

AMERICAN SAMOA

American Samoa is a U.S. Territory located approximately 4,200 km south of Hawaii (Figure AMSAM-1). It is the only U.S. jurisdiction in the South Pacific. American Samoa comprises seven islands (five volcanic islands and two coral atolls) with a combined land area of approximately 200 km². The five volcanic islands, Tutuila, Aunu'u, Ofu, Olosega, and Ta'u, are the major inhabited islands of American Samoa. Tutuila, the largest island, is also the center of government and business. Rose Atoll is uninhabited, while Swains Island is inhabited by a subsistence population (of about 10 people). Due to the steepness of the main islands, shallow water habitats around the islands are limited and consist primarily of fringing coral reefs (85% of total coral reef area) with a few offshore banks (12%) and two atolls (3%). The fringing reefs have narrow reef flats (50 to 500 m); depths of 1000 m are reached within 2 to 8 km from shore.

Coral reefs in American Samoa provide an important source of food for villagers through daily subsistence use and sales at local stores. They also provide infrastructure and shoreline protection from storm wave action, and are important to the Samoan culture. Other potential uses of the reefs are low at present (e.g., tourism or the aquarium trade).

In recent years, the corals have demonstrated considerable resilience following a series of natural disturbances, including four hurricanes in the past 18 years, a devastating crown-of-thorns starfish, *Acanthaster planci*, invasion in 1978, and several recent bleaching events. Following each disturbance, the corals eventually recovered and grew to maintain the structural elements of the reefs. However, because serious fishing pressure has occurred, the Territory's coral reef ecosystem cannot be considered healthy based on the resilience of the corals alone. Furthermore, climate change impacts (e.g., coral bleaching and disease) are becoming increasingly apparent and pose a major, repetitive impact to the structure and function of local reefs. Additionally, the Territory's high population growth rate (2.1% per year) continues to strain the environment with issues such as extensive coastal alterations, fishing pressure, loss of wetlands, soil erosion and coastal sedimentation, solid and hazardous waste disposal, and pollution.

American Samoa has several MPAs, three Federal, one territorial, and several village-managed. Rose Atoll is designated as a NWR under the joint jurisdiction of the FWS and the Department of Commerce in cooperation with the Territory of American Samoa (WPRFMC 2001). Fagatele Bay National Marine Sanctuary encompasses a small embayment, and the National Park of American Samoa administers land and coral reef areas on four islands. The territory has also established Ofu Vaoto Marine Park. For the past three years, several villages have instituted community-based fisheries management regimes, banning fishing in part or all of their adjacent reef. Each village writes its own fisheries management plan with the assistance of the American Samoa Department of Marine and Wildlife Resources, but the primary goal overall is to enhance fisheries resources on the reefs. Territorial coordination of coral reef decision-making resides with the Coral Reef Advisory Group, a collaboration of Federal and territorial agencies including NOAA, DOI, the local Department of Commerce and the local Department of Marine and Wildlife Resources, American Samoa Environmental Protection Agency, and the American Samoa Community College's Sea Grant Program.¹³

¹³ Introductory material was taken, with slight modifications, from Craig (2002) and Craig et al. (2005).

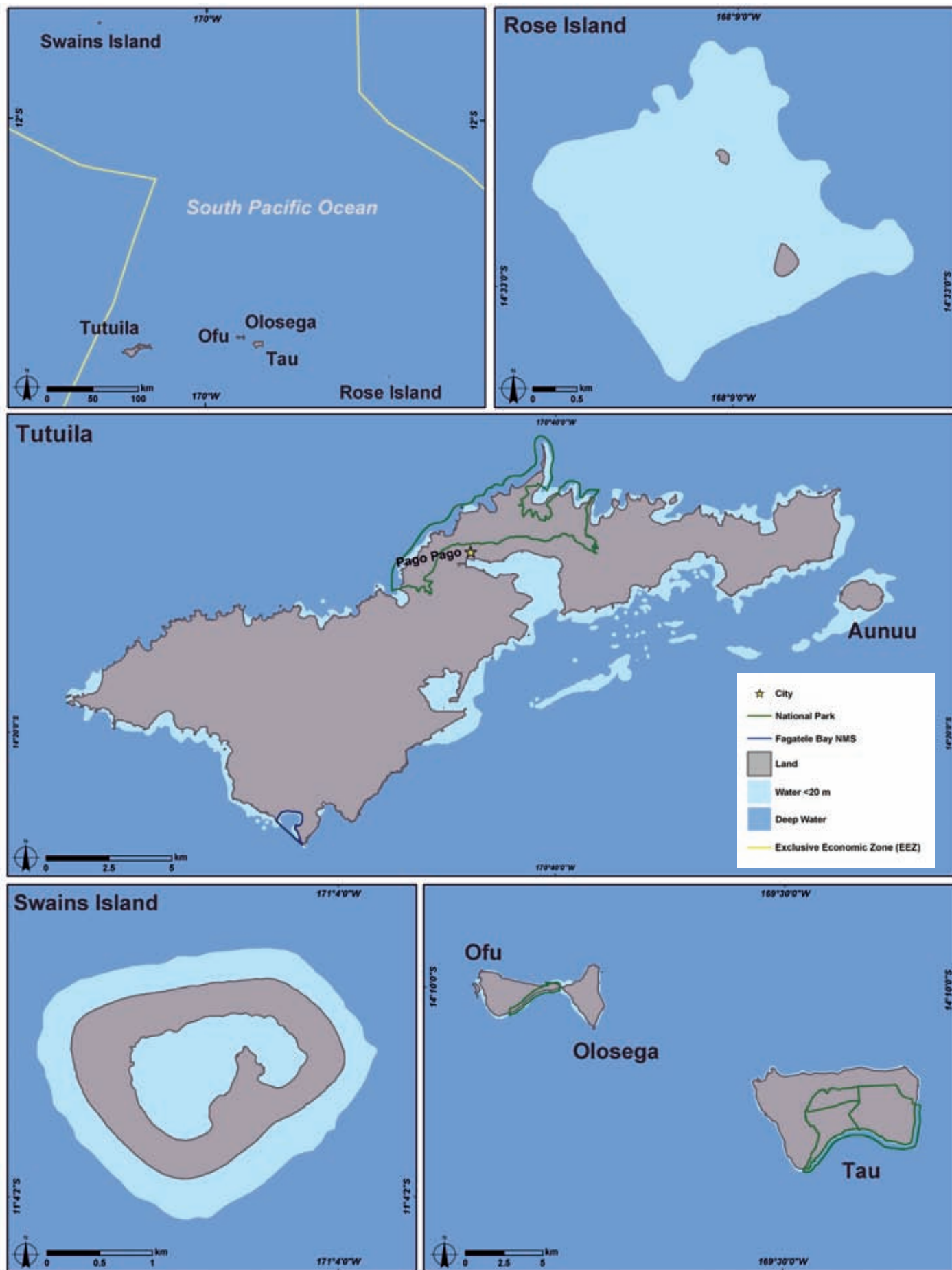


Figure AMSAM-1. Locator map for American Samoa. (See Figure 5 for geographical context.) Map: A. Shapiro. Source: Craig et al. (2005).

Research Needs

American Samoa	FISHING
Management Objective	Research Need
<p>Conserve and manage fisheries to prevent overfishing, rebuild stocks, and minimize destructive fishing.</p> <p><i>See Jurisdiction-Wide Section for additional research needs.</i></p>	<p>Determine sustainable harvest levels and fishing limits for the various fisheries.</p> <p>Assess the socioeconomic and biological implications of the recent ban on scuba spearfishing.</p> <p>Assess the impact of harvest in subsistence, artisanal, and export fisheries.</p>
<p>Evaluate aquaculture projects that minimize impacts to habitats, fishery stocks, and existing fishing communities.¹⁴</p>	<p>Assess the cost and benefits of aquaculture of local organisms with regard to their ease of production, economic potential (for local markets and export), and environmental impact.</p> <p>Conduct a socioeconomic survey to determine the level of acceptance of aquaculture products in the local market, appropriate products and potential economic returns, and interest levels of potential aquaculture farmers.</p> <p>Evaluate a demonstration aquaculture facility(s) that promotes environmentally-friendly culture systems (e.g., green water tank culture and aquaponics) that can be used for training, education, and research.</p>

American Samoa	POLLUTION
Management Objective	Research Need
<p>Reduce the impacts of pollutants on coral reef ecosystems by improving the understanding of their effects.</p> <p><i>See Jurisdiction-Wide Section for additional research needs.</i></p>	<p>Clarify the role of pollution in causing degradation of coral reef ecosystems.</p> <p>Evaluate the ability of monitoring programs to detect ecosystem change associated with inputs of land-based pollutants.</p> <p>Develop a circulation model for the main islands in the territory, including nearshore waters.</p>
<p>Improve water quality by reducing land-based pollutant inputs and impacts on coral reef ecosystems.</p> <p><i>See Jurisdiction-Wide Section for additional research needs.</i></p>	<p>Analyze and evaluate coral reef condition and water quality of reef sites adjacent to selected watersheds to help determine the efficacy of the nonpoint source program.</p> <p>Develop criteria to use in the review of environmental assessments and environmental impact statements.</p> <p>Identify potential modifications to water and sewer facilities and evaluate their effectiveness in preventing cyclones from spilling contaminants into nearshore waters.</p>

¹⁴ While managers and scientists in American Samoa take a cautious view of aquaculture, based on negative experiences elsewhere and the industry's potential to harm coral reef ecosystems, the Territory's homogenous economic base makes it attractive to small-scale aquaculture ventures similar to those found elsewhere in tropical areas. It has therefore been recognized that management-driven research, while not currently a priority, may be desired on an as-needed basis in the future.

American Samoa	COASTAL USES
Management Objective	Research Need
Reduce the impacts from recreational use, industry, coastal development, and maritime vessels on coral reef ecosystems. <i>See Jurisdiction-Wide Section for additional research needs.</i>	Evaluate the effectiveness of land use permits aimed to mitigate impacts on adjacent reefs.
	Quantify soil erosion resulting from coastal development on steep volcanic soils and associated impacts to coral reef ecosystems.
	Evaluate and update BMPs for watersheds.
Restore injured and degraded coral reef habitat.	<i>See Jurisdiction-Wide Section for research needs.</i>
Reduce rapid population growth in American Samoa.	Evaluate social, economic, and population impacts on coral reef ecosystems and model the future of these ecosystems with continued population growth.
Evaluate and improve the effectiveness of MPAs as a management tool.	<i>See Jurisdiction-Wide Section for research needs.</i>

American Samoa	INVASIVE SPECIES
Management Objective	Research Need
Minimize the introduction and spread of alien species.	<i>See Jurisdiction-Wide Section for research needs.</i>

American Samoa	CLIMATE CHANGE
Management Objective	Research Need
Minimize the effects of climate change on coral reef ecosystems. <i>See Jurisdiction-Wide Section for additional research needs.</i>	Identify populations or communities that have endogenous factors which make them less susceptible to the effects of climate change.

American Samoa	EXTREME EVENTS
Management Objective	Research Need
Identify causes and consequences of diseases in coral reef ecosystems and mitigate their impacts.	<i>See Jurisdiction-Wide Section for research needs.</i>

Jurisdiction-Wide Research Needs

Broad overarching research needs that apply to all jurisdictions (except where noted) are based on the discussion in Part I of this Plan and are presented below. Research needs that are specific to a jurisdiction are detailed under the sections entitled *Jurisdiction-Specific Research Needs*.

RESEARCH SUPPORTING MANAGEMENT

Fishing

ALL JURISDICTIONS	FISHING
<i>Management Objective</i>	<i>Research Need</i>
<p>Conserve and manage fisheries to prevent overfishing, rebuild stocks, and minimize destructive fishing.</p>	<p>Determine the population status of managed reef species using fishery dependent and independent programs.</p>
	<p>Determine the level of fishing pressure and the distribution of effort for subsistence, recreational, and commercial fisheries, and the impact of these activities on fisheries resources and coral reef habitats.</p>
	<p>Determine the effects of habitat degradation and loss of coral on fish community structure and stability.</p>
	<p>Determine the effects of various fisheries (gear and techniques) on coral reef ecosystems, including physical impacts on habitat, trophic effects, and incidental catch; and identify alternatives to minimize impacts.</p>
	<p>Determine the effectiveness of fishery management actions, including size limits and seasonal closures.</p>
	<p>Determine the current status and locations of reef fish spawning aggregations.</p>
	<p>Characterize fish movements and habitat utilization patterns of different life stages to assist in the identification of essential fish habitat.</p>
	<p>Characterize the life histories of important fish species and their movement patterns within and among different habitats.</p>
	<p>Characterize recruitment patterns for commercially and ecologically important species.</p>
<p>Quantify fish community structure including size, diversity, and abundance among reefs and across multiple habitat types.</p>	

Pollution

ALL JURISDICTIONS	POLLUTION
<i>Management Objective</i>	<i>Research Need</i>
<p>Reduce the impacts of pollutants on coral reef ecosystems by improving the understanding of their effects.</p>	<p>Ascertain pollutant loads, their primary sources, flow rates, and transport pathways, and net flow rate (flux) to coral reef communities.</p>
	<p>Determine atmospheric deposition rates and concentrations of pollutants on coral reefs.</p>
	<p>Identify the component(s) in air samples from dust sources (e.g., Africa and Gobi Desert) and downwind sites that are toxic to coral reef organisms.</p>
	<p>Identify target concentration loading rates and develop bioindicators for pollutants to detect organismal and ecosystem stress at sublethal levels.</p>
	<p>Develop and test indicators for land-based pollutants and prioritize their use in environmental and injury assessments.</p>
	<p>Identify, evaluate, and track anthropogenic activity through the use of biogeochemical and biological tracers, and indicator organisms.</p>
	<p>Investigate algal community dynamics in response to pollutant level changes to determine their utility as an indicator of future changes in coral reefs.</p>
	<p>Investigate microbial organisms as indicators of nutrient, sediment, and chemical pollutants in coral reef ecosystems.</p>
	<p>Integrate current biological monitoring techniques with water quality monitoring data to assess potential affects of water quality on various habitat types and associated organisms.</p>
<p>Improve water quality by reducing land-based pollutant inputs and impacts on coral reef ecosystems.</p>	<p>Quantify, characterize, and prioritize the land-based sources of pollution that need to be addressed based on identified impacts to coral reefs and develop strategies to eliminate, reduce, and mitigate these impacts.</p>
	<p>Evaluate changes in water quality to determine the success of management actions to reduce sediment, nutrient, and chemical pollutants and other factors that degrade water quality.</p>

Coastal Uses

ALL JURISDICTIONS	COASTAL USES
<i>Management Objective</i>	<i>Research Need</i>
<p>Reduce the impacts from recreational use, industry, coastal development, and maritime vessels on coral reef ecosystems.</p>	<p>Quantify and characterize, both spatially and temporally, threats from commercial and recreational non-extractive activities and the impact of these activities on coral reef ecosystems, and develop strategies to eliminate, reduce, and/or mitigate these impacts.</p>
	<p>Develop scientific criteria to determine the carrying capacity of the reef ecosystem, and determine the level of recreational use (e.g., diving, snorkeling, and boating) that specific areas can support.</p>
	<p>Design and conduct demonstration projects to evaluate science-based management options for improving shoreline stability, while maintaining coral reef ecosystem functions.</p>
	<p>Identify and apply biological indicators toward quantification and characterization of impacts associated with coastal uses.</p>
	<p>Develop new technologies, construction practices, and management measures to eliminate, reduce, and/or mitigate impacts from coastal uses.</p>
	<p>Conduct research to better understand the economic and social factors of the human dimension and their impact on coral reef ecosystems.</p>
	<p>Quantify and track vessel discharges, spills, and anchor damage, and their impacts on coral reef ecosystems; and recommend mitigation measures.</p>
<p>Protect, conserve, and enhance the recovery of protected, threatened, and other key species.</p> <p><i>Research needs related to acroporids are for the Atlantic Ocean only.</i></p>	<p style="text-align: center;"><u>Acroporids</u></p>
	<p>Identify the historical and current distribution of acroporids, compile this into a GIS database, and analyze spatial changes and relationships with physical, environmental, and anthropogenic factors.</p>
	<p>Assess (region-wide) the abundance and condition of acroporids incorporating colony size and counts per unit area of the different life stages (i.e., colonies, fragments, and new recruits).</p>
	<p>Evaluate the efficacy of measures to reduce anthropogenic stressors (including sedimentation, pollution, eutrophication, climate change, overfishing, and ship groundings) in enhancing recovery of existing populations of acroporids and promoting sexual recruitment.</p>
	<p>Evaluate the effects of storms and other natural stressors (e.g., coral predators) on the destruction and recovery of coral populations, and determine how anthropogenic disturbances may affect these natural processes.</p>
	<p>Evaluate the costs and benefits of various acroporid restoration strategies at promoting recovery of degraded populations, including efforts to reseed areas with larvae, optimal reattachment methods for fragments, and strategies to treat colonies affected by disease, predators, and other natural stressors.</p>
	<p>Identify microbial communities associated with diseased and healthy acroporid colonies; identify how these microbial communities change spatially, temporally, and under varying environmental conditions; and determine relationships between these communities and the health and mortality of colonies.</p>
	<p>Characterize the genetic structure and conduct demographic modeling of acroporid populations to predict population response to future disturbances and stresses encompassing a range of spatial and temporal scales.</p>

ALL JURISDICTIONS	COASTAL USES
<i>Management Objective</i>	<i>Research Need</i>
Manage coral reef ecosystems and their uses in a holistic manner.	Assess the extent and condition of deep-water hermatypic coral reef ecosystems and their importance as essential fish habitat.
	Expand ecological and taxonomic understanding of functionally important, but understudied, coral reef ecosystem groups, such as sponges, octocorals, mollusks, polychaetes, crustaceans, echinoderms, tunicates, seagrasses, algae, and microbial diversity.

Invasive Species

ALL JURISDICTIONS	INVASIVE SPECIES
<i>Management Objective</i>	<i>Research Need</i>
Minimize the introduction and spread of alien species.	Identify possible vectors and pathways of alien introductions and develop prevention measures, where applicable.
	Determine the threat and impact of hull fouling and ballast water as mechanisms for introducing and dispersing invasive species.
Control or eradicate invasive species that have the potential to cause damage to coral reef ecosystems.	Quantify the presence and evaluate the impact of invasive species on coral reef ecosystems.
	Establish protocols for early detection and eradication of invasive species.
	Develop methods to mitigate impacts of invasive species on coral reef ecosystems and evaluate the efficacy of these methods.
	Develop and evaluate methods to monitor, contain, and sterilize ballast water to prevent introduction of invasive species to coral reef ecosystems.

Climate Change

ALL JURISDICTIONS	CLIMATE CHANGE
<i>Management Objective</i>	<i>Research Need</i>
Minimize the effects of climate change on coral reef ecosystems.	<u>Bleaching of Coral Reef Organisms</u>
	Assess the spatial and temporal scales of bleaching of coral reef organisms during identified bleaching events.
	Quantify the relationships between severity of bleaching events and mortality including factors that exacerbate bleaching impacts or confer resistance and resilience.
	Quantify the socioeconomic impacts of coral bleaching events on user groups and the economy and investigate user group perceptions of coral bleaching events.
	Identify factors and their thresholds that cause coral bleaching (including physical parameters, environmental factors, and anthropogenic stressors) and investigate interactions between factors and the severity of bleaching events and the ability of corals to recover from bleaching.
	Identify the potential for coral reefs to adapt to future bleaching events through changes in clades of zooxanthellae in individual species and shifts in taxonomic composition of symbiotic organisms.
	Develop early warning systems for coral reef bleaching based on known or predicted relationships with environmental factors (e.g., temperature and light) and catastrophic pollution events (e.g., oil spills and toxic discharges).
	Develop models to predict long-term impacts to coral reef ecosystems from coral bleaching events and climate change incorporating relationships with environmental and anthropogenic stressors.
	<u>Calcification</u>
	Investigate variations in rates of coral calcification among species, temporally and spatially, and within different life stages, and how those variations may affect survivorship.
	Investigate how differing levels of atmospheric CO ₂ will affect ocean pH, carbonate saturation state, and coral calcification and growth rates.
	Quantify the effects of temperature, pH, and aragonite saturation state on calcification, reproduction, and recruitment.
	Measure biogenic CaCO ₃ production, seawater chemistry, CaCO ₃ dissolution and accumulation, bioerosion, and off-shelf export of CaCO ₃ to improve the accounting of coral reef carbonate budgets and predict how reef accretion may change in the future.
	Determine how variations in calcification rates affect associated organisms, food web dynamics, carbon and nutrient cycling, and ecosystem services.
	Examine how reduced saturation states of CaCO ₃ affect rates of bioerosion.
<u>Waves</u>	
Determine the relationships among wave energy, coral reef damage, and factors that increase or minimize damage to reefs and coastal communities.	
Mitigate the impacts from climate change on coral reef ecosystems.	Determine the effectiveness of management strategies to reduce anthropogenic stressors in mitigating the severity of bleaching.
	Evaluate available tools and develop new tools to quantify and mitigate the impacts of climate change on coral reef ecosystems.
Predict the future composition and condition of coral reefs under various climate change scenarios	Quantify organism and ecosystem responses to climate change and determine their relationships with stressors and pertinent physical, biological, and chemical parameters.
	Examine the impacts of past climate fluctuations on coral community structure.
	Develop tools to detect and describe decadal changes in relation to natural and anthropogenic disturbances.

Extreme Events

ALL JURISDICTIONS	EXTREME EVENTS
<i>Management Objective</i>	<i>Research Need</i>
<p>Identify and reduce the incidence of disease in coral reef ecosystems.</p>	<p>Determine temporal and spatial variations in disease prevalence among reef-building coral species across habitats, depths, and varying distances from land and their relationships with environmental factors and anthropogenic stressors.</p>
	<p>Quantify the rates and extent of partial and whole colony mortality from diseases, the effect of partial mortality on individual colonies (e.g., effect on reproduction and growth), and long-term impacts on affected coral reef ecosystems.</p>
	<p>In the event of a major die-off of corals resulting from disease, quantify the ecological and socioeconomic impacts.</p>
	<p>Identify external sources of pathogens (e.g., human sewage and dust) and disease vectors and quantify their distribution and abundance.</p>
	<p>Determine the distribution, abundance, and impact of diseases affecting other ecologically important benthic coral reef invertebrates (e.g., sponges and urchins) and fishes.</p>
	<p>Identify factors that increase the prevalence and impact of diseases (e.g., toxins, pollutants, sedimentation, temperature, and biotic agents), including factors and processes that increase the virulence of pathogens, increase host susceptibility and/or reduce resistance, and contribute to the transmission and spread of diseases.</p>
	<p>Identify and characterize the etiology of key coral diseases, including identification of biotic and abiotic causes.</p>
	<p>Characterize microbial communities associated with corals and coral mucus; the variations among species, seasons, and locations; identify factors that cause variations in microflora; and characterize the consequences of these changes to the host (e.g., shift from a symbiotic association to a disease-causing state).</p>
	<p>Develop standardized nomenclature, diagnostic characteristics, standardized field and laboratory methodologies, and rapid response protocols to enhance the comparability of data, improve capacity to respond to disease outbreaks and report on findings, and to identify viable management responses.</p>
	<p>Develop early warning systems for disease outbreaks based on known or predicted relationships of coral reefs with environmental factors (e.g., temperature and hurricanes) and catastrophic pollution events (e.g., oil spill and toxic discharge).</p>
	<p>Develop models to forecast long-term effects of disease on population dynamics, community structure, and ecosystem function incorporating information on biotic agents, environmental factors, and anthropogenic stressors known or predicted to affect disease prevalence and incidence.</p>
	<p>Characterize healthy and diseased corals on a cellular and physiological level (e.g., histological changes, immunological responses, and production of stress proteins).</p>
<p>Develop tools to reduce the prevalence of diseases, mitigate their impacts, and treat affected corals.</p>	

TECHNOLOGY SUPPORTING RESEARCH & MANAGEMENT

Marine Protected Areas

ALL JURISDICTIONS	MARINE PROTECTED AREAS
<i>Management Objective</i>	<i>Research Need</i>
Evaluate and improve the effectiveness of MPAs as a management tool.	Develop site-selection criteria for MPAs to assist in the conservation of coral reef ecosystems and management of commercially important fishery species, taking into account: <ul style="list-style-type: none"> o Species diversity, trophic structure, and abundance of economically or ecologically important species. o Habitat utilization patterns of different life stages. o Larval recruitment, dispersal, and connectivity (including sources and sinks). o Connectivity between habitat types (including seagrass beds, mangroves, and other associated communities), spawning aggregations, and nursery areas. o Environmental factors and anthropogenic stressors.
	Develop models to predict changes to coral reef resources that may occur under different zoning schemes, taking into account ways to conserve and possibly enhance marine resources.
	Evaluate the effectiveness of MPAs, including no-take reserves and other marine zoning schemes, taking into account: <ul style="list-style-type: none"> o Abundance of ecologically and economically important species. o Spillover of fishery species into adjacent habitats. o Improvements in the condition of the sessile benthic community and abundance of mobile invertebrates. o Cascading effects on non-target species.
	Develop useful indicators (biophysical and socioeconomic) of management effectiveness.
	Determine the socioeconomic and ecological costs and benefits of MPAs as a management tool, including relationships between levels of compliance and achieved benefits.

Habitat Restoration

ALL JURISDICTIONS	HABITAT RESTORATION
<i>Management Objective</i>	<i>Research Need</i>
Restore injured and degraded coral reef habitat.	Identify and test new coral reef restoration strategies, including transplantation and attachment techniques; optimal fragment size, shape, and orientation; ability to withstand high-energy events; and use of environmentally-friendly exotic materials.
	Determine the effectiveness of efforts to collect and settle coral larvae as a restoration tool.
	Design and evaluate techniques to control or eradicate organisms that may inhibit recovery of damaged or degraded habitats.
	Evaluate the effectiveness of current strategies to restore degraded reefs (e.g., culturing corals in a laboratory, transplanting fragments, and creating coral nurseries), taking into account the ability to maintain genetic variability, mitigate source(s) of the damage, maintain the historical distribution of the species within that habitat, and restore habitat function.
	Evaluate effectiveness of restoration techniques for associated habitats, including mangroves, seagrass beds, sandy beaches, and riparian habitats.
	Determine the impacts of exotic materials (e.g., iron, cement, rubber, and fiberglass) on recruitment efficiency, biodiversity, and community structure.
	Evaluate the ecological recovery of restored areas.
Evaluate the effectiveness of restocking ecologically important species (e.g., <i>Diadema</i> and herbivorous fishes), and the costs and benefits of restocking using species raised in captivity versus wild populations.	