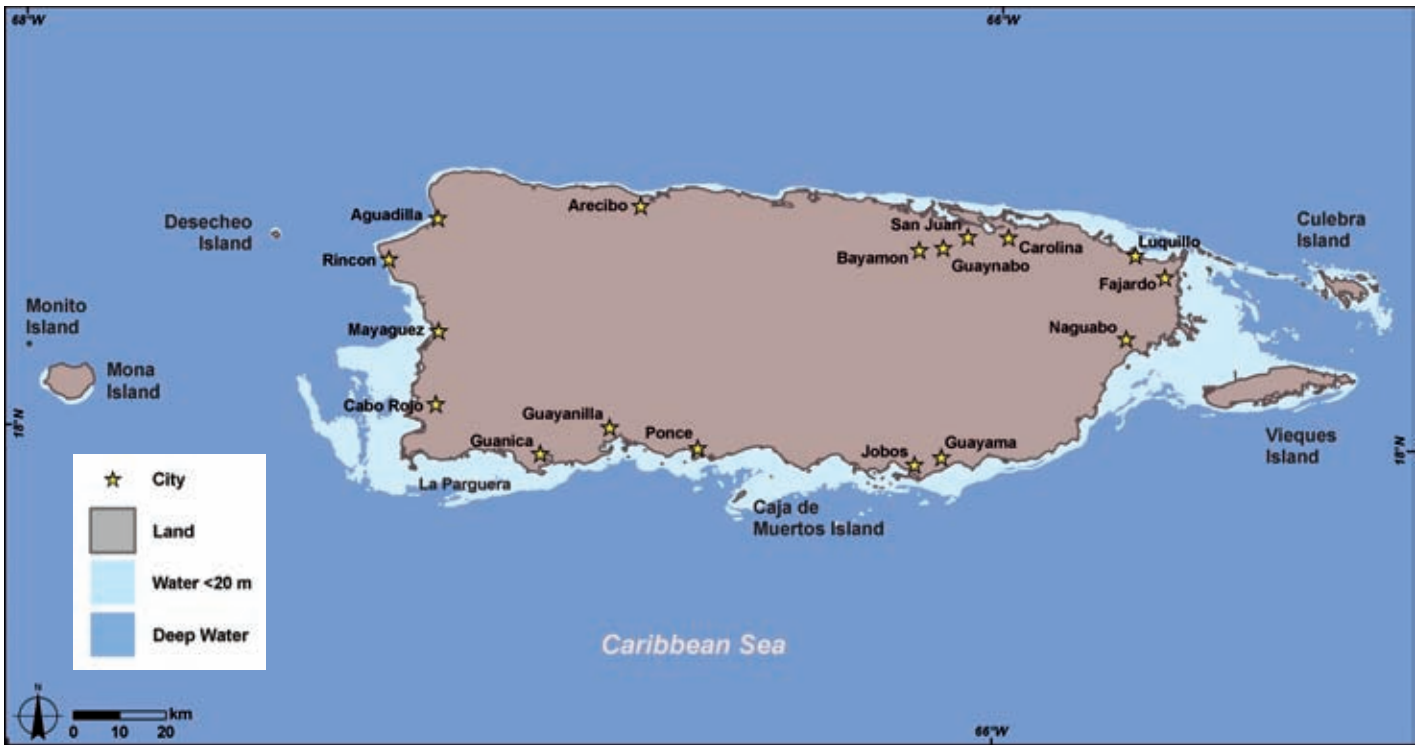

Figure PR-1. A map of Puerto Rico. (See Figure 4 for geographical context.) Map: A. Shapiro. Source: Garcia-Sais et al. (2005).

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.