U.S. VIRGIN ISLANDS

View of a bay from St. John, U.S. Virgin Islands.

The U.S. Virgin Islands (USVI) includes three main islands – St. Croix, St. Thomas, and St. John – and several smaller islands (Figure USVI-1). St. Thomas and St. John are geologically part of the Lesser Antilles and sit on the same shelf platform as Puerto Rico. The shelf platform ranges from 40 to 60 ft, with fringing, patch, and spur and groove reefs distributed patchily. Extensive coral reefs lie in water along the shelf edge in depths from 120 to 200 ft. These deeper reefs are dominated by plating forms of the *Agaricia* spp. and *Montastraea* spp. complexes, while corals in shallower water vary from columnar forms of *Montastraea* spp. to *Acropora* spp. to gorgonian dominated habitats. Maps of USVI benthic habitats (to 30 m) show that 61% of the 485 km^2 area is coral reefs and coral on hard bottom; 33% is predominantly seagrass beds, and 4% is sediment or rocky bottom.

St. Croix is part of the Greater Antilles and sits on a narrow, shallow shelf platform that drops off into the 4,000+ m deep Virgin Islands Trough. The shallow (46 to 60 ft) shelf edge is relatively close to shore in many places with classic back bay/lagoons to reef crest and fore reef habitats. The eastern and southern ends of the island are protected by a barrier reef system. Stocks and resources do not appear to move across the Puerto Rico Trench, whereas St. Thomas and St. John have fish populations more similar to Puerto Rico. Thus, St. Croix and St. Thomas/St. John are not considered a single management unit.

Many stresses affecting marine resources in the Caribbean may be causing degradation of USVI coral reef ecosystems. Over the past 40 years, living coral cover has decreased, while macroalgal cover has increased. Intensive fishing along with habitat degradation has been blamed for the loss of spawning aggregations and decreases in mean size and abundance of reef fish. Groupers and snappers are far less abundant now, while herbivorous fishes comprise a greater proportion of samples in traps and visual surveys than they did in the 1960s. Other damage to marine resources results from natural stresses such as hurricanes and coral diseases, as well as land-based pollution and other anthropogenic factors.

The jurisdiction over these coral resources is shared by several U.S. agencies and the Virgin Islands Government. In 2001, the Virgin Islands Coral Reef National Monument off St. John was established, and the Buck Island Reef National Monument off St. Croix was expanded. Both areas are managed by the National Park Service. In 2002, the St. Croix East End Marine Park, which is managed by the USVI Department of Planning and Natural Resources, was established as the first in a series of marine parks for the territory. These areas are designed to provide protection for important marine resources, including coral reef areas, thus allowing depleted populations of certain marine organisms (groupers, snappers, corals) to recover. Other managed areas in St. Thomas and St. John include: the Hind Bank Marine Conservation District (established in 1999) and Lang Bank designated by the Caribbean Fishery Management Council to protect spawning aggregations and coral habitats; the Grammanik Bank, established as a temporary seasonal closure area for 2005 (permanent regulations are pending); and the Cas Cay/Mangrove Lagoon and St. James Marine Reserves, established in 1994 to protect juvenile reef fish and associated habitat. In St. Croix, MPAs include the seasonal Mutton Snapper Spawning Area Closure, the seasonal Lang Bank Red Hind closure, and the Salt River Bay National Historical Park and Ecological Preserve. The latter was designated in 1995, but the regulations have yet to be signed.[4]

