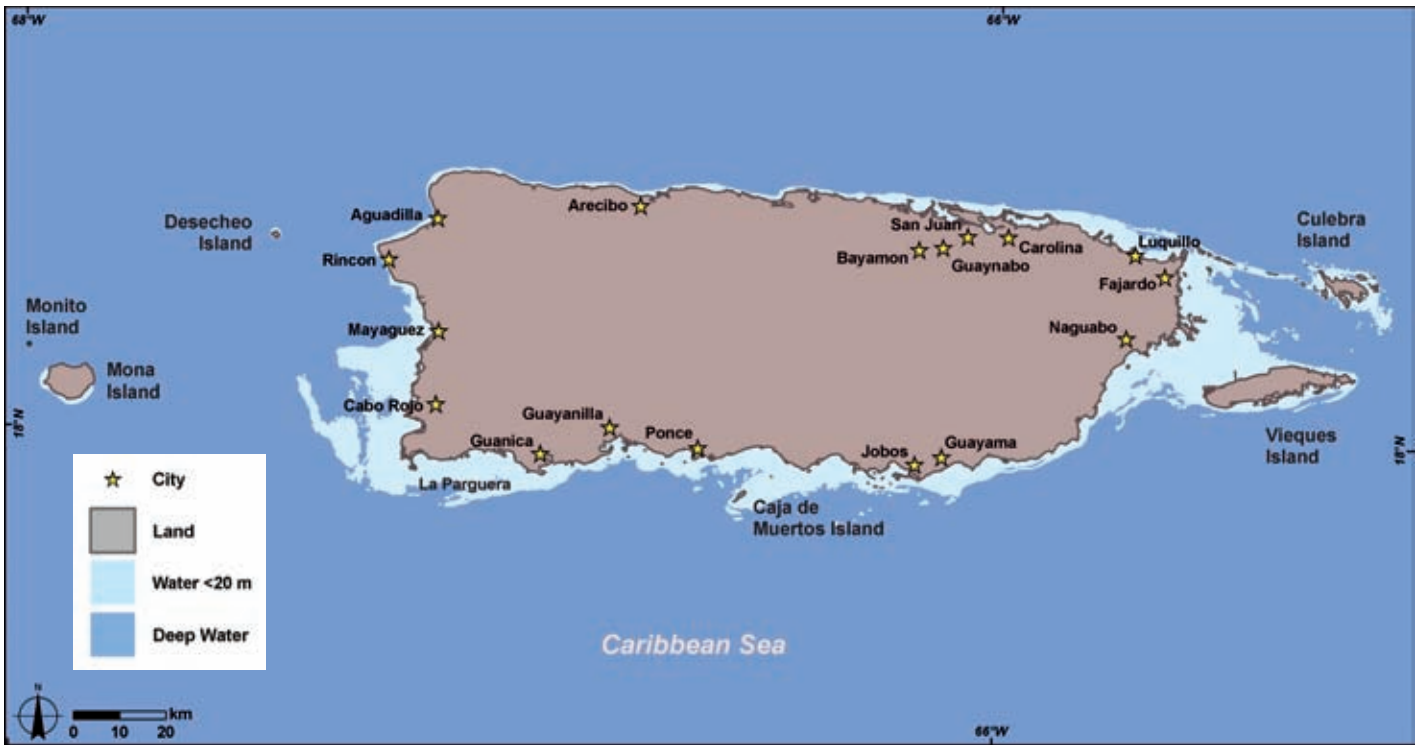

Figure PR-1. A map of Puerto Rico. (See Figure 4 for geographical context.) Map: A. Shapiro. Source: Garcia-Sais et al. (2005).

PUERTO RICO

The Commonwealth of Puerto Rico is a six island archipelago in the north-central Caribbean between the island of Hispaniola and the U.S. Virgin Islands. Puerto Rico has 3,370 km^2 of fringing coral reefs surrounding the island's east, south, and west coasts, as well as the two inhabited (Culebra and Vieques) and three uninhabited (Mona, Monito, Desecheo) small islands off Puerto Rico (Figure PR-1). Other parts of the shelf consist of hard ground areas, algal plains, and soft bottom communities with isolated coral colonies.

Reefs are characterized by a high diversity of corals (i.e., about 65 species of stony corals and 112 species of soft corals and gorgonians), although most nearshore locations have been badly degraded over the last 30 years. Most inshore reefs have a high cover of macroalgae with live coral cover ranging from 4 to 49% (mean 16%). While many offshore reefs are in better condition, these and other locations experienced massive losses of living coral cover during the 2005 bleaching event.

There are 242 reported reef fish species, many of which are targeted by commercial, recreational, and ornamental fisheries. Reef fish catches have plummeted during the last 20 years indicating classic signs of overfishing: reduced total landings, declining catch per unit effort, shifts to smaller fish, and recruitment failures (e.g., commercial fish landings fell by 69% between 1979 and 1990). In one study, reef fish density (individuals per 30 m^2) ranged from 93.2 near Desecheo Island to 12.6 near Caja de Muertos, with both reef fish density and species richness correlated with coral cover and rugosity. In 2003, 219,910 recreational anglers made over 1.1 million fishing trips in Puerto Rico. Most (56 to 64%) recreational fishing was from the shoreline, 35 to 40% was from private boats, and the rest (1 to 3%) were charter trips. In 2002, there were 1,163 active commercial fishers. Between 1995 and 2002, commercial fishers caught 1.6 million tons of fish per year, with 87% of the fishers targeting reef fish and invertebrates, including conch and lobster.

One of the major factors contributing to coral reef degradation is accelerated urban and industrial development on the coast combined with a lack of effective coastal zone management. Massive clearing of mangroves, dredging of rivers for sand and harbors, runoff from large-scale agricultural developments, deforestation in large watersheds, raw sewage disposal, and building of power plants have contributed to coral reef damage. Other major anthropogenic impacts include oil spills, anchoring of large cargo vessels, overfishing, uncontrolled recreational activities, eutrophication, and military bombing activities (at Vieques and Culebra Islands). Additionally,

anthropogenic factors are exacerbating the impacts from a number of natural stressors such as hurricanes, coral bleaching, and coral diseases.

The coastal zone is managed by the Puerto Rico Department of Natural and Environmental Resources, but the determination of consistency with the Coastal Zone Management Plan for Puerto Rico is the responsibility of the Puerto Rico Planning Board. The Environmental Quality Board monitors water quality, in part through its water quality certification program, and the Regulations and Permits Administration governs land use regulations. Development in the coastal zone that may result in impacts to water bodies, including wetlands, is also regulated by the U.S. Army Corps of Engineers. The Puerto Rico Department of Natural and Environmental Resources and the Caribbean Fishery Management Council share responsibility for managing 24 MPAs. In an effort to convert a collapsing fishery into a sustainable one, the Government of Puerto Rico has enacted new fishing regulations that require recreational fishing licenses, prohibit recreational spearfishing with scuba, eliminate beach seine nets, establish size limits and daily quotas on several species, require species-specific permits for high-value and sensitive species, and create MPAs around Mona, Monito, and Desecheo Islands, and the Condado Lagoon.[3]

3 Introductory material was taken, with slight modifications, from Kelty (2004).

Research Needs

PUERTO RICO	FISHING
Management Objective	***Research Need***
Conserve and manage fisheries to prevent overfishing, rebuild stocks, and minimize destructive fishing. *See Jurisdiction-Wide Section for additional research needs.*	Produce high resolution bathymetric and habitat maps to 200 m in depth.
	Evaluate the bioeconomic costs and benefits of current fishing regulations (i.e., size limits, closed areas, and closed seasons associated with spawning aggregations) and the effectiveness of these regulations.
	Assess the distribution, abundance, and ecological role of aquarium trade species and the impacts associated with their extraction.
	Identify areas that are essential as nursery grounds for exploited fisheries.
	Determine the economic value of commercial and recreational fisheries.
	Determine the level of engagement and dependence of communities on coral reef ecosystems and stakeholder attitudes, perceptions, and preferences regarding their utilization and identify methods to integrate fishery dependent information into the management process.
Protect, conserve, and enhance the recovery of protected, threatened, and other key species.	Queen Conch, Spiny Lobster, and Octopi
	Evaluate commercial, subsistence, and recreational fishing pressure on conch, lobster, and octopi and the adequacy of existing regulations.
	Characterize the population dynamics, habitat utilization, recruitment and ontogenetic movement patterns of conch, lobster, and octopi in key locations.

PUERTO RICO	FISHING
Management Objective	***Research Need***
Develop and support aquaculture projects that minimize impacts to coral reef ecosystems, fishery stocks, and existing fishing communities.	Evaluate the socioeconomic impacts of aquaculture projects on existing fishing communities.
	Determine the viability of restocking reef fish populations of commercial and recreational importance to aid in their recovery.
	Evaluate the impacts of new and existing aquaculture operations (especially offshore fish pens) with emphasis on the introduction of diseases, escapees, genetics, habitat impacts, and status as fish aggregating devices.

PUERTO RICO	POLLUTION
Management Objective	***Research Need***
Reduce the impacts of pollutants on coral reef ecosystems by improving the understanding of their effects. *See Jurisdiction-Wide Section for additional research needs.*	Develop internal circulation models for Puerto Rico to understand and predict the fate and effect of nutrients and other pollutants.
	Determine the impact of the Culebra municipal landfill to the eastern side of the Canal Luis Peña Natural Reserve.
	Determine the impacts of high-use marinas in areas with poor water circulation.
	Evaluate the effects of wastewater discharges from treatment plants and untreated sewage entering water bodies on adjacent coral reef ecosystems.
Improve water quality by reducing land-based pollutant inputs and impacts on coral reef ecosystems. *See Jurisdiction-Wide Section for additional research needs.*	Develop BMPs with relevance to tropical areas to reduce or eliminate the highest priority sources of pollution and evaluate the effectiveness of implemented measures (e.g., erosion and sediment control regulations).
	Evaluate the role of coastal wetlands in reducing contaminants before they are released into the marine environment.
	Evaluate water quality and its impacts on coral reef ecosystems in relation to changes in land and marine use in coastal areas.

PUERTO RICO	COASTAL USES
Management Objective	***Research Need***
Reduce the impacts from recreational use, industry, coastal development, and maritime vessels on coral reef ecosystems. *See Jurisdiction-Wide Section for additional research needs.*	Design and conduct demonstration projects to evaluate science-based management options for improving shoreline stability while maintaining coral reef ecosystem functions.
	Determine the impact of onshore and offshore coastal development on coral reef ecosystems.

PUERTO RICO	COASTAL USES
Management Objective	***Research Need***
Balance resource use to minimize user conflicts, provide equitable uses, and ensure optimal benefits to present and future generations.	Conduct an economic valuation of coral reef ecosystems (including mangrove and seagrass habitats) in Puerto Rico.
Protect, conserve, and enhance the recovery of protected, threatened, and other key species. *See Jurisdiction-Wide Section for additional research needs.*	<u>Acroporids</u>
	Identify critical habitat for ***Acropora*** spp. in Puerto Rico, including the historical and current distribution of acroporid populations, and factors that affect their spatial extent.
	Identify the direct causes of mortality (e.g., disease, predation, and storms) to acroporids, the role of anthropogenic stressors in increasing their susceptibility or resistance to these factors, and benefits of existing and new management measures at mitigating threats and rebuilding acroporid populations.
	Evaluate the effectiveness of ***Acropora cervicornis*** nurseries as a restoration tool, including potential implications of translocation of these corals from the south coast to Culebra.
	<u>Sea Turtles</u>
	Determine the impact of continuing development around Culebra Island on green sea turtles and their habitat.
Reduce impacts from and restore habitat damaged by vessel anchoring and groundings.	Assess the extent and impact of damage caused by grounding, anchoring, or human trampling in coral reefs and associated habitats.
	Evaluate the effectiveness of restoration at the grounding sites of the ***Fortuna Reefer*** (Mona Island), ***Magara*** (Guayanilla), and other recent restoration efforts at promoting biological and ecological recovery.
Restore injured and degraded coral reef habitats. *See Jurisdiction-Wide Section for additional research needs.*	Develop recommendations for coral reef habitat restoration measures based on the quality of the habitat and the potential for success.
Evaluate and improve the effectiveness of MPAs as a management tool. *See Jurisdiction-Wide Section for additional research needs.*	Evaluate the effectiveness of existing management plans for natural reserves to determine whether strengthening of these plans is warranted.
	Determine if existing managed areas are facilitating the recovery of protected, threatened, and other key species, including conch, grouper, and lobster.

PUERTO RICO	INVASIVE SPECIES
Management Objective	***Research Need***
Minimize the introduction and spread of alien species.	*See Jurisdiction-Wide Section for research needs.*
Control or eradicate invasive species that have the potential to cause damage to coral reef ecosystems.	Determine the distribution and abundance of the paperbark tree and identify its impact on coastal wetlands.
	Determine the distribution and abundance of the green iguana and identify its impact on mangrove habitats and potential methods to control/eradicate it without introducing alien species.
	Determine the effect of Casarina Pine trees on nesting turtle populations around Mona Island, and the benefits of removal programs at improving the quality of coastal habitats.

PUERTO RICO	CLIMATE CHANGE
Management Objective	***Research Need***
Improve the capacity to forecast and respond to bleaching events. *See Jurisdiction-Wide Section for additional research needs.*	Develop and implement a rapid response protocol to characterize and manage future bleaching events.

PUERTO RICO	EXTREME EVENTS
Management Objective	***Research Need***
Identify causes and consequences of diseases in coral reef ecosystems and mitigate their impacts. *See Jurisdiction-Wide Section for additional research needs.*	Assess the differences in disease prevalence, incidence, and impacts between deeper and shallower reefs at nearshore and offshore locations, and their relationships with other environmental stressors.
Reduce impacts to and promote restoration of coral reef organisms affected by extreme events.	Develop a model to predict the potential impact of storms to coral reef habitats including factors such as spatial extent and degree of storm damage; storm strength, speed, and path; and benthic habitat characteristics.
	Identify the factors that need to be addressed to enhance the recovery of coral reefs following hurricane and storm damage.

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
Management Objective	***Research Need***
Conserve and manage fisheries to prevent overfishing, rebuild stocks, and minimize destructive fishing.	Determine the population status of managed reef species using fishery dependent and independent programs.
	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.
	Determine the effects of habitat degradation and loss of coral on fish community structure and stability.
	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.
	Determine the effectiveness of fishery management actions, including size limits and seasonal closures.
	Determine the current status and locations of reef fish spawning aggregations.
	Characterize fish movements and habitat utilization patterns of different life stages to assist in the identification of essential fish habitat.
	Characterize the life histories of important fish species and their movement patterns within and among different habitats.
	Characterize recruitment patterns for commercially and ecologically important species.
	Quantify fish community structure including size, diversity, and abundance among reefs and across multiple habitat types.

Pollution

ALL JURISDICTIONS	POLLUTION
Management Objective	***Research Need***
Reduce the impacts of pollutants on coral reef ecosystems by improving the understanding of their effects.	Ascertain pollutant loads, their primary sources, flow rates, and transport pathways, and net flow rate (flux) to coral reef communities.
	Determine atmospheric deposition rates and concentrations of pollutants on coral reefs.
	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.
	Identify target concentration loading rates and develop bioindicators for pollutants to detect organismal and ecosystem stress at sublethal levels.
	Develop and test indicators for land-based pollutants and prioritize their use in environmental and injury assessments.
	Identify, evaluate, and track anthropogenic activity through the use of biogeochemical and biological tracers, and indicator organisms.
	Investigate algal community dynamics in response to pollutant level changes to determine their utility as an indicator of future changes in coral reefs.
	Investigate microbial organisms as indicators of nutrient, sediment, and chemical pollutants in coral reef ecosystems.
	Integrate current biological monitoring techniques with water quality monitoring data to assess potential affects of water quality on various habitat types and associated organisms.
Improve water quality by reducing land-based pollutant inputs and impacts on coral reef ecosystems.	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.
	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.

Coastal Uses

ALL JURISDICTIONS	COASTAL USES
Management Objective	***Research Need***
Reduce the impacts from recreational use, industry, coastal development, and maritime vessels on coral reef ecosystems.	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.
	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.
	Design and conduct demonstration projects to evaluate science-based management options for improving shoreline stability, while maintaining coral reef ecosystem functions.
	Identify and apply biological indicators toward quantification and characterization of impacts associated with coastal uses.
	Develop new technologies, construction practices, and management measures to eliminate, reduce, and/or mitigate impacts from coastal uses.
	Conduct research to better understand the economic and social factors of the human dimension and their impact on coral reef ecosystems.
	Quantify and track vessel discharges, spills, and anchor damage, and their impacts on coral reef ecosystems; and recommend mitigation measures.
Protect, conserve, and enhance the recovery of protected, threatened, and other key species. *Research needs related to acroporids are for the Atlantic Ocean only.*	<u>Acroporids</u>
	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.
	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).
	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.
	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.
	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.
	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.
	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.

ALL JURISDICTIONS	COASTAL USES
Management Objective	***Research Need***
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
Management Objective	***Research Need***
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
Management Objective	***Research Need***
Minimize the effects of climate change on coral reef ecosystems.	Bleaching of Coral Reef Organisms
	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.
	Calcification
	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.
	Waves
	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
Management Objective	***Research Need***
Identify and reduce the incidence of disease in coral reef ecosystems.	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.
	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.
	In the event of a major die-off of corals resulting from disease, quantify the ecological and socioeconomic impacts.
	Identify external sources of pathogens (e.g., human sewage and dust) and disease vectors and quantify their distribution and abundance.
	Determine the distribution, abundance, and impact of diseases affecting other ecologically important benthic coral reef invertebrates (e.g., sponges and urchins) and fishes.
	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.
	Identify and characterize the etiology of key coral diseases, including identification of biotic and abiotic causes.
	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).
	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.
	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).
	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.
	Characterize healthy and diseased corals on a cellular and physiological level (e.g., histological changes, immunological responses, and production of stress proteins).
	Develop tools to reduce the prevalence of diseases, mitigate their impacts, and treat affected corals.

TECHNOLOGY SUPPORTING RESEARCH & MANAGEMENT

Marine Protected Areas

ALL JURISDICTIONS	MARINE PROTECTED AREAS
Management Objective	***Research Need***
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: 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: 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
Management Objective	***Research Need***
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., *Diadema* and herbivorous fishes), and the costs and benefits of restocking using species raised in captivity versus wild populations.