NATIONAL SUMMARY

Overview

The purpose of the national summary is to catalogue results of the preceding jurisdictional chapters into a common assessment framework and provide a broad measure of ecosystem status and response. In addition, this summary identifies key research, monitoring, and management needs that must be addressed in the future to ensure continued refinement of a robust and accurate assessment of the status of coral reef ecosystems. In order to incorporate the diverse information from mapping, monitoring, research, and management efforts, the framework provided here is qualitative. This summary data will form a basis for comparison with future assessments of coral reef ecosystem status. It is important to note that this information has not been developed for interjurisdictional comparisons; rather, it has been designed to track the status of coral reef ecosystems over time. To develop the jurisdiction chapters, writing teams were tasked with identifying, interpreting and summarizing the results of ongoing mapping, monitoring, research, and management activities. Although each team cast a broad net to gather such information, it is likely that some important activities were not identified and therefore are not represented in this report. Much of the information and all of the examples used in this summary chapter are drawn from the content of the jurisdictional chapters.

Background

In June 2002, the National Oceanic and Atmospheric Administration (NOAA) and its U.S. Coral Reef Task Force (USCRTF) partners crafted the National Coral Reef Action Strategy (NCRAS, 2002). This strategy was developed to fulfill the requirements of the Coral Reef Conservation Act of 2000 (CRCA; 16 U.S.C. § 6401 et seq.) and to help track implementation of the National Action Plan to Conserve Coral Reefs that was adopted by the USCRTF in 2000 (USCRTF, 2000). The strategy was divided into two main themes aimed to: (1) provide a better understanding of coral reef ecosystems, and (2) reduce the adverse impacts of human activities. The goals for theme 1 include such objectives as the development of habitat maps of U.S. coral reef ecosystems; assessment, monitoring and research related to ecosystem status; and an increased understanding of social and economic factors relevant to the conservation of coral reef ecosystems. Theme 2 goals focus on, among other things, improving the use of marine protected areas (MPAs) in coral reef ecosystems, reducing adverse impacts of fishing and other extractive activities, and improving education and outreach. The following sections outline some of the many initiatives underway within U.S. jurisdictions and on a national level to address a selection of the goals defined in the NCRAS.

Mapping U.S. coral reef ecosystems

Accurate benthic habitat (e.g., corals, seagrass, sand) maps are necessary for resource managers to make informed decisions about the protection and management of a wide range of marine resources (Monaco et al., 2001; Kendall et al., 2004). Several initiatives are currently underway in the U.S. to map shallow-water benthic habitats to provide an inventory of resources and support ecosystem assessment and monitoring programs (NOAA, 2002). NOAA's Ocean Service (NOS) initiated a coral reef research program in 1999 to map, assess, inventory, and monitor U.S. coral reef ecosystems (Monaco et al., 2001). The mapping activities were outlined by the USCRTF Mapping and Information Synthesis Working Group (MISWG) in the Coral Reef Mapping Implementation Plan (USCRTF, 1999), which charged NOS with leading the production of comprehensive digital coral reef ecosystem maps for shallow-water areas of all U.S. states, territories, and commonwealths. In response to Executive Order 13089 and the CRCA, NOS and its partners are conducting research to digitally map biotic resources and coordinate a long-term monitoring program that can detect and predict change in U.S. coral reefs, as well as their associated habitats and biological communities. This work involves partnerships within NOS and NOAA, as well as with other Federal agencies, states, territories, and commonwealths, universities, research institutes, and the private sector.

The primary outcomes have included: (1) comprehensive and detailed benthic habitat maps for many areas of coral reef in U.S. waters (see Table 18.1); (2) hierarchical habitat classification schemes and methods manuals; (3) advancement of research methods for the digital classification of remotely sensed data for coral reef mapping; and (4) utilization of the map-based data in ecological studies. Products and methods are readily accessible online (http://biogeo.nos.noaa.gov/products, Accessed 02/28/05) and are designed to provide a

Table 18.1. Status of NOS's shallow-water coral reef ecosystem mapping activities that use satellite and aerial imagery to delineate benthic habitats in tropical and subtropical U.S. waters as of January 2005.

REGION	AREA (km^2) OF SHALLOW-WATER (≤ 10 FM) *	AREA (km^2) OF SHALLOW-WATER MAPPED	PROJECT STATUS
U.S. Virgin Islands	344	318	Completed 2001
Puerto Rico	2,302	1,837	Completed 2001
Navassa	3	0	Planned
Florida	30,801	5,023; 0	Florida Keys maps completed in 1998; larger effort to map South Florida planned for 2006-2009
Flower Garden Banks	0	0	In progress
Main Hawaiian Islands	1,231	681; 0	Initial effort completed 2003; larger effort in progress
Northwestern Hawaiian Islands	1,595	1,238	Completed 2003
American Samoa	55	39	Completed 2004
Pacific Remote Island Areas	252	0	Planned
Marshall Islands	13,456	0	Planned
Federated States of Micronesia	14,517	0	Planned
Northern Mariana Islands	124	111	Completed 2004
Guam	108	84	Completed 2004
Palau	2,529	0	In progress

* Estimate of shallow-water area from Rohmann et al., in press.

spatial framework with which to implement and integrate research programs and provide the capability to effectively communicate information and results to coral reef ecosystem managers (Figure 18.1).

The digital shallow-water benthic habitat maps described above were primarily created through visual interpretation of aerial photographs and satellite imagery. However, some coral reef ecosystems, such as those in areas of high turbidity or deeper than about 30 m, do not lend themselves to a method based on visual interpretation. In such cases, efforts have been undertaken to map benthic habitats utilizing complementary methods, often through the use of multibeam sonar technology. For example, NOS and its partners have undertaken two mapping missions (in 2004 and 2005) to characterize deeper areas in the U.S. Virgin Islands (USVI) near Buck Island Reef National Monument in St. Croix and along the mid-shelf reef south of St. John and St. Thomas. The cumulative result of these and other efforts will be continuous map coverage of benthic cover and bathymetry from the shoreline to deep water areas beyond the insular shelf.

In the Pacific Islands region, significant efforts are also underway to integrate shallow-water maps with multibeam sonar data in areas deeper than 20 m (Figure 18.1). Since 2000, NOAA's Pacific Islands Fisheries Science Center's Coral Reef Ecosystem Division (PIFSC-CRED) has been conducting benthic habitat mapping in the Northwestern Hawaiian Islands (NWHI), Main Hawaiian Islands (MHI), Territory of American Samoa, Territory of Guam, Commonwealth of the Mariana Islands (CNMI), and Pacific Remote Island Areas (PRIAs) of Baker, Howland, Jarvis, Kingman, Palmyra, and Wake Islands. Benthic habitat mapping activities in 20-200 m include the use of single-beam and

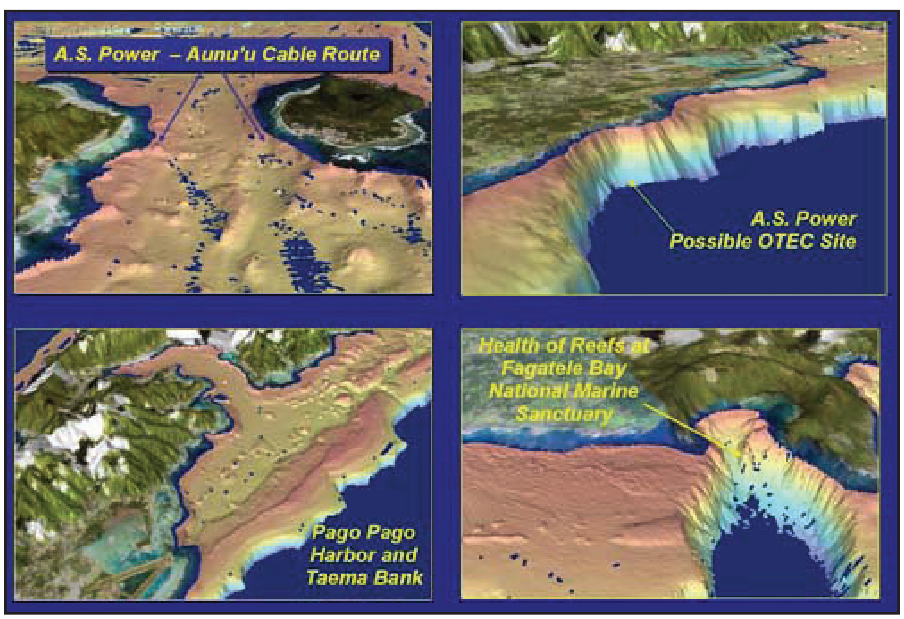

Figure 18.1. Multibeam shaded bathymetry maps (5 m resolution) of areas of American Samoa will facilitate better resource management. Source: PIFSC-CRED.

multibeam sonar instruments and bottom camera towing. In 2005, two multibeam sonars were installed on the recently commissioned NOAA vessel *Hi'ialakai*. These sonars will increase NOAA's Pacific multibeam mapping capabilities to waters deeper than 200 m; multibeam mapping in the MHI and PRIAs will commence in 2005. Table 18.2 provides a summary of Pacific benthic habitat mapping activities conducted by PIFSC-CRED.

Table 18.2. Status of PIFSC-CRED multibeam mapping activities in the Pacific Islands from 2002-2005. Source: PIFSC-CRED.

REGION	ESTIMATED AREA WITH WATER DEPTHS OF 20-200 M (km^2)	AREA WITH WATER DEPTHS OF 20-200 M MAPPED (km^2)	MULTIBEAM PROJECT STATUS
Main Hawaiian Islands	36,261	*	*Synthesis Underway
Northwestern Hawaiian Islands	58,602	13,640	Mapping cruises undertaken in 2002 and 2004; +25,727 km^2 mapped; Approximately 100 mapping days planned in 2005.
American Samoa	1,556	271	Mapping cruise undertaken in 2004; Approximately 45 mapping days planned in 2006.
Guam and the Commonwealth of the Northern Mariana Islands	30,464	244	Mapping cruise undertaken in 2003; Saipan anchorage analysis and report expected in May 2005; Approximately 45 mapping days planned in 2006.

Assessing, monitoring, and forecasting coral reef ecosystem condition

As part of the National Action Plan to Conserve Coral Reefs, USCRTF members solicited extensive input from government agencies, non-governmental organizations, academic scientists, resource managers, and other stakeholders to identify key threats (see 'Threats and Stressors' chapter) to coral reef ecosystems. The perceived level of each of these key threats was then evaluated for all jurisdictions (Turgeon et al., 2002). Results of this effort were also published in the inaugural State of the Coral Reef Ecosystems of the United States and Pacific Freely Associated States report (Turgeon et al., 2002). In this report, threats were again evaluated to allow comparison with the 2002 information (Table 18.3). This current information provides an overview of the suite of key threats for each jurisdiction, their relative importance, and the direction of change, if any, since 2002.

According to expert opinion, 74% of all threats across all jurisdictions remain unchanged from 2002 to 2004, of which 24% remain a high level threat, 24% remain a medium level threat, and 52% remain a low level threat. Twenty-six percent of all threats were perceived to have changed since 2002, of which 18% decreased in threat level and 8% increased in threat level. High level threats to coral reef ecosystems, across all jurisdictions, were considered to have decreased by approximately 6% since 2002 (Table 18.3). Fifty percent of all decreases were changes from a medium to a low threat and 15% were changes from high to low threat levels. The majority (60%) of increases was from a low to medium threat, and 26% increased from a medium to a high threat. Only one jurisdiction, Guam, exhibited a change in threat level from low to high, although this appeared to represent an anticipated increase in climate change-related coral bleaching.

Across all jurisdictions, eight of 14 threat categories were perceived to have decreased in severity since 2002: coastal pollution; trade in coral and live reef species; marine debris; security training activities; and ships, boats, and groundings. Four threat categories were perceived to have increased in severity since 2002: fishing; climate change and coral bleaching; tropical storms; and diseases. Across all jurisdictions, there was no net change in the perceived threat for oil and gas exploration or tourism and recreation. Within jurisdictions,

Table 18.3. A comparison of the 2002 and 2004 perceived levels of threat to coral reef ecosystems in the U.S. and FAS, based on expert opinion. Red squares represent high threat (2 points), orange represents moderate threat (1 point), and yellow represents little or no threat (0 points). Scores were tallied horizontally to calculate the level of threat from individual stressors across jurisdictions and vertically to calculate overall threat by jurisdiction for all stressors combined. Red arrows indicate a net increase in threat level,and green arrows indicate a net decrease in threat level. Horizontal bars indicate no change. Only data for 2004 are available for Navassa. *Following the 2000 census, population growth emerged as a major issue in American Samoa; although this issue is highlighted in the 'Other' section of that chapter, the high threat rating was assigned to the Coastal Development and Runoff threat to be consistent within the table. **For CNMI, 2002 data were based on the southern islands only, while 2004 data include the northern islands; the perceived threat for the southern islands did not change from 2002 to 2004. Note: The actual impacts of each threat category will likely vary widely within and among regions.

																Jurisdictional Composite Trend	Δ (2002 to 2004)
USVI	2002															14	↑
	2004															16	
Puerto Rico	2002															18	↓
	2004															11	
Navassa	2002																N/A
	2004															4	
Florida	2002															17	↑
	2004															18	
Flower Gardens Banks	2002															3	↑
	2004															4	
MHI	2002															17	-
	2004															17	
NWHI	2002															9	↓
	2004															5	
American Samoa	2002															11	↓
	2004														*	9	
PRIAs	2002															7	↓
	2004															5	
Marshall Islands	2002															8	↓
	2004															7	
Federated States of Micronesia	2002															11	↓
	2004															6	
CNMI **	2002															14	↓
	2004															9	
Guam	2002															8	↑
	2004															13	
Palau	2002															11	↓
	2004															6	
Stressor Change Assessment	2002	12	6	7	19	17	9	18	9	17	10	10	5	1	8		
	2004	16	7	8	18	11	9	20	5	13	7	5	2	1	4		
Δ (2002 to 2004)		↑	↑	↑	↓	↓	-	↑	↓	↓	↓	↓	↓	-	↓		
Temporal Composite Threat																	

eight of 14 jurisdictions perceived an overall decline in the severity of threats since 2002; four perceived an overall increase in threat; and two jurisdictions were perceived no net change. Threats decreased most for Puerto Rico, where coastal pollution, disease, trade in coral and live reef species, and security training activities were considered less severe in 2004. The Federated States of Micronesia (FSM), NWHI, PRIAs, CNMI, Palau, American Samoa, and the Marshall Islands also reported overall decreases in threats to coral reef ecosystems for 2004.

Perceived threats have increased the most in Guam and USVI, followed by Florida and Flower Garden Banks. In Guam, threats from climate change-related bleaching events, tourism and recreation, fishing, and marine debris are perceived to have increased since 2002. In the USVI, threats from tourism and recreation as well as marine debris are perceived to have increased since 2002. In Florida, the increase was represented solely by a perceived increase in threat from human activity in the “Other” category, which included cable laying operations. In both the MHI and American Samoa, high threat levels remained unchanged since 2002.

Of particular concern was the impact of fishing on coral reef ecosystems. Fishing was reported as a high level threat for eight jurisdictions and a medium level threat for the other six jurisdictions, thereby supporting conclusions in several other international reports that have highlighted fishing as a major threat to coral reef ecosystems (Burke and Maidens, 2004; Turgeon et al., 2002; Wilkinson, 2002, 2004). Furthermore, experts who contributed to this report perceived that the threat from fishing has increased since 2002. In addition, for all jurisdictions except the most remote islands, land-based human activity (coastal development and runoff, coastal pollution) was a medium to high level threat, which also supported the conclusions of other reports (Bryant et al., 1998; Turgeon et al., 2002; Wilkinson 2002, 2004). However, in contrast to nonpoint source pollution from runoff, the threat of coastal pollution from point sources was considered to have decreased overall since 2002, especially in Puerto Rico, American Samoa, Palau, and CNMI.

Perceived threat levels were designated through the expert opinion of writing teams with extensive local knowledge. However, interpretations of the perceived threat levels must be undertaken with some knowledge of the caveats associated with this type of information. For instance, the number of threats impacting a region may not accurately reflect the magnitude of the combined threats. Trade in coral and live reef species may have less overall impact on the coral reef ecosystems of the MHI than does the impact of fishing, yet they are both tabulated equally as a high threat. Furthermore, it is difficult to make a definitive assessment accounting for the combined impacts of multiple stressors, as each has a variety of manifestations in coral reef environments. As such, it also is important to interpret the perceived impact change for each threat independently, and to look for context and corroborating evidence in each of the jurisdictional chapters. In addition, while most perceived threat levels were based on data from rigorous monitoring programs, some were based on more casual and infrequent observations. Also, many of the jurisdictions included in this report are comprised of a number of islands, ranging in population density and human activity. Therefore, assessments of perceived threat may, in fact, refer only to a region within a jurisdiction. For example, American Samoa is comprised of six islands, yet most of the population resides on one island.

Monitoring through a continued program of surveys, systematically undertaken to provide a series of observations over time, is an important process in understanding and reducing threats to coral reef ecosystems. Monitoring can also be used to evaluate the effectiveness of specific management strategies, evaluate restoration projects, and serve as an early warning system for identifying declines in ecosystem health. The USCRTF National Action Plan to Conserve Coral Reefs calls for a coordinated national program to assess, inventory, and monitor the health of U.S. coral reef ecosystems.

For this report, monitoring programs across jurisdictions were characterized using a checklist of biotic and abiotic variables including indicators of water quality, indicators of the condition of the benthos, and abundance patterns of ecologically and economically important marine animals (Table 18.4). This selection represents a wide range of variables that are: (1) well-documented as indicators of specific stressors; (2) likely to be of concern if levels change markedly; (3) can be used to define a desired biological condition; and (4) may contribute to the development of an index of biotic integrity. These variables are also easily quantified and widely used in marine monitoring programs, thereby facilitating comparisons through time and space. Many other variables were also measured; however, these 15 were the most widely used across the jurisdictions.

Table 18.4. Key biotic and abiotic variables included within marine monitoring programs across jurisdictions. Circles indicate variables reported in this report. Data collection may occur at a single location on a single occasion or multiple locations on multiple occasions.

	WATER QUALITY					BENTHOS					ASSOCIATED BIOTA					
	Turbidity	DO	Chlorophyll	Nutrients	Bacteria	Live coral % cover	Coral recruitment	Algal % cover	Coral disease	Coral bleaching	FIsh abundance	Commercially important fish	Ecologically important macroinvertebrates	Commercially important macroinvertebrates	Protected species	% of key variables currently being monitored
USVI	●	●		●	●	●	●	●	●	●	●	●	●	●	●	93
Puerto Rico	●	●		●	●	●		●	●	●	●	●	●	●		80
Navassa				●		●	●	●	●	●	●	●	●	●	●	73
Florida	●	●	●	●		●	●	●	●	●	●	●	●	●	●	93
Flower Gardens Banks	●	●	●	●		●		●	●	●	●	●	●	●	●	87
MHI	●	●	●	●	●	●		●	●	●	●	●	●	●	●	93
NWHI	●	●	●			●	●	●	●	●	●	●	●	●	●	87
American Samoa	●	●	●	●	●	●		●	●	●	●	●	●	●	●	93
PRIAs	●	●	●			●	●	●	●	●	●	●	●		●	80
Marshall Islands						●		●	●	●	●	●	●	●	●	60
FSM	●	●			●	●		●			●	●	●	●		60
CNMI	●	●	●	●	●	●		●	●	●	●	●	●	●	●	93
Guam	●	●		●	●	●	●	●		●	●	●	●	●	●	87
Palau	●	●			●	●	●	●	●	●	●	●				67
% of jurisdictions currently monitoring each key variable	86	86	50	64	57	100	50	100	86	86	100	100	93	86	79	

Examination of the monitoring programs detailed in this report indicates that water quality variables were less widely monitored than benthic variables and associated biota. For example, fewer than half of the jurisdictions measured chlorophyll concentrations, but all monitored percentage live coral cover and all but one measured percentage algal cover and fish abundance. Overall, remote islands (excluding the MHI) were monitored less frequently than other regions. For example, Navassa and the Marshall Islands did not report monitoring of water quality variables, while the MHI reported monitoring most of the water quality, benthic, and associated biotic variables. Importantly, the frequency of sampling, which in some regions was sporadic, has been identified as a major limitation in the interpretation of monitoring data. Furthermore, this suite of variables (Table 18.4) will form the basis for more detailed analyses in future assessments of the status of coral reef ecosystems.

Improving the use of marine protected areas in coral reef ecosystems

MPAs are being used nationally and internationally as management tools to protect, maintain, or restore natural and cultural resources in coastal and marine waters (Salm et al., 2000). Examples of MPAs in the U.S. include national marine sanctuaries, parks and wildlife refuges, national seashores, historical monuments, marine reserves, fish reserves, ecosystem reserves, conservation areas, sanctuaries, research reserves, spawning sites, and other critical habitats. Executive Order 13158 defines a MPA as "any area of the marine environment that has been reserved by Federal, State, tribal, territorial, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein" (Federal Register, 2000). As such, the term MPA encompasses a wide variety of approaches to place-based management ranging from complex multi-use strategies, to areas with restrictions on specific types of fishing gear and research reserves with no public access. Most MPAs in the U.S. have one or more conservation goals that focus on natural heritage, cultural heritage, and/or sustainable production of marine resources. These conservation goals are generally derived from the site's statutory mandate and are reflected in the implementing regulations and management plan (National MPA Center, http://mpa.gov/mpa_center/about_mpa_center.html, Accessed 01/10/05). The two primary approaches to protection are multiple-use or no-take. Typically, a multiple-use approach requires zoning, with each zone varying in the types of activities permitted. Marine zoning is being implemented in the Florida Keys National Marine Sanctuary (FKNMS) to assist in the protection of ecologically important areas by ensuring that human activity is dispersed in a way that avoids concentrating impacts on the heavily used coral reefs and minimizes user conflicts (Figure 18.2). Zone types include wildlife management areas to minimize disturbance to sensitive wildlife and their habitats; ecological reserves to protect diverse habitats that are both large and contiguous; sanctuary preservation areas to protect heavily used reefs; and special-use areas for scientific research, education, restoration, or monitoring.

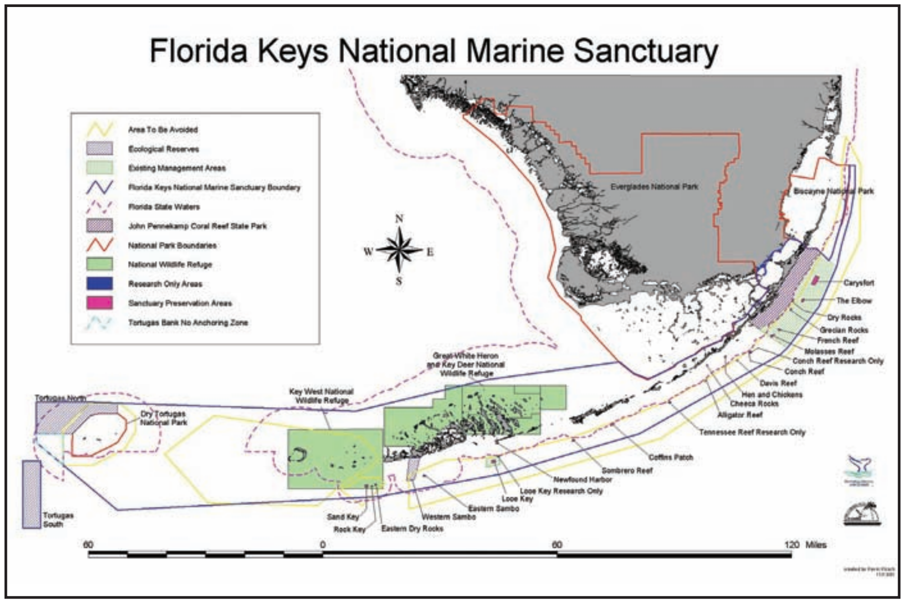

Figure 18.2. A marine zoning plan is being implemented in the FKNMS to protect sensitive habitats and minimize conflicts among various user groups. Source: FKNMS, http://www.floridakeys.noaa.gov/regs/zoning.html, Accessed 02/28/05.

A very small portion of U.S. waters are currently designated as no-take areas (National MPA Center, http://mpa.gov/information_tools/pdf/Factsheets/mpamisconceptions2.pdf, Accessed 04/04/05). In Guam, approximately 11.8% of the coastline has been designated as no-take to protect habitat and allow fish populations, particularly fisheries species, to recover. In these preserves, fishing is either prohibited or restricted to certain cultural use practices that do not threaten restoration goals. No-take zones have often proven successful in protecting and enhancing reef fish populations within protected areas, and in some cases, significant spillover effects in neighboring areas have also been reported (Gell and Roberts, 2002; Halpern and Warner, 2002, 2003; Russ and Alcala, 2004; Williamson et al., 2004).

The National MPA Center is compiling a reference database of marine managed areas (MMA) under U.S. jurisdiction. MMAs encompass a broader spectrum of management purposes, including protection of geological, cultural, or recreational resources that may not fall under the official U.S. definition of MPAs (MMA Inventory Database, http://mpa.gov/inventory/about_inventory.html, Accessed 04/20/05). MMAs exist in all of the jurisdictions containing coral reef ecosystems and are the subject of a forthcoming NOAA report. Individual protected areas in coral reef ecosystems range in size from the 0.05 km^2 national wildlife refuge at Green Cay near St. Croix, USVI to the NWHI Coral Reef Ecosystem Reserve, which covers an area of more than 347,000 km^2. Although several areas are large, many are less than 10 km^2 (MMA Inventory Database, http://mpa.gov/inventory/about_inventory.html, Accessed 04/20/05). The size of a MPA is important in relation to the diversity and quantity of habitat types protected and the life cycle movement patterns of the species of interest (Botsford et al., 2003; Halpern and Warner, 2003; Pittman and McAlpine, 2003).

Executive Order 13158 requires relevant agencies to "develop a national system of MPAs" and to "strengthen the management, protection, and conservation of existing marine protected areas and establish new or expanded MPAs." Central to the success of a MPA network is sustained participation by key stakeholder groups, particularly local communities, in all phases of the design, implementation, and evaluation of the system. In response to the Executive Order, work is underway in the U.S. to ensure representation of major coral reef habitat types and communities in a national system of MPAs. Traditionally, MPAs have not been established specifically to function as part of a network, although in some areas they may already provide connectivity and adequately represent the full range of habitat types. The National Research Council's review of 32 studies estimating the area of marine reserves required to achieve a wide range of conservation or management objectives found that 26 studies recommended areas in the range of 10-40% of all marine habitats (NRC, 2001). Interconnected networks that protect the same species and habitat types through replication in several different sites are likely to increase their resilience to disturbance and boost subsequent recovery through the provision of new recruits. Furthermore, it has been acknowledged that adaptive management, a process for continually improving management policies and practices by incorporating the results of past actions, is needed to monitor and evaluate the adequacy of the design of MPAs for the level of protection provided and efficacy with regard to protecting and improving ecosystem structure and function (USCRTF Working Group on Ecosystem Science and Conservation, http://www.coralreef.gov/whycare/ecowg/marinepro.html, Accessed 05/02/05).

To coordinate its implementation, the Executive Order directed NOAA to create the National MPA Center in collaboration with the U.S. Department of the Interior. The MPA Center, headquartered in Silver Spring, Maryland, is responsible for consultation, coordination, outreach, and education related to MPAs. The headquarters staff also support the MPA Federal Advisory Committee, which consists of 30 stakeholder representatives appointed by the Secretary of the U.S. Department of Commerce. MPA Center regional liaisons are located in Boston, Massachusetts; Monterey, California; and Honolulu, Hawaii. The MPA Center's Science Institute, with offices in Santa Cruz and Monterey, California, focuses on bringing sound science into the MPA policy arena. It fosters targeted research, assessment, and policy analysis on aspects of the design, management, and evaluation of MPAs. The MPA Center's Training and Technical Assistance Institute in Charleston, South Carolina provides training, needs assessments, and technical support to managers and stakeholders involved in MPAs. Information on individual MMAs, including a general description and site characteristics such as location, purpose, and type of site, as well as detailed information on natural and cultural resources, legal authorities, site management, regulations, and restrictions, are available through the MPA Center's on-line database (MMA Inventory Database, http://mpa.gov/inventory/about_inventory.html, Accessed 01/10/05).

The USCRTF has also called for strengthening and expanding the Nation's existing networks of coral reef MPAs and increasing the effectiveness of existing MPAs as part of the National Action Plan to Conserve Coral Reefs (USCRTF 2000) and NCRAS (2002). Since 2000, USCRTF members have made progress towards these goals. Between 2000-2003, for example, 26 new MPAs and reserves have been established in several jurisdictions including the USVI, Hawaii, Puerto Rico, American Samoa, and CNMI. USCRTF members have also conducted activities to strengthen effectiveness of existing coral reef MPAs, including the creation or revision of management plans for coral reef MPAs in Florida, Hawaii, and Puerto Rico.

Reducing adverse impacts of fishing and other extractive uses

In almost all jurisdictions, fishing is an important activity often with a long history and strongly integrated into the culture. Fishing provides food, supplemental income, recreation, and full-time employment for many people. In Palau, for example, surveys showed that 87% of households had someone that fishes either for subsistence or commercial purposes. However, catches from recreational and subsistence fishing are rarely reported or factored into estimates of total catch and in many locations are thought to exceed the commercial reef fisheries catch (F. Magron, pers. comm.).

Experts across all 14 jurisdictions perceived fishing as a medium (6) or high (8) threat to coral reef ecosystems. Reducing the adverse impacts of fishing, therefore, is critical to reducing the overall threat to coral reef ecosystems. Adverse impacts include the alteration of the faunal community structure and composition through direct removal of fauna and the physical damage to benthic habitats through various methods of extraction. Abandoned fishing gear is also of major concern in some jurisdictions, as derelict traps and nets continue to capture fish, mammals, and turtles over time (Figure 18.3). Significant declines, low abundance, or a conspicuous absence of large-bodied species, specifically of species targeted by fisheries, were reported in many regions, even in relatively remote areas. For instance, large-bodied and commercially valuable groupers that were once considered an important component of the fishery catch around Kosrae in the FSM are no longer seen in the area. Declines in large-bodied target species were also reported in areas where the fisheries were considered to be in good condition overall. In some areas, however, no baseline data exist to adequately evaluate their status. At Navassa Island, commercial and recreational fisheries are unmanaged despite its status as a national wildlife refuge.

Figure 18.3. A derelict fish trap encountered on the bank shelf south of St. John in 2005. Photo: M. Kendall.

A wide range of management activities and tools have been developed and implemented to address the impacts of fishing, and preliminary results presented in this report suggest that many have been effective in providing protection for coral reef ecosystems and promoting recovery in local fisheries. For example, in response to substantial declines in its fishery, the Puerto Rico government enacted new regulations, such as improving licensing; prohibiting spearfishing using scuba equipment; eliminating beach seining; and establishing size limits and daily quotas on several species. Elsewhere, closures have been used with measurable success. For example, in the USVI, an important red hind (*Epinephelus guttatus*) spawning aggregation site south of St. Thomas was closed in 1990, and by 2003 the average length of red hind landed had increased by 8 cm. Recent observations in the USVI also reveal that several species of grouper including the Nassau grouper (*E. striatus*) are re-establishing spawning aggregations, although these currently occur in unprotected areas and are being targeted by local fishers.

Reserves have been established in most jurisdictions and measures to reduce fishing pressure have been implemented on several levels, ranging from closures to limits on fish size or abundance. The FKNMS has numerous management zones, some of which restrict or prohibit fishing. Fisheries for Nassau grouper (*E. striatus*), goliath grouper (*E. itajara*), queen conch (*Strombus gigas*), and stony corals (Scleractinia spp.) are closed there. Enforcement and effectiveness of MPAs are the major concerns in most jurisdictions. Reserves have enhanced recovery of local fish communities in Hawaii, Puerto Rico, and the USVI, and are currently being assessed in Guam and Palau. A broad consensus of expert opinion across jurisdictions highlights the need for greater measures of enforcement to improve MPA effectiveness. In Hawaii, for example, a major concern of fishers is a perceived lack of adequate enforcement of fishing and marine resource laws. However, despite illegal fishing in no-take preserves of Guam, significant increases in fish abundance have been recorded.

Mitigation activities, such as stock enhancement, artificial reef deployment, and installation of fish aggregating devices (FADs), have also been used to address fishing impacts. Stock enhancement and artificial reefs were used to improve catch at specific locations, while FADs were used to encourage a shift in fishing pressure from sensitive, overexploited reef fish populations to pelagic non-reef species. These and other opportunities to reduce adverse impacts of fishing and other extractive uses on coral reefs should be explored and monitored for efficacy.

To restrict the harvesting of coral and live reef species, regulations have been passed in the CNMI, Flower Garden Banks, Hawaii, PRIAs, Palau, and USVI, while Puerto Rico plans to design management strategies to address the high exportation of aquarium trade target species. Catch and export data for the trade in live reef animals are limited, often with no monitoring even in areas with a significant industry. Where data are collected, catch is often considered to be underreported. After analyzing the results of several surveys, Puerto Rico is proposing a stock assessment and management strategy to address export of live reef species. In Hawaii, a network of fish replenishment areas established to ensure sustainability of the aquarium fishery has demonstrated success, with increases in the abundance of several targeted species.

Restoring damaged coral reef ecosystems

Coral reefs worldwide are experiencing increasing pressure from a multitude of stressors that have resulted in adverse changes to ecosystem structure and function. Although protection and conservation of coral reef habitats are the preferred approaches, restoration of damaged habitats is an additional tool that may be utilized in cases of physical damage (e.g., ship groundings) to enhance coral ecosystem recovery. Efforts to increase protection of coral reef ecosystems need to be supported by strategies designed to restore functionality and structural integrity to damaged and disturbed habitats. Restoration can be defined as "the process of reestablishing a self-sustaining habitat that closely resembles a natural condition in terms of structure and function" (NOAA, 2003) and must include consideration of the integrity of the surrounding landscape. Restoration of habitats in a coral reef ecosystem is a multidisciplinary effort that includes managers and policymakers and must be supported with hypothesis-driven ecological studies and quantitative long-term monitoring programs.

Clearly defined goals are essential for restoration. Key restoration goals that have been used in wetlands are applicable to the restoration of coral reef ecosystems (as well as rocky intertidal, mangrove, and seagrass ecosystems). These include attempting to restore essential ecological processes, integrating the project with its surroundings, and creating a persistent and resilient system. Generally, restoration should result in the historic ecosystem type, but it may not always result in the historic biological community and structure. Therefore, development of structural and functional objectives and performance standards for achievement should include consideration of these potential departures from pre-injury conditions (SWS, 2000).

Despite the broad scope of stressors that a coral reef ecosystem can encounter, restoration efforts have focused more on physical injuries of anthropogenic origin and of a clearly defined nature, such as vessel groundings. One example of a resource injury documentation and restoration process is in the FKNMS, where vessel groundings have damaged over 12,000 ha and pose a major threat to coral reefs and seagrass beds (FKNMS, 1996). In the FKNMS, depending on the extent of the injury, a vessel grounding can initiate a sequence of restoration activities that includes injury assessment, emergency triage and/or stabilization, possible litigation between the trustee (or primary management entity) and the responsible party, and a restoration project (Figure 18.4; Precht et al., 2003). Acting as trustees for the FKNMS, NOAA and the State of Florida have the legal authority to seek monetary damages for injury to these resources under the National Marine Sanctuaries Act (16 U.S.C. § 1441 et seq.). This Act charges the national marine sanctuaries with a

Figure 18.4. Restoration of seagrass beds damaged by a vessel grounding required the addition of gravel substrate at Calda Bank off Key West, Florida. Photo: A. Farrer.

"strong legal mandate to procure compensatory restoration and an established economic process to calculate damages" (16 U.S.C.§ 1443). The process now entails: 1) collection of a monetary damage claim (Shutler et al., in review) to restore damaged natural resources to a condition as close as possible to their pre-injury condition (i.e., primary restoration), and 2) public compensation for the lost use of those resources until such time as those resources have fully recovered (i.e., compensatory restoration). NOAA has adopted a protocol called the Habitat Equivalency Analysis (HEA) to determine the amount of compensation required for such injuries. HEA combines biological and economic principles to calculate ecosystem services lost in the interim between the time of the injury and return to baseline conditions (NOAA, 2000b). Losses are calculated in perpetuity if no recovery is expected (NOAA, 2000b). The HEA calculation requires an estimate of the time it takes for the injured services to recover, as well as the shape of that recovery function (Fonseca et al., 2000, 2004).

Computer models have been used successfuly to generate recovery horizons for use with the HEA method to prosecute injury cases in Federal courts. A recovery model can also be used as a null model for habitat restoration. In this way, projected recovery horizons can be used to evaluate the effectiveness of a no-action restoration alternative. Recovery prediction models could also be adapted to project recovery from other types of environmental stressors. To date, this type of model has been used for predictions of seagrass injury recovery (Fonseca et al., 2000), and is under development for application to coral reefs (Whitfield et al., 2001; Fonseca et al., 2003).

Restoration techniques for physical injuries of anthropogenic origin on coral reefs, seagrass meadows, and mangrove forests are based on the same general concepts: assessment and mapping of the injury, site stabilization, structural replacement or enhancement if necessary, transplanting, and monitoring. The preferred and selected restoration actions are extremely dependent on the type and scale of injury as well as specific environmental factors (e.g. current, sediment type). A large-scale coral reef injury can not only damage living coral, but also remove physical reef structure, causing habitat loss and reduction in substrate for new recruitment. Some techniques that have been used to replace biotic structure after an injury include the use of artificial structures such as limestone boulders, concrete revetment mats, or structures of various custom designs (NOAA, 2000a, 2002). Materials that have been used to stabilize loose coral include epoxy, concrete, wire ties, or cable ties (Figure 18.5). Coral colonies may be transplanted onto the artificial structures. Effective seagrass restoration techniques include filling the injury to grade (Figure 18.6), transplanting seagrass into the injured area, and increasing nutrient availability to enhance species succession in the area using

Figure 18.5. Living coral fragments are attached to a reef by a diver using wire ties. Photo: NOAA Restoration Center.

bird stakes. The generally accepted technique for mangrove habitat restoration is seedling planting (Ellison, 2000). Because the driving factor for mangrove ecosystem structure and function is the hydrologic regime, site stabilization may also be incorporated into a restoration project (Ellison, 2000).

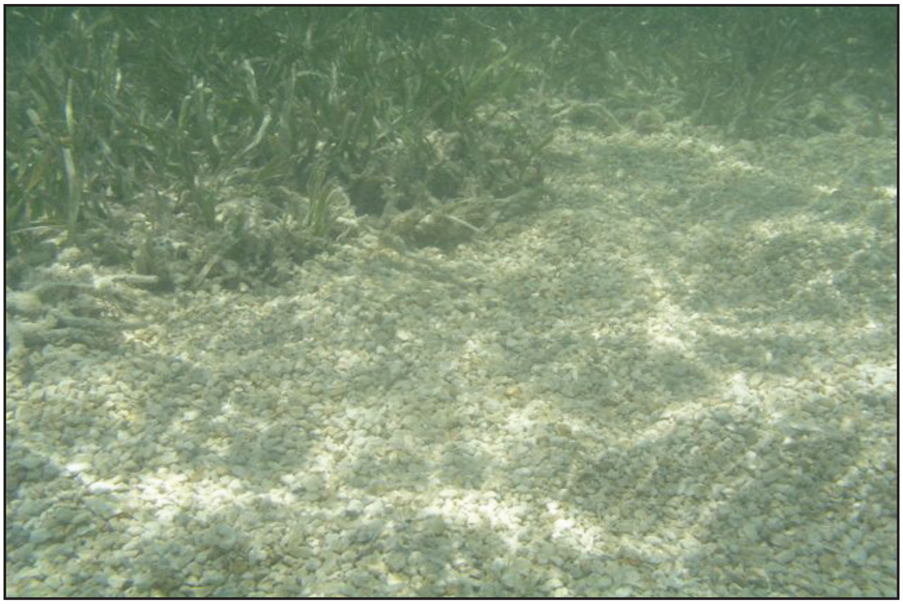

Figure 18.6. The addition of gravel to a grounding site in the Florida Keys levels the injury area to grade and provides a substrate conducive to seagrass recovery. Photo: A. Farrer.

The implementation of restoration projects would be incomplete without a process to monitor and evaluate their effectiveness. Restoration monitoring has been defined by Thayer et al. (2003) as "the systematic collection and analysis of data that provides information useful for measuring project performance at a variety of scales (locally, regionally, nationally), determining when modification of efforts is necessary, and building long-term public support for habitat protection and restoration." Quantitative long-term monitoring of restoration projects provides a unique opportunity to evaluate current projects, improve future projects, and validate and refine the predictive recovery and HEA models being developed. The consistent execution of such evaluative monitoring of coral reef restoration projects remains an important goal.

To improve socioeconomic valuation of injured natural resources and build public support, NOAA has also initiated a Community-Based Restoration Program (NOAA Restoration Center, http://restoration.noaa.gov/welcome.html, Accessed 02/09/05). Conservation and habitat restoration projects, such as those supported by this program, are intended to enhance partnerships at local, regional, and national levels. Projects in tropical coral reef ecosystems have included training volunteers to help recognize and stabilize vessel grounding injuries; establishing a community rapid biotic assessment team; establishing coral nurseries; removing commercial trap debris and derelict fishing gear from seagrass, coral reefs, and mangroves; and replanting mangroves (NOAA Restoration Center, http://restoration.noaa.gov/welcome.html, Accessed 02/09/05).

Figure 18.7. Hands-on learning about nearshore organisms with high school students in St. Thomas, USVI. Photo: N. Sbeih.

Improving outreach and education

Many outreach and education initiatives are reported in the jurisdictional chapters, often with specific personnel employed to increase public awareness of coral reef ecology and issues affecting the condition of coral reefs. Activities are largely aimed at visitors, local school children, and legislators, but also extend to fishing communities and other users of coral reef ecosystems (Figure 18.7).

NOAA's Coral Reef Conservation Program (CRCP) also continues to develop a collection of outreach and educational resources that are available on-line (CRCP, http://www.coralreef.noaa.gov/outreach/welcome.html, Accessed 02/04/05; Coral Health and Monitoring Program, http://www.coral.noaa.gov/cleo, Accessed 02/04/05).

Local action strategies

In 2002, the USCRTF adopted the Puerto Rico Resolution which calls for the development of three-year local action strategies (LAS) by each of the seven member states, territories, and commonwealths. These LAS are locally-driven roadmaps for collaborative and cooperative action among Federal, state, territory and non-governmental partners to identify and implement priority actions needed to reduce key threats to valuable coral reef resources.

The goals and objectives of the LAS are linked to those found in the U.S. National Action Plan to Conserve Coral Reefs. From the 13 goals identified in the Plan, the USCRTF prioritized six threat areas as the focus for immediate local action: overfishing, land-based sources of pollution, recreational overuse and misuse, lack of public awareness, climate change and coral bleaching, and disease. Additional focus areas were identified in some jurisdictions. Florida, Hawaii, Guam, the USVI, American Samoa, Puerto Rico, and the CNMI created specific LAS for locally relevant threats, using the six priority focus areas as a guide. Applying a collaborative decision-making process based on local needs, concerns, and capacities, each jurisdiction developed strategies containing a variety of projects to be implemented over a three-year period (Fiscal Years 2005-2007). For example, Guam has initiated a LAS for coral reef fishery management focusing on increasing the effectiveness of Guam's marine preserves.

The USCRTF is currently working with each jurisdiction to finalize and implement their LAS by inventorying opportunities; identifying resources, gaps, and needs; and seeking ways to increase funding and capacity support. (USCRTF, http://www.coralreef.gov/taskforce/las.html, Accessed 02/04/05).

Looking ahead

This report is the result of a tremendous amount of effort and coordination by the jurisdictional writing teams and attests to their dedication to conserving and protecting coral reef ecosystems throughout the United States and Pacific Freely Associated States. The information contained in the jurisdictional chapters demonstrates the considerable progress that has been made toward the major goals outlined in the NCRAS (2002) of better understanding coral reef ecosystems and reducing the adverse impacts of human activities.

Plans are to continue to improve the quality of future reports in this series through greater incorporation of quantitiative data and peer-reviewed publications. Many jurisdictions are now in position to track changes over time, using metrics that quantify coral reef ecosystem parameters associated with water quality, benthic habitats, and associated biological communities. The timing on development and publication of the next report in this series is under discussion between the USCRTF All Islands Committee and NOAA. In addition, discussions are underway on how to continue to improve the quality of the reports, increase efficiency of report production, and improve communications on the state of coral reef ecosystems based on the experience gained in the development of this report. For now, *The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005* provides the most comprehensive summary of the condition of coral reef ecosystems in the U.S. and Pacific Freely Associated States available, based on the collective efforts of the jurisdictional partners.

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United States Department of Commerce

Carlos M. Gutierrez
Secretary

National Oceanic and Atmospheric Administration

Vice Admiral Conrad C. Lautenbacher, Jr. USN (Ret.)
Under Secretary of Commerce for Oceans and Atmosphere

NOAA's Ocean Service

Richard W. Spinrad, Ph.D.
Assistant Administrator for Ocean Service and Coastal Zone Management