GUAM

Guam, a U.S. territory located at 13° 28' N, 144° 45' E, is the southernmost island in the Mariana Archipelago (Figure GUAM-1). It is the largest island in Micronesia, with a land mass of 560 km^2 and a maximum elevation of approximately 405 m. It is also the most heavily populated island in Micronesia with a population of about 164,000 people (est. July 2003). The northern portion of the island is relatively flat and consists primarily of uplifted limestone. The island's principle source aquifer "floats" on denser sea water within the limestone plateau; and is recharged from rainfall percolating through surface soils (Guam Water Planning Committee 1998). The southern half of the island is primarily volcanic, with more topographic relief and large areas of highly erodible soils (Young 1988). This topography creates a number of watersheds throughout the southern areas which are drained by 96 rivers (Best and Davidson 1981).

The condition of Guam's coral reefs (including fringing reefs, patch reefs, submerged reefs, offshore banks, and barrier reefs) varies considerably, depending on a variety of factors including geology, human population density, degree of coastal development, levels and types of marine resource uses, oceanic circulation patterns, and frequency of natural disturbances (e.g., typhoons and earthquakes). Many of Guam's reefs have declined in health over the past 40 years. The average live coral cover on the fore reef slopes was approximately 50% in the 1960s (Randall 1971), but by the 1990s had dwindled to less than 25% live coral cover and only a few having over 50% live cover (Birkeland 1997). Still, in the past, Guam's reefs have recovered after drastic declines. For example, an outbreak of the crown-of-thorns starfish, *Acanthaster planci*, in the early 1970s reduced coral cover in some areas from 50 to 60% to less than 1%. Twelve years later, greater than 60% live coral cover was recorded for these areas (Colgan 1987). A more distressing indicator of the condition of Guam's coral reefs is the marked decrease in rates of coral recruitment.

Guam's coral reefs are an important component of its tourism industry. The reefs and the protection that they provide make Guam a popular tourist destination for Asian travelers (70 to 80% from Japan). According to the Guam Economic Development Authority, the tourism industry accounts for up to 60% of the government's annual revenues and provides more than 20,000 direct and indirect jobs. Guam hosted nearly 1 million visitors in 2003 (GVB 2004).

Traditionally, coral reef fishery resources formed a substantial part of the local Chamorro community's diet and included finfish, invertebrates, and sea turtles (Amesbury and Hunter-Anderson 2003). Today, coral reef resources are both economically and culturally important. Reef fish, although somewhat displaced from the diet by westernization and declining stocks, are still found at the fiesta table and at meals during the Catholic Lenten season. Many of the residents from other islands in Micronesia continue to include reef fish as a staple part of their diet (Amesbury and Hunter-Anderson 2003). Sea cucumbers, sea urchins, mollusks, marine algae, and a variety of crustaceans are also eaten locally. In addition to the cash and subsistence value of edible fish and invertebrates, reef-related fisheries are culturally important as family and group fishing is a common activity in Guam's coastal waters.

Over 10% of Guam's coastline has been set aside in five Marine Preserves: Tumon Bay, Piti Bomb Holes, Sasa Bay, Achang Reef Flat, and Pati Point. The preserves were established by local law in 1997 in response to decreasing reef fish stocks, but were not fully enforced until 2001. Fishing activity is restricted in the preserves with limited cultural take permitted in three of the five areas. The preserves are complemented by the War in the Pacific National Historical Park; Ritidian NWR; the two Naval Ecological Reserve Areas, Orote and Haputo; and the Guam Territorial Seashore Park. While the five marine preserves are enforced, the other areas currently have limited management and enforcement. [12]

12 Introductory material was taken, with slight modifications, from Porter et al. (2005).

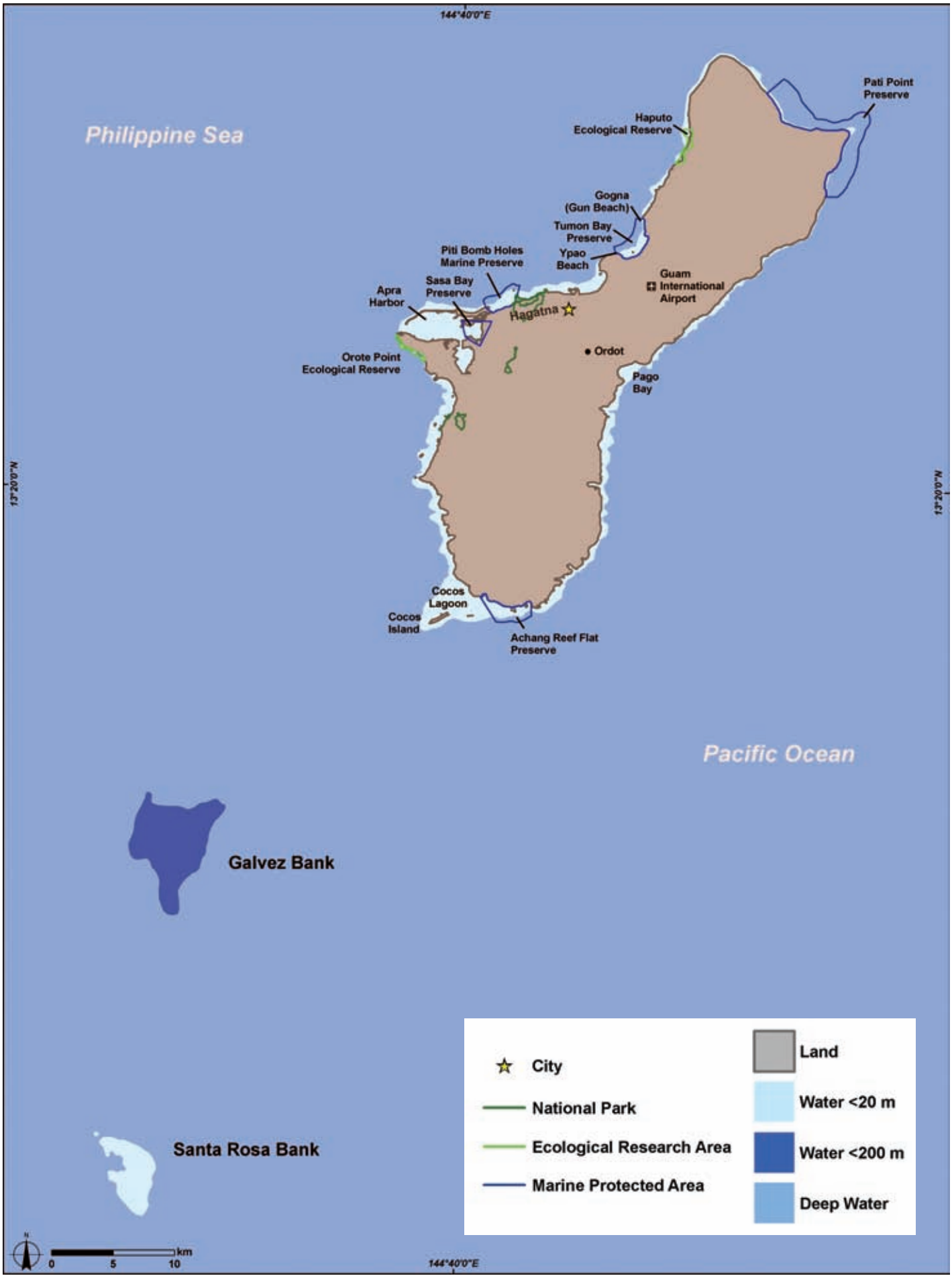

Figure GUAM-1. Locator map for Guam. (See Figure 5 for geographical context.) Map: A. Shapiro. Source: Porter et al. (2005).

Research Needs

GUAM	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.*	Analyze fisheries stock assessment data, including creel surveys and in situ visual assessments, to determine the condition of different functional groups (e.g., herbivores, detritivores, and piscivores) and determine possible causes of any community shifts, if present.
	Study the role of soft corals as reef fish habitat.
Evaluate and improve the effectiveness of MPAs as a fisheries management tool. *See Jurisdiction-Wide Section for additional research needs.*	Evaluate the effectiveness of marine preserves in enhancing fish populations in adjacent areas (i.e., spillover) using inshore creel and participation surveys.
	Assess, inside and outside MPAs, the relationship between herbivorous fishes and algal abundance, composition, chemical defense, and other environmental factors on Guam reef flats.

GUAM	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.*	Model water circulation patterns around reefs and adjacent inshore habitats.
	Develop a digital watershed atlas for Guam.
	Develop a GIS-based erosion potential model to estimate sediment delivery to estuarine and coral reef environments of southern Guam.
	Determine the status of the waters found in each of Guam's 20 watersheds.
	Conduct primary screening for chemicals of environmental concern in Guam's coastal waters.
	Conduct screening for heavy metals in marine organisms in Pago Bay into which the Ordot Dump Watershed drains.
	Evaluate the effectiveness of using soft corals as bioindicators of persistent contaminants in Guam's coastal waters.
Improve water quality by reducing land-based pollutant inputs and impacts on coral reef ecosystems. *See Jurisdiction-Wide Section for additional research needs.*	Study the effects of tree planting and erosion control measures in reducing pollution from Fouha Watershed.

GUAM	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.*	Characterize and assess the major threats to and use of Guam's coast.
	Conduct an assessment of all recreational activities along Guam's coastline and their effects on coral reef ecosystems, including seagrass beds.
	Determine the effects of motorized personal watercraft on coral reef ecosystems.
	Evaluate the effectiveness of the implementation of the New Seashore Reserve Plan.
	Determine the effectiveness of the existing public awareness and outreach materials and programs.
Balance resource use to minimize user conflicts, provide equitable uses, and ensure optimal benefits to present and future generations.	Expand Guam's coral reef valuation study to better capture the value of the coral reef to Guam's traditions and culture.
	Assess the societal costs of coral reef ecosystem degradation.
	Conduct a feasibility study of instituting a recreational user fee for management and monitoring parameters.
Restore injured and degraded coral reef habitat. *See Jurisdiction-Wide Section for additional research needs.*	Assess the effectiveness of coral restoration efforts that are coupled with watershed restoration, MPA designation, and pollution abatement programs.
Protect, conserve, and enhance the recovery of protected, threatened, and other key species.	Characterize the role of protected species (i.e., marine mammals, sea turtles, and birds) in coral reef ecosystems and the threats impacting these species, and develop measures to enhance their conservation.
Manage coral reef ecosystems and their uses in a holistic manner. *See Jurisdiction-Wide Section for additional research needs.*	Characterize the size, condition, productivity, and seasonal changes in seagrass beds and impacts associated with human activities.
Evaluate and improve the effectiveness of MPAs as a management tool. *See Jurisdiction-Wide Section for additional research needs.*	Conduct a study of the non-extractive value of icon species in marine preserves.
	Assess the connectivity and replenishment among the offshore banks and the island of Guam with particular attention to the role of marine preserves.
	Identify additional protections needed to provide long-term stability and resilience of Guam's coral reef ecosystems.
	Assess socioeconomic factors influencing the effectiveness of Guam's MPAs.

GUAM	INVASIVE SPECIES
Management Objective	***Research Need***
Control or eradicate alien and native invasive species that have the potential to cause damage to coral reef ecosystems. *See Jurisdiction-Wide Section for additional research needs.*	Develop protocols and tools to control the growth of the native green alga, *Enteromorpha clathrata*, in the intertidal zone of Tumon Bay and East Agana Bay.
	Assess the population and distribution of the native invasive red algae, *Gracilaria salicornia* and *Acanthophora spicifera*, in Pago Bay and in reefs of Tumon Bay, East Agana Bay, and Cocos Lagoon; and develop protocols and tools to control the growth of the algae.

GUAM	CLIMATE CHANGE
Management Objective	***Research Need***
Minimize the effects of climate change on coral reef ecosystems. *See Jurisdiction-Wide Section for additional research needs.*	Assess and quantify the impacts of bleaching on corals during and after bleaching events.
	Identify areas to protect to ensure long-term stability of coral reef ecosystems.

GUAM	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.*	Conduct a baseline assessment of coral diseases.
	Establish a protocol for rapidly identifying, assessing, and mitigating disease epizootics, bleaching episodes, and predator outbreaks.
Reduce the occurrence and intensity of harmful algal blooms.	Investigate the relationship between cyanobacteria, pollution, and reef condition, including elements (e.g., nutrients, iron, and temperature) which may trigger or cause cyanobacterial blooms.