4 The sources for the introduction are Vasques (2005), Kelty (2004), and Jeffrey et al. (2005).

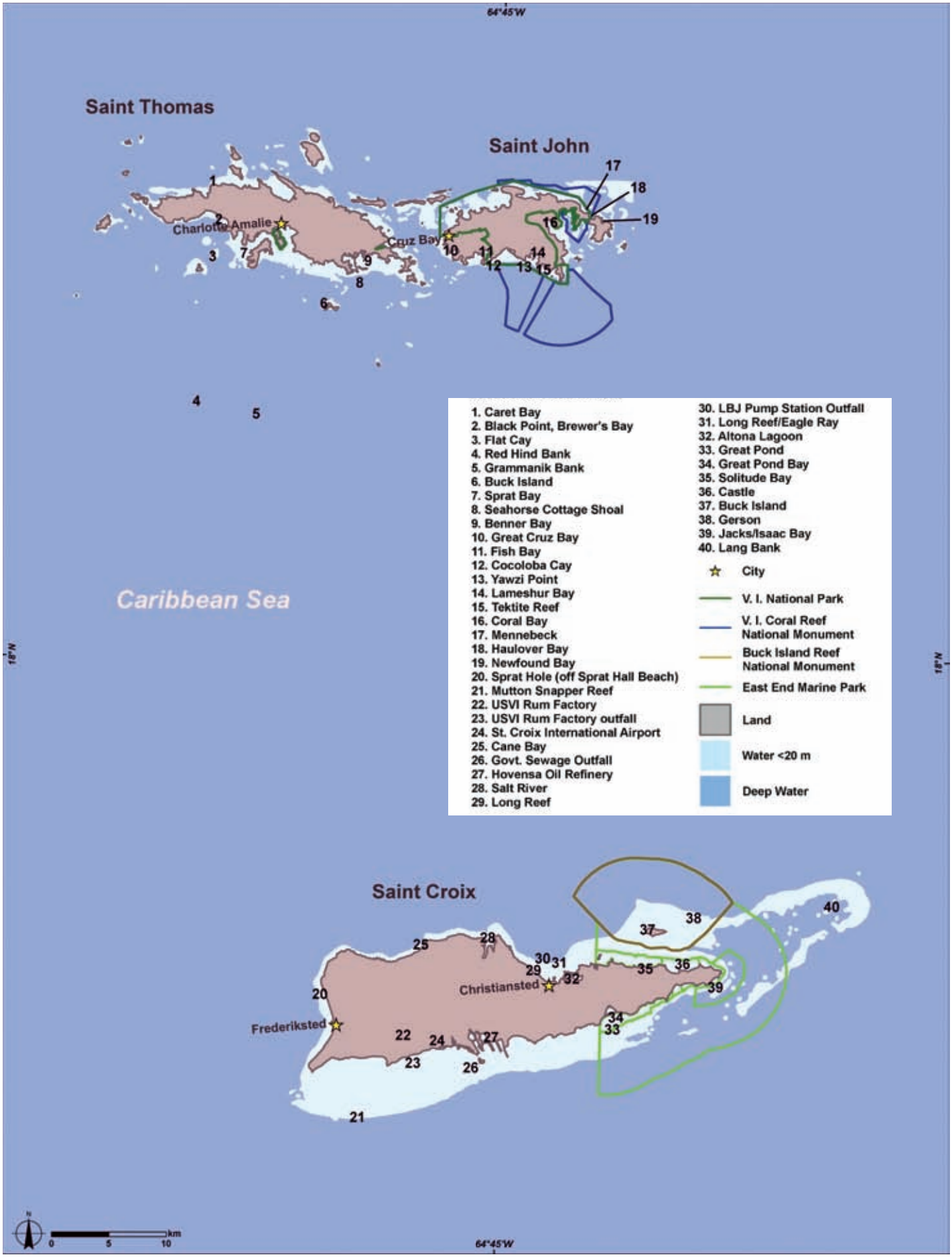

Figure USVI-1. A map of USVI showing managed areas, municipalities, and other locations of interest. (See Figure 4 for geographical context.) Map: A. Shapiro. Source: Jeffrey et al. (2005).

Research Needs

U.S. Virgin Islands	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.*	Assess the impacts of fishing on spawning aggregations and monitor their recovery after regulations are enacted, especially at Grammanik Bank off St. Thomas.
	Assess the total catch and the value of local fisheries and the number of fishermen employed.
	Investigate the viability and effectiveness of enhancement programs (e.g., use of fishery aggregating devices to remove fishing pressure away from reefs) to mitigate fishing pressure on target organisms of commercial and recreational importance.
	Investigate expansion of pelagic fisheries within user groups affected by the establishment of MPAs, including benefits to coral reef ecosystems, socioeconomic implications, and other factors.
	Compare the population status of managed reef species in representative coral reef areas in St. Croix and St. Thomas, and identify environmental and anthropogenic factors that may explain differences in population dynamics of these species.
	Characterize fish assemblages on gorgonian dominated habitats and determine their importance as essential fish habitat.
Protect, conserve, and enhance the recovery of protected, threatened, and other key species.	Identify factors that promote or inhibit the recovery of key species and identify those factors which can be managed.
	Queen Conch, Spiny Lobster, 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 patterns, and ontogenetic movement patterns of conch, lobster, and octopi in specific locations.
Evaluate and improve the effectiveness of MPAs as a fisheries management tool. *See Jurisdiction-Wide Section for additional research needs.*	Evaluate the level of enforcement and assess what effect increased enforcement would have on juvenile reef fish stocks and reef habitat.
	Quantify abundance and size structure of different life stages of commercially and ecologically important fish and invertebrate species, coral condition, and major reef processes (e.g., herbivory and recruitment) within and outside protected areas in Buck Island Reef National Monument, Virgin Islands Coral Reef National Monument, the St. Croix East End Marine Park, St. Thomas Marine Conservation District, Cas Cay/Mangrove Lagoon Marine Reserve, St. James Marine Reserve, and the Salt River Bay National Historical Park and Ecological Preserve.
	Determine whether user groups displaced by the establishment of MPAs have shifted to pelagic fish species.
	Evaluate the efficacy of the marine reserves in St. Thomas and determine if additional management measures are necessary.
	Determine if existing managed areas are facilitating the recovery of protected, threatened, and other key species including, conch, grouper, and lobster.
	Assess the costs and benefits of the Marine Conservation District on the commercial fishing community of St. Thomas.

U.S. Virgin Islands	FISHING
Management Objective	***Research Need***
Develop and support aquaculture projects that minimize impacts to coral reef ecosystems, fishery stocks, and existing fishing communities.	Determine the viability of restocking populations of commercially and recreationally important reef species to aid in their recovery.

U.S. Virgin Islands	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.*	Quantify the impacts of sewage and sedimentation associated with accelerated coastal development and assess temporal changes in the abundance of key organisms, such as macroalgae and corals.
	Quantify the impacts on coral reef ecosystems of effluents from Cruzan Rum Distillery and Hovensa Oil Refinery in St. Croix.
	Quantify the impacts of run-off or effluents from land fills, rum distilleries, and other industrial effluents on sensitive habitats (e.g., Mangrove Lagoon).
	Develop internal circulation models for USVI to understand and predict the fate and effect of nutrients and other pollutants.
	Investigate the effects of sewage and sedimentation on USVI coral reefs. Adapt the GIS-based sediment delivery model developed for St. John for application to St. Croix and St. Thomas and implement the model to predict effects of future coastal development.
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 to reduce or eliminate the highest priority sources of pollution and evaluate the effectiveness of implemented measures (e.g., erosion and sediment control regulations).
	Determine the effectiveness of upgrading regional primary sewage treatment facilities and monitor the long-term effects of upgrading on water quality and coral reef ecosystems.
	Evaluate the role of coastal wetlands in reducing contaminants before they are released into the marine environment.

U.S. Virgin Islands	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.*	Investigate the effects of oil pollution, cruise ship discharge, sedimentation (and resuspension), and other factors and assess whether they offset the benefits associated with designation of MPAs.
	Investigate the impacts of vessel traffic, including cruise ships, and the lack of designated anchorages on coral reef ecosystems in St. Thomas and St. Croix.
	Investigate changes in coastal land use and benthic habitat over time to determine whether and how increased development in certain areas has impacted coral reef ecosystems.
Balance resource use to minimize user conflicts, provide equitable uses, and ensure optimal benefits to present and future generations.	Examine coral reef-related recreation and tourism links to the economy and the environment.
	Determine the effectiveness of management efforts, such as the installation of mooring buoys in seagrass and reef areas and the elimination of fishing by assessing changes in seagrasses, macro and turf algae, and coral cover.
	Assess the costs and benefits of protective management tools (e.g., the installation of mooring buoys in seagrass and reef areas and the elimination of fishing) on the community.
Protect, conserve, and enhance the recovery of protected, threatened, and other key species. *See Jurisdiction-Wide Section for additional research needs.*	Acroporids
	Identify critical habitat for ***Acropora*** spp. in USVI, including the historical and current distribution of acroporid populations, and identify factors that contributed to the expansion/reduction in the spatial extent of these corals.
	Sea Turtles
	Determine the impact of rum distilleries and other anthropogenic impacts on sea turtles, their food sources (e.g., sponges and grasses), and their habitat.
Reduce the impacts from and restore habitat damaged by vessel anchoring and groundings.	Investigate the impacts of recreational vessel anchoring to benthic habitats to determine whether management measures, such as the installation of mooring buoys, are necessary.
	Assess the damage of large vessels (e.g., propeller damage) on the shallow water habitats of St. Thomas.
	Quantify the impacts of ferry and recreational vessel groundings.

U.S. Virgin Islands	COASTAL USES
Management Objective	***Research Need***
Restore injured and degraded coral reef habitat.	*See Jurisdiction-Wide Section for research needs.*
Manage coral reef ecosystems and their uses in a holistic manner. *See Jurisdiction-Wide Section for Additional Research Needs.*	Develop and evaluate ecosystem or trophic models for use in ecosystem management. Identify the connectivity of resources between eastern Puerto Rico and northern USVI, focusing on larval dispersal and movement of reef fish species that travel long distances to spawning aggregations (i.e., grouper and snapper).
	Identify the connectivity of resources between the British Virgin Islands and USVI to inform management practices that address the sharing of resources.
	Characterize interactions among reefs, mangroves, and seagrass beds and how deterioration of these contributes to changes in reef communities.
Evaluate and improve the effectiveness of MPAs as a management tool. *See Jurisdiction-Wide Section for additional research needs.*	Evaluate the ecological impacts of the de facto marine reserve (no transit zone) off the oil refinery in St. Croix.
	Conduct socioeconomic studies of recreational and commercial user groups affected by closures and restrictions in East End Marine Park.

U.S. Virgin Islands	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. *See Jurisdiction-Wide Section for additional research needs.*	Investigate the status of known invasive species within coastal waters of USVI, and establish a response network and protocol in the event of new invasive species introductions.

U.S. Virgin Islands	CLIMATE CHANGE
Management Objective	***Research Need***
Minimize the effects of climate change on coral reef ecosystems. *See Jurisdiction-Wide Section for additional research needs.*	Develop and implement a response plan to address bleaching events in the USVI.

U.S. Virgin Islands	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.*	Determine the spatial and temporal distribution and abundance of the different coral diseases present in the USVI and their effects on affected corals and overall reef condition (e.g., species diversity and community composition).
	Examine coral community structure and impacts of disease and predation on coral reefs found in deeper areas such as Red Hind Bank Marine Conservation District.
	Inventory which diseases are present, their associated pathogens, and possible correlations with environmental factors such as temperature and nutrients.
	Assess the recovery of coral species impacted by disease (particularly acroporids).
Reduce impacts to and promote restoration of coral reef organisms affected by extreme events.	Examine the role of hurricanes in the decline of *Acropora* and how hurricanes influence patterns of recovery, including synergies with other stressors.
	Develop a model to predict the potential impact of storms to coral habitats including, factors such as spatial extent and degree of storm damage; storm strength, speed, and path; and benthic habitat characteristics.
	Identify anthropogenic factors that need to be addressed to enhance the recovery of reefs following hurricane and storm damage.
	Develop a system of coral mariculture farms as a strategy to maintain propagule sources through a wide geographic range and evaluate the value of these sources of corals for use in coral reef restoration projects in response to storms and ship groundings.

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.