12 banks of the Marianas Archipelago in 2005.

Before the first Marianas Archipelago RAMP (MARAMP) cruise in 2003, management agencies in Guam were considering implementation of a large-scale eradication effort to address concerns about a mass *Acanthaster planci* (crown-of-thorns seastar) infestation reported around the island of Guam. However, extensive towed-diver surveys during MARAMP 2003 found little evidence to support the infestation claims, and the government redirected funds to other reef conservation activities. In CNMI, before the 2003 surveys, government agencies reported apex-predator-dominated, near-pristine conditions in the northern islands based on limited surveys completed a decade earlier. The 2003 and 2005 RAMP surveys found a significant decrease in large fish abundance in the northern islands, suggesting higher levels of fishing pressure than predicted for the region. In partial response to these findings, CNMI resource management agencies are now investing limited funds to deploy passive Electronic Acoustic Recorders (EARs) during MARAMP 2007 to conduct acoustic monitoring of vessel traffic in the northern islands.

The coral reef ecosystems of the six primary islands/atolls of American Samoa were surveyed during Pacific RAMP cruises to the territory in 2002, 2004, and 2006. ASRAMP fish observations and analyses are being provided to help settle an ongoing controversy among management agencies in American Samoa regarding the abundance of reef fish in the territory. During ASRAMP 2003, towed-diver surveys around Ta'u Island found areas with *Porites* coral heads of exceptional size

(~8-10 meters high) thought to be among the largest and oldest ever observed. Based on these findings, the American Samoa government is evaluating the establishment of a marine protected area to conserve these amazing corals. The deployment of four EARs around Tutuila (one in Fagatele Bay National Marine Sanctuary, two in the National Park of American Samoa, and one in Alega Bay) have helped resource managers understand the pattern of vessel intrusion. For example, the EARs deployed in the National Park showed surprisingly high vessel traffic in Park waters after dark.

To communicate the results of the RAMP cruises, NOAA is nearing completion of the Coral Reef Ecosystem Monitoring Report for American Samoa, the first in a series of monitoring reports for each of the jurisdictions. Using easy-to-comprehend visualizations of the complex Pacific RAMP data sets, these reports provide extensive and detailed spatial and temporal information documenting the benthic habitats, oceanography and water quality, and status of fish, corals, other invertebrates, and algae. In addition to the hardcopy reports, the data used to produce them will be made available online.

The National Park Service (NPS), with partner USCRTF members, continued collaborations to advance scientific understanding of coral reefs in National Parks and at regional scales in the Pacific. The NPS has developed scientifically and statistically rigorous protocols for the long-term Vital Signs monitoring program for coral reefs at National Park units in the Pacific Islands. Recruitment of juvenile corals, one of the Vital Signs indicators, has been very low at the NPS sites on the West Hawai'i Island coast and at the War in the Pacific National Historic Park (NHP) in Guam. The NPS will continue to monitor this indicator and others, and will consider trends in coral recruitment



when developing adaptive management plans for these parks.

### Pacific Remote Island Areas

In 2004 and 2006, RAMP cruises were organized to survey the Pacific Remote Island Areas in the Line and Phoenix Island groups and Johnston and Wake Atolls, where military activities have continued since World War II. The 2004 and 2006 surveys augment data collected in the PRIAs in 2000, 2001, and 2002, and permit scientists to evaluate conditions over time at these seven remote and largely uninhabited islands. First-time coral disease surveys completed in 2006 at uninhabited islands such as Jarvis Island and Kingman Reef National Wildlife Refuge provide a basis against which to compare levels of disease prevalence in human-impacted coral reef environments. These quantitative assessments indicate a low mean overall prevalence of coral disease in the PRIAs, affecting between 0.01 and 2.8 percent of colonies. These values are comparable to the levels reported for the NWHI. NOAA, with the U.S. Fish and Wildlife Service (USFWS), led an effort in the Pacific Remote National Wildlife Refuges to resurvey all 60 accessible permanent transects and establish 10 new permanent transects.

### On-going Monitoring Activities in the Atlantic/Caribbean

In contrast to the Pacific, no consistent regional assessment ability exists for coral jurisdictions in the U.S. Caribbean, Atlantic, and Gulf of Mexico. However, in 2006, NOAA co-led a collaborative project to assess the feasibility of implementing a periodic, broad-scale assessment of coral reef communities across the U.S. Caribbean. This ongoing project—the Comprehensive Caribbean Coral Reef Ecosystem Monitoring Project—focuses on

increasing collaboration and integration of current monitoring efforts and expanding monitoring to additional sites through the development of an online project database and GIS link.

