

12. STATUS OF THE CORAL REEFS IN MICRONESIA AND AMERICAN SAMOA: US AFFILIATED AND FREELY ASSOCIATED ISLANDS IN THE PACIFIC

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ABSTRACT

The coral reefs in this region are comparatively healthy, although there was extensive damage to the reefs in Palau during the coral bleaching event in 1998 and levels of human pressures are increasing, but not to the levels of reefs in nearby Asia. These countries and territories are affiliated with the USA and are currently included in many of the initiatives through the auspices of the US Coral Reef Task Force for improved mapping, monitoring and training to the eventual aims of strengthening coral reef conservation. Thus there has been a major expansion of all coral reef activities since the last report in 2000. In American Samoa, the reefs are recovering from crown-of-thorns starfish invasions, 3 typhoons, and warm water bleaching, as well as chronic human impacts around the towns and the aftermath of removing 10 shipwrecks. Fish populations, however, are not recovering at the same rate due to serious over-fishing on the populated islands. The local government has recently banned the export of 'live rock' and scuba fishing. In the Commonwealth of the Northern Mariana Islands, there was moderate coral bleaching during the summer of 2001 and the reefs continue to suffer from increased sedimentation from poor land use and over-fishing around the populated islands. There have been major advances in coral reef monitoring with considerable training and the establishment of permanent monitoring stations. Coral reefs on Guam vary from excellent to poor, depending on adjacent land activities. Those reefs under the influence of excess sedimentation from soil erosion have low coral cover. There is excellent monitoring and research capacity on Guam and the 5 MPAs established in 2000 show that corals and fish populations are recovering well, however enforcement is weak in other areas. The coral reefs of the Federated States of Micronesia are generally good to excellent, with some problems around developments on the high islands and some fishing impacts. Capacity to monitor and manage their reefs is improving, but more progress is needed before adequate areas are protected as no-take reserves. In general, the reefs of the Marshall Islands are in good condition, including those in the former nuclear test sites. The reefs near the urban areas of Majuro are stressed, but still have an abundance of fish and invertebrates. Capacity to monitor and manage their reefs previously lagged behind adjacent countries, however there has been significant recent progress in developing capacity and establishing monitoring. Palau's coral diversity is among the highest in the

world and the remote reefs are generally in good condition. Reefs closer to population centres are degraded due to sediment flows and sewage pollution, and increasing fishing pressures. Bleaching severely affected most reefs in Palau in 1998, however, monitoring is showing strong recovery and recruitment at many sites. A growing problem is sediment and dredging resulting from road development around the main island. Since the last report in 2000, the Palau International Coral Reef Center has opened with active research and education programs and is coordinating coral reef monitoring in the region for the GCRMN.

INTRODUCTION

This region contains countries, states and territories that have traditional ties with the USA. They are all participants involved in the US Coral Reef Task Force directly and through the All Islands Committee, and are constituted into a Node of the GCRMN, called the MAREPAC node, made up of American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), the Federated States of Micronesia (FSM), Guam, the Republic of the Marshall Islands and Palau, which hosts the headquarters of the Node in the Palau International Coral Reef Center. FSM, the Marshall Islands and Palau are Freely-Associated States, whereas the others are US Flag islands.

American Samoa

The Territory is a group of 5 small volcanic islands and 2 atolls in the central South Pacific Ocean. The largest and most populated island is Tutuila (142km²). The total reef area is 296km² with 85% fringing reefs, 12% of offshore banks, and 3% of atolls. The Samoan reefs have a diverse range of species: 890 fishes, 200 corals; and 80 algae, but less than reefs further west.

Commonwealth of the Northern Mariana Islands

The CNMI contains 15 islands in 2 sections, with large variations in the coral reefs between them. There are no reliable estimates of coral reef area, but there is a 417km shoreline that is potential coral habitat. The southern islands (Saipan the capital, Tinian, Agijuan, Rota, and Farallon de Medinilla) are mostly raised limestone, sloping platforms protected by barrier reefs and well-developed fringing reefs to the west. The largely uninhabited northern islands (Anantahan, Sariguan, Gugan, Alamagan, Pagan, Agrihan, Ascuncion, Maug, Uracas, and Farallon de Pajaros) are mostly volcanic, including some active volcanos, and have much less reef development.

Guam

This U.S. territory is the most southern of the Mariana Archipelago and the largest island in Micronesia (560km²). Half the island is a relatively flat uplifted limestone plateau, while the rest is primarily volcanic, with large areas of highly erodible lateritic soils. There are fringing reefs, patch reefs, submerged reefs, offshore banks, and a barrier reef to the south. The reefs vary in width from a few meters to well over 100m. The combined area of coral reef and lagoon is 69km² in nearshore waters, and an additional 110km² offshore. Guam is near the centre of coral reef biodiversity with many species: 306 macroalgae; 403 hard corals; 77 soft corals; 1,019 fishes; 128 sponges; 1,673 molluscs; 3 sea turtles; and 13 marine mammals. The coral reefs are economically and culturally important to the cash and subsistence economies.

Federated States of Micronesia

The FSM consists of the states of Kosrae, Pohnpei, Chuuk, and Yap, with each island having its own language, customs, local government, and reef tenure system. Traditional leaders (Chiefs or their equivalent) and community groups are active in traditional governance as well as western-style democracy. There are high volcanic islands surrounded by barrier reefs (Pohnpei, Chuuk) or very broad fringing reefs that are nearly barrier reefs (Kosrae, Yap). All states (except Kosrae) also include remote clusters of atolls and low coral islands, with a total shallow-water coral reef area of about 5,440km².

Marshall Islands

There are 1,225 islands and islets with 29 atolls and 5 solitary low coral islands, with a total land area of 181km². However, the Exclusive Economic Zone adds another 1,942,000km² of ocean to the Republic of the Marshall Islands. There are also 11,670km² of atoll lagoons in the atolls, varying from Kwajalein, the world's largest atoll (2,174km²) to Namdrik with only 8.4 km² of lagoon. Most of the atolls are large with many islets on the windward side, and around the deeper lagoon.

Palau

The Republic of Palau is a separate group at the end of the Caroline Islands, 741km east of Mindanao and 1,300km southwest of Guam. There are 20 larger islands and 500 small islands stretching over 700km. The biggest island, Babeldaob, is volcanic and contains the capital, Koror. The southwestern islands of Palau are 339-599km to southwest of the main archipelago. There is a 144km well-developed barrier reef with 86km on the western coast. Ngchesar and Airai islands also have barrier reefs. The total coral reef area of Palau is 1,661km². The Southern lagoon is the largest lagoon covering 500km² and has many islands including the famous 'rock islands' and marine lakes. The east coast barrier reef is less diverse with about 80% of the 150km coast having a fringing reef with limited barrier reefs, lagoons, and patch reefs to the south.

STATUS OF THE CORAL REEFS

American Samoa

The reefs have experienced a series of natural disturbances over the past two decades including a crown-of-thorns starfish (COTS) outbreak (1979); three typhoons (1986, 1990, 1991); and warm water related mass coral bleaching (1994, 2002). These impacts were most severe on the main island of Tutuila, which also has moderate levels of fishing and chronic pollution, particularly Pago Pago Harbour. The reefs of American Samoa escaped the major bleaching events that struck Fiji and (Western) Samoa over the last 3 years. In 1995, a highly efficient commercial fishery (night-time scuba fishery) became established on Tutuila, which threatened the reef fish populations on the island. Fortunately, the scuba fishery was banned in 2001. By comparison, fishing and other pressures are much lower on the other islands of American Samoa (the Manu'a Islands and two remote atolls).

Coral reef surveys on all 7 islands in the Territory showed that the coral communities on Tutuila were recovering from the disturbances by the mid 1990s. Crustose coralline algal growth was abundant and new coral recruitment was high. Surveys in 2002 report dramatic recoveries of the coral communities at most sites on Tutuila, and even the reefs

in Pago Pago Harbour are improving for the first time due to improved water quality, and the removal of 9 shipwrecks in the Harbour. However, reef fish populations on Tutuila are not recovering as well. Small coral associated fishes are recovering in parallel with the coral communities, however, the density and biomass of target fish species is very low on Tutuila compared to the Manu'a Islands, correlating with the over-fishing on Tutuila. The Manu'a Island reefs have experienced chronic pressures from COTS over many years, which has reduced coral cover, particularly on Ofu and Olosega. However, the reef fish populations are much larger than on Tutuila because fishing pressure is lower. Similarly, the corals and fishes on the two remote atolls (Rose and Swains) remain in good condition.

CNMI

There are 256 coral and 41 octocoral species, with higher diversity in the south on older, more developed reefs. Saipan's reefs are the best studied in the CNMI; the reef fronts and terraces have higher coral cover than inner reef areas, probably because lower water levels result in higher temperatures and salinity fluctuations. The coral reefs surrounding Tinian and Rota have lower coral diversity, with only 74 species of hard corals in localised coral communities. Seagrasses are found only in the extensive Saipan Lagoon and in a small area on Rota. COTS are found in low densities on most reefs in Saipan, Tinian, and Rota, and larger populations exist on the eastern side of Puntan Naftan near Boy Scout Beach on Saipan and Unai Babui on the eastern side of Tinian. Green and hawksbill sea turtles occur in the CNMI, but details of their population size or feeding habitats are unknown, although green turtles nest on most of Tinian's beaches. There are also spinner, striped and bottlenose dolphins and numerous whale species.

Sewage pollution, dredging, and sedimentation from unpaved roads and development have reduced water quality in the CNMI and smothered nearshore corals, but these are not quantified. Deforestation by feral animals has increased sedimentation on the northern islands, and Farallon de Medinilla has been used as a Navy bombing target since 1981. The CNMI are adopting stringent nutrient standards for nearshore water quality and regular monitoring is occurring on beaches of Saipan, Tinian, Rota, and Managaha. Coral bleaching was observed around Saipan in 1994, 1995 and around both Saipan and Pagan in 1997, but there are no data. Most shallow water corals as deep as 18m on Saipan, Rota, and Tinian were affected by coral bleaching during the summer of 2001. Many encrusting *Montipora* and staghorn *Acropora* coral colonies died, and more detailed assessments are proceeding.

Guam

There are a mix of excellent to poor coral reefs on Guam. The condition is directly related to adjacent land-use patterns, accessibility, location of ocean outfalls and river discharges, recreational pressure and circulation patterns. The reefs off the northern limestone end of the island are generally in better condition, with higher coral cover and diversity than those affected by erosion and sedimentation in the south. There is also some eutrophication on the reef flats from nutrients percolating through the limestone. The eastern reefs are heavily affected by sedimentation and freshwater runoff during the rainy season, when sediments wash onto the reef flats and reef slope. Road developments have caused heavy sedimentation and massive coral mortality on a 10km section of fringing reef along the southern side, where the fringing reefs are generally in poor to fair condition.

The fringing and patch reefs near Apra Harbor are in relatively good condition, but corals in the harbour have been damaged by freshwater runoff, sediment and power plant discharges. The inner areas of Agana, Tumon, and Piti Bays are also in relatively poor condition, affected by land runoff and tourism activities e.g. jet ski operations and sewage treatment plant discharges. It is expected that water quality will improve after planned upgrades to the plants and restoration activities on the shore and reefs.

There is 35-70% coral cover on the good to excellent reefs, and less than 10% cover on the most damaged sites, where fleshy algae and sediment dominate the bottom. A comparison of data from the 1960s reported most reefs with over 50% coral cover, but only 7 of the same 113 transects had 50% live coral cover (and 88 had less than 25% live coral) when measured in the 1980s and 1990s. Few coral species remain near the Northern District sewer outfall and coral cover is less than 25%. Coral recruitment has declined around Guam since 1979, when 0.53 coral recruits per plate were found on 525 fouling plates, while in 1989 and 1992 only 0.004 and 0.009 recruits were found per plate respectively.

Coral diseases, the competitive sponge *Terpios*, and coralline algal lethal orange disease (CLOD) have all been observed on Guam's reefs, but none are critical now. However, a recent increase in abundance of COTS juveniles in the late 1990s is causing concern. Recent increases in blue-green algae are also a problem as these can overgrow corals. Sedimentation rates in Fouha Bay are sufficient to 'fill' the bay approximately 8 times per year, while the bay flushed on average 4 times per year. These sediments are re-suspended during strong swells and reduce light penetration and smother corals. The community in Umatac Village has been cooperating to control the activities responsible for accelerated erosion and runoff.

Coral bleaching has been documented during El Niño events, with both hard and soft corals affected, with some high mortality. However, Guam escaped the damage in the 1998 bleaching that affected reefs further south e.g. Palau. Other potential climate change impacts include inundation of low lying coastal areas, and increased sedimentation from drought followed by heavy rains.

Federated States of Micronesia

The condition of FSM coral reefs is generally good to excellent, and most of the reefs around the low islands are excellent. On the island of Pohnpei coral cover ranged from around 20% adjacent to Sokehs channel to 70% at selected sites on the barrier reef. In 1996, coral cover around Yap was about 29%. Crustose coralline algae are abundant on all reefs. In all FSM States, the greatest threats to the reefs come from land-based developments which cause increased sediment runoff, and pollution, along with sand-mining and dredging. Water quality is good on the uninhabited atolls and the coral cover in Chuuk Lagoon is indicative of good water quality. Dredging and filling for building roads, causeways, ports, and airfields over coral reefs have degraded water quality on Kosrae, and on some of the other high islands.

The potential for sea level rise from global warming to inundate the low lying areas is causing concern on the low islands and atolls of FSM. Likewise any increases in tropical storms are also a worrying issue. A typhoon in 1990 passed over remote reefs in Pohnpei State and picked up massive coral heads from the lagoon and threw them on the reef flat,

crushing the corals. FSM reefs have experienced some bleaching, but information is limited. Efforts to reduced deforestation on Pohnpei, Kosrae and Yap are being made to control erosion and sedimentation.

Marshall Islands

The reefs are generally in good condition with those around Majuro showing signs of stress. RMI biodiversity consists of about 860 species of reef fishes, 362 hard and soft corals, 40 sponges, 1,655 molluscs, 728 crustaceans and 128 species of echinoderms. There are also 5 species of turtles and 27 marine mammals around the Marshall Islands. The reefs in the former nuclear test sites show remarkable recovery, although the larger bomb craters may not fill in for years.

Water quality has deteriorated due to coastal construction for ports, docks, airfields, causeways, and roads. Development projects often involve using fill material and expanding into adjacent reef areas, which all mobilise suspended sediments, increase turbidity, and can change the circulation patterns in lagoons.

The average sea temperature around the Marshall Islands in 2002 was about 29°C, near the upper limit for coral survival. A further increase of 1°C could trigger massive coral bleaching and die-off. A 2000 report on climate change in the Marshall Islands projected that air temperatures will continue to rise on all atolls with the highest increases in the northern areas.

Palau

The coral diversity is among the highest in the world with 425 species of hard corals and 120 species of octocorals, which is approximately 25% higher than on Guam. Four species of sea turtles use Palauan reefs. The Rock Islands once had large numbers of hawksbill nesting sites, but egg poaching and the killing of turtles for bekkō jewelry have drastically reduced nesting activity. The species and the nesting habitats are protected within the Rock Island Reserve. The egg-laying banded sea snake and the yellowbellied sea snake are found in Palau, and the endangered dugong has been reported.

Coral cover on reefs in good condition, ranges from 50-70% with 45-95 species at a given site. For example, a comparison of the fringing reef at the southern tip of Malakal from 1976-1991 indicated no significant differences in coral cover and this is probably true for most areas. Before the 1998 bleaching event severely affected most reefs in Palau, the remote reefs were generally in good condition. Reefs closer to population centres or where there are developments show signs of degradation.

There was massive coral bleaching in 1998 when 30% of the reefs were heavily impacted. There was high levels of mortality of adult *Acropora* corals (30-50%), and 75-85% mortality of soft corals. Many juvenile colonies, however, survived. On many lagoon patch reefs, only a few blue corals (*Heliopora*) and brain corals (*Porites*) remain alive. Similar mortality was observed again in 1999 with *Acropora* corals showing the highest mortality. Corals in estuaries close to shore survived better, particularly in Ngiwal where coral survivorship was highest closer to land. Mortality of *Acropora* was nearly 100% at all depths on offshore reefs, like Short Drop-Off. Coral mortality approached 90% at 30m,

*These summary data of coral cover on Palauan reefs by the Palau International Coral Reef Center clearly shows the impacts of the coral bleaching mortality in 1998 on those reefs marked with a *. Other reefs have very healthy coral cover.*

Location	Average coral cover	Coral Species per site
Barrier reef lagoon slopes	60%	45
Northeast slopes *	10%	35
Protected bay south of Ngkesol*	25%	45
Western ocean-facing reef slopes	60-70%	35
Northwestern ocean-facing reefs *	10-20%	50
Kayangel Atoll	50-70%	126
Babeldaob lagoon patch reefs	50%	45-70
Ngermeduu Bay	50-70%	50-60

including *Favia*, *Porites*, *Fungia* and *Acropora*. Of 3,630 coral colonies from 52 genera surveyed in 1999 at several sites, 48% were living, 31% were dead and 21% suffered various degrees of mortality. The abundance of fish that are closely associated with corals (e.g. butterflyfish) decreased dramatically from 1992 levels.

Non-*Acropora* coral cover ranged from 6-25% at 95 of 217 sites surveyed around Palau. Only 22 sites had coral cover ranging from 50-100%. For *Acropora*, 189 sites had coral cover ranging from 0-5%, with only 2 sites having *Acropora* cover above 50%. Patch reefs had the best *Acropora* cover and fringing reefs had the best non-*Acropora* cover. These results show that recovery is occurring, but at a slow rate.

Between 1999 and early 2002, 11,991 COTS were removed from Palau reefs. The largest number collected was in 2001 with 9,862 taken from reefs that had been cleaned in previous years. This is evidence for a developing outbreak of COTS that could seriously damage the reefs, particularly as the COTS target the few *Acropora* corals that survived bleaching.

STATUS OF CORAL REEF FISH AND FISHERIES

AMERICAN SAMOA

Fish and invertebrate populations are not recovering at the same rate as the corals on Tutuila. Night time spear fishermen began using SCUBA in 1995, greatly increasing their catches, particularly of parrotfish. This led to a territorial ban on SCUBA-assisted fishing in April 2001. Surgeonfish, groupers, snappers, and giant clams are overfished. Data are insufficient on commercial and recreational catches for effective management, but communities report declining fish and target invertebrate numbers.

The illegal harvest of hawksbill turtles and destruction of nesting habitats threatens the species, which are approaching extinction in the Pacific. Green sea turtle populations have also declined and they may also be endangered. Conservation efforts are complicated by the complex migration patterns of turtles e.g. from American Samoa to Fiji and French Polynesia, such that their conserving will require international cooperation.

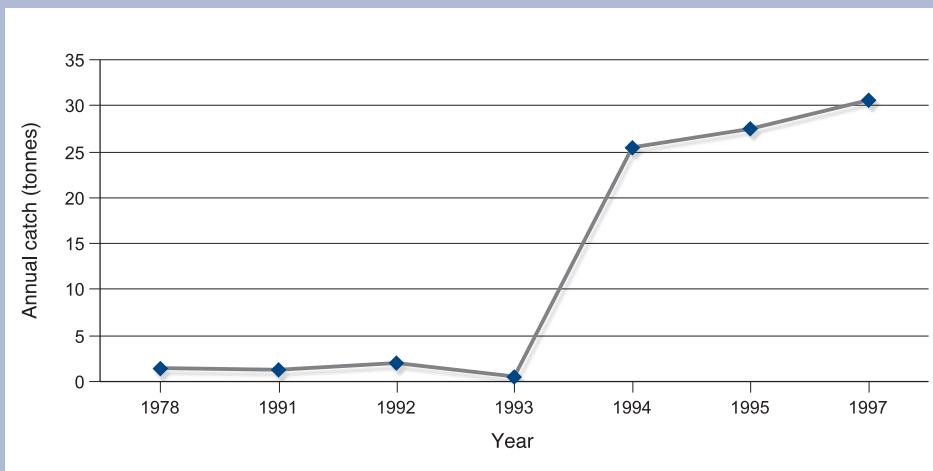
CNMI

There 1,019 fish species around the CNMI, but only the yellow-crowned butterflyfish (*Chaetodon flavocoronatus*) and 2 species of Guam reef damselfish (*Pomachromis*

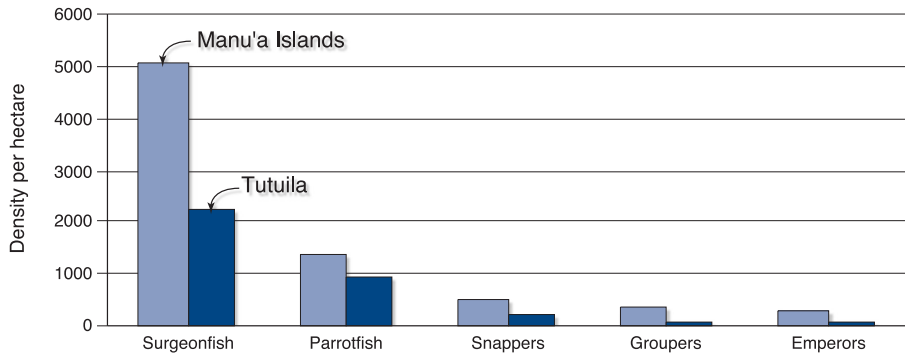
BANNING OF SCUBA FISHING IN AMERICAN SAMOA

Local resource managers can often be surprised by how rapidly fishers adopt new techniques to catch fish more efficiently, and then the managers have to react rapidly to prevent serious destruction of breeding stock. Here is one example from American Samoa where a high technology, commercial fishery became established the mid 1990s, which dramatically increased the catch of reef fishes on the main island of Tutuila. Teams of fishermen were working their way around the island at night using scuba to spear fish, particularly sleeping parrotfish. This was proving to be extremely efficient, such that local reef fish populations were being rapidly depleted and causing considerable concerns among the local subsistence fishers. The evidence was gathered by the Department of Marine and Wildlife Resources: there was a dramatic increase in reef fish catch after the fishery commenced (below); scientists and local managers reported that fish populations on Tutuila were showing signs of severe overfishing, based on long term monitoring data; and the local community were complaining that subsistence fishing had become more difficult since the scuba fishery started. Decisive action was needed to stop this destructive (and non-traditional) fishery, but it would require about 18 months to gather all the necessary scientific data to support the preliminary evidence, but by then the fish populations could be irreparably depleted.

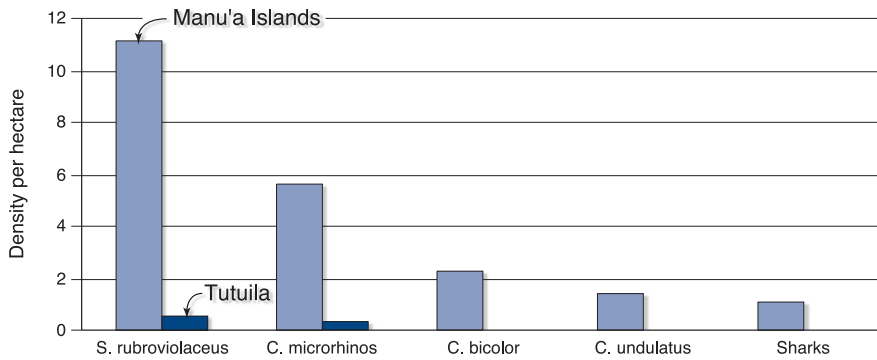
The resource managers put the position to Tauese Sunia, the Governor of American Samoa, who reacted immediately and banned the scuba fishery by Executive Order in April 2001, which was followed by banning regulation in January 2002. What helped the arguments were comparisons of fish populations of the major target reef fish around the heavily populated island of Tutuila and nearby Manu'a, where there are many fewer people and fishing pressure is lower. These clearly show the effects of fishing on the target species.



Annual harvest of parrotfish on Tutuila island from 1978 to the mid 90s when there was a 15 times increase in harvests.



Previous monitoring of the densities of the 5 major target fish families show much lower populations on Tutuila than nearby Manu'a Islands.



The resource managers could also present data on the target parrotfish (Cetoscarus bicolor, Chlorurus microrhinos, and Scarus rubroviolaceus), humphead or maori wrasse (Cheilinus undulatus) and sharks, showing the effects of strong fishing pressure on Tutuila.

This study demonstrates how managers should take the precautionary approach and use the best available information to protect their marine resources that are under threat. Sound scientific evidence is always preferable as a basis for management decisions, but if it is not available then action may be required using scientific and management judgement. In this case, the Governor acted decisively, because there was strong, coordinated support for the ban from local managers, scientists and the community. Since the bans were introduced, there seems to be little, if any, scuba fishing occurring on Tutuila, but the fishery has now been displaced to neighbouring Samoa, where the local government is also considering banning it. From Alison Green, GBRMPA, alison@gbrmpa.gov.au

gumaensis, *Prealticus poptae*) are endemic. There are few data, but fish resources in the northern islands are considered to be healthier and have less fishing pressure than the more populated southern islands. Fish caught by scuba and spear-fishing around Saipan in 1993 and 1996 were generally smaller than those from Tinian. Destructive fishing methods are difficult to regulate, due to a lack of staff and funding for enforcement agencies. Fishing using poisons chlorine bleach and Derris roots does occur, but has not been documented. The use World War II bombs for blast fishing was prevalent in the past, but appears to be nonexistent today. Over-harvesting of topshell (*Trochus niloticus*) and edible sea cucumbers has resulted in moratoriums being placed on their collection.

Federated States of Micronesia

Most (873 of 1,125 species) of the fish on FSM are reef-associated, however, catch and export data are limited although scale of the fisheries operation may be substantial. The gross value of FSM fisheries in 1998 was estimated at US\$86.4 million, and this is having the greatest impact on FSM fisheries, compounded by over-fishing by foreign vessels. FSM earns about US\$18-24 million annually from licensing fees for foreign vessels fishing for tuna in its waters. Fish export from Yap and Kosrae is limited and mostly for personal and family use. Chuuk had the largest commercial export. Commercial export of fish and crab from Pohnpei occurred until a recent cholera outbreak shut it down. Destructive fishing practices, including the use of explosives taken from World War II wrecks, have caused localised reef damage, especially in Chuuk lagoon. A small sea cucumber fishery operating in Yap was closed down in the mid-1990s. Better quantitative assessments of fisheries resources within the FSM are needed.

Guam

The monitoring of the 5 MPAs established in 2000 has demonstrated an increase in both mean size and abundance of both herbivorous and carnivorous fishes, particularly in Tumon Bay, the main tourism centre on Guam. Large schools of grazing surgeonfishes and larger and conspicuous snappers are now seen. The rebound of fish populations within this easily accessible area is a good demonstration of MPA effectiveness. However, the granting of permits for the 'International Birdman Rally' in the protected area demonstrated that political will is weak, even following the objections of the regulatory agencies and most of the public. Elsewhere, fish populations have declined 70% over 15 years, and total fish catches have more than halved

Marshall Islands

Seven of the 860 species of reef fishes in the Marshall Islands are endemic, and the endemic three-banded anemonefish (*Amphiprion tricolor*) is exported for aquariums. Live rock and molluscs are also exported for the aquarium trade and crafts respectively. There is no commercial food fishery in the Marshalls as a result of the 67 nuclear tests conducted between 1946-1958, although there has been no significant accumulation of heavy radioactive elements in fish muscle tissue. Some other radionuclides have been shown in fish from near the bomb tests on Bikini and Enewetak lagoons, however, the concentrations of these radionuclides are reducing and in some species it is below detection. The RMI reported a gross value of the fishing industry at US\$19.2 million, but this was mostly for oceanic pelagic species.

Palau

The largest number of reef fish species occur on Palau (1,278 species). Commercial fisheries generate US\$6.4 million in gross value output, however, foreign-based fishing activities are a problem, including poachers from Indonesia and the Philippines on Helen Reef. Fish populations in the main islands of Palau show signs of over-fishing compared to the Southwest islands where there is less fishing pressure. Highly desired species of fish are either absent or present in low numbers in the main islands of Palau.

ANTHROPOGENIC THREATS TO CORAL REEFS

Threats from fishing and climate change are addressed in previous sections. The major threats to reefs are directly attributed to increases in human activities such as development and more efficient exploitation of coral reef resources. For example in American Samoa, there has been an increase of 35% in the population during the last 10 years, and in the Northern Marianas, the increase has been over 300% in 15 years. These population increases result in over-fishing (and destructive fishing) of reef resources, and more coastal development and habitat destruction, which result in more sediment and wastewater runoff with increased loads of nutrients and eutrophication in reef waters. Major tourism growth in the Northern Marianas, Guam, Palau and FSM has resulted in the clearing of coastal lands for developments, harbour construction, golf courses and roads with major losses in habitat and water visibility on near-shore reefs and direct reef damage from tourists e.g. using jet skis.

American Samoa

In 1999, overfishing of reef resources, coastal development and habitat destruction, and oil and hazardous waste spills in Pago Pago Harbor were the top ranked human stresses in American Samoa. Sedimentation, dumping and improper waste disposal, and nutrient loading with eutrophication in Pago Harbor were identified as medium threats, and sedimentation, dumping and improper waste disposal, and nutrient loading and eutrophication in Pago Harbor, marine debris, alien species, coral disease, and aquarium trade were ranked as low threats.

CNMI

The reefs near towns on Saipan, Tinian, and Rota, and those surrounding Farallon de Medinilla receive most of the human impacts from coastal development, population growth, fishing, and tourism. Concerns over the potential impacts of marine recreational sports on the environment caused the authorities to limit the number of tourist boat permits. The Government and the local dive operators association are installing more mooring buoys at major dive sites using money through the Coral Conservation Act.

More than 20 ships have grounded on CNMI reefs over the past 20 years, usually during typhoons, and nearly half remain on the reefs. CNMI is working with NOAA to remove them before they disintegrate and cause more damage. There is a significant amount of war debris and unexploded ordnance in the nearshore waters. An unfortunate attempt in 1996 to clear some sunken bombs caused significant damage to the nearby Sasanhaya Fish Reserve, killing numerous fish, smashing coral, and killing a turtle. The resultant sediment plume blanketed an area around the Coral Garden site from months.

Guam

Sediment released from soil erosion in the Ugum River Watershed is 176,500 tons/km²/year; with 46% from sloped roads, and 34% from cleared vegetation. Erosion rates in the Ugum Watershed doubled from 1975 to 1993 (from 1,547,250 to 3,039,750 tons/km²/year), as a result of road construction and development projects. Guam's main power generation facilities are located on Cabras Island, in Apra Harbor. Elevated temperatures from the discharge of seawater used to cool the generators has resulted in coral mortality. The discharge of cleaning chemicals has also occurred, with subsequent impacts on local coral populations. Over 1 million tourists visit Guam each year, and damage to reefs is inevitable. In addition to impacts of 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 aims to address these problems but needs enforcement and should be updated to cover new activities and areas. Groundings of fishing vessels, recreational watercraft and ships carrying cargo and illegal immigrants have resulted in localised damage to reefs.

Federated States of Micronesia

As with the other high islands, road construction and development projects without adequate erosion control have been responsible for reef damage from sedimentation. Dredging projects associated with airport and harbour construction have localised impacts, and subsequent increases in freshwater runoff have limited recovery. Increasing populations are a concern for some islands as they must increase associated infrastructure, including sewage processing plants and outfalls. Ship groundings have been a problem for both the high and low islands. Foreign long-liners have been abandoned on numerous FSM reefs, with no funds available to clean up oil spills or remove ships. Larger shipping vessels have also run aground, most recently in Satawal and on Pohnpei. There has been an increase in deforestation and agriculture development for Sakau farming in Pohnpei, which has increased the amount of runoff into the reef lagoons. There is a low rate of connection to sewerage systems in the islands, therefore most human waste runs untreated or partially treated over coral reefs.

Marshall Islands

A general lifestyle change, loss of traditional conservation knowledge, and urbanisation are evident in increased dumping of wastes in reef lagoons and poaching of reef species. Ship groundings directly destroy reef habitat, and invasive species pose a more subtle, but potentially more permanent threat. Fouling marine invertebrates, algae and fishes have been introduced, but their impacts have not been studied. Harvest of live rock and molluscs is a growing concern. The most destructive events were nearly 50 years ago when nuclear bombs were detonated on Bikini Atoll. A huge crater resulted and large areas of reef were vaporised. The reefs are slowly recovering, but insufficient is known about the lasting impacts of the bombs, including long-lasting radioactive wastes. The reefs are still off limits to the original inhabitants.

Palau

The greatest immediate threat to Palau's reefs is a compact road project for Babeldaob as the associated erosion and sedimentation, and damaged upland habitats will result in

sediments pouring onto the reefs. Additionally, the road will open large areas to development, increasing both land and reef use resulting in poorer water quality and reef health. Plans to dredge for fill materials needed to build the road base also have the potential for reef damage. The increased population will require additional sewage treatment and other support facilities. Ship groundings have also been occurring off the main islands as well as those in the south. Palau has done a great deal toward limiting the impacts of tourists on reef resources. Mooring buoys, laws preventing the collection of corals, and diving tour operator education help conserve the culturally and economically important reef resources. Now the largest direct impact on some reef sites is the volume of divers, with varying levels of training.

In Palau, much new residential housing has been developed along one of the main rivers in Airai State, which flows directly into the bay on east coast. Corals in the bay are suffocating from the sediments and this is exacerbated by additional runoff from the 80km compact road. The Palau International Coral Reef Center have used data on watershed discharges and coastal water quality to support a moratorium on mangrove clearing and uncontrolled land clearing. Eutrophication in Malakal Harbor is linked to fishing vessels disposing of wastes directly into the water.

CURRENT CONSERVATION MANAGEMENT

American Samoa

Maps of Fagatele Bay National Marine Sanctuary and Pago Pago Harbor were made with multibeam technology in 2001 (see dusk.geo.orst.edu/djl/samoa.) by NOAA and will include habitat maps of the surrounding reefs. Corals, invertebrates, fish, and algae have been monitored by nearly 20 years in Fagatele Bay National Marine Sanctuary and at other Tutuila locations. In addition, coral monitoring from 1917 on a Pago Pago Harbor reef flat has been repeated several time since then. There are 4 Marine Protected Areas (MPAs) in American Samoa, only one of which is a 'no-take' area. Unfortunately, protection and enforcement in these areas is generally lacking and poaching in all the MPAs is an on-going problem e.g. 9% of the local commercial fishery occurs illegally within the National Park of American Samoa on Tutuila Island. Moreover, there are no 'no-take' MPAs on the main islands where over-fishing occurs.

Existing MPAs in American Samoa showing the proportion that has 'no-take' status. Unfortunately the largest MPA is on remote Rose Atoll.

MPA	Island	MPA Area (km ²)	Coral Reef Area (km ²)	No-take Status	Adequate enforcement
Rose Atoll National Wildlife Sanctuary	Rose Atoll	158.8	7	Yes	No
National Park of American Samoa	Tutuila, Ofu, Ta'u	9.1	9.1	No	No
Fagatele Bay National Marine Sanctuary	Tutuila	0.7	0.7	No	No
Vaoto Territorial Park	Ofu	0.2	0.2	No	No
Total		168.8	17		

CNMI

The first reef map for the CNMI was developed in 1959 and is still used for ecological comparisons. Now new maps of the coral reefs in Saipan's western lagoon are being made by the local authorities and NOAA. These will be expanded to all the coral reefs. The CNMI increased local monitoring capacity and hired a manager to coordinate the coral reef program using recent funds. Now 13 sites off Saipan Island, 8 sites off Rota, 7 sites off Tinian, and 1 site off Aguijan are monitored to provide the CNMI with a comprehensive baseline survey and track changes in coral reef health through time. The Fisheries Section has been collecting data on fish diversity and abundance primarily within existing and proposed conservation areas on Saipan, Tinian, and Rota since 1999. During fish surveys, data are also collected on reef topography (vertical relief) and estimated hard coral cover.

The CNMI have established 8 MPAs, which protect an area of 12.32km². The Sasanhaya Bay Fish Reserve in Rota, the Mañagaha Marine Conservation Area, Forbidden Island Sanctuary, and Bird Island Sanctuary are no-take zones for all marine resources. Enforcement remains a problem, but support from the NOAA Coral Conservation Program is helping. An MPA has been proposed for Tinian to protect approximately one-third of the western shoreline; this is currently under review by the government.

Guam

NOAA habitat mapping of Guam's coral reef ecosystems will begin in 2002. There is current water quality monitoring at 30 stations (10 fresh water, and 20 marine) as part of the National Coral Reef Monitoring Program. High risk stations are monitored intensively. The University of Guam Marine Laboratory has ongoing coral reef monitoring programs, in collaboration with government agencies. The university database dates back to 1970, and focuses on the marine biota. A joint educational outreach program exists as a collaboration among the stakeholders as part of the Guam Coastal Management Program. A NOAA Coastal Oceans Program awarded a Coral Reef Ecosystems grant to Guam, Palau and the FSM to study water quality and pollution and impacts on corals.

There are two federal (War in the Pacific National Historical Park and Guam National Wildlife Refuge) and 11 territorial MPAs, with 5 of the territorial MPAs being no-take 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. All 5 marine reserves are fully enforced and 2 more ecological no-take reserves were established in 1986, but they have not been enforced.

Federal States of Micronesia

Some FSM shallow-water coral reef and associated benthic habitats have been mapped but only off major towns. Coastal resource inventories and atlases have been prepared for Pohnpei, Yap, Kosrae, and Moen Island in Chuuk Lagoon. The College of Micronesia-FSM has staff trained in marine resource assessment and monitoring and works with the Environmental and Marine Resource agencies to monitor FSM reefs. There is regional cooperation under the Marine Resources Pacific Consortium (MAREPAC) and funded by the U.S. Dept. of the Interior to increase local and regional capacity for assessment and monitoring. The Nature Conservancy provides technical and financial assistance for monitoring programs, and Peace Corps volunteers also assist in monitoring. Coral reefs

are protected by MPAs in the Trochus Sanctuaries Heritage Reserve and Kosrae Island Heritage Reserve. Other conservation areas are presently being negotiated in partnership with the FSM National Government. Chiefs and other traditional leaders usually control protection of specific areas. In Yap, the villages own the reefs, and have authority over resource use. A number of the islands have areas set aside for reef protection and limit resource extraction, but currently the FSM lacks the enforcement capacity to protect these MPAs.

Marshall Islands

Coastal resource atlases prepared for the region include mapping of coral reefs and uses for Arno, Majuro, and Kwajalein atolls, but better habitat mapping is needed. There were pioneering studies on coral reefs in several atolls before the bomb tests 1955 and a 1987 report on the resources of Enewetak Atoll is one of the most comprehensive reef assessments in the world. Coastal resource inventories and atlases of Arno, Kwajalein, and Majuro Atolls were conducted in 1998. In 2001, a systematic survey of coral reef resources was undertaken by the College of the Marshall Islands and the Marshall Islands Marine Resources Authority. More are planned for the northern atolls of Ailinginae and Rongelap and the southern atoll of Jaluit. The U.S. Army regularly monitors Kwajalein Atoll because it leases the area for ballistic missile testing.

Several agencies are involved in protecting coral reef ecosystems: Marshall Islands Marine Resources Agency; and the Environmental Protection Authority. A National Biodiversity plan addresses the need for conservation and management of the natural resources, and contains extensive lists of marine organisms. One recommendation is a strengthening of 'mo' a traditional system of taboo that identified certain areas as 'pantries' for periodic harvesting. Another is a need for sustainable fