STATUS OF THE CORAL REEFS OF GUAM

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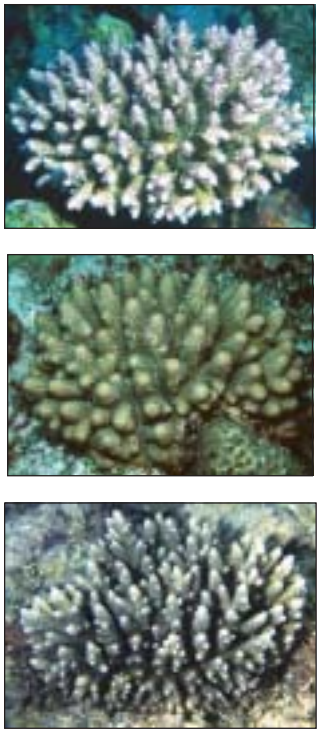
Introduction

Guam is a U.S. territory located at 13° 28' N, 144° 45' E and is the southernmost island in the Mariana Archipelago. It is the largest island in Micronesia, with a land mass of 560 km^2 and a maximum elevation of approximately 405 m. The northern portion of the island is relatively flat and consists primarily of uplifted limestone. The southern half of the island is primarily volcanic, with more topographic relief and large areas of highly erodible lateritic soils.

The island possesses fringing reefs, patch reefs, submerged reefs, offshore banks, and a barrier reef surrounding the southern shores. The reef margin varies in width, from tens of meters along some of the windward areas, to well over 100 meters. The combined area of coral reef and lagoon is approximately 69 km^2 in nearshore waters between 0-3 nmi, and an additional 110 km^2 in federal waters greater than 3 nmi offshore (Hunter 1995).

Guam lies close to the center of coral reef biodiversity. Sea surface temperatures range from about 27-30°C with higher temperatures measured on the reef flats and in portions of the lagoons. According to G. Paulay (pers. comm.), 4 seagrass species, 306 marine macroalgae species, 403 stony and 77 soft coral species, 128 sponge species, 295 foraminiferan species, 53 flatworm species, 1,673 mollusk species, 104 polychaete species, 840 arthropod species, 194 echinoderm species, 117 ascidian species, 3 sea turtle species, and 13 marine mammal species have been recorded from Guam's coral reef ecosystems. Myers and Donaldson (in press) list 1019 species of shorefishes (epipelagic and demersal species found down to 200 m) from the islands of the Southern Marianas, making no distinction among Guam, Rota, Tinian, and Saipan.

Figure 268. Common Acropora species (Photo: Gustav Paulay).



Coral reef fisheries include both finfish and invertebrates. These fisheries are both economically and culturally important. Reef fish have been historically important in the diet of the population, however, westernization and declining stocks have reduced the role of reef fish overall. Many of the residents from other islands in Micronesia continue to include reef fish as a staple part of their diet. Sea cucumbers, a variety of crustaceans, molluscs, and marine algae 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.

Condition of Coral Reef Ecosystems

The condition of Guam's reefs is variable, ranging from excellent to poor, depending on adjacent land and land-use characteristics, accessibility, location of ocean outfalls and river discharges, recreational pressures and oceanic circulation patterns. Due to the limestone nature of northern Guam (hence no natural lakes or streams), the northern reefs are generally in better condition than those affected by erosion and sedimentation in the south. Aquifer discharge and associated eutrophication effects are evident on some northern reefs. Coral cover and diversity are generally highest on the northeastern (windward) exposures, with a variety of *Acropora* species dominating the reef crest and slope (Fig. 268). The eastern reefs along the central and southern portions of the islands are heavily affected by sedimentation and freshwater runoff during the rainy season that occurs from June through November. During this period, terrigenous sediments often accumulate on the reef flats and reef slope.

During the early 1990s, a road project along the southern shores of the island resulted in particularly heavy sedimentation of a 10 km section of

fringing reef, killing all the coral. Most of the fringing reefs along the southern part of the island, continuing up along the southwestern shores are in poor to fair condition.

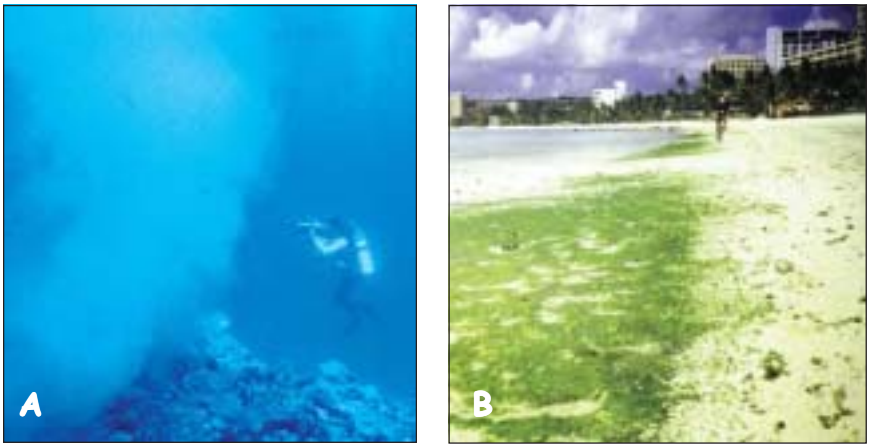


Figure 269. Sewage from ocean outfalls (A) contributes to euthrophication (B) algae washed up on tourist beaches (Photo: Bob Richmond and Donna Turgeon).

Apra Harbor is off the central part of the island, on the Philippine Sea (western side). The harbor is home to a large Navy Base and is also the location of the port facilities. Both fringing reefs and shoals (patch reefs) are found within the harbor, and those closest to the harbor mouth are in relatively good condition. Further into the harbor, corals and reefs have been impacted by freshwater runoff, sediment and thermal discharges from the Island's main power generation facilities.

Agana, Tumon, and Piti Bay (also known as Tapungun) Bays have heavy human use. The inner areas of these bays are in relatively poor condition, affected by discharges from land as well as the impacts of recreational activities. Agana and Tumon Bays are centers for tourism. East Agana Bay serves as a main site for commercial watercraft (jet ski) operations. West Agana has a sewage treatment plant built on the reef flat that had a pipe discharge in 60 ft of water (Fig. 269). Infrastructure upgrades presently underway are expected to improve water quality within these bays, and limited/experimental restoration activities are planned.

Coral and other Invertebrates – Coral cover on the good-to-excellent reefs ranges from 35-70%, while the most damaged sites have less than 10% coral cover and fleshy algae and sediment dominate the substratum. Data compiled by Birkeland (1997b) found transect data taken in the 1960s generally showed reefs with over 50% live coral cover, but only 7 of 113 transects measured in the 1980s-1990s had over 50% live coral cover, while 88 had less than 25% live coral. In surveys taken off the Northern District sewer outfall in the early 1990s, not only was coral cover below 25%, most of the live coral was restricted to a few species, particularly the rapidly growing, common lobe and plate coral [*Porites* (= *Synarea) rus*], with indications of an overall reduction in coral species diversity.

Figure 270. Crown-of-thorns starfish (Photo: Donna Turgeon).

Recruitment data also support the observations of an overall decline in coral reef condition. In 1979, 278 coral recruits were found from 525 fouling plates placed out on reefs around Guam (0.53 corals/plate), while data collected in 1989 and 1992 found only 0.004 and 0.009 recruits/plate respectively (Birkeland pers. comm.).

Coral diseases, the competitive black encrusting sponge *Terpios hoshinota*, and coralline algal lethal orange disease (CLOD) have all been observed on Guam's reefs, but none seem to be at a critical level at this time.

While the crown-of-thorns starfish occurred in small to moderate numbers over the past few years, a greater abundance of juveniles now is cause for concern about the potential for a future outbreak (Fig. 270).

Algae – Blue-green algae that recently are overgrowing coral have been a concern at some sites.

Fish – Fish populations have declined 70% over the past 15 years, as documented by the Guam Division of Aquatic and Wildlife Resources.

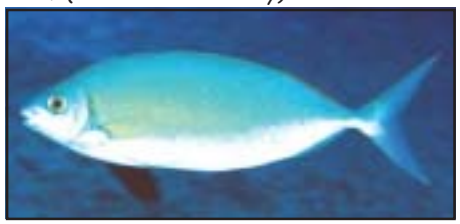
Total day and night finfish harvest for 1985 was estimated at 151,700 kg. In 1999, this number had dropped to 62,689 kg. Acanthurid fishes (surgeons), important reef herbivores, accounted for approximately 23% of the total catch in 1999 (Fig. 271). Catch-per-unit-effort has dropped by over 50% since 1985, and large reef fish are rare. Seasonal runs of juvenile rabbitfish (Fig. 272), a local favorite, were considered poor for the 1997-1999 seasons, but numbers increased last year. Regulations and protected reserves are being enforced to deal with this problem. SCUBA spear fishing and gill netting are still allowed on Guam, which is contrary to the prevailing conservation ethic. Legislation is being proposed to regulate these fishing methods.

Figure 271. Two species of Acanthurid fish from Guam (Photo: Gustav Paulay).

Water Quality – Increased stormwater runoff from an airport expansion project, new roads, hotels, shopping centers and golf courses resulted in reduced coastal water quality, especially in bays and areas of restricted water circulation. The salinity of waters over coastal reefs was found to drop below 28 ppt after periods of rainfall during summer coral spawning, which results in reproductive failure (Richmond 1996). Stormwater collection passes into sewer lines, and during heavy rain the sewage treatment plants divert the wastewater directly into the ocean outfall pipes, often with only primary treatment. Three of the Island's outfall pipes discharge within 200 m of the shoreline, in depths of 20-25 m and in areas where corals are found. Extension of the Northern and Central District outfalls into deeper waters further offshore is planned.

A variety of pollutants has been found in the sediments of Apra Harbor, including PCBs, heavy metals, and PAHs. A harbor dredging project is in the planning stages and poses a concern for surrounding reefs. Agrochemicals are also a concern for coastal waters.

Figure 272. Two species of rabbitfish from Guam (Photo: Gustav Paulay).



Coastal Populations and Reef Economics

The island underwent a development boom in the late 1980s and early 1990s, resulting in a 15.4% increase in the past ten years to its current population of 154.8 thousand (U.S. Census Bureau 2000). Additionally over 1.4 million tourists visit the island each year (OIA 1997).

Tourism, primarily from Japan and other Asian countries, is the largest industry on island. In 1990, tourist expenditures contributed $936 million to Guam's economy (UNESCAP 2002). Hence, coral reefs and associated marine recreation are of substantial economic value, contributing over $80 million per year.

Guam's coral reef fisheries, both finfish and invertebrates, are economically and culturally important. The annual ex-vessel value of commercial fisheries landings on Guam is currently $1.3 million (NMFS 2001). Marine algae also are eaten locally.

Environmental Pressures on Coral Reefs

Human Stresses – Sedimentation is the major anthropogenic problem for the central and southern reefs. For the Ugum River Watershed, soil erosion was estimated at 176,500 tons/km^2/year (DeMeo 1995). Forty six percent of this was attributed to sloped roads, while 34% was contributed from badlands. Ugum Watershed erosion rates doubled from 1975 to 1993 (from 1,547,250 to 3,039,750 tons/km^2/year), from new road construction and development projects. Sediment accumulation on reefs has been docu-

Figure 273. Sediment plume in Southeast Guam extends out towards a reef (Photo: Gerry Davis).

mented to substantially reduce both coral diversity and abundance (Fig. 273, Randall and Birkeland 1978).

Fish populations and catch-per-unit-effort have measurably declined since data collection began in 1985 (Fig. 274). Fishing practices, including the use of unattended gill nets, bleach, SCUBA spearfishing, and fish traps have contributed to the problem. However, habitat loss due to sedimentation, pollution, and physical damage has also been responsible for reduced fish populations.

With over 1 million tourists visiting Guam each year, many from countries where a coral reef conservation ethic is not fully developed, damage to reefs is inevitable. In addition to impacts from SCUBA divers and snorkellers, underwater walking tours using surface-supplied equipment and a large number of personal watercraft (jet skis) have affected reefs and water quality. A coastal use zoning law called the Recreational Water Use Master Plan was passed into law to address these problems but it needs enforcement support and updating to cover new activities and areas of concern.

Groundings of fishing vessels, recreational watercraft, and ships carrying cargo and illegal immigrants have resulted in localized damage to reefs.

Guam's main power generation facilities are located on Cabras Island, in the northern portion of Apra Harbor (Fig. 275). Water that used to cool the generators has killed coral. Cleaning chemicals have also been discharged, with subsequent impacts on local coral populations.

Natural Stresses – Guam is in the tropical Pacific 'typhoon belt,' and experiences an average of one substantial tropical storm or typhoon each year. The coral reefs are of major value in providing protection from storm waves and associated coastal erosion.

Climate Change and Coral Bleaching – Coral bleaching has been documented to coincide with elevated water temperatures associated with El Niño events. Potential climate change impacts include inundation of low lying coastal areas, and increased sedimentation from drought followed by heavy rains.

Coral bleaching has been observed at a number of sites including within Apra Harbor and in Piti Bay just to the north. Both scleractinians and alcyonarians have been affected, with a few pockets of high mortality. However, the 1998 bleaching event in the Pacific did not cause widespread coral mortality in Guam.

Current Conservation Management

Mapping – Guam needs coral reef habitat mapping. With current funding levels, NOAA habitat mapping of Guam's coral reef ecosystems is planned to begin in 2002.

Monitoring – In FY00, NOAA awarded a grant to the Guam Division of Aquatic and Wildife Resources (DAWR) for water quality monitoring at 30 stations (10 freshwater, and 20 marine) within the Agana and Tumon sub-watersheds. After reviewing existing data and survey work, sites identified as high risk for altered water quality were sampled for a battery of key microbial, chemical, and physical water quality parameters.

Figure 274. Total fisheries harvest in Guam, 1985-1996 (Modified from Birkeland 1997).

These two watersheds are located in urban-use areas (i.e., the primary hotel area and a major portion of Guam's business district), and are high human-contact zones (recreationally, commercially, and consumptively).

This project will be the basis for the development of future long-term coral reef monitoring strategies and sound management approaches to preserve and restore Guam's coral reef systems. In FY01, Guam continued its water quality monitoring of urbanized bays and initiated coral cover monitoring.

The University of Guam Marine Laboratory has ongoing coral reef monitoring programs, in collaboration with the DAWR and the Guam Environmental Protection Agency (GEPA). The Marine Lab database dates back to 1970, and focuses on the marine biota. The DAWR collects data on fish catch through creel censuses, while GEPA has routine water quality sampling programs. A joint educational outreach program exists as a collaboration among the three aforementioned groups as well as the Guam Coastal Management Program.

Figure 275. Guam's main power plant (Photo credit: Donna Turgeon).

MPAs and No-take Reserves – There are two Federal (War in the Pacific National Historical Park and Guam National Wildlife Refuge) and 11 territorial MPAs. Five of the territorial MPAs are no-take marine reserves (Pati Point, Tumon Bay, Piti Bomb Holes, Sasa Bay, and Achang Reef Flat Preserves) representing approximately 12% of the coastline and 28% of the coral reefs. Established in 1998, all five marine reserves are under full enforcement.

In 1986 two ecological no-take reserves were established as mitigation. These reserves would add 2% more coastline and 5% more reef area to the total but they have not been enforced. An ocean current assessment is presently underway at the Pati Point Preserve to determine the areas most likely to be seeded by larvae originating from this preserve. Fish abundance, size, and diversity data are being collected to document the value of the preserves and the success of the program.

Government Policies, Laws, and Legislation

Guam's natural resource legislation protecting coral reef resources is presented in two laws. The prevailing legal authority is the Guam Legislature or statutory law. These laws are relatively old and have not been revised in the past 20 years. For this reason, although it is specifically referenced, coral is considered a fish. When these laws were created, the only group likely to impact reefs were fishermen. Guam's statutory laws regulate the taking of coral and have penalties for fishing damage.

Coral can be taken only under a permit issued by the Department of Agriculture. But no permits have been issued since 1982. The law has provisions for both personal and commercial take but limits such permits to five days and requires specific collecting locations be identified.

This same title (5 GCA chapter 63) also regulates fishing net mesh sizes used in coastal waters as well as illegal chemical and explosives. In addition, the legislature also delegated the authority and responsibility of management and oversight for all aquatic and wildlife resources to the Department of Agriculture. Recently, the Department of Agriculture's DAWR used its regulatory authority to amend and expand the existing fishing regulations.

Title 16 regulates the size restrictions and seasons for aquatic fauna. Also contained in these regulations is an expanded definition section which now properly defines coral and other freshwater and marine fauna types, with a section preventing transplanting of corals or other aquatic fauna.

A major component of these new regulations are the rules governing the five newly established permanent marine preserves and maps defining their boundaries (Fig. 276). These areas define nearly 12% of Guam's coastline as no-take fisheries areas. Statutes have authority over regulations. The penalty for violating both statutes and regulations is a petty misdemeanor, with a fine of up to $500.

There are also laws that provide indirect protection to coral reefs. GEPA has local water quality standards. These fines can be charged daily and cumulatively, up to $10,000 a day.

The Seashore Protection Commission has review and approval authority over construction projects proposed within the area from 10 meters inland of the mean high tide mark out to a depth of 60 ft. This is a 21-member government review group who look at all the various impacts. Once this group reviews the proposal for a project, their comments are submitted to a commission made up of appointed members of the public for consideration of approval or rejection.

This commission has not been very successful in upholding their responsibilities. Guam still needs laws to address ship groundings and ways to assess damage and levy fines for large-scale human induced coral reef damage. It is also in the process of converting the misdemeanor penalties to a magistrate court system that could be used to issue citations instead of requiring a court hearing to collect penalties.

Gaps in Current Monitoring and Conservation Capacity

Guam is fortunate to have a large number of technical experts in coral reef ecology, management, and policy. Three government agencies have staff dedicated to dealing with coral reef and coastal resource monitoring and protection – the DAWR, the Guam Coastal Management Program within the Bureau of Planning, and GEPA. In addition, there are two research units at the University of Guam that focus on coral reef and coastal environmental issues – The University of Guam Marine Laboratory and the Water and Environmental Research Institute. Collaboration and cooperation is high among these agencies and institutions. Funds specifically earmarked for monitoring are limited, especially for water quality monitoring. More stakeholder involvement is needed.

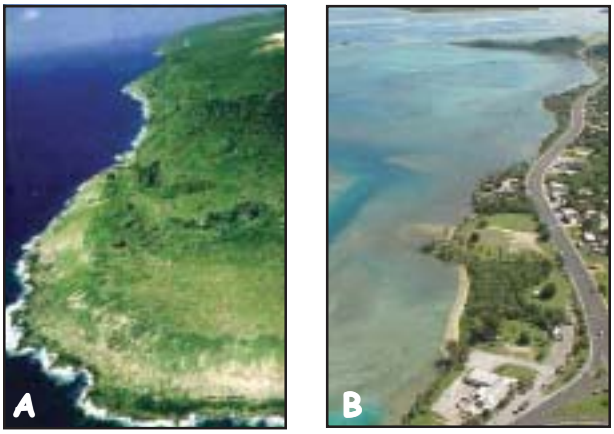


Figure 276. Pati Point Preserve (a) and Piti Bomb Holes Preserve (b) are two of the newly established MPAs (Photos: Jay Gutierrez and Danko Taborosi/WERI UOG).

Conclusions and Recommendations

In general, Guam's coastal reefs continue to decline, primarily as a result of land-based activities. Data on coral recruitment indicate significant reductions over the past two decades. Areas impacted by natural disturbances, including typhoons, crown-of-thorns outbreaks, and earthquakes are simply not recovering in specific areas. Community education initiatives have been paying off in terms of increased awareness and the political will to address reef decline is improving. However, there is far more to be done in these areas. Overfishing is still a concern, but establishing five marine reserves that formally received enforcement protection in June 2000 is a very positive step forward. Enforcement of existing laws and environmental regulations is still a major problem. More infrastructure improvements and erosion control programs are needed to reduce the land-based stresses on reefs.