HAWAIIAN ARCHIPELAGO

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CORAL REEF MANAGEMENT PRIORITIES

2010

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The State of Hawai'i and NOAA Coral Reef Conservation Program. 2010. *Priorities for Coral Reef Management in the Hawaiian Archipelago: 2010-2020.* Silver Spring, MD: NOAA.

The NOAA Coral Reef Conservation Program would like to thank all those involved in the process to identify and publish the coral reef management priorities for the Hawaiian Archipelago. The commitment, time and effort invested in this process is greatly appreciated. These priorities will play an important role in defining NOAA's partnership with the jurisdiction to work towards coral reef conservation. Special thanks to Zhe Liu for graphic design and Lauren Chhay for photo support.

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INTRODUCTION

The purpose of this Priority Setting document is to articulate a set of strategic coral reef management priorities developed in consensus by the coral reef managers in Hawai'i. NOAA will use this document in conjunction with its *NOAA Coral Reef Conservation Program Goals & Objectives 2010-2015* (available at www.coralreef.noaa.gov) to direct its investment in activities in each jurisdiction through grants, cooperative agreements and internal funding. NOAA will also make the document available to other potential funders (non-governmental organizations [NGOs], federal partners, etc.) and encourage leveraging and new or expanded partnerships to build common coral reef conservation goals.

NEED AND PURPOSE OF AN ARCHIPELAGIC CORAL REEF MANAGEMENT PRIORITIES DOCUMENT

Recent federal initiatives by the National Oceanic and Atmospheric Administration (NOAA) have provided an impetus for the development of this Hawaiian Archipelago Coral Reef Management Priorities document. While NOAA's national level goals and objectives have special emphasis on addressing the impacts of climate change, fishing and land-based sources of pollution, it was recognized that state and territory priorities also needed to be identified to effectively manage coral reefs in the United States. In Hawai'i, NOAA's Coral Reef Consevation Program built upon the priority setting process for the Main Hawaiian Islands being led by the State of Hawai'i to further consult with site managers in the Northwestern Hawaiian Islands (NWHI) and develop archipelagic reef management priorities for the years 2010-2020 addressing key threats to reefs. NOAA CRCP will use this document to direct its investment and activities in each jurisdiction through grants, cooperative agreements and internal funding. NOAA will prioritize investments where actions will address the national level goals and objectives as well as the jurisdictional priorities. NOAA will also make the document available to other potential funders (NGOs, federal partners, etc.) and encourage leverage and partnership to build common coral reef conservation goals.

HAWAIIAN ARCHIPELAGO CORAL REEF MANAGEMENT PRIORITIES DOCUMENT PROCESS

The Hawaiian Islands Archipelago has often been divided into two separate geographic regions when developing management strategies: the Main Hawaiian Islands (MHI) and the Northwestern Hawaiian Islands (NWHI). This distinction has been made mainly due to the vast geographic scope that the archipelago represents stretching for over 1,500 miles across the Pacific, as well as the distinct differences in threats in the larger eight populated islands versus the smaller non-populated islands to the northwest. However, this document is aimed at representing the coral reef resource management priorities throughout the entire archipelago, recognizing the value and importance of managing reefs at an ecoregional scale as well as coordinating and leveraging management efforts among both regions. The Hawaiian Archipelago has been designated as its own distinct Large Marine Ecosystem (Sherman et al., 2004).

To coordinate and leverage management efforts at an ecoregional scale, this document identifies a set of goals and objectives designed to serve as a framework for management activities affecting coral reefs in the Hawaiian Archipelago for the next decade. This priorities framework is the result of the analysis of relevant ocean management plans, numerous past public meetings and interviews of key stakeholders representing input by hundreds of individuals and organizations. There are two specific processes and plans that significantly inform the scope of this document. They are:

1. *The Hawai'i Coral Reef Strategy:* Priorities for Management in the Main Hawaiian Islands, 2010–2020, and
2. The Papahānaumokuākea Marine National Monument Management Plan

In addition, recent efforts made by the Hawai'i Conservation Alliance to address climate change are referenced as they will provide valuable leverage throughout the archipelago in addressing this threat.

THE HAWAI'I CORAL REEF STRATEGY: PRIORITIES FOR MANAGEMENT IN THE MAIN HAWAIIAN ISLANDS, 2010–2020

The eight main Hawaiian Islands support over 140,000 acres of coral reef habitat. On the most southern and largest island—Hawai'i—reefs are still forming around an island that continues to grow in size due to an active volcano. The types and variety of marine habitats are highly varied from island to island, from coral communities to fringing reefs, to unique patch reefs, reef slopes and barrier reefs. Reefs around population centers in the urban areas have been heavily impacted by development, runoff and overuse, experiencing increasing stress from human and land-based impacts due to ever-increasing population pressures (Friedlander et al., 2008).

The State of Hawai'i Department of Land and Natural Resources (DLNR) Division of Aquatic Resources (DAR) is the primary agency responsible for managing Hawaii's aquatic resources and coordinating Hawaii's reef management efforts in the main Hawaiian Islands. Over the past 10 years, DAR has led the development of six multi-agency Local Action Strategies (LAS) (under guidance from the U.S. Coral Reef Task Force): Climate Change and Marine Disease, Lack of Public Awareness, Coral Reef Fisheries, Land-Based Sources of Pollution (supported by the EPA and NRCS), Recreational Impacts to Reefs, and Aquatic Invasive Species. LAS were developed as three-year strategic documents and included goals, objectives

and activities to abate respective threats. DAR also completed the marine component of the Comprehensive Wildlife Conservation Strategy, and developed a draft Marine Protected Areas (MPA) framework to provide clarity on the goals, objectives and key activities that currently exist in a suite of different types of marine managed sites.

While DAR has sought to coordinate these efforts, each strategy was developed somewhat independently. In order to provide a more cohesive strategy for coral reef management in Hawai'i, DAR began development of *The Hawai'i Coral Reef Strategy: Priorities for Management in the Main Hawaiian Islands 2010–2020* (HCRS) in May 2007. The Coral Reef Working Group (CRWG), made up of key state and federal partners involved in coral reef management, was established to help provide guidance for the state of Hawaii's coral program and in 2008 restructured to advise the development of The Hawai'i Coral Reef Strategy.

Initial steps in the strategic planning process included review and analysis of numerous ocean, coral reefs, watershed, coastal zone management and ecosystem-based management plans. The DLNR–DAR administrator, program managers and biologists were interviewed to gather their insights regarding gaps in coral reef conservation, emerging priorities and key management tasks necessary to improve overall coral reef conservation in Hawai'i. Similar questions were asked of members of the CRWG, LAS Advisory Groups and other key stakeholders. Draft priorities were completed with an initial set of goals, objectives and actions in 2008.

The process of refining and ranking goals and objectives for The Hawai'i Coral Reef Strategy began in November 2008 and was guided by the CRWG. DAR partnered with the NOAA CRCP consultant and local NOAA staff to design and implement a priority setting process for the ten-year strategy. The process included an ongoing exchange of expert opinion between the CRWG, LAS Advisory Groups, and DAR biologists. Further details on the process for development of goals and objectives can be found in Appendix 1 (HCRS, Section 3: Development of Goals and Objectives).

PAPAHĀNAUMOKUĀKEA MARINE NATIONAL MONUMENT MANAGEMENT PLAN

In addition to the eight main islands, the Hawaiian Island Archipelago also includes a chain of ten small islands and atolls. Starting 155 miles north and west of the island of Kaua'i, these small islands and atolls, once referred to as the NWHI, were recently designated as the Papahānaumokuākea Marine National Monument (PMNM). Extending over 1,200 miles and encompassing an area of approximately 140,000 square miles, Papahānaumokuākea is one of the largest MPA in the world. The abundant coral ecosystem that can be found in the subtropical waters of Papahānaumokuākea were one of the primary reasons for imposing a restrictive management system over the area. Coral covers an area of 911,077 acres within the boundaries of Papahānaumokuākea. Fifty-seven species of stony corals have been identified in the shallow subtropical waters including seventeen species found only in the Hawaiian Archipelago [Papahānaumokuākea Marine National Monument Plan, 2008, 27].

Management of the PMNM is shared by three trustees acting on behalf of the State of Hawaii's Department of Land and Natural Resources, the U.S. Department of Interior [through the Fish and Wildlife Service] and the Department of Commerce (through NOAA). Except for Midway, Laysan and Tern

Islands and French Frigate Shoals, the islands of Papahānaumokuākea are uninhabited. Access to PMNM and its resources is carefully regulated by the PMNM management staff and a rigorous permitting process. Activities with potentially adverse impacts, such as commercial fishing, are being phased out by 2011. As part of this process, co-trustee agencies and their staff were consulted to identify priority coral management objectives for the NWHI.

Between 2000 and 2005, NOAA conducted an extensive information-gathering process, including over 100 meetings with jurisdictional agency partners, the Reserve Advisory Council, NGOs, fishing and other stakeholder groups with the aim of developing a range of alternatives to create a National Marine Sanctuary in the NWHI. When the Monument was designated in June 2006, the proclamation instructed the co-trustees to use the draft Sanctuary Management Plan as the basis for the development of a comprehensive Monument Management Plan. Additional public informational meetings on each island as well as a formal request for additional input and public hearings on the draft Monument Management Plan provided significant opportunity for input into the develop of the final plan. Between 2000 and 2009, over 65,000 public comments were received, which provided the basis for the final documents.

HAWAIʻI CONSERVATION ALLIANCE

Also to be noted in this document are recent efforts to address the current and future impacts from global climate change by the Hawaiʻi Conservation Alliance (HCA). HCA is a collaboration of conservation leaders representing 15 state and federal agencies, educational institutions and nonprofit organizations. Collectively, HCA members are responsible for managing the biodiversity of Hawaii's lands and waters. HCA also represents people who work and use the land and water for social, cultural and agricultural purposes. The member organizations of HCA are at the forefront of research on climate change impacts, the development of management solutions that encompass mitigation and adaptation, and effective communications about climate change. As climate change is a threat to the entire archipelago, it is anticipated that HCA will become a strong partner in mitigating this threat to coral reefs. To do this, HCA and its members will continue:

- conducting critical research on climate change impacts to natural systems and native species;
- developing, implementing and sharing best management practices;
- crafting policy recommendations for mitigation and adaptation strategies;
- convening conferences, forums and other meetings to enable the sharing of knowledge and strategies by experts from a variety of disciplines;
- providing education and outreach to residents and visitors about climate change impacts on Hawaii's lands, waters and native species;
- coordinating between member organizations; and
- directing funding and other resources to Hawaiʻi.

This Priority Setting document is divided into the following sections:

1

Context: This section describes the coral reef ecosystems of the Hawaiian archipelago and the threats they face.

2

Management Framework and Guiding Principles: This section describes the colllaborative conservation approach suggested for managing reefs in the archipelago. It also identifies a core set of principles to serve as the foundation for how work will be conducted to address the primary threats to coral reefs in Hawai'i.

3

Ten Year Priority Goals and Objectives: This section presents the entire framework of goals and objectives developed and agreed upon by the core group during this process. The Priority Goals and Objectives are highlighted in this section. These are the top priorities for management action as agreed upon by the core managers group.

4

Priority Site Selection Process and Next Steps: This section lists priority sites for application of the Priority Goals and Objectives. It also describes the process by which the sites were determined.

5

Relationship Between Hawaii's Reef Management Priorities and Those of the NOAA CRCP: This section describes how the local jurisdiction management priorities align with NOAA CRCP's priorities and direction forward.

SECTION ONE: CONTEXT

CORAL REEF ECOSYSTEM

As one of the most isolated archipelagos on earth, Hawai'i has estimated rates of endemism of 25% or greater for most coral, fish, and invertebrate species. This unique marine life is found nowhere else in the world (DLNR–DAR 2005). This isolated island chain consists of two regions, the Main Hawaiian islands (MHI) and the Northwestern Hawaiian Islands (NWHI). The MHI, where the state's 1.3 million residents live, consists of high volcanic islands with nonstructural reef communities and fringing reefs abutting the shore. In contrast, the NWHI consists of mostly uninhabited atolls, islands, and banks that span over 2,000 kilometers (km) northwest of the MHI (Friedlander et al., 2005a).

Historically, coral reefs played an important role in Hawaiian culture and subsistence agriculture (Friedlander et al., 2008). Native Hawaiians had intimate knowledge of their ocean resources and employed a system to manage resources in ways that reduced waste and ensured long-term use. Some of these methods included the "kapu" system in which the chiefs would decree an area off-limits to regulate fishing during certain times (e.g., spawning season). Species restrictions were also practiced (DLNR–DAR 2005). Over time, these practices have eroded due to cultural, political and demographic changes that have affected water rights, land use and land ownership. These changes have disrupted ecosystem functions and sustainable management practices over just a few generations (Friedlander 2004).

Notwithstanding these changes, reefs remain extremely important as habitats, natural buffers, sites for recreation and cultural practices and as a key component of the marine economy. In addition to providing protection from large ocean swells and providing food for sustenance and commerce, it is estimated that the state's coral reefs generate approximately $800 million annually in added value to the state's economy from marine tourism (Friedlander et al., 2008). Reef species also provide medical benefits, including the development of new medicines—some of which are applied to the treatment of HIV, cancer, ulcers and cardiovascular diseases. Hawaii's physical setting and extensive marine science research facilities have made the state a significant player in the marine biotechnology industry.

THREATS TO MARINE RESOURCES

Hawaii's coral reef and coastal ecosystems reflect a wide variety of habitats as described above. In the Main Hawaiian Islands these habitats are impacted by a combination of natural- and human-induced events. According to the Hawai'i section of the *Status of the Coral Reef Ecosystems of the United States* (Friedlander et al., 2008), the condition of marine resources has generally degraded in the MHI over the past 20 years. This is not the case for the more isolated and protected NWHI. While Hawaii's reefs are still in fair to good condition, many urban areas and popular destinations have suffered from land-based sources of pollution, fishing pressure, recreational overuse and invasive species.

Left Image: Sediment runoff along the Kahana coast of Maui threatens local reefs with the potential for partial burial in sediment and the potential introduction of toxins and disease. Photo Credit: US EPA Right Image: Sediment from land-based sources of pollution covers coral near the Kaunakakai wharf, HI. Photo Credit: Kathy Chaston, NOAA CRCP

LAND-BASED SOURCES OF POLLUTION

Land-based sources of pollution are not a threat to the reefs of the NWHI. However, Land-based sources of pollutants, such as sediment, nutrients and other pollutants, represent one of several factors threatening the quality of coral reef ecosystems in the MHI. These pollutants are transported in surface-water runoff and by groundwater seepage into coastal waters. While the complex interrelationship between land-based sources of pollution, water quality, overfishing and the health and integrity of coral reef ecosystems is not well understood, enough is known to require management policies that minimize polluted surface-water runoff and prevent overfishing (Davidson et al., 2003).

Sediment is probably the leading land-based pollutant causing alteration of reef community structure in the MHI (Friedlander et al., 2008). Although some major sources of erosion have been removed or reduced with the closure of several large mono-crop plantations, recent years have seen damage to nearshore coral reefs due to coastal construction projects. Other significant pollutants include pesticides, petroleum hydrocarbons, pharmaceuticals, heavy metals, pathogens and excess nutrients. These pollutants can cause or exacerbate the deleterious effects of watershed transport of pollutant constituents onto coral reefs (Richmond, 1993).There are an estimated 100,000 cesspools in Hawai'i, which contribute to nutrient and pathogen runoff onto reefs. Excess nutrients, including dissolved nitrogen and phosphorus from sewage, wastewater and fertilizers, promote the growth of algae that compete with juvenile and adult corals for space on benthic reef surfaces and can affect success of coral settlement (Sammarco, 1996). Many nearshore areas of Hawai'i are comprised

Left Image: Abundance and size of fish, such as the bluefin trevally vary greatly between the MHI and NWHI. Photo Credit: © James D. Watt / Oceanstock Right Image: Apex predators, such as sharks, are also more prevalent around the uninhabited NWHI. Photo Credit: Luiz Rocha

of a mix of seawater and freshwater from submarine groundwater discharge or surface-water runoff. Groundwater in Hawai'i typically contains two to three orders of magnitude higher concentrations of dissolved nitrogen and phosphorus than seawater. Impacts from toxic pollutants are also poorly understood but also potentially severe.

FISHING PRESSURE

Coral reef fisheries are an integral part of life in Hawai'i, providing resources such as food, recreation, commerce and culture. However, there is evidence from both researchers and resource users that coral reef fisheries have been steadily declining over the past century. Friedlander and DeMartini's 2002 study showed that the numerical density, size and biomass of fish that inhabit shallow reefs are dramatically lower in the MHI compared to the remote and lightly fished NWHI. This same comparative study revealed "dramatic differences" in abundance, size and species composition.

Specifically:

- Standing fish stock in the NWHI was more than 260% greater than in the MHI.
- More than 54% of the total fish biomass in the NWHI consisted of apex predators, compared to less than 3% in the MHI.
- Most of the dominant species by weight in the NWHI were either rare or absent in the MHI and the target species that were present, regardless of trophic level, were nearly always larger in the NWHI.

A trend of declining catches despite increasing effort has been observed in several studies of time series data. In a review of commercial landings data between 1980 and 1990, the DAR found that "while catch per unit effort (CPUE) was declining... an equivalent amount of landings was being shared among an increasing number of fishermen" (Smith, 1993). This indicated the

Corals at many popular Hawaiian dive locations exhibit damage from divers and snorkelers standing upon them, like these coral heads at Kahalu`u Beach Park . Photo Credit: Ziggy Livnat, For the Sea Productions / Marine Photobank

decline was due to decreasing fish stocks and not decreased fishing effort. Also, CPUE for species that are harvested by recreational and subsistence users has declined dramatically over time, despite new developments in fisheries technology (Friedlander, 2003).

The quantitative evidence of declining reef fisheries is corroborated by qualitative information from public surveys, oral histories and interviews with members of fishing communities. In 1997, DAR surveyed 863 fishermen and found reports of "a decline in the amount of fish that they're able to catch now compared with what they were able to catch 20 or 30 years ago" (Hawai'i Division of Aquatic Resources, 1998). In a compilation of over 130 oral history interviews with kupuna ("elders") and kama'aina (Hawaiian residents; literally "those who are of the land"), the majority of interviewees reported changes in the quality of the fisheries as well as a significant decline in fish abundance, and they attributed these trends to overfishing (Maly, K. and Maly, O. 2003).

RECREATIONAL OVERUSE

Hawaii's Local Action Strategy to Address Recreational Impacts to Reefs (2005) identifies the ways in which marine recreational activities, such as snorkeling, diving and boating, may affect coral reefs. Specifically:

- Breakage of coral skeletons and tissue from direct contact such as walking, touching or gear contact;
- Breakage of coral skeletons and tissue from boat anchors;
- Alteration in the behavior of marine life from feeding or harassment; and
- Potential introduction of pollution from discharged grey water or sunscreen or transfer of aquatic invasive species (AIS).

Coral reefs in the MHI are under increasing strain from recreational use as Hawaii's resident population and thriving marine tourism industry continue to grow at nearly

Left Image: Invasive algae, Kappaphycus spp.*, overgrowing coral in northern Kaneohe Bay, Oahu. This is only one of the problematic marine invasive species currently found in HI. Photo Credit: Tony Montgomery/DLNR Right Image: Invasive algae removal efforts often utilize divers and the Supersucker Junior or Senior--shipboard vacuums that physically remove the algae while leaving the underlying reef in tact. Right Image: Sterling Kaya*

exponential rates. From 1990 to 2007, there was a 59% increase in tourism, which represents almost 4 million visitors. Slightly over half of these visitors from the U.S. West and Canada went snorkeling or diving (Hawai'i Department of Business, Economic Development and Tourism, 2007). There are over 1,000 ocean tourism companies in Hawai'i, generating an estimated $700 million in gross revenues annually. This increase in visitors and ocean tourism companies places additional pressure on marine resources, as many visitors seek calmer waters in areas with corals in shallow areas. A study by Holland and Meyers (2003) found that the greatest concentration of human-substrate contact occurred at shoreline entry points, where people tend to congregate. Although long-term impacts of heavy recreational use of reefs in Hawai'i are not fully understood and the relative impacts of different activities have not been evaluated, negative impacts from recreational activities are well documented.

INVASIVE SPECIES

Invasive species are organisms not native to a region that, when introduced either accidentally or intentionally, outcompete native species for available resources, reproduce prolifically and dominate regions and ecosystems. Invasive species are particularly damaging to Hawaiian marine ecosystems, which are ecologically fragile due to their geographic isolation. Introduced aquatic species can arrive in Hawai'i from anywhere in the world, often transported by maritime boat traffic but also sometimes deliberately introduced in a misguided attempt to supplement local fisheries and aquaculture. Once they arrive these new introductions can wreak havoc by displacing and outcompeting native plants and animals, upsetting the delicate balance of reef species that for thousands of years have evolved to inhabit Hawaiian reef ecosystems.

Coral reefs in Hawai'i are currently struggling with numerous invasive species, including algae, fish and invertebrates. Several different species of alien algae have smothered acres of reefs around O'ahu, while floating mats of algae have taken over large areas off of Maui. Many introduced fish have caused the decline of native species through competition for food and habitat. Non-native invertebrates like snowflake coral (*Carijoa riisei*) and orange keyhole sponge (*Mycale armata*) have been shown to impact coral reefs in Hawai'i (Grigg, 2003). When native coral reef species have been smothered or displaced by an invasive species the damaged, sometimes non-functioning ecosystem can be very difficult or impossible to restore. The import of new species, both deliberate and accidental, is a large threat. State efforts also work to control the spread and distribution of existing alien species so that impacted reefs can eventually be restored.

In sharp contrast to the MHI, which harbors at least 287 introduced invertebrates, only five introduced invertebrates have been established in the NWHI, mainly around the harbor at Midway Atoll and French Frigate Shoal—the sites with the longest histories of human activity. Only two introduced species are found throughout the NWHI archipelago: a hydroid and Ta'apae. The populations of AIS that have become well established and colonized in areas of the MHI are the most likely sources of invasive species in the NWHI. To address this threat, the PMNM requires hull inspections of all vessels entering these waters from the MHI.

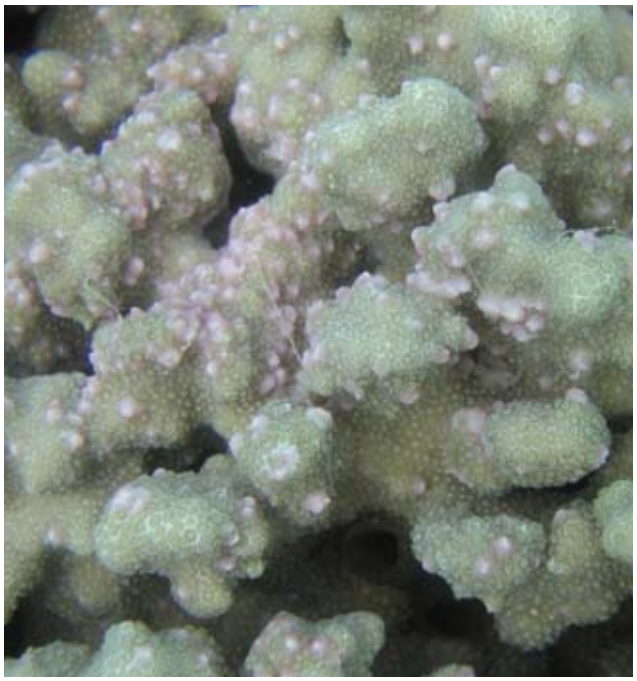
GLOBAL WARMING, CORAL BLEACHING, OCEAN ACIDIFICATION AND DISEASE

Ocean warming is a result of global climate change and can be extremely dangerous to coral organisms, which are very sensitive to changes in temperature. Coral bleaching can occur in response to several different stressors such as changes in salinity, light irradiance or temperature fluctuation. Usually though, mass bleaching events are associated with increased sea surface temperature. The first large-scale coral bleaching in the Hawai'i region occurred in 1996 predominantly in Kāne'ohe Bay on the island of O'ahu (Jokiel and Brown, 2004). The bleaching event was attributed to increases in sea-surface temperature and high light during a cloudless period. Bleaching has also been documented in the NWHI in both 2002 and 2004 (Kenyon et al., 2006; Kenyon and Brainard, 2006).

The first recorded incidents of mass coral bleaching were documented in the NWHI in 2002 and again in 2004 throughout the NWHI. In both years, the incidents of bleaching were greatest at the northern-most three atolls of Pearl and Hermes, Midway and Kure. Bleaching was most extensive on the shallow back reef flats and inner lagoon habitats, with evidence of some coral mortality.

Ocean acidification is a risk throughout the archipelago. Worldwide, oceans absorb approximately one-third of the additional CO2 generated every year by human activities, making the ocean more acidic (Caldeira and Wickett, 2003). This uptake of CO2 results in changes to the chemistry of ocean waters by decreasing pH levels, impacting the calcification cycle and various organisms, including corals. Calcification rates in reef-building and reef-associated organisms have already been reduced due to ocean acidification, with mass coral bleaching events occurring worldwide. (De'ath et al., 2009).

Disease can be defined as any impairment of vital body functions, systems or organs. There has been a worldwide increase in the reports of diseases affecting marine organisms. Outbreaks of disease in corals may be aggravated or caused by the introduction of



Left Image: Coral bleaching at Pearl and Hermes Atoll. Photo Credit: © James D. Watt / Oceanstock Right Image: Trematodiasis, or 'coral zits', is one of the most prevalent coral disease in the Hawaiian archipelago. Photo Credit: Greta Aeby, HIMB

novel pathogens to an environment or shifts in environmental conditions. Water quality and habitat deterioration have also been identified as potential environmental drivers of coral disease (Kaczamrski et Al., 2005; Harvell et al., 2007). Because temperatures modulate the metabolic rate and growth of organisms, pathogens can become more virulent at higher temperatures. Thus, disease conditions can be facilitated by opportunistic infectious pathogens whose virulence is enhanced during increased temperature episodes. Although the study of coral disease within Hawai'i is still in its infancy, a number of patterns are starting to emerge. Aeby (in press) and Aeby and Work (unpub. data) found that the most common disease in both the Main and Northwestern Hawaiian Islands is *Porites trematodiasis* (CCMD LAS, 2006). Levels of disease appear stable throughout time in most areas of the archipelago with the exception of *Acropora* white syndrome at French Frigate Shoals, and *Porites* growth anomalies and *Montipora* white syndrome at sites in the MHI.

LACK OF AWARENESS

A lack of public awareness and appreciation regarding the significance of coral reef communities and how they can be harmed is another threat to reefs. While Hawai'i is an ocean state, many residents and visitors are not aware of the direct or indirect impacts their activities have on ocean environments. Several surveys of Hawai'i residents conducted with regards to public awareness found high levels of public awareness of the declining reefs (Ward Research, 2001). However, in another study, focus group participants had a difficult time connecting their personal behavior to the impacts on local reefs and had little knowledge as to what caused the reefs to decline or how to preserve them. Participants did state a need to be given specific instructions and directions to save or help protect coral reefs (Ward Research, 2007). In 2004, a major outreach campaign with the slogan "A living reef gives our islands life" aimed to build and increase

general public awareness of the importance of the coral reef ecosystem to Hawaii's lifestyle. This statewide campaign was based on the belief that increased public knowledge and community involvement in the protection of coral reefs will help to decrease the threats to this valuable natural resource.

Active community involvement in marine resource management often results in locally acceptable resolution of resource management issues, increased conservation and compliance with the rules and greater capabilities within the community to influence resource management decisions. Opportunities for communities to become involved in coastal and marine stewardship projects have resulted in a network of at least 32 communities statewide taking action. Many of these groups are also interested in preserving traditional knowledge and have incorporated mechanisms to document this knowledge into their resource management actions. The NWHI provides a unique opportunity for some of these practitioners to experience the marine resources in a natural state, and to compare and contrast the relatively pristine areas with the resources in their own backyards. As a result of lessons learned from coral reef awareness outreach campaigns and community stewardship projects the current outreach efforts through the Hawai'i Coral Program are focused on specific audiences with key messages.

MARINE DEBRIS

Marine debris from marine and terrestrial sources continues to wash up on the shores of the islands throughout the Hawaiian Archipelago daily. Marine debris, specifically derelict fishing gear (DFG), continues to present a potentially lethal entanglement hazard to various marine species of concern, including the critically endangered Hawaiian monk seal, the threatened green turtle, several protected species of whales and other wildlife. DFG also causes significant physical damage to sensitive reef habitats, including corals and other flora and fauna, and may serve as a potential vector for invasive species. Between 2005 and 2007, over 100 tons of marine debris were removed from beaches in the MHI (Friedlander et al., 2008). The amount that washes ashore is likely much higher, as this figure only represents the documented efforts of community groups.

In the NWHI, efforts to reduce entanglements to the Hawaiian monk seal have been underway since 1982. To date, over 600 metric tons of marine debris, mainly comprised of DFG, has been removed from the reefs and beaches of the NWHI. While DFG is the main source of the marine debris, more than 70% of the smaller debris that washes ashore is made of plastic, including buoys, bottles and cigarette lighters (Morishige, 2007). There is also evidence to suggest an increase in marine debris on the shores of the NWHI during the El Niño periods (Morishige, 2007).

CUMULATIVE IMPACTS

While each of these threats is described separately, it is nearly impossible to link only one as the main threat to coral reefs in the Hawaiian Islands. For example, excessive nutrient runoff increases macro-algae (often invasive) blooms. This problem is exacerbated through over-fishing with the removal of herbivores from the system who normally keep algal populations down. Collectively, threats reduce coral fitness, which in turn reduces the organism's ability to withstand and recover from impacts such as elevated water temperatures and the resulting bleaching. To improve ecosystem health these threats have to be managed comprehensively and in a holistic manner.

SECTION TWO: MANAGEMENT FRAMEWORK AND GUIDING PRINCIPLES

MANAGEMENT FRAMEWORK

To comprehensively and effectively address threats to coral reefs and carry out priority management goals, it is important that management agencies and organizations involved in coral reef conservation approach their work collaboratively and where appropriate with an ecoregional and/or archipelagic view. No longer is it appropriate to manage Hawaii's resources as two separate units. As such, the management framework proposed in this document is one that fosters coordination, information sharing, resource-sharing and appropriately scaled research and management to bridge solutions across the two ends of the archipelago.

Additionally, it has been established that resource management is more successful when stakeholders are engaged. As such, Hawaii's communities should be included as constituents and stakeholders of both the areas where they live and the remote, uninhabited islands, atolls and reefs of the NWHI. This management framework also promotes the engagement of communities in ways that (1) encourage an understanding of the numerous values and threats to our nearshore resources, and (2) empower them with skills to be stewards of the reefs.

GUIDING PRINCIPLES

In determining the management priorities for coral reefs across the archipelago, core principles and practices were identified during both MHI and PMNM planning processes as crucial for success. As such, a core set of principles have been identified that will serve as the foundation for how work will be conducted to address the primary threats to coral reefs in Hawai'i.
These principles should help guide the development of coral reef management projects and programs to maximize effectiveness of these efforts. As such, these principles can also assist decision-makers in how resources will be allocated to address the key threats. Those efforts that incorporate these principles should be considered more likely for success and therefore higher priority over those efforts that do not take these

A healthy reef ecosystem in Hawai'i supports an abundance of coral and fish species, among others. Photo Credit: Ziggy Livnat, For the Sea Productions / Marine Photobank

principles into consideration.

Coral reef management efforts in the Hawaiian Archipelago should aim to:

- Integrate and foster land-sea (reef-to-ridge) connections.
- Bridge indigenous, local and community knowledge with western science by directly engaging Hawaiian scholars, practitioners, ocean-users and communities.
- Involve social science as well as biophysical science in an interdisciplinary ecosystem-based management approach.
- Incorporate community needs and priorities in project planning, implementation and evaluation.
- Address priority needs and threats through an archipelago-wide and/or ecoregional approach as appropriate.
- Build local capacity, enabling on-the-ground managers and communities to increase their respective abilities to conduct local-level management.
- Foster communication that is locally/culturally appropriate, and effectively conveys information to various stakeholders.

SECTION THREE: TEN-YEAR PRIORITY GOALS AND OBJECTIVES

SCOPE OF THE CORAL REEF MANAGEMENT PRIORITIES

The scope of these priorities covers coral reef ecosystems and related land management activities in the Hawaiian Islands from 2010–2020.

The complete list of "long-term goals and objectives" for coral conservation developed through both the MHI Coral Strategy process and Papahānaumokuākea Marine National Monument management planning process can be found in Appendix One (HCRS, Appendix B: Long-Term Goals and Objectives). However, the intent of this document is to identify medium-term goals and objectives for conserving Hawaii's coral reefs. These Priority Goals and Objectives identified will guide Hawai'i coral management activities over the next ten years. Those objectives identified as having a geographic focus of ARCH will be targeted for partnership activities among state agencies and PMNM. Those objectives identified as only a PMNM geographic focus will be primarily implemented by the PMNM while those identified as having a MHI geographic scope will be primarily implemented through activities funded by the Hawai'i Coral Reef Management and Monitoring grant.

In this section, the Priority Goals and Objectives are highlighted in **turquoise/bold** and *turquoise/italic* font, respectively. Each objective is also associated with a specific region of Hawai'i; for the purposes of brevity, the following abbreviations are utilized below: MHI = Main Hawaiian Islands, PMNM = Papahānaumokuākea Marine National Monument, and ARCH = Archipelago wide.

GOAL 1: Coral reefs undamaged by pollution, invasive species, marine construction and marine debris.

Objectives:

1.1 (MHI) Reduce key anthropogenic threats to two priority nearshore coral reef sites by 2015 using ahupua'a-based management. Two sites—Ka'anapali-Kahekili and Pelekane-Puako-Anaeho'omalu Bay—were identified as 3–5 year priority areas for the program funding support.

Marine debris like these nets (left image) directly impact Hawaii's reefs, while pervasive waterborne plastics (right image) in the uninhabited NWHI impact reef ecosystems and their inhabitants before being deposited on beaches like Laysan Island. Photo Credits: Left Image: NOAA NMFS PIFSC CRED Marine Debris Team, Right Image: Dwayne Meadows, NOAA PIFSC CRED

1.2 (ARCH/MHI) Prevent new AIS introductions and minimize the spread of established AIS populations by 2020.

1.3 (PMNM) Derelict fishing gear will be removed from coral reef environments at or above the rate at which it is introduced, minimizing damage to coral reefs.

GOAL 2: Productive and sustainable coral reef fisheries and habitat.

Objectives:

*2.1 (MHI) Increase the abundance and average size of ten targeted coral reef fisheries species critical to reef health and ecological function by 2020.**

**Species to be determined by FLASH advisory group*

2.2 (MHI) Designate a sufficient area of marine waters under effective conservation by 2020 to ensure sustainable and resilient coral reef ecosystems.

2.3 (MHI) Reduce anchor damage and trampling on coral reefs through the implementation of no-anchor zones, utilization of day-use mooring buoys and other means by 2020.

GOAL 3: Coral reef ecosystems resilient to climate change, invasive species and marine disease.

Objectives:

3.1 (PMNM) Establish a baseline and tracking of information over 10 years by which the PMNM can be used as a sentinel site for assessing impacts of climate change and ocean acidification in the MHI.

3.2 (ARCH) Develop and implement protocols that enable state and federal managers to effectively and consistently

Left Image: White syndrome is the second most prevalent coral disease in the Hawaiian archipelago, shown here at French Frigate Shoals in the NWHI. Photo Credit: Bernardo Vargas-Angel, NOAA PIFSC CRED Right Image: Porites sp. *showing partial bleaching during the 2002 bleaching event in the NWHI. Photo Credit: © James D. Watt / Oceanstock*

assess and respond to incidents of coral bleaching, disease, aquatic invasive species and sedimentation by 2012.

GOAL 4: Increased public stewardship of coral reef ecosystems.

Objectives:

*4.1 (ARCH) Provide at least 8 community organizations working at priority sites** with technical support needed to implement coral reef management strategies that are consistent with ahupua'a principles and that enhance ecological resilience by 2020.*

*** priority sites have been selected and are identified in Section Four*

SECTION FOUR: PRIORITY SITE SELECTION PROCESS AND NEXT STEPS

SITE SELECTION PROCESS AND RESULTS

It was recognized early in the HCRS process that many of the management activities identified in the goals and objectives need to be implemented at a site-specific level to effectively and realistically show success (e.g., reduction of sediment and nutrient runoff, sufficient areas under effective conservation, etc.). For this reason, the CRWG decided that identifying "priority sites" to implement specific ridge-to-reef management activities was critical.

To do this, a process was developed to utilize the expertise of LAS Advisory Groups, the CRWG and key biologists to assess and prioritize reef sites for future Hawai'i coral reef program activities. Site prioritization was guided by (1) criteria developed by the Coral Reef Working Group (see Appendix One [HCRS, Section 5, Table 2: Criteria for Hawai'i Program Site Prioritizations]) and (2) the Priority Goals and Objectives for the Hawai'i Coral Strategy. The Hawai'i Coral Program also utilized the results of the Marine Ecoregional Assessment for the Main Hawaiian Islands, recently completed by The Nature Conservancy (TNC), as a starting point for site prioritization (see Appendix One [HCRS, Appendix C: Overview of the Marine Ecoregional Assessment for the Main Hawaiian Islands]). This plan identified 43 areas of biological importance for long-term resiliency of coral reefs based on similar criteria as the CRWG, extensive databases of scientific information, rigorous analyses and expert reviews. From this plan, a preliminary set of nine priority sites were identified by all of the LAS Advisory Groups, the CRWG and personnel from key partner organizations. Full details on the process for site prioritization can be found in Appendix One (HCRS, Section 5: Priority Site Selection Process).

These nine sites were further ranked by the CRWG in terms of "readiness" (availability of information, ability to leverage funding, availability of potential partners and existing plans), "urgency" (current or potential threats such as land-based sources of pollution, AIS, over-fishing, nearshore development, etc.), "cross-LAS potential" (opportunities for LAS to collaborate) and "potential for effective management" (potential for success in maintaining or improving reef health). Two sites— Ka'anapali-Kahekili (Maui) and Pelekane Bay-Puako-Anaeho'omalu Bay (Hawai'i)—were identified as 3–5 year priority areas for the program funding support.

Table 1: Ranked Sites and Level of Support Available

Site	Level of Support Available
Ka'anapali-Kahekili (M-7)*	Hawai'i Coral Program Priority Site 3–5 years to receive funding and technical assistance
Pelekane Bay-Puako-Anaeho'omalu Bay (H-1)	
Maunalua Bay (O-4)	Technical support, continued LAS projects through 2010
Kāne'ohe Bay (O-2)	
Olowalu (M-6)	
Hā'ena-Hanalei (K-2)	
Kealakekua (H-9)	
Wai'anae (O-6)	No action at this time/re evaluate site after 3 years/ Sites in need of additional community/agency engagement
South Shore Moloka'i (MO-4)	

**Site identifier corresponds with maps in The Hawai'i Coral Reef Strategy Site Prioritization Maps Appendix One (HCRS, Appendix D).*

Table 1 above lists all nine sites considered by the CRWG and levels of support that will be provided based on the ranking results. The two priority sites will receive program funding and technical assistance support from the Hawai'i Coral Management Grant in the initial three to five years. Some sites will continue to have technical support and also receive funds for implementation of LAS projects throughout 2010. Several sites identified have received large amounts of LAS funds in the past and there is a continued desire on the part of several LAS advisory groups to support initiatives in these areas when possible. The final group of sites are in need of additional community/agency engagement before designation as a HCRS priority site. Sites will be reevaluated in 2013 and additional sites could be added as priorities at that time.

IMMEDIATE NEXT STEPS

In 2010, the CRWG has worked to initiate site-based management planning for Ka'anapali-Kahekili and Pelekane Bay-Puako-Anaeho'omalu Bay. Some of the initial tasks have included: defining the scope of the site, assembling a planning team and coordinator and carrying out a stakeholder analysis. The development of strategies and activities for objectives not related to site-based management are being led by the LAS Advisory Groups.

The extensive planning process used to develop the HCRS has led to increased participation of key stakeholders and an enhanced dialogue between DAR, partner agencies and other statewide ocean initiatives. Throughout this process the CRWG, LAS Advisory Groups and other stakeholders worked towards a more strategic approach to address threats to coral reefs in Hawai'i. Full details on the proposed strategies for implementation of priority objectives can be found in the attached HCRS document (see Appendix One [HCRS, Section 5, Table 4: Hawaii's MHI Priority Coral Reef Management Objectives, Activities and Outcomes).

SECTION FIVE: RELATIONSHIP BETWEEN HAWAII'S REEF MANAGEMENT PRIORITIES AND THOSE OF NOAA CRCP

The NOAA CRCP Roadmap identifies three key priority threats to coral reef ecosystems:

1. Understanding and addressing the impacts of fishing.

2. Understanding and addressing land-based sources of pollution.

3. Understanding and addressing the impacts of climate change (NOAA CRCP, 2008).

This document reflects these national priorities. The threats to reefs posed by fishing, land-based sources of pollution and climate change are incorporated in Hawaii's goals. Two of Hawaii's priority objectives directly address the CRCP's priorities. Hawai'i has committed to a watershed-based approach to addressing critical land-based sources of pollution at critical sites. Hawai'i has also committed to reducing fishing impacts on reefs through education, new regulations, more rigorous enforcement and improved habitat protection.

Table 2 shows how Hawaii's Priority Goals and Objectives correlate to NOAA CRCP's National Goals and Objectives for coral reef conservation. Table 2 was developed to explicitly identify potential partnerships between the managers in Hawai'i and NOAA CRCP. Addressing both local jurisdictional priorities and national goals and objectives will increase efficiency and leveraging of the resources available for coral reef conservation. NOAA CRCP will use this table to inform future investments in coral reef conservation in Hawai'i.

These priorities are each also assigned a geographic priority (MHI, PMNM, and/or ARCH), as noted in the table to the right.

Hawaii's Ten-Year Priority Goals and Objectives	NOAA CRCP's National Goals and Objectives for Coral Reef Conservation	Explanation of Correlation (as needed)
GOAL 1: Coral reefs undamaged by pollution, invasive species, marine construction and marine debris.		
Objective 1: Reduce key anthropogenic threats to two priority nearshore coral reef sites by 2015 using ahupua'a-based management. Two sites—Ka'anapali-Kahekili and Pelekane Bay-Puako-Anaeho'omalu Bay—were identified as 3–5 year priority areas for the program funding support. (MHI)	LBSP Impacts Objective 1.3: Implement watershed management plans and relevant Local Action Strategies (LAS) within priority coral reef ecosystems and associated watersheds to improve water quality and enhance coral reef ecosystem resilience. Where needed, develop (or update) watershed management plans that incorporate coral reef protection measures. Fishing Impacts Objective 2.4: Work with relevant agencies, offices, and communities to create, implement, and improve the management of MPAs that protect key coral reef ecosystem components and functions.	The intent of the Hawai'i objective is to reduce anthropogenic threats to key reef areas, regardless of their origin (land or water). The correlation to national goals and objectives therefore includes objectives found in both the Land-Based Sources of Pollution (LBSP) section and Fishing Impacts sections. The first objective identifies the need to develop and implement watershed management plans to reduce LBSP and the second identifies improving management of MPAs for coral reef protection.
Objective 9: Prevent new AIS introductions and minimize the spread of established AIS populations by 2020. (ARCH/MHI)	None	
Derelict fishing gear will be removed from coral reef environments at or above the rate at which it is introduced, minimizing damage to coral reefs. (ARCH/MHI)	None	

Hawaii's Ten-Year Priority Goals and Objectives	NOAA CRCP's National Goals and Objectives for Coral Reef Conservation	Explanation of Correlation (as needed)
GOAL 2: Productive and sustainable coral reef fisheries and habitat.		
Objective 1: Increase the abundance and average size of ten targeted coral reef fisheries species critical to reef health and ecological function by 2020.*** ***Species to be determined by FLASH advisory group (MHI)	Fishing Impacts Goal 1 Increase the abundance and average size of key[1] coral reef fishery species to protect trophic structure and biodiversity and improve coral reef ecosystem condition. Objective 1.1: Support the creation or improvement of coral reef fisheries management plans that address ecological, social, and economic considerations. Objective 1.2: Prioritize key coral reef associated species or functional groups (e.g. herbivores, apex predators, etc.) on which to focus management, research and monitoring activities for each jurisdiction or managed area. Objective 1.3: Obtain essential life history and ecological information on key species or functional groups to support management actions. Objective 1.4: Obtain necessary information on fishing effort in U.S. coral reef ecosystems by measuring fishing intensity, fishing mortality, frequency, area coverage, community dependence, etc. to inform management activities. Objective 1.5: Predict appropriate levels of extraction for key species or groups by developing and utilizing valid, precise, place-based and realistic ecosystem dynamics models.	No explanation needed.

Table 2 continued

[1] *Key coral reef species (or functional groups) should be identified by each jurisdiction or managed area, and are defined as the composite of species essential to effective ecosystem-based function. Key species/groups may be those most affected by extractive activities, those that serve as indicator or keystone species or other criteria.*

Hawaii's Ten-Year Priority Goals and Objectives	NOAA CRCP's National Goals and Objectives for Coral Reef Conservation	Explanation of Correlation (as needed)
GOAL 2: Productive and sustainable coral reef fisheries and habitat.		
Objective 2: Designate a sufficient area of marine waters under effective conservation by 2020 to ensure sustainable and resilient coral reef ecosystems. (MHI)	Fishing Impacts Goal 2 Support effective implementation and management of marine protected areas[2] (MPAs) and ecological networks[3] of MPAs that protect key coral reef ecosystem components and functions. Objective 2.1: Identify, characterize and rank priority areas for protection within each jurisdiction, including (but not limited to): • spawning sites, nursery habitats, or other areas critical to particular life-history stages • biodiversity hotspots • areas with greatest resilience or potential for restoring resilience • areas facing greatest threats Objective 2.2: Synthesize research on the performance of MPAs that protect key coral reef ecosystem components and functions. Objective 2.3: Using outputs of Objective 2.1 and 2.2, appropriate models, and socioeconomic considerations, identify MPAs that require increased protections or improved management, and areas to be considered for siting of new MPAs that protect key coral reef ecosystem components and functions. Objective 2.4: Work with relevant agencies, offices, and communities to create, implement, and improve the management of MPAs that protect key coral reef ecosystem components and functions. Objective 2.5: Conduct biological and socioeconomic research and monitoring to assess the performance of MPAs with respect to protection and restoration of key coral reef ecosystem components and functions.	No explanation needed.

Table 2 continued

[2] *Marine Protected Area (MPA): An area of the marine environment that has been designated by law or regulation to provide lasting protection for part or all of the resources therein.*

[3] *Ecological Network: A set of MPAs that are connected through ecological processes and that share complementary purposes and synergistic protections.*

Hawaii's Ten-Year Priority Goals and Objectives	NOAA CRCP's National Goals and Objectives for Coral Reef Conservation	Explanation of Correlation (as needed)
GOAL 2: Productive and sustainable coral reef fisheries and habitat.		
Objective 5: Reduce anchor damage and trampling on coral reefs through the implementation of no-anchor zones, utilization of day-use mooring buoys and other means by 2020. (MHI)	None	
GOAL 3: Coral reef ecosystems resilient to climate change, invasive species and marine disease.		
Establish a baseline and tracking of information over 10 years by which the PMNM can be used as a sentinel site for assessing impacts of climate change and ocean acidification in the MHI. (PMNM)	Climate Change Impacts Objective 2.1: Characterize physical and chemical changes in coral reef environments by enhancing question-based monitoring to fill gaps in our current observations. This both establishes a baseline to assess climate change impacts on coral reef ecosystems and reveals changes through time.	No explanation needed.
Develop and implement protocols that enable state and federal managers to effectively and consistently assess and respond to incidents of coral bleaching, disease, aquatic invasive species and sedimentation by 2012. (ARCH)	Climate Change Impacts Objective 1.3: Develop and implement climate-related crisis response plans in all U.S. coral reef jurisdictions to provide a framework for early warning, communication, monitoring, research, and management response to protect coral reef ecosystems from acute events such as coral bleaching, infectious disease outbreaks, tropical storm impacts, and major rainfall events.	The intent of the jurisdictional objective is to develop tools for managers responding to coral bleaching, disease and aquatic invasive species. The national objective that correlates to this jurisdictional objective calls on jurisdictional crisis response planning for acute events related to climate change. However, it does not identify response to aquatic invasive species introductions as that is not a priority across all jurisdictions.

Table 2 continued

Hawaii's Ten-Year Priority Goals and Objectives	NOAA CRCP's National Goals and Objectives for Coral Reef Conservation	Explanation of Correlation (as needed)
GOAL 4: Increased public stewardship of coral reef ecosystems.		
Provide at least 8 community organizations working at priority sites** with technical support needed to implement coral reef management strategies that are consistent with ahupua'a principles and that enhance ecological resilience by 2020. ** priority sites have been selected and are identified in Section Four (ARCH)	Climate Change Objective 1.5: In collaboration with reef managers, develop, test, and apply the best available science to provide new and innovative tools to help managers prepare and respond to climate change and ocean acidification related impacts. Fishing Impacts Objective 2.4: Work with relevant agencies, offices, and communities to create, implement, and improve the management of MPAs that protect key coral reef ecosystem components and functions. Fishing Impacts Objective 3.2: Strengthen local agency and community capacity for effective and consistent enforcement of regulations or behaviors that reduce impacts of fishing on coral reef ecosystems. LBSP Impacts Objective 3.2: Build partnerships among local, state, federal, and non-governmental entities to identify, leverage, and apply financial and other resources to facilitate improved coastal and upland watershed management to protect coral reef ecosystems from impacts of land-based sources of pollution.	The jurisdictional priority objective refers to technical support to community organizations for coral reef management consistent with ahupua'a principles. In a ridge-to-reef approach, you must integrate technical assistance and capacity building for all three threats to coral reef ecosystems. Therefore, there are four associated national objectives that correlate to the jurisdictional objective.

Table 2 continued

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APPENDIX ONE:
The Hawai‘i Coral Reef Strategy: Priorities for Management in the Main Hawaiian Islands, 2010–2020

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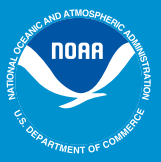

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