In Florida, the USCRTF works with many partners to accomplish long-term, annual monitoring of fish, coral, and macroinvertebrate species in marine protected areas in the Dry Tortugas National Park, the Florida Keys, and throughout southeast Florida.

The Dry Tortugas National Park quadrupled the number of long-term coral reef monitoring sites in 2004 and 2005, in an effort to assess the continued decline of reef-building corals and to better understand coral status and trends. The availability of this information was a key factor in the designation of a 47-nautical-square-mile Research Natural Area in the Dry Tortugas in 2006 (see page 64 and 76 for more information). Common species and shallower, rare coral community types in the park, including the major remaining stands of staghorn coral (*Acropora species*), are now being monitored, as are seagrass and associated benthic communities. Surveys at 275 sites found increased size and abundance of some targeted reef fishes in the Florida Keys National Marine Sanctuary (FKNMS) Tortugas North Ecological Reserve (compared to findings from 1999 and 2000, before the Reserve was established), and stable species diversity throughout the region. Condition of reef fish stocks varied between management zones: stocks were more abundant and individuals were larger in areas with greater resource protection (i.e. less fishing).

The 12th consecutive year of long-term status and trends monitoring for seagrass, coral reef, and water quality has been completed in the FKNMS at a cumulative cost of about



Mapping the staghorn (*Acropora cervicornis*) stands off of Broward County, Florida.

\$12 million. Multiple stressors acting at local, regional, and global scales continue to negatively impact coral reefs in the FKNMS, and are implicated in the decreases in stony coral cover and species richness documented by the Coral Reef Evaluation and Monitoring Project (CREMP).

The coral reef ecosystem in Florida extends beyond the Florida Keys northward through Miami-Dade, Broward, Palm Beach, and Martin counties. But until the development and implementation of the Southeast Florida Coral Reef Initiative in 2004, coral reef research and long-term monitoring was primarily focused on the Florida Keys and Dry Tortugas. Since 1996, the CREMP has documented changes in reef resources throughout the Florida reef tract from Key West to Carysfort. In 1999, the project was expanded to include three sites in the Dry Tortugas. In 2003, CREMP was further expanded to include 10 sites offshore southeast Florida in Miami-Dade, Broward, and Palm

Beach counties. In 2006, three additional sites were installed in Martin County. This CREMP expansion is referred to as the Southeast Florida Coral Reef Evaluation and Monitoring Project.

In 2004—following creation of a Memorandum of Agreement to facilitate sharing knowledge and best practices for resilience-based management among the State of Florida, NOAA, and Australia’s Great Barrier Reef Marine Park Authority—project partners launched the Florida Reef Resilience Program (FRRP). The FRRP is working to bring together scientists, reef managers, and the people whose livelihoods and recreational pursuits depend on healthy coral reefs to improve the collective understanding of coral reef resilience by exploring the biological and environmental aspects of reef health. The FRRP seeks to develop strategies to improve the health of Florida’s reefs and enhance the economic sustainability of reef-dependent commercial enterprises. The FRRP has



completed a characterization of different reef zones throughout the entire Florida reef tract from the Dry Tortugas to Martin County, creating a common spatial framework in which to analyze old and new data. The FRRP has designed and successfully completed a pilot deployment of a disturbance response monitoring program to capture data on the impacts of bleaching and other disturbances throughout the reef tract.

Long-term monitoring continues in the coral-rich bank tops in the East and West Flower Garden Banks National Marine Sanctuary (FGBNMS), located in the Gulf of Mexico about 115 miles off the coast of Texas, in water depths of 18 to 49 meters. Monitoring results during the 2004-2006 period continue to highlight the relative health of these reefs. The occurrences of disease and bleaching were low from 0 to 0.50 percent, and the living coral cover continues to be approximately 57 percent. The coral reef ecosystem of the Flower Garden Banks has been well characterized by studies sponsored by the Minerals Management Service (MMS) since the 1970s. When the banks were designated as a National Marine Sanctuary in 1992, NOAA joined with MMS to sponsor the long-term monitoring program that continues today.

DoD (Navy) entered into a cooperative agreement with the University of Miami to compile existing coral reef monitoring data from the Navy's facility at Andros Island, Bahamas, into a format to facilitate analysis and combination with other datasets. The Navy has been monitoring this area for several decades.

During 2004-2006, federal and territorial partners completed years five to seven of a long-term NOAA-led project monitoring benthic and fish communities in the USVI and Puerto Rico. Semi-annual surveys in the USVI focus on sites at Buck Island Reef

National Monument in St Croix. In late 2006, scientists transferred survey design approaches and data collection methodologies to the adjacent East End Marine Park to ensure easier comparison of data collected around the island. Annual surveys at St. John encircle the island, encompassing National Park and National Monument waters as well as at a deep reef three to four kilometers off the south shore of the island.

Complementary surveys conducted in Puerto Rico by the Department of Natural and Environmental Resources include 18 reefs in seven natural reserves, including the Tres Palmas Marine Reserve which harbors one of the most extensive and healthy populations of *Acropora palmata*—a species recently designated as threatened under the Endangered Species Act. Sampling efforts for all sites include the monitoring of reef fish and large invertebrates. Because field work in Puerto Rico was completed in August 2005, the massive Caribbean bleaching event was not recorded until the 2006 monitoring cycle. Surveys in 2006 detected a major decline in live coral cover—up to 59 percent at one location—and a shift in organism that make-up the benthic community persisting in late 2006. In all cases, the decline of total live coral cover at the community level was driven by mortality of the *Montastrea annularis* complex—a highly dominant species in terms of reef substrate cover and the principal reef-building species.

Other monitoring at priority reserves around Puerto Rico resulted in a characterization of La Parguera Natural Reserve reefs, which was submitted to DNER in 2004, with management recommendations to reduce the impacts on the reefs. In 2006, some of these recommendations were implemented, such as the installation of mooring buoys and aids to navigation. Other characterizations focused on the Caja de Muertos and Berberia Islands off

A bleached *Acropora palmata* colony in St. Croix, US Virgin Islands. The quadrat is 1m<sup>2</sup>.



the coast of Ponce and Cayo Aurora in Guánica State Forest; these projects were completed in 2005. In 2006, a characterization of the reefs in La Cordillera Natural Reserve off the northeast coast of Puerto Rico was conducted.

Biennial monitoring cruises continue to assess fish, benthic habitats, and *Acropora* status in the Navassa National Wildlife Refuge (see box on page 67 for further detail).

Additional monitoring efforts are conducted by the National Park Service, often in partnership with other federal and academic partners, to enable managers to conserve coral reef ecosystem resources within the National Park System. Scientists with the South Florida/Caribbean Inventory and Monitoring Network (SFCN) monitor coral reefs within four National Parks: Dry Tortugas National Park and Biscayne National Park (Florida), and Virgin Islands National Park (St. John, USVI), and Buck Island Reef National Monument (St. Croix, USVI). Hurricanes, bleaching

events, and coral disease outbreaks brought unprecedented change and stress to coral reefs in these parks in 2004 and 2005. Using statistically rigorous and peer-reviewed methods, SFCN scientists are able to track changes and advise managers of conditions within these coral reefs before, during, and after major reef-altering events.

### The 2005 Caribbean Coral Bleaching Event and Interagency Response

In 2005, coral reefs in the wider Caribbean suffered a widespread and severe bleaching event, which resulted in extensive coral death in much of the region. Persistent elevated sea surface temperatures caused this bleaching event, resulting in severe stress to coral communities, many of which were later killed by disease. More than one year after the 2005 bleaching/disease event, and despite the return of more “typical” sea-water temperatures, many corals continue to suffer lingering effects from the event, and mortality from disease

continues to claim coral colonies. As of October 2006, coral cover had declined over 50 percent at many sites throughout the region.

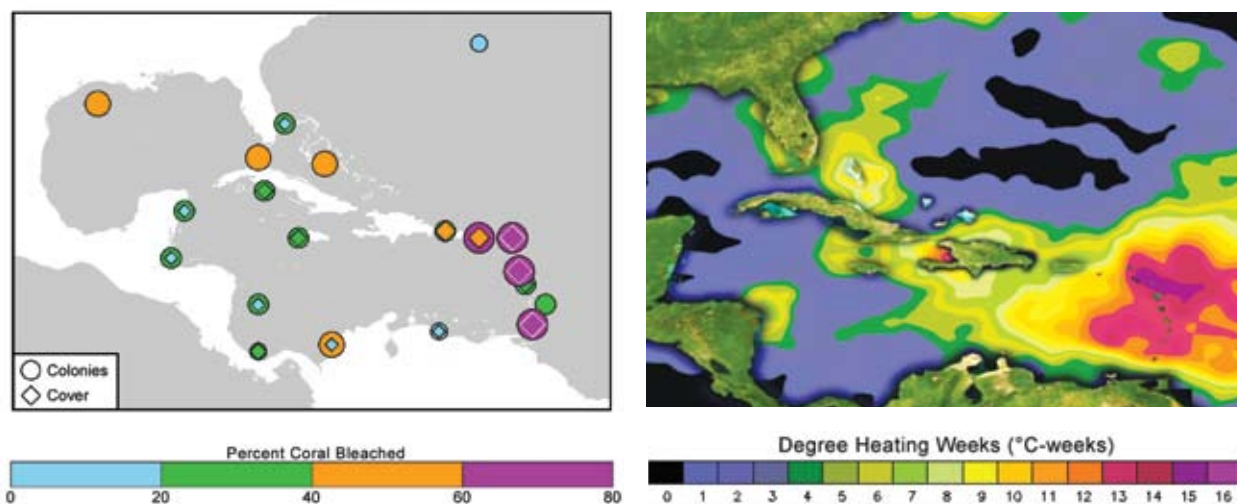
Most reef-building tropical corals host symbiotic algae called zooxanthellae, which live inside their tissue. Coral bleaching is the temporary or permanent loss of zooxanthellae from the coral, which can be caused by many types of physiological stress (e.g., ultraviolet rays, excessive warm or cold water temperatures, bacterial infection, etc.). However, recent mass bleaching events, including the 2005 Caribbean bleaching episode, were caused by persistent elevated sea water temperatures and resulted in widespread coral mortality of coral reefs throughout the world.

Since 2000, NOAA has been developing and refining a system to predict and track thermal stress on corals using satellite-based sea surface temperature data. When conditions are detected which may lead to coral bleaching, automated Satellite Bleaching Alerts are e-mailed to managers worldwide. The first alerts issued for the 2005 Caribbean bleaching event were transmitted to the Florida Keys in

August 2005, and to Puerto Rico and the USVI in September 2005. During the 2005 event, satellites detected thermal stress expected to trigger mass bleaching throughout most of the Caribbean and nearly twice this value around the northern Lesser Antilles.

Presented with these data, the USCRTF passed a resolution in November 2005 to mobilize efforts across the Caribbean to monitor, assess, and research short- and long-term impacts of the 2005 warming and bleaching event. The USCRTF Bleaching Committee coordinated the efforts of NOAA, NASA, the DOI's USGS and NPS, other government agencies, NGO partners, university researchers, and local managers.

NOAA continues to lead an international collaborative effort to fully document the spatial extent and severity of this event. Surveys from more than 3,600 bleaching observations from 100 researchers in 28 jurisdictions indicate the abnormal, warm Caribbean ocean temperatures in 2005 resulted in the most widespread, intense bleaching (Figure 3), and perhaps highest mortality (over 50 percent at many sites) of corals



**Figure 3:** Thermal stress and bleaching during the 2005 Caribbean bleaching event. (a) Maximum NOAA Coral Reef Watch Degree Heating Week values (DHW) showing the maximum thermal stress recorded at each pixel during 2005. Each DHW represents one week of temperatures 1°C above the maximum highest monthly average. Values of 4 °C-weeks typically results in significant bleaching; 8 °C-weeks typically results in widespread bleaching and mortality. (b) Jurisdiction averages of bleached percent of live coral colonies (circles) and cover (diamonds).



ever recorded in the Caribbean. During the 2006 coral monitoring survey in Puerto Rico, approximately six to nine months after the bleaching event, a high proportion of live corals, in particular *Montastrea annularis*, remained partially bleached. The potential recuperation of these corals is uncertain at this point. Monitoring and data collection efforts will continue in order to assess coral survival and mortality at various intervals following the bleaching event.

At the time of the 2005 bleaching event, the NPS South Florida/Caribbean Inventory and Monitoring Network (SFCN) used 120 permanent monitoring transects within six study sites to detect changes in coral condition in and around three parks in the USVI. In response to the bleaching alerts, NPS scientists intensified the frequency and expanded the scope of monitoring during and after the event. Partnering with USGS scientists, they recorded and compared videotapes of 4,153 colonies and measured the extent of disease along the video transects. An average of 90 percent of coral cover was bleached at the six monitoring sites in September and October 2005, affecting all species of hard coral including elkhorn coral (*A. palmata*)—a species which had not previously bleached. In 2006, as many corals began to recover their normal coloration, a major disease outbreak (primarily white plague) hit the region, afflicting the already stressed corals. Mortality from disease at the NPS sites ranged from four to 80 times higher than normal levels after bleaching on these study sites, indicating the stress-response of bleaching was a precursor to disease and subsequent coral die-offs. Coral mortality from bleaching and subsequent outbreaks of disease had never been observed before on so many reef-building coral species and over such a wide depth gradient. These high losses are alarming because coral reefs take centuries to form, and these particular reefs had some

of the highest coral cover, species diversity, habitat value, and management protection of any reefs in the northeastern Caribbean. These findings reinforce the value of repeated, statistically valid, long-term monitoring; without this monitoring, managers would not have known the extent of coral bleaching, or that disease was the primary cause of the corals' demise.

NASA deployed a team and aircraft to make remote and in situ observations of coral reefs sites in Puerto Rico and the USVI impacted by the coral bleaching event. Aircraft-based sensors were used to document the extent of the bleaching; gather biological and optical data on healthy, bleached, and recovering corals; and measure reef ecosystem properties to understand the dynamics of the bleaching event. These sensors provide high spectral and spatial resolution data to enhance understanding of satellite data such as the global one-kilometer Moderate Resolution Imaging Spectroradiometer (MODIS). Field measurements were collected coincident to the airborne mission in Puerto Rico and the USVI by NASA, NOAA, DOI, and university scientists to validate the airborne data and quantify the complex coral reef sites with instrument measurements relating to the airborne image data. Coupling remotely sensed and in situ data will allow researchers to better understand the ecology of this region impacted by environmental events and improve modeling of future bleaching events.

As part of the Florida Reef Resilience Program (FRRP), reef managers and scientists were trained in the rapid disturbance response methods piloted throughout the Florida Reef Tract during peak bleaching months in 2005 and 2006. The large number of sample sites (>130) combined with the large geographic range required the involvement and coordination of 12 teams and over 40





divers from multiple agencies, universities, and NGOs. This effort documented the extent and severity of this bleaching event and results from these surveys are revealing spatial and temporal patterns in coral bleaching, diseases, and mortality. Although bleaching in Florida was much less severe than bleaching in the U.S. Caribbean, data from the FRRP are yielding important insights, demonstrating how some reef types may be more vulnerable to disturbance than others. To increase the predictability of thermal stress, these results are also being used to help calibrate high-resolution (~one kilometer), satellite-sensed sea surface temperature maps. For more information, see: <http://coralreefwatch.noaa.gov/caribbean2005/>.

**Objective 2:** *Develop a web-enabled data management and information system for U.S. reef monitoring and data mapping with a 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.*

### **Data Collection and Dissemination: Coral Reef Information System**

Acting on recommendations of the USCRTF, in 2002, NOAA created the Coral Reef Information System (CoRIS) to allow the public to access to an array of diverse scientific data on coral reef ecosystems and new information products.

CoRIS is a web-based information system that functions as a portal to products from coral reef research and management activities funded by and/or conducted in partnership with NOAA. Activities include coral reef mapping, monitoring, and assessment; natural and socioeconomic research and modeling; outreach and education; and management and

stewardship. CoRIS functions as an archive through the NOAA National Oceanographic Data Center (NODC) to preserve coral reef data and project metadata, while offering a variety of search tools to assist users in the discovery of this information. As of December 2006, users had access to:

*Over 18,000 data products related to coral reef ecosystems and over 1,600 metadata records;*

*The CoRIS library, which includes citations of peer-reviewed articles, references to publications, conference proceedings, and links to coral reef websites;*

*Essays on topics such as coral biology, deep-water corals, coral diseases, other hazards, and descriptions of coral reef ecosystems such as those of the Papahānaumokuākea National Monument of the Northwestern Hawaiian Islands;*

*An illustrated glossary of over 5,000 scientific and technical terms with definitions, explanations, and illustrative materials to help the public understand the complex language of coral reef ecosystem science; and*

*Educational resources, including links to the “Coral Kingdom” photo library and transcripts from discussions among coral reef experts and enthusiasts around the world on topics such as coral genetics and the future of coral reefs.*

CoRIS is developing a new portal to allow users to search for data by specific region. More information is online at: <http://coris.noaa.gov/>.