



1 *Assess and Characterize U.S. Coral Reefs: Coral Reef Ecosystem Integrated Observing System (CREIOS)*

Introduction

The goal of the category Assess and Characterize U.S. Coral Reefs includes mapping and monitoring activities that provide data and information as a foundation for management activities and conservation efforts. These efforts form the CRCP Coral Reef Ecosystem Integrated Observing System (CREIOS), comprising mapping, monitoring, and data dissemination. The National Coral Reef Action Strategy (National Action Strategy) directs NOAA, through the CRCP, to undertake activities that improve the understanding of coral reef ecosystems and reduce the adverse impacts of human activities on coral reefs. Mapping provides a detailed picture of the physical and biological structure of coral reef communities. Monitoring also includes both biological and physical aspects: direct, periodic field observations of the health of critical reef ecosystems, and automated, continuous monitoring of key environmental factors that are known to affect their health. The CRCP integrates its mapping and monitoring activities to accurately document the status and changes in the habitats, depth ranges, geomorphologic zones, and reef types present in coral reef environments. These CRCP activities address the primary goals of the Coral Reef Conservation Act (CRCA) and the National Action Strategy, which include creating comprehensive maps of all U.S. coral reef habitats and implementing long-term monitoring programs to track the condition of coral reef ecosystems over time.

Exhibit III-1-1 demonstrates how integrated mapping and monitoring activities contribute to a number of other functions of the CRCP. The data produced through CRCP mapping and monitoring projects are disseminated to coral reef managers and other users through a variety of NOAA websites and databases that make this information publicly available. The CRCP implemented the Coral Reef Information System (CoRIS) to serve as a single portal for managing its coral reef related metadata.



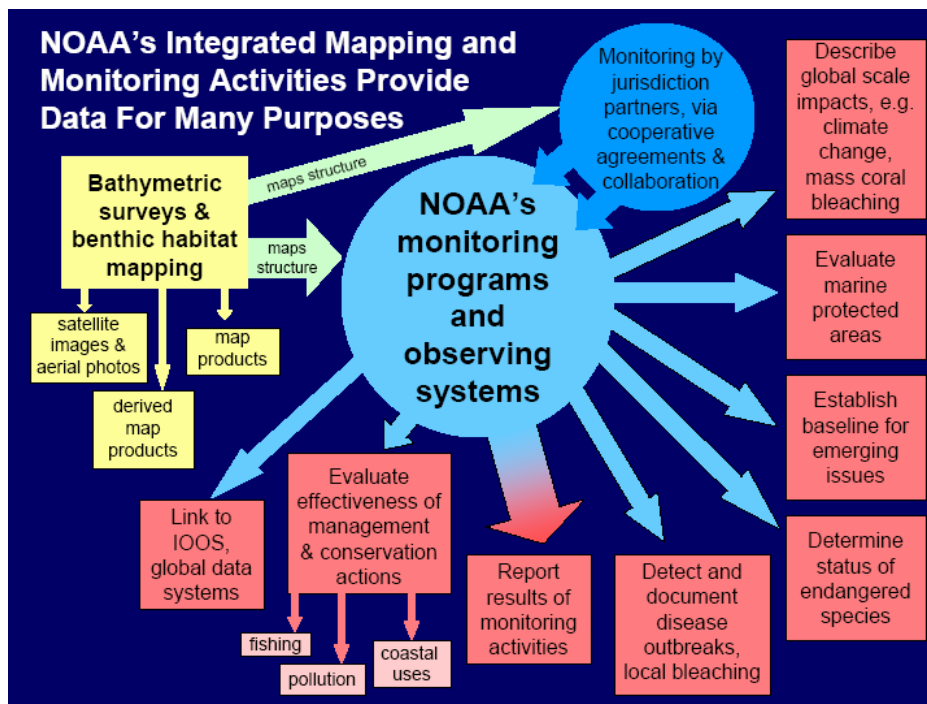


Exhibit III-1-1. Mapping and monitoring are linked to many other CRCP activities.

Between 2002 and 2006, the CRCP provided \$42.2 million (M) to support 199 projects in this category, and accounted for 33% of the overall CRCP funding and 15% of the overall number of projects (Exhibit III-1-2a). The Climate Change (Tab 3, Chapter 7) portion of this report includes a portion of the monitoring that is focused on climate change. As it is not possible to clearly divide monitoring activities into climate and non-climate components, CRCP’s climate work strongly leverages portions of the monitoring budget contained in this chapter.

Exhibit III-1-2a Investments to Assess and Characterize U.S. Coral Reefs, 2002-2006						
Spend Plan Category	# of Projects	% Category Projects	% Total Projects	Funding	% Category Projects	% Total Projects
Assess and Characterize U.S. Coral Reefs (CREIOS)	199	100	15.3	\$42,241,114	100	32.6
Mapping	59	29.6	4.5	\$15,365,236	36.4	11.9
Monitoring	111	55.8	8.5	\$22,907,265	54.2	17.7
Data Dissemination	29	14.6	2.2	\$3,968,613	9.4	3.1





The CRCP supports both internal NOAA projects and external grants under this category. These projects fall within three subcategories:

- Mapping
- Monitoring
- Data Dissemination

Exhibit III-1-2b shows the distribution of investments in each of these subcategories during 2002-2006.

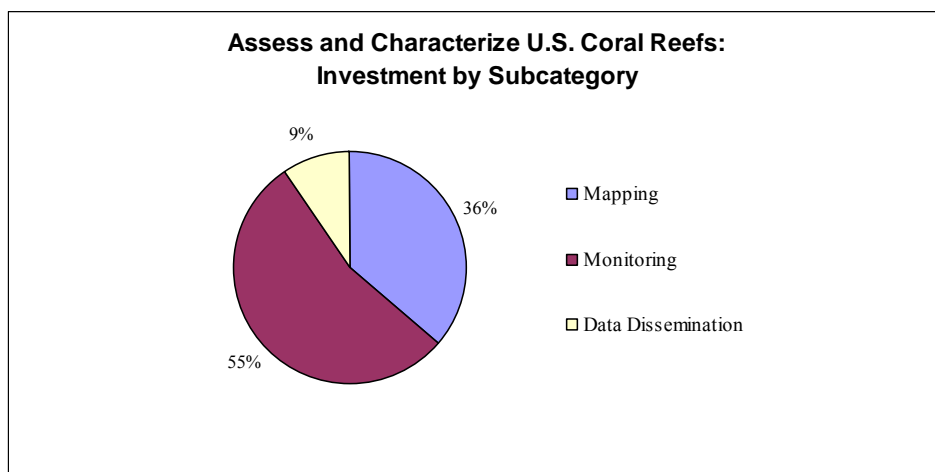


Exhibit III-1-2b. Distribution of Investments by Subcategory, 2002-2006

Subcategory: Mapping

a. Introduction to Subcategory

Mapping the spatial extent and characteristics of coral reef ecosystems is an integral component of CREIOS. Mapping activities include projects that use image analysis and acoustic sensing to map coral reef ecosystems from the shoreline to a maximum depth of about 200m, which roughly represents the depth limit at which hermatypic (symbiotic) corals can survive due to light availability.

One of our primary goals is to map all U.S. shallow-water coral reef ecosystems by 2009. When this mandate was established in 2000, fewer than 10% of all U.S. shallow reefs had been mapped and characterized. This meant that reef managers were designing and implementing management efforts with little specific information on the spatial distribution of the coral habitats they were tasked with managing.





In shallow water areas (to 20-30m), CRCP has generated benthic habitat maps through visual interpretation of features that are visible in georeferenced aerial photographs and high-resolution satellite imagery. These maps classify reef ecosystems using a hierarchical classification scheme based on geomorphological zones, underlying structure, and biological cover. Areas too deep to be clearly visible in imagery (20-30 to 200m) are surveyed using acoustic technologies, including sidescan sonar, single- and multibeam sensors, and bathymetric Light Detecting and Ranging (LIDAR) systems. These sensors provide data used primarily to develop high resolution bathymetric maps of the seafloor and simplified habitat maps.

Most of the funds allocated for mapping efforts use the above approaches. However, a limited number of additional projects have focused on activities such as socioeconomic mapping, the development of a multibeam data processing center, and research into development of new, cutting- edge mapping technologies.

In addition to the work conducted by internal CRCP projects, the CRCP provided over \$2.1M in grants between 2002 and 2006 to external partners for complementary mapping activities.

Between 2002 and 2006, the CRCP provided \$15.4M to support 59 projects in this subcategory. The mapping subcategory accounted for 36% of funding within the Assess and Characterize category and 12% of overall CRCP funding, and 30% of projects in the category and 5% of overall CRCP projects between 2002-2006 (see Exhibit III-1-2a).

Exhibit III-1-3a shows the investments by tool for mapping during 2002-2006.





**Exhibit III-1-3a
Mapping
Investments by Tool, 2002-2006**

Tool	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	% of Total Subcategory Projects	Funding	% of Total Subcategory Funding
	2002		2003		2004		2005		2006		TOTALS 2002-2006			
Ecosystem Research	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0	0	0	\$0	0
Socioeconomic Research	1	\$30,100	0	\$0	0	\$0	0	\$0	0	\$0	1	1.7	\$30,100	0.2
Mapping and Monitoring	16	\$5,033,694	12	\$2,506,799	13	\$4,129,135	10	\$1,793,700	7	\$1,871,808	58	98.3	\$15,335,136	99.8
Outreach	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0	0	0	\$0	0
Management: Direct Implementation	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0	0	0	\$0	0
Management: Training and Technical Assistance	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0	0	0	\$0	0
None or N/A	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0	0	0	\$0	0
TOTAL	17	\$5,063,794	12	\$2,506,799	13	\$4,129,135	10	\$1,793,700	7	\$1,871,808	59	100	\$15,365,354	100





Exhibit III-1-3b shows the distribution of investments by tool for mapping during 2002-2006.

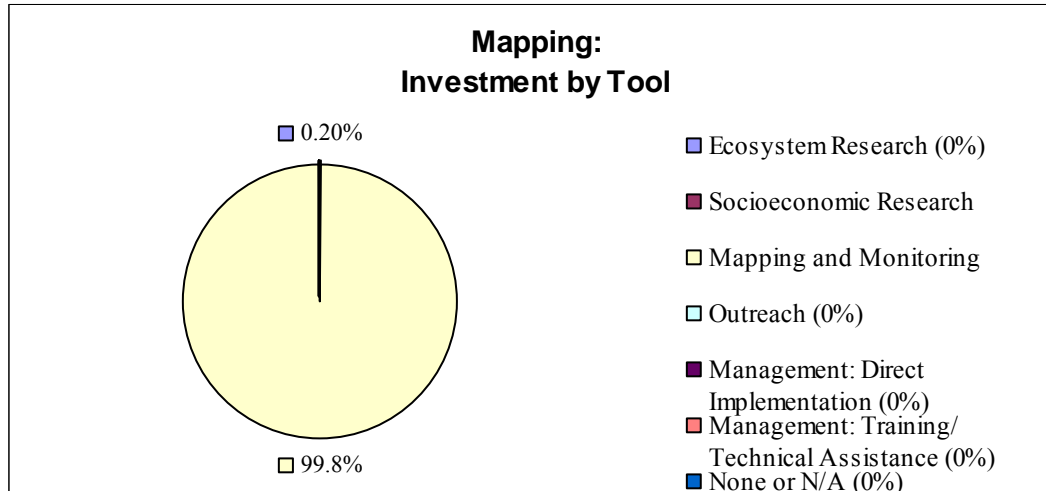


Exhibit III-1-3b. Distribution of Investments by Tool, 2002-2006

Exhibit III-1-4a shows the investments by region for mapping during 2002-2006.

Exhibit III-1-4a Mapping: Investments by Region, 2002-2006														
Region	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	% of Total Subcategory Projects	Funding	% of Total Subcategory Funding
	2002		2003		2004		2005		2006		TOTALS 2002-2006			
Atlantic/Caribbean	8	\$1,042,315	3	\$455,820	6	\$1,079,235	3	\$675,000	3	\$764,305	23	38.3	\$4,016,675	26.1
Pacific	9	\$4,021,479	9	\$2,050,979	6	\$2,615,782	6	\$1,093,700	4	\$1,107,503	34	56.7	\$10,889,443	70.9
Freely Associated States	0	\$0	0	\$0	2	\$434,118	1	\$25,000	0	\$0	3	5.0	\$459,118	3.0
International	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0	0	0	\$0	0
All Regions	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0	0	0	\$0	0
TOTAL	17	\$5,063,794	12	\$2,506,799	14	\$4,129,135	10	\$1,793,700	7	\$1,871,808	60	100	\$15,365,236	100





Exhibit III-1-4b shows the distribution of investments by region for mapping during 2002-2006.

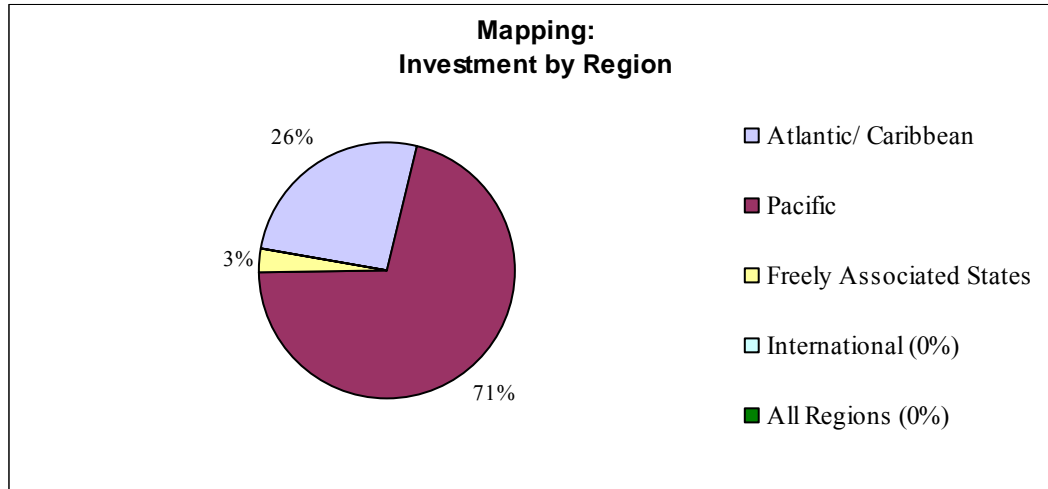


Exhibit III-1-4b. Distribution of Investments by Region, 2002-2006

b. Activities

Producing benthic habitat maps is a labor-intensive process. The first step is collecting remote sensing data, followed by careful QA/QC of the data to ensure thematic and geospatial accuracy of the data. Once the data are "clean," they are analyzed using both human visual interpretation and computer classification algorithms. The benthic habitat maps are then produced using geographic information system (GIS) technology and distributed via the internet, DVDs, and hard copy map atlases.

Before mapping work began in each area, we held several meetings with stakeholders from the management, non-governmental organizations (NGOs), and scientific communities to define product need and how the digital maps would be used in their region. In addition, consultation with local experts helped to refine the ecosystem classification scheme to include unique habitats for specific islands.

Prior to 2000, few U.S. shallow reefs had been mapped and characterized by habitat type. Since then, CRCP has led efforts to deliver shallow water benthic habitat maps that were developed using visual interpretation and/or spectral analysis of aerial photos and satellite imagery. We have also performed targeted mapping of high priority moderate-depth (30-200m) coral reef habitats in many areas.

Mapping activities funded by grants to the South Atlantic, Caribbean, Gulf of Mexico, and Western Pacific Fishery Management Councils helped them perform surveys that delineate essential fish habitat, characterize protected areas, and describe offshore banks and continental





shelf areas. Funding to jurisdictional agencies under the State and Territorial Coral Management Grants program supported targeted mapping in Southeast Florida, integration of biological data with GIS layers, and placement of GIS technical assistants in coral jurisdictions. Funds allocated under the General CRCP grants supported a targeted mapping effort for the Saipan Lagoon in advance of the expansion of a military anchorage area.

c. Funding Recipients and Partners

To carry out the projects in this subcategory, the CRCP partnered with the NOAA offices and external partners listed in Exhibit III-1-5.

Exhibit III-1-5 Mapping Funding Recipients and Partners			
NOAA Offices	Other Federal Agencies	States and Territories	Fishery Management Councils
<ul style="list-style-type: none"> • NMFS - Pacific Islands Fisheries Science Center • NMFS - Southeast Fisheries Science Center • NOS - National Centers for Coastal Ocean Science 	<ul style="list-style-type: none"> • U.S. Environmental Protection Agency • DOI – U.S. Fish and Wildlife Service • DOI – U.S. Geological Survey • DOI – U.S. Mineral Management Service • DOI - National Park Service 	• Florida	• Western Pacific
		• Hawaii	• Caribbean
		• American Samoa	• South Atlantic
		• Puerto Rico	• Gulf of Mexico
		• U.S. Virgin Islands	
		• Guam	
		• CNMI	
		• Republic of Palau	

d. Outputs

Consistently derived, digital benthic habitat maps are now available for the shallow coral reef areas of Puerto Rico, the U.S. Virgin Islands (USVI), the Florida Keys, Hawai’i, the Northwestern Hawaiian Islands (NWHI), American Samoa, Guam, the Commonwealth of the





Northern Mariana Islands (CNMI), and the Republic of Palau. These maps characterize more than 9,000 km² of shallow-water reef ecosystems throughout the nation, using a scale of 1:6,000 and a minimum mapping unit of 1 acre (4,047 m²).

The goal of characterizing high priority moderate-depth areas has been achieved in most of the Pacific, except in the Papahānaumokuākea Marine National Monument, where approximately 28% of the extensive bank areas between 20 and 200m have been completed. At the current rate of effort, ten more years will be required to complete this work in the Monument. In the Main Hawaiian Islands, limited multibeam surveying was undertaken in mid-depth areas to augment extensive university-collected data already available. In the remainder of the Pacific Islands, including American Samoa, Guam, CNMI, and the equatorial Pacific, approximately 90% of the moderate depth habitat has been mapped using multibeam sonars, and the data have been processed and made available to regional management agencies.

In the Caribbean and Atlantic, targeted moderate depth mapping has been undertaken in Navassa, Puerto Rico, the USVI, Florida, and the Gulf of Mexico. In the Southeast region, CRCP has conducted multibeam bathymetric and acoustic backscatter mapping on the outer continental shelf associated with two Marine Protected Areas (MPAs) in the eastern Gulf, and has used multibeam sonar to map corals and other habitat on the deepest hermatypic coral reef in the continental U.S. at Pulley Ridge off the coast of southwest Florida. These efforts leveraged earlier mapping projects by other Federal and academic partners to significantly expand benthic coverage.

Through performing these mapping activities, CRCP has also provided many other products and services, including:

- Aerial photos, satellite imagery, derived products, accuracy data, ground control points.
- Improved geopositioning for remote Pacific islands.
- High resolution hydrographic data for NOAA nautical charts.
- Bathymetric and derived information such as slope and rugosity for habitat mapping and boundary definition.
- Backscatter data used to determine seafloor character.
- Optical validation data.
- Standardized coral reef classification schemes.

Performance Metrics

The CRCP tracks mapping performance under the metric, “Map all U.S. shallow coral reef ecosystems and priority moderate-depth reef systems.” The goal to map all shallow-water coral reef ecosystems in the U.S. by 2009 will be met in most areas, but will not be met in Florida due to insufficient funding. Florida has the largest potential area of coral reefs in the U.S. and requires about \$4M to complete the work. In addition, an effort is now underway to remap the





shallow water habitats of the NWHI since the original maps were produced to meet a critical need, but lack the accuracy required to be consistent with other regions. Map products collected according to NOAA hydrographic standards also contribute to NOAA goals in Commerce and Transportation, Weather and Water, and Ecosystem Resources. Progress and performance are also measured at the project level.

e. Outcomes

Maps have been used by NOAA and external partners in a wide variety of ways, including:

- Monitoring: Defined baselines and structured monitoring programs, improved nautical charts, determined overall distribution of coral reef ecosystems in U.S. waters.
- Fisheries management: Maps were used by fisheries managers to define Essential Fish Habitat in Hawaii and the eastern Gulf of Mexico.
- MPA management: Delineated biologically appropriate boundaries for MPAs, delineated boundaries by depth in NWHI, influenced marine zoning schemes to reduce habitat destruction (e.g., defining no-anchor zones in Florida and the Caribbean), defined sites for aquaculture facilities in Puerto Rico, defined coral mitigation areas in Guam, informed decision-making and site selection for anchorage expansion in CNMI, supported damage assessment litigation and restoration, evaluated efficacy of Agricultural Best Management Practices implemented in watersheds.

Habitat maps support site selection for coral ecosystem monitoring by enabling random stratified sampling of the seascape. This allows researchers to determine the location and number of stations required to detect change and/or quantitatively characterize reef metrics. For example, the USVI, the National Park Service (NPS), and NOAA are jointly monitoring the effectiveness of MPAs based on a robust sample design to compare ecological metrics inside and outside of “no take” areas for the purposes of modifying the boundaries of the NPS Virgin Islands Coral Reef National Monument. The Department of the Interior and the USVI have agreed to modify the Monument boundary to include high quality habitats and associated fish populations, in part due to the research conducted by CRCP based on digital map products. In addition, NPS has used the digital maps to define “no anchoring” zones to minimize impacts to coral reef habitats at Buck Island, USVI. Finally, using benthic maps to stratify sampling has resulted in at least a 10% increase in the precision of fish abundance estimates in the Caribbean.

Benthic habitat mapping of the main Hawaiian Islands has been underway for about six years. In 2003, CRCP published the first set of digital benthic habitat maps for 65% of the main Hawaiian Islands as a pilot study using digital aerial photography. A completely new suite of digital map products for all of the main Hawaiian Islands will be published in 2007. The digital maps have enabled CRCP, in partnership with the Oceanic Institute and the Hawaii Department of Lands and Natural Resources (DLNR), to conduct one of the most robust studies in the literature to evaluate the effectiveness of main Hawaiian Island MPAs. The study showed that in all cases, greater habitat quality and greater abundance, biomass, and size of reef fish are present in





DLNR's Marine Life Conservation District's "no-take areas" when compared to outside fished areas. This work enabled DLNR managers to work with the Hawai'i legislators to modify pending MPA legislation that could have removed the no-take areas. Thus, use of the digital map products directly impacted legislation to continue no take protection for Hawai'i marine resources in the conservation districts.

Collaborative projects within NOAA enable data collected for habitat mapping to also be used for nautical charting. For example, 2003 multibeam "reconnaissance" data showed anomalous depths in Saipan harbor, and a 2007 charting survey using CRCP resources (R/V *AHI*) is being used to update nautical charts. Similar actions may result from Virgin Islands CRCP surveys, which were executed to International Hydrographic Organization standards.

In the Southeast, a definitive outcome from CRCP projects was the extension of the area closures in two northeast Gulf of Mexico MPAs. The original closures were for four years (June 2000 – June 2004). CRCP's surveys, based on benthic habitat maps, were a leading factor in the Gulf of Mexico Fishery Management Council (GMFMC) decision to extend the closures for six more years, resulting in a new sunset date of June 2010.

Grant funding for mapping in the Atlantic supported documentation of a drastic decline in fish populations and coral cover in the *Oculina* Habitat Area of Particular Concern since the 1970s. These grants also documented that structures (cement blocks and reef balls) deployed in 1996 were successfully recolonized by *Oculina varicosa* coral by 2003. Data on fish and coral provided critical information used by the South Atlantic Fishery Management Council in its decisions to deploy a Vessel Monitoring System to aid enforcement of the closure and continue the closure indefinitely to all bottom fishing.

f. Challenges

Shallow Imagery-based Mapping: Although seven of the eight primary jurisdictions have been mapped as of 2007, the goal of mapping all U.S. shallow-water coral reef ecosystems by 2009 may not be attainable due to the large area and complexity presented by the State of Florida. A robust plan has been developed for benthic habitat mapping of Florida, with an estimated cost of \$4.5M, to map approximately 10,000 km² of south Florida. Current CRCP funding for this region is around \$450K per year, limiting map development due to resource constraints. A shortage of NOAA shiptime has also been a challenge. Mapping projects have been conducted from non-NOAA platforms, but vessel charter fees are often more than double project costs. At present funding levels, it could take up to 10 additional years to complete shallow mapping of Florida.

Moderate-depth Acoustic Mapping: At seven remote locations in the equatorial Pacific, multibeam sonar data in shallow depths (10-30m) have been processed and satellite imagery is available, but interpreted benthic habitat maps have yet to be produced. Moderate depth mapping (20-200m) is complete in most of the areas of the Pacific. However, in the





Papahānaumokuākea Marine National Monument in the NWHI, only 28% of the banks have been mapped due to limited operational time in this large geographic area and the amount of area (12,167 km²) in the moderate depth range. At the present rate of effort (approximately 30 days per year), approximately 10 additional years will be needed to complete moderate depth mapping in the Monument.

Mapping Validation: A lack of optical data with which to ground-truth and analyze satellite, aerial, and acoustic data presents a challenge for mapping validation. Without large sets of photographic, video, and/or visual observations, providing accuracy estimates for interpretations of mapping data is not possible. To date, only limited sets of optical data have been collected by towed cameras and diver observations. Because of operational difficulties in steep terrains typical of coral habitats, new technologies such as bottom-tracking Automated Undersea Vehicles are being considered and tested.

Technological Challenges: Technological challenges include developing expertise to apply known mapping technologies and techniques for new requirements, and developing techniques to integrate satellite, optical, acoustic, and diver data into seamless products for benthic habitat mapping. The development of integrated data products that meet diverse management needs is time-consuming, and mapping efforts must meet the changing needs of managers as projects mature.

g. Future Directions

The foremost objective for CRCP's mapping effort is the completion of maps for shallow coral reef ecosystems and priority moderate-depth reef systems. The key actions the CRCP plans to address in the future include:

- Technological advances to increase accuracy and resolution of products: Collecting optical data using new techniques, increased application of advanced and alternate technologies, targeting acquisition of optical validation data to resolve questions of habitat types and usage, moving toward greater automation in acoustic and optical techniques, applying statistical techniques to data interpretation in order to increase objectivity and repeatability in results.
- Increasing capacity for management applications: Training managers and monitoring personnel in application of maps to structure monitoring and answer management questions, making mapping data more easily accessible to users who may not have access to high-end computers or specialized GIS software, integrating mapping data into databases with biological and oceanographic data.





Subcategory: Monitoring

a. Introduction to Subcategory

Successful conservation of coral reef ecosystems must respond to changes in environmental, economic, and social conditions. This requirement drives the CRCP monitoring programs to track the condition of coral reefs over time. To meet this need, NOAA's CREIOS examines both the biological components of coral reef ecosystems and the physical environmental conditions that influence the development and maintenance of those systems. Monitoring allows managers and others to assess reef conditions, diagnose problems, prioritize and implement solutions, evaluate the results of management decisions, and forecast future conditions. In and around the reef ecosystems of the U.S, NOAA uses instrumented buoys, subsurface moored instruments, satellite remote sensing, satellite-tracked drifting buoys, *in situ* oceanographic and biological observations, site-specific ecological assessments, and broad-scale towed-diver surveys conducted by an interdisciplinary team of scientists (see Exhibit III-1-6).

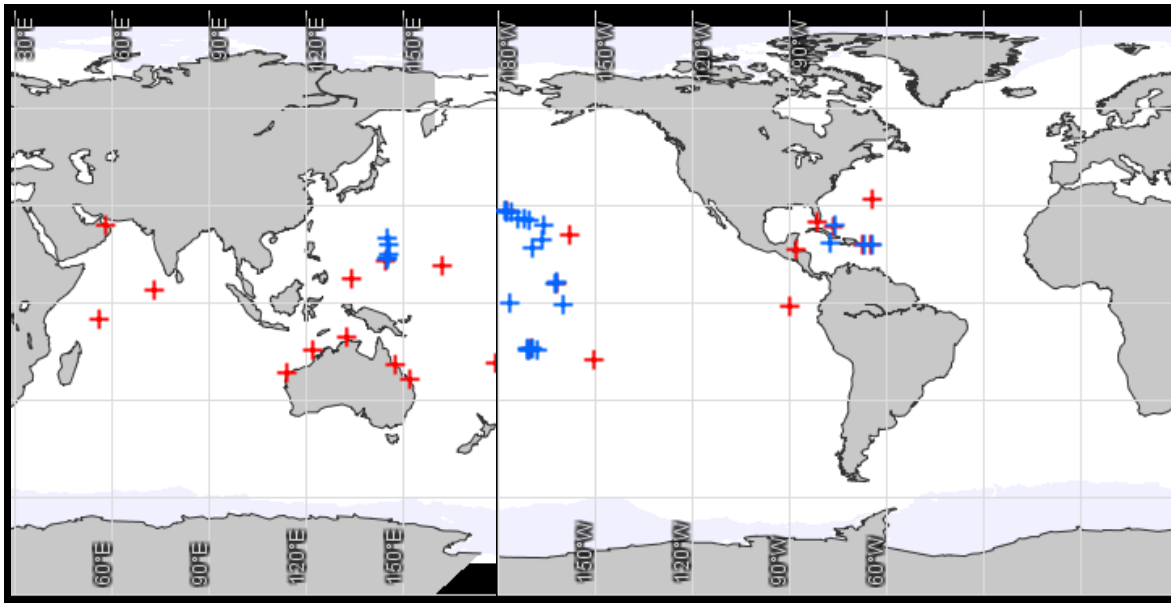


Exhibit III-1-6. CREIOS *in situ* (blue) and satellite (red) monitoring stations.

Monitoring activities have also been sponsored by the CRCP grants program, which provided more than \$5.3M over five years in support of monitoring activities. The primary mechanism is the CRCP State and Territorial Coral Reef Ecosystem Monitoring Grants program, which funds the National Coral Reef Ecosystem Monitoring Program (NCREMP). Between 2002 and 2006, more than \$4M was provided through NCREMP to natural resource agencies in the jurisdictions to support in-water monitoring of coral reef ecosystems, including water quality, benthic habitats, and associated biological communities. The Monitoring grants are structured as cooperative agreements with significant NOAA involvement, thus the jurisdictional monitoring programs complement monitoring activities undertaken by NOAA offices. Funds for CRCP-





supported monitoring activities totaled over \$1.3M were distributed under other grant categories, including General grants, Management grants, Research grants, and Fisheries Management Council grants.

Data and information products generated under NCREMP, along with results from CRCP monitoring projects discussed above, form the backbone of a series of quantitative reports entitled, “The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States” (published in 2002, 2005, and scheduled for 2008). Summary information from this report also appears in the Global State of the Reefs report published by Global Coral Reef Monitoring Network (GCRMN).

Between 2002 and 2006, the CRCP provided \$22.9M to support 126 projects in the monitoring subcategory. Monitoring accounted for 54% of funding within the Assess and Characterize category and 18% of overall CRCP funding between 2002 and 2006. Exhibit III-1-7a shows the investments in monitoring, by tool, for 2002-2006.

Exhibit III-1-7a Monitoring Investments by Tool, 2002-2006														
Tool	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	% of Total Subcategory Projects	Funding	% of Total Subcategory Funding
	2002		2003		2004		2005		2006		TOTALS 2002-2006			
Ecosystem Research	2	\$349,576	2	\$152,000	1	\$15,000	0	\$0	0	\$0	5	4.5	\$516,576	2.3
Socioeconomic Research	0	\$0	0	\$0	1	\$99,913	0	\$0	0	\$0	1	0.9	\$99,913	0.4
Mapping and Monitoring	19	\$4,381,084	19	\$2,379,997	21	\$4,013,360	21	\$5,628,711	23	\$5,770,574	103	92.8	\$22,173,726	96.8
Outreach	1	\$43,000	0	\$0	0	\$0	0	\$0	0	\$0	1	0.9	\$43,000	0.2
Management: Direct Implementation	0	\$0	0	\$0	1	\$74,050	0	\$0	0	\$0	1	0.9	\$74,050	0.3
Management: Training and Technical Assistance	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0	0	0	\$0	0
None or N/A	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0	0	0	\$0	0





TOTAL	22	\$4,773,660	21	\$2,531,997	24	\$4,202,323	21	\$5,628,711	23	\$5,770,574	111	100	\$22,907,265	100
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Exhibit III-1-7b shows the distribution of investments by tool for monitoring during 2002-2006.

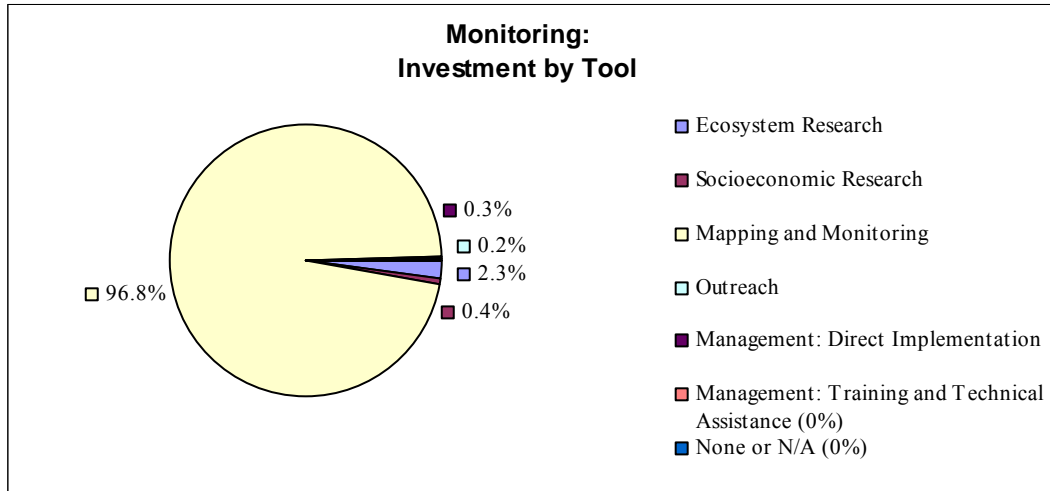


Exhibit III-1-7b. Distribution of Investments by Tool, 2002-2006.

Exhibit III-1-8a shows the investments in monitoring by region for 2002-2006.

Exhibit III-1-8a Monitoring Investments by Region, 2002-2006														
Region	2002		2003		2004		2005		2006		TOTALS 2002-2006		% of Total Subcategory Funding	
	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	% of Total Subcategory Projects		Funding
Atlantic/Caribbean	10	\$1,108,846	9	\$806,190	8	\$732,230	12	\$1,519,500	12	\$1,614,182	51	40.5	\$5,780,948	25.2
Pacific	11	\$2,600,409	10	\$1,598,091	15	\$2,057,112	6	\$2,776,685	7	\$2,665,708	49	38.9	\$11,698,005	51.1
Freely Associated States	2	\$234,405	3	\$77,716	5	\$468,941	2	\$38,526	3	\$107,538	15	11.9	\$927,126	4.0
International	0	\$0	0	\$0	2	\$26,540	2	\$404,000	1	\$406,808	5	4.0	\$837,348	3.7
All Regions	1	\$830,000	1	\$50,000	2	\$917,500	1	\$890,000	1	\$976,338	6	4.8	\$3,663,838	16.0





TOTAL	24	\$4,773,660	23	\$2,531,997	32	\$4,202,323	23	\$5,628,711	24	\$5,770,574	126	100	\$22,907,265	100
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Exhibit III-1-8b shows the distribution of investments in monitoring by region for 2002-2006.

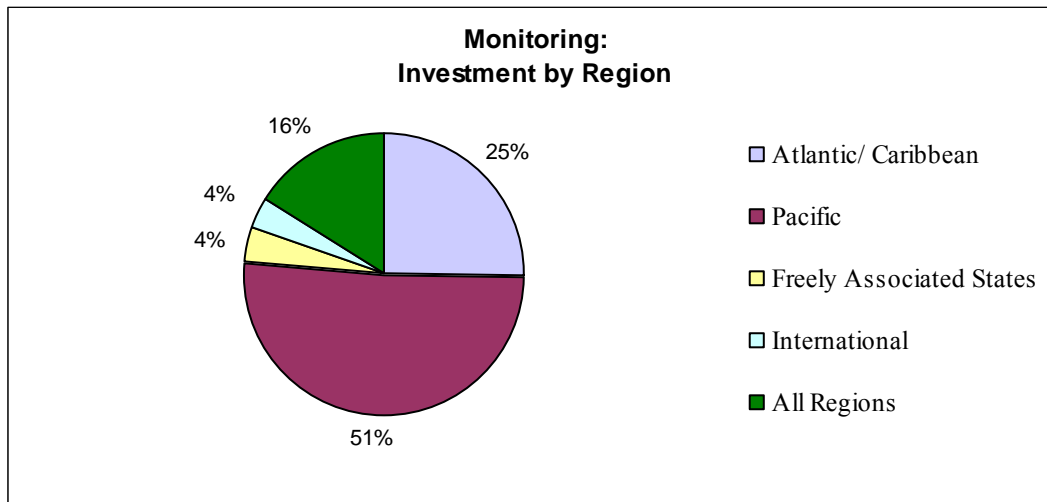


Exhibit III-1-8b. Distribution of Investments by Region, 2002-2006

b. Activities

Pacific Monitoring

A full suite of assessment methodologies has been implemented by CRCP to conduct annual or biennial monitoring at 55 U.S. Pacific islands, atolls, and reefs located throughout the Hawaiian Archipelago, American Samoa, Pacific Remote Island Areas (PRIAs), Guam, and CNMI. These surveys are complemented by an array of *in situ* observing instrumentation. This unprecedented spatial and temporal monitoring of oceanographic processes and biological populations allows an integrated, baseline understanding of both healthy and impacted reefs.

Biological monitoring throughout the U.S. Pacific uses an integrated, ecosystem-based approach to understand reef dynamics. Several complementary techniques are used to enumerate the diverse reef fish fauna: belt-transects, stationary-point-counts, and towed-diver surveys. For benthic monitoring, rapid ecological assessments (REA) monitor reef benthos at genus- or species-level taxonomic resolution. Specialists in coral, algae, and macroinvertebrate communities use complementary survey methods including video transects, photoquadrats, *in situ* taxonomic observations, and sample collection. Towed-diver surveys record benthic composition and distribution patterns using video and still cameras, as well as observational notes. These biological observations are then coupled to the oceanographic observations to better understand the influence of ocean temperature, wave energy, and currents on ecosystem health and dynamics.





To record physical data, 42 Pacific islands and banks are instrumented with 27 telemetered surface buoys and more than 125 subsurface data recorders. Instrumentation on the surface buoys provides a high-resolution time series of sea surface temperature (SST), salinity, photosynthetically available radiation (PAR), ultraviolet radiation-B, air temperature, barometric pressure, and wind velocity. The surface telemetered observations are augmented by a cost-effective network of subsurface instruments recording water temperature, salinity, current profiles, wave, tide, and acoustic data. In addition, during Pacific Reef Assessment and Monitoring Program (RAMP) cruises, conductivity-temperature-depth profiles and acoustic Doppler current profiler transects are conducted to provide a more detailed spatial description of ocean conditions. *In situ* water samples measure concentrations of chlorophyll *a*, nutrients, dissolved inorganic carbon, and other constituents. Integration of the data from moorings and *in situ* observations provides an improved understanding of the influences of environmental processes on the surrounding coral reef ecosystems.

Atlantic Monitoring

The CRCP long-term biological monitoring program tracks annual changes in benthic composition and fish community structure within coral reef ecosystems of the Atlantic, Caribbean, and Gulf of Mexico. Biological sampling is allocated randomly among benthic habitat strata, so that trends in resource condition and the efficacy of management actions can be evaluated.

Biological monitoring in the Southeast region has focused on two general areas: the greater Florida Keys system and Navassa Island (between Haiti and Jamaica). In the Florida Keys, we have monitored reef habitat condition and reef fish composition and abundance annually for five years. The Navassa Island projects established a bi-annual schedule for mapping and monitoring cruises to assess reef assemblages and fishing activity. Monitoring work is also being done in collaboration with the National Park Service and other local partners around Buck Island National Park on St. Croix, the Virgin Islands National Park and Coral Reef Monument on St. John, the La Parguera region and the island of Vieques in Puerto Rico, and the Flower Garden Banks National Marine Sanctuary in the Gulf of Mexico.

For monitoring physical conditions, CRCP currently manages data from four *in situ* marine and meteorological monitoring stations in the Florida Keys National Marine Sanctuary and other major coastal reef sites in the Caribbean and Gulf of Mexico. Data gathered hourly include sea temperature, salinity, depth or tide level, PAR, UV radiation, light attenuation, wind speed, direction and gust, barometric pressure, air temperature and other meteorological data. At key sites in the Florida Keys, Puerto Rico, and Jamaica, surface partial pressure of CO₂ and related parameters are also gathered hourly. These data are integrated with available satellite, radar, and other remote sensing data, and are monitored by artificial intelligence software for indications of ecologically significant events. These ecoforecasts are continually refined and verified using the latest available literature and in collaboration with field observers. When data indicate that





severe and significant ecological events are likely, automated alerts are sent to users. CRCP is in the process of extending these near-real-time ecoforecasts to approximately 100 other reef sites throughout the Caribbean, Pacific, and Indian Oceans, using satellite data only.

Global Satellite Monitoring

Complementing *in situ* monitoring in the Pacific and Atlantic regions, CRCP provides global satellite monitoring of SST, thermal stress, and other parameters of the coral reef environment. The operational near-real-time system of watches and warnings alerts coral reef researchers, managers, and stakeholders to environmental conditions that threaten coral reefs. CRCP conducts a wide variety of research-to-operations activities using satellite data, including satellite data reprocessing, operational maintenance of coral bleaching products, enhancement of existing products and development of new satellite products, operational Virtual Stations at key coral reef sites, and ocean wind and doldrums products. Recent research has focused on detecting mass coral bleaching from high spatial resolution satellite imagery, modeling sea surface CO₂ partial pressure, analyzing coral core and skeletal growth records from Florida and the Caribbean to extend climate records into pre-instrumental periods, and modeling hydrodynamic mixing around coral reefs to understand sub-satellite pixel scale processes. To help build capacity for local coral reef management, domestic, and international workshops have trained users to apply these satellite tools for local and regional coral bleaching monitoring.

c. Funding Recipients and Partners

To carry out the projects in this subcategory, the CRCP partnered with the NOAA offices and external partners listed in Exhibit III-1-8.

**Exhibit III-1-8
Monitoring
Funding Recipients and Partners**

NOAA Offices	Other Federal Agencies	States and Territories	Fishery Management Councils	Academic Institutions	Non-Governmental Organizations
<ul style="list-style-type: none"> NESDIS - Center for Satellite Applications and Research NESDIS - Office of Satellite Data Processing and Distribution 	<ul style="list-style-type: none"> U.S. Environmental Protection Agency National Aeronautics and Space Administration 	<ul style="list-style-type: none"> American Samoa CNMI 	<ul style="list-style-type: none"> Western Pacific Caribbean 	<ul style="list-style-type: none"> James Cook University (Australia) Florida Institute of Oceanography 	<ul style="list-style-type: none"> Ocean Research and Education Foundation Reef Environmental Education Foundation





**Exhibit III-1-8
Monitoring
Funding Recipients and Partners**

NOAA Offices	Other Federal Agencies	States and Territories	Fishery Management Councils	Academic Institutions	Non-Governmental Organizations
<ul style="list-style-type: none"> NESDIS - National Geophysical Data Center 	<ul style="list-style-type: none"> DOI – U.S. Geological Survey 	<ul style="list-style-type: none"> Florida 	<ul style="list-style-type: none"> Gulf of Mexico 	<ul style="list-style-type: none"> Nova Southeast University 	<ul style="list-style-type: none"> Bishop Museum
<ul style="list-style-type: none"> NMFS - Pacific Islands Fisheries Science Center 	<ul style="list-style-type: none"> DOI – U.S. Minerals Management Service 	<ul style="list-style-type: none"> Guam 		<ul style="list-style-type: none"> University of Hawaii 	<ul style="list-style-type: none"> Florida Reef Resiliency Program
<ul style="list-style-type: none"> NMFS - Southeast Fisheries Science Center 	<ul style="list-style-type: none"> DOI - National Park Service 	<ul style="list-style-type: none"> Hawaii 		<ul style="list-style-type: none"> University of North Carolina, Wilmington (NURP Center) 	<ul style="list-style-type: none"> Mote Marine Laboratory
<ul style="list-style-type: none"> NOS - National Centers for Coastal Ocean Science 	<ul style="list-style-type: none"> Australian Institute of Marine Science 	<ul style="list-style-type: none"> Puerto Rico 		<ul style="list-style-type: none"> University of Queensland (Australia) 	<ul style="list-style-type: none"> The Nature Conservancy
<ul style="list-style-type: none"> NOS - Florida Keys National Marine Sanctuary 	<ul style="list-style-type: none"> Australian Research Council 	<ul style="list-style-type: none"> U.S. Virgin Islands 		<ul style="list-style-type: none"> University of South Florida 	<ul style="list-style-type: none"> ReefBase and WorldFish
<ul style="list-style-type: none"> NOS - Flower Garden Banks National Marine Sanctuary 	<ul style="list-style-type: none"> Great Barrier Reef Marine Park Authority (Australia) 	<ul style="list-style-type: none"> Federated States of Micronesia 		<ul style="list-style-type: none"> University of Texas at Austin 	<ul style="list-style-type: none"> The World Bank and the Global Environment Facility
<ul style="list-style-type: none"> NOS - Papahānaumokuākea Marine National Monument 		<ul style="list-style-type: none"> Republic of Palau 		<ul style="list-style-type: none"> University of the Virgin Islands 	<ul style="list-style-type: none"> Coral Reef Degradation in the Indian Ocean
<ul style="list-style-type: none"> NOS - Office of National Marine Sanctuaries 					<ul style="list-style-type: none"> Fondation pour la Protection de la Biodiversite Marine (Haiti)
<ul style="list-style-type: none"> OAR - Atlantic Oceanographic and Meteorological Laboratory 					<ul style="list-style-type: none"> Sanctuary Friends of the Florida Keys National Marine Sanctuary





**Exhibit III-1-8
Monitoring
Funding Recipients and Partners**

NOAA Offices	Other Federal Agencies	States and Territories	Fishery Management Councils	Academic Institutions	Non-Governmental Organizations
<ul style="list-style-type: none"> • OAR - National Undersea Research Program (NURP) 					

d. Outputs

CRCP has produced many monitoring products and services using a variety of methods:

- Reports and publications, including “The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States” (published in 2002, 2005, and scheduled for 2008).
- Export of survey methods to partners, including a web-accessible guide with protocols for creating or enhancing a reef fish monitoring program.
- Web-accessible data sets available to partners and through CoRIS for use in other research efforts, including the “Caribbean Reef Ecosystem Assessment and Monitoring Database” that provides data on benthic composition and reef fish community structure for the U.S. Caribbean.
- Development of expertise of value to managers in grappling with events such as invasive species, vessel groundings, and bleaching/disease outbreaks, including training staff and resource managers from the St. Croix East End Marine Park and the University of the Virgin Islands on how to develop and conduct a robust reef fish monitoring program for the East End Marine Park.

CREIOS provides long-term monitoring which enables coral reef managers to detect and act on significant natural or anthropogenic changes to these ecosystems. Integration of the long-term spatial and temporal data from surface and subsurface moorings, *in situ* observations, and satellite remote sensing provides researchers and resource managers an improved understanding of the influences of global climate changes on coral reef ecosystems. (For more detailed information on Climate Change, please see Tab 3, Chapter 7.)

CRCP has joined with managers from all U.S. marine sanctuaries and a variety of academic partners to develop a decision support tool that will provide a single, timely interface to integrated data, research, modeling, ecoforecasts, and field monitoring results for sites under





management. The goal is to allow MPA managers and other decision makers to respond to changing conditions at these sites in ways which will best meet the needs of all stakeholders.

CRCP implemented operational production of global maps of 50-km near-real-time Polar Operational Environmental Satellite SST, SST anomalies, HotSpots, and Degree Heating Weeks that relate thermal stress to conditions conducive to mass coral bleaching. Satellite Bleaching Alerts (SBAs) are an operational automated e-mail alert system of coral bleaching watches and warnings for 24 Virtual Stations worldwide. Of the 240 registered SBA users from at least 28 nations, 20% are from universities, 15% are from NGOs, and 25% are governmental. More than 130 coral reef managers and scientists worldwide have been trained in the use of these satellite data products.

CRCP and external partners have analyzed coral cores and skeletal growth records from five reefs in the Florida Keys, and calibrated temperature and salinity records against available oceanographic data. These paleoclimate surveys will be used to study the temperature history at these reef sites, extending the record back to a time before satellite and instrumental data were available. The University of Texas has developed a new environmentally-sensitive design for a coral drill that uses seawater in place of hydraulic fluid. They have built one drill for NOAA that will be used on the NOAA ships *Oscar Elton Sette* and *Hi'ialakai* for drilling cores during upcoming CRCP-funded cruises in the Pacific.

Performance Metrics

The CRCP tracks monitoring performance under the metric “Develop and make operational a comprehensive integrated coral reef ecosystem monitoring program.” Progress and performance are also measured at the project level. Monitoring performance metrics include:

- Number of geographic regions and the range of habitats in which oceanographic instrumentation are deployed.
- Range of parameters sensed, recorded, and/or telemetered by deployed instrumentation.
- Taxonomic range of reef organisms monitored with appropriate biological survey protocols and the addition of new species records.
- Range of geographic regions and habitats in which biological monitoring is conducted.
- Number of satellite applications developed and implemented for coral reef management.
- Number of training workshops conducted and outreach materials developed to build local and regional capacity for coral reef monitoring and bleaching response.
- The adaptability of methods to technological advancements.
- The adaptability of resource allocation to emerging questions and concerns.
- The accessibility of pertinent oceanographic and biological data to users, including reef managers.





e. Outcomes

Pacific Monitoring

In situ CREIOS observations provide biological and physical time series data for defining community dynamics, detecting ecological phase shifts and ecosystem change, and detecting trends in oceanographic, atmospheric, and climatic conditions. High-resolution long-term time series data of various oceanographic and meteorological parameters (such as wave heights, sea surface temperature, wind, and ocean currents) are also important to our understanding of diel, monthly, seasonal, interannual, and decadal variability. Key findings of the suite of observations include:

- The importance of localized upwelling on benthic and fish population composition.
- The impact of reef morphology on coral bleaching and mortality.
- The establishment of a variety of methods for determining the flushing rates of coral reefs.

Intangible outcomes from U.S. Pacific monitoring have included some changes in perception. For example, it has been widely assumed that algal-dominated reefs are intrinsically degraded reefs, but studies throughout the U.S. Pacific report that most remote, near-pristine reefs are naturally dominated by algae rather than corals. Additionally, documentation of two mass bleaching events in the Northwestern Hawaiian Islands (2002 and 2004) challenged the prevailing thinking that this region was relatively invulnerable to bleaching because of its latitude and oceanographic setting. Our observations lend support to the idea that global-scale threats may drive the condition of these remote reefs in the decades to come.

The CREIOS network's Pacific geographic coverage enables comparisons of heavily impacted reef systems with remote, relatively pristine reefs. Through this direct comparison, researchers are able to better assess the affects of nutrient loading, sedimentation, fishing, tourism, and other human-related pressures. The CREIOS network also covers disparate climatic and oceanographic regimes, important for characterizing coral reef ecosystems' response to variable physical forcing mechanisms. An improved understanding of natural variability is also a scientific priority to allow better discernment of anthropogenic effects and implementation of ecosystem-based management.

Coral disease and bleaching baseline data have now been characterized in the Pacific, and some local outbreaks have been documented. As a result of these new understandings, the State of Hawai'i has developed a Climate Change and Marine Disease Local Action Strategy to address this focal area identified in 2002 by the U.S. Coral Reef Task Force. The Papahānaumokuākea Marine National Monument has developed protocols to prevent the introduction and spread of coral diseases and alien species to the NWHI.





In American Samoa, the documentation of exceptionally large *Porites* colonies in the Manu'a group has stimulated local government efforts to designate MPAs to conserve these unique features. Key findings by the American Samoa Department of Marine and Wildlife Resources include several new discoveries. Despite a lack of severe fishing pressure, the largest reef fish are uncommon or rare, as opposed to most locations where lightly fished or unfished reefs generally have larger fish; this finding has led to consideration of possible local management actions. The first reported annual summer mass bleaching of a multi-species coral assemblage has provided an opportunity to study a phenomenon that is predicted to increase around the world in coming decades.

Palau monitoring grant funding has supported the Palau International Coral Reef Center (PICRC) in characterizing the overall condition of reefs throughout Palau, including assessment of areas that are recovering rapidly from the 1998 bleaching, and those that are not recovering well. The information on critical areas in Palau, and important areas for conservation, is being used for implementing a Protected Areas Network (PAN).

Atlantic Monitoring

The CRCP has provided resource managers in the U.S. Caribbean with fairly precise data on benthic composition and community structure of coral reefs. These data have increased the understanding of the spatial distribution and abundance of reef fishes and macro-invertebrate such as conch, lobster, and sea urchins. Additionally, local managers, such as the National Park Service and the U.S. Virgin Islands Coastal Zone Management program, are using these data to help determine the effectiveness of local management regulations and to track changes in managed and unmanaged areas through time.

Through the National Coral Reef Ecosystem Monitoring Grant Program, CRCP has implemented a nationally coordinated long-term monitoring program to assess the condition of U.S. coral reef ecosystems, and to evaluate the efficacy of coral ecosystem management. This program has resulted in a comprehensive and quantitative national report on the status of coral reef ecosystems of the United States and its Territories.

CRCP-funded monitoring conducted by the Florida Keys National Marine Sanctuary has supported the evaluation of reef community structure and factors contributing to coral reef change. The Rapid Assessment project has documented abundant and relatively healthy coral communities in patch reefs in the Florida Keys, which will benefit managers in planning additional sanctuary resources. Based on the findings of this project, managers appreciate that no-take zoning has not yet resulted in detectable changes in coral communities after a decade, despite rapid increases in reef fish and spiny lobster populations within Fully Protected Marine Zones; more time may be required for changes to become apparent, such as those reported in a Bahamas marine reserve after 20 years of protection.





Monitoring in Navassa has documented recent trends in resource condition, including decline in size and abundance of reef fishes, decline in coral cover, increased coral disease outbreak conditions, and coral bleaching events. However, there has also been some good news: increases in abundances of *Diadema* urchins and elkhorn coral, *Acropora palmata*.

Partnerships with the scientific community and field experts in Puerto Rico, the U.S. Virgin Islands, Florida Keys National Marine Sanctuary and other Southeast Florida coastal waters have resulted in wider data dissemination, significantly improved ecoforecasts for coral bleaching and other events, and contributed to a more integrated understanding of conditions at these ecologically sensitive sites. CRCP, together with the Florida Institute of Oceanography, supports semi-monthly site maintenance at seven *in situ* monitoring stations in the Florida Keys. Partnerships with regional research institutes in U.S. and foreign territorial waters of the wider Caribbean allow frequent site visits at *in situ* monitoring stations in the Caribbean, including visual observation and sampling, to evaluate ecological conditions on the reefs of these sites.

CRCP has partnered with the Florida Reef Resiliency Program and Mote Marine Laboratory on integrated satellite and *in situ* monitoring efforts. In 2005, Mote Marine Laboratory began routinely making use of NOAA products in their monthly coral bleaching outlook for the Caribbean basin. This Florida Keys Coral Bleaching Early Warning Network (BleachWatch) program is similar to Australia's CoralWatch program.

Global Satellite Monitoring

Near-real-time *in situ* data telemetry alerts resource managers and researchers to environmental events significant to the health of the surrounding coral reef ecosystem, allowing managers to implement additional protective measures in a timely manner, if warranted. These *in situ* measurements provide important data to ground-truth and extend satellite observations globally in issuing coral bleaching alerts and warnings at Virtual Stations worldwide. CREIOS uses this information to improve the quality of our satellite-based coral bleaching monitoring tools.

Through the Coral Bleaching Satellite Tools workshops, domestic and international reef managers improve their understanding of how NOAA satellites can help them monitor for the conditions that cause coral bleaching. In addition, the success of these workshops has led to an expansion of the training program to include content from *A Reef Manager's Guide to Coral Bleaching*. These future workshops, in partnership with the Great Barrier Reef Marine Park Authority, the World Bank/Global Environment Facility's Coral Reef Targeted Research Program, and The Nature Conservancy, will add a focus on concrete actions reef managers can take to protect their reefs from coral bleaching.

f. Challenges

Biological monitoring in the U.S. Pacific is moving towards longer intervals between survey periods, due to the high cost of conducting surveys in this vast region and generating useful data





products in a timely fashion. Surveys in the NWHI undertaken annually from 2000 to 2004 have since moved to biennial surveys, and biennial surveys elsewhere in the U.S. Pacific may change to triennial surveys in the near future. Given the pace of global changes that will influence reefs in the decades to come, longer intervals between surveys mean that scientists may easily miss important events such as bleaching, disease outbreaks, *Acanthaster* outbreaks, alien species invasions, urchin die-offs, or other signature events.

Timely dissemination of results from Pacific monitoring cruises has, unfortunately, been a problem in the past, triggering complaints from state and territory partners. We have addressed this challenge through several means:

- Setting up a password-protected FTP site where jurisdictional partners can access raw datasets.
- Onsite visits to meet with partners, distribute cruise reports, and discuss data sharing.
- Posting cruise reports, with data appendices, on a public website.
- Accelerating processing of formal monitoring reports.

Other monitoring challenges include:

- Maintaining consistency in data collection and personnel.
- Building and maintaining local capacity for monitoring.
- Responding to extreme events.
- Incomparability of data due to differences in monitoring approaches and methods.
- Lack of data sharing due to intellectual property concerns.
- Lack of high-performance computing capacity for hydrodynamic modeling and climate-scale forecast modeling.

The availability of appropriate scientific monitoring and assessment information is a necessary, but not sufficient, condition to implement effective coral reef management. Even with localized training, it is very difficult for capacity-building efforts to reach all potential users and stakeholders.

The lack of overarching international agreements has been a major challenge. Every international project requires a complicated process of writing, clearing, and signing an agreement. In the case of Navassa, disputed international sovereignty issues, remoteness, and a lack of management resources and focus have so far precluded any meaningful management planning or implementation.

g. Future Directions

By more clearly defining reef “health” and the key indices by which it can be scored, our current “report card” of reef condition (State of the Reefs Report) could be improved to be more useful to managers and the general public.





Expansion of existing monitoring programs to increase spatial and temporal resolution of monitoring data—and the establishment of new ones to fill gaps—is a priority. Expansion of monitoring programs will help address climate change impacts and episodic events such as mass coral bleaching, coral disease outbreaks, invasive species, and mass fish kills. Expansion of satellite-based Virtual Stations to include all major U.S. reef locations will increase the utility of these complex data products for a broader management community.

Monitoring at multiple spatial and temporal scales to provide comparable data across regions and across the nation is needed. Standardizing data collection methods and techniques across monitoring programs, or at least calibrating among the methodologies used by different programs, is necessary to ensure comparable data streams. This challenge is increased by the need to coordinate monitoring efforts with others outside of NOAA: other Federal agencies, states and territories, and NGOs.

In contrast to the Pacific, no consistent *in situ* regional assessment exists for coral jurisdictions in the U.S. Caribbean, Atlantic, and Gulf of Mexico. However, in 2006, NOAA co-led a collaborative project, planning periodic broad-scale assessments of coral reefs across the U.S. Caribbean. The ongoing project, known as Comprehensive Caribbean Coral Reef Ecosystem Monitoring Project (C-CCREMP), is focused on integrating current monitoring efforts and expanding to additional sites. Additionally, the C-CCREMP project developed a web-accessible geospatial database that could be used for identifying spatial and thematic gaps in reef monitoring. Until a regional approach is implemented, NOAA will continue to participate in the jurisdiction-based programs detailed above.

Monitoring coral reef ecosystems, especially those in remote locations, is a challenging task. The Ecological Acoustic Recorder (EAR) is a cost-effective tool developed for passive acoustic monitoring of coral reef habitats and human activities in marine areas of special concern. Numerous species of coral reef fish produce sounds, as do several invertebrates and marine mammals. Tracking their acoustic activity is a promising approach for assessing patterns of change, stability, and seasonality in biological processes. Furthermore, anthropogenic sounds (e.g., boat engines, blast fishing, and anchor chains) are particularly well-suited for passive acoustic monitoring, as they are readily detectible and distinguishable from naturally occurring sounds.

Partnerships with international NGOs and universities will help training and outreach programs branch out to more locations. There is also a need to expand training domestically, to increase the capacity of U.S. coral reef managers to interpret monitoring data for reef management. The development of online tutorials will extend training workshops to those who are not able to attend workshops in person.





Subcategory: Data Dissemination

a. Description of Subcategory

One objective identified by the National Action Strategy for Assessing and Monitoring Coral Reef Health is to develop a web-enabled data management and information system for U.S. reef monitoring and mapping data. The CRCP developed the Coral Reef Information System (CoRIS) to meet this objective. The goal for CoRIS is to be a user-friendly system with GIS mapping and querying capabilities, presenting information in usable formats for all possible users. CREIOS mapping and monitoring projects include data dissemination as an integral part of the project scope, and these products are routinely provided to the public in the form of reports, peer-reviewed publications, hard copy and digital maps, and query-able databases. Quality-controlled historical data and metadata archives, including input from all participants in CREIOS, are maintained by the NOAA National Data Centers (NNDCs), in coordination with CoRIS.

The Southeast Coral Reef Database System (SeCoRDS) was developed to address information and data management in the region, including the need to store, share, and analyze voluminous data with a wide range of formats in support of program management, research, collaboration, and education/outreach. The technologies and data management strategies developed under SeCoRDS complement CoRIS, and help to strengthen NOAA's ability to integrate coral reef information.

CRCP grant programs have provided nearly \$600K to support data dissemination, including the provision of approximately \$500K to Fisheries Management Councils, \$30K as National Fish and Wildlife Foundation grants, \$30K as management grants, and \$45K under the General Grant Program. The bulk of the funding is used to support data management and database improvements, produce hard copy maps, and maintain systems that provide GIS information about the location of essential fish habitat for reef fish and habitat areas of particular concern for coral reefs via the internet.

Between 2002 and 2006, the CRCP provided \$4.0M to support 29 projects in this subcategory. The data dissemination subcategory accounted for 9% of funding within the Assess and Characterize category and 3% of overall CRCP funding; and 15% of projects in the category and 2% of overall CRCP projects between 2002-2006 (see Exhibit III-1-2). The distribution of funds by tool for this subcategory is shown in Exhibits III-1-9a and 9b.





**Exhibit III-1-9a
Data Dissemination
Investments by Tool, 2002-2006**

Tool	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	% of Total Subcategory Projects	Funding	% of Total Subcategory Funding
	2002		2003		2004		2005		2006		TOTALS 2002-2006			
Ecosystem Research	0	\$0	1	\$30,000	0	\$0	0	\$0	0	\$0	1	3.4	\$30,000	0.8
Socioeconomic Research	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0	0	0	\$0	0
Mapping and Monitoring	2	\$75,000	1	\$26,950	2	\$70,480	1	\$55,000	2	\$107,390	8	27.6	\$334,820	8.4
Outreach	4	\$1,153,000	5	\$787,000	4	\$545,348	2	\$395,000	3	\$508,445	18	62.1	\$3,388,793	85.4
Management: Direct Implementation	1	\$40,000	1	\$175,000	0	\$0	0	\$0	0	\$0	2	6.9	\$215,000	5.4
Management: Training and Technical Assistance	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0	0	0	\$0	0
None or N/A	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0	0	0	\$0	0
TOTAL	7	\$1,268,000	8	\$1,018,950	6	\$615,828	3	\$450,000	5	\$615,835	29	100	\$3,968,613	100



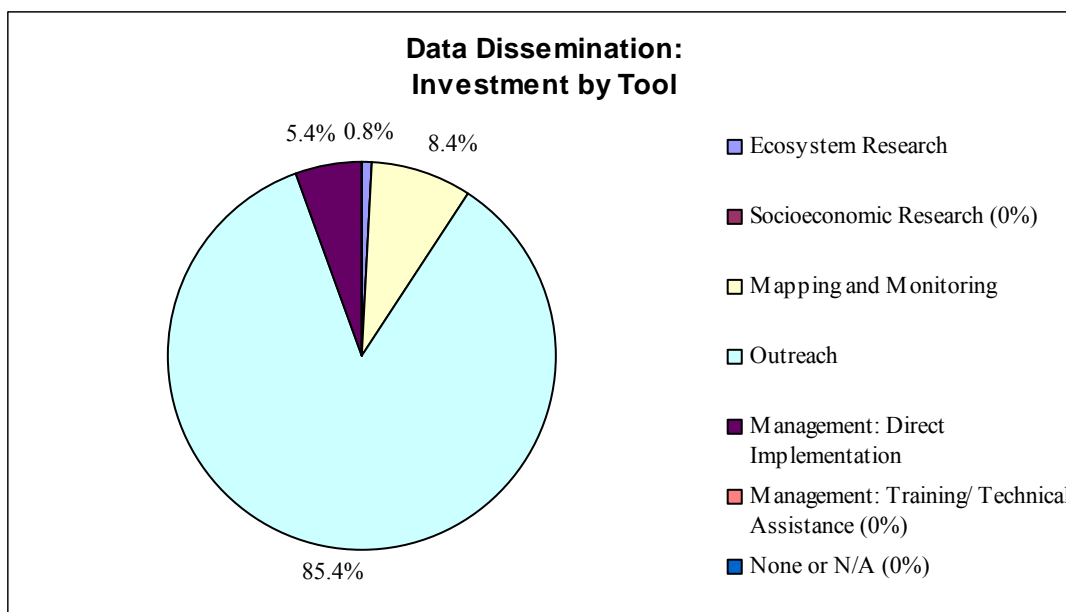


Exhibit III-1-9b. Distribution of Investments by Tool, 2002-2006

The distribution of funds by region for this subcategory is shown in Exhibits III-1-10a and -10b.

Exhibit III-1-10a Data Dissemination Investments by Region, 2002-2006														
Region	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	Funding	Number of Projects	% of Total Subcategory Projects	Funding	% of Total Subcategory Funding
	2002	2003	2004	2005	2006	TOTALS 2002-2006								
Atlantic/Caribbean	3	\$324,000	3	\$231,950	2	\$91,980	1	\$55,000	3	\$147,390	12	35.3	\$850,320	21.4
Pacific	3	\$465,200	3	\$299,800	2	\$26,648	1	\$23,450	1	\$33,038	10	29.4	\$848,136	21.4
Freely Associated States	1	\$14,800	1	\$13,200	1	\$8,200	1	\$11,550	1	\$16,272	5	14.7	\$64,022	1.6
International	0	\$0	0	\$0	0	\$0	0	\$0	0	\$0	0	0	\$0	0
All Regions	1	\$464,000	2	\$474,000	2	\$489,000	1	\$360,000	1	\$419,135	7	20.6	\$2,206,135	55.6
TOTAL	8	\$1,268,000	9	\$1,018,950	7	\$615,828	4	\$450,000	6	\$615,835	34	100	\$3,968,613	100



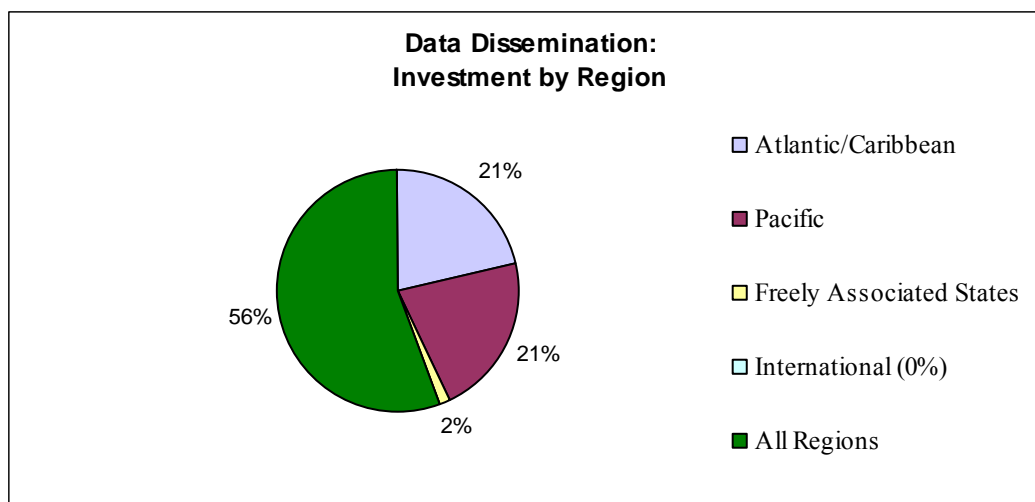


Exhibit III-1-10b. Distribution of Investments by Region, 2002-2006

b. Activities

CoRIS hosts metadata and information about the availability of near-real-time and archived data products. CoRIS activities include:

- Development of web portal and information management system that supports CRCP managers, all project teams, non-NOAA research/science communities, education, and public audiences.
- Development and maintenance of the information technology (IT) infrastructure needed to support querying multiple databases using multiple strategies, including simple search, advanced search, map-based search, and simple browsing.
- Archiving CRCP data and information products, with related metadata, at the appropriate NNDCs.

Data collected through *in situ* and remote sensing monitoring are publicly disseminated through integrated assessments such as “The State of the Reef” reports, published journal articles, annual and multiyear monitoring reports, websites, and metadata records provided to CoRIS.

c. Funding Recipients and Partners

To carry out the projects in this subcategory, the CRCP partnered with the NOAA offices and external partners listed in Exhibit III-1-11.





**Exhibit III-1-11
Data Dissemination
Funding Recipients and Partners**

NOAA Offices	States and Territories	Fishery Management Councils	Non-Governmental Organizations
<ul style="list-style-type: none"> • NESDIS - National Coastal Data Development Center • NESDIS - National Geophysical Data Center • NESDIS - National Oceanographic Data Center • NMFS - Pacific Islands Fisheries Science Center • NMFS - Southeast Fisheries Science Center • OAR - Sea Grant Program • OAR - National Undersea Research Program 	<ul style="list-style-type: none"> • Hawaii • Puerto Rico 	<ul style="list-style-type: none"> • Western Pacific • Caribbean • South Atlantic 	<ul style="list-style-type: none"> • Ocean Research and Education Foundation • The Ocean Conservancy

d. Outputs

In its first year, CoRIS managed 161 metadata records for 8362 information products. By 2006, CoRIS was managing 1424 metadata records for 16,697 individual data and information products. The ‘coral library’ has grown from 598 publications to include 1376 publication citations and website links. The glossary, one of the most popular CoRIS accomplishments, included more than 5000 terms by the end of 2006. CoRIS web use statistics show visitor sessions growing 500% from about 15,000 visitor hits per month in 2002 to more than 75,000 per month by the end of 2006.

Key innovations of the SeCoRDS effort include:

- Linkage between data contents in Oracle internet Filesystem and ArcGIS Internet Map Server, which allows easy spatial visualization of data and metadata spatial footprints.
- SeCoRDS and CoRIS advanced search functionality.

Performance Metrics

Primary performance metrics for CoRIS are the number of records managed in the metadata management system; number of publications, websites, and other citations accessible from the web portal; and the number of data and information products from the CRCP available through





the CoRIS data discovery systems. Progress and performance of individual data dissemination efforts are also measured at the project level.

e. Outcomes

CoRIS is helping to raise awareness of the current condition of our nation's coral reefs, in addition to changing the public's perception of reef ecosystems and NOAA's activities. By working with the NOAA Central Library and NNDCs to archive and provide long-term access to CRCP-funded data and information products, CoRIS is helping to provide stewardship for irreplaceable ecosystem information and baseline observational data for unanticipated future uses.

CoRIS is used by many science managers throughout the world as a web portal to data and information to help in coral reef management. For example, the Marine Protected Areas Task Force for the Department of Environment and Heritage in Australia thanked CoRIS for the satellite bleaching alerts, which alerted managers of Ningaloo Marine Park to an increase in dangerous thermal stress conditions within their MPA.

The CoRIS web site was selected by Thomson Scientific *ISI Web of Knowledge*SM for inclusion in *Current Web Contents*TM, a selection of scholarly web sites complementing the journal coverage, in *Current Contents Connect*[®], the *Web of Science*[®], and other *ISI* applications. CoRIS was also selected for the Eisenhower National Clearinghouse "Digital Dozen," a monthly list of twelve exemplary websites for educators.

f. Challenges

Significant planning is required to track evolving standards for data collection, storage, analysis, retrieval, and sharing. Software development and testing is required to integrate data from multiple sources into a usable interface. Increased resources to facilitate adoption of open-source data sharing standards will be important to overcoming this hurdle in the future.

Technical and funding limits have hampered efforts to make subsets of large data holdings available in a timely manner and in an acceptable format. Video, high-resolution still imagery, and large raster data present particular access and distribution challenges. Additionally, NOAA IT infrastructure limitations and government security protocols restrict development of certain data access and dissemination tools. The need to apply rigorous data QA/QC procedures to older data prior to dissemination slows data distribution efforts, as does the changing nature of many of the data collection efforts.

Funding and resources limitations have presented serious challenges to maintaining and improving the CoRIS technology infrastructure, including web map services (GIS), web-based search and discovery services, and library cataloging resources, thus reducing access to





information that may be of use to NOAA and global coral ecosystem managers. As CoRIS's main functions are to provide metadata and to direct users to data residing in other websites and servers, it is difficult for CoRIS to stay abreast of changes to those host sites. Limited resources have been allocated for archiving data and information products at the appropriate NNDC, resulting in a smaller volume and breadth of data preserved for unanticipated future use.

g. Future Directions

The "coral archive" includes data that have been archived at a NNDC and for which CoRIS maintains metadata; as of 2006, the 'coral archive' contained 66 individual data collections. An additional 286 data products and collections were identified as near-term candidates for transfer to the appropriate NNDC. The long-term goal is to have all data and products funded by CRCP archived at the appropriate NNDC; this effort will require considerable planning and support by CRCP and other NOAA offices.

CoRIS will work to increase the quantity of data and information products available from the website, improve metadata and keywords for better data discovery, upgrade IT infrastructure to support more sophisticated discovery and analysis techniques, update GIS capabilities within the site, develop regional portals, and improve website usability. Outreach to CRCP grant projects and other partners will increase in order to collect, archive, and make their data and information available to the world.

CRCP is developing a geospatial database for all its coral reef monitoring observations, along with a suite of GIS services to facilitate data search, visualization, and access online. Also in development stages is a web-based data access interface called OceanEye, which provides data subsetting and map generation from multidimensional remotely-sensed, modeled, and *in situ* data products. Near-real-time data sources for OceanEye include CREIOS *in situ* field stations, buoys and moorings, and satellite-based products. Additionally, CRCP has been involved in a coral and climate Integrated Ocean Observing System (IOOS) pilot project where Pacific buoy observations are served in web-standard data formats with proper metadata by the National Oceanographic Data Center. When complete, these data will be accessible through visualization tools such as Live Access Server and OceanEye.





Appendix III-1 Publications Resulting from CRCP Funding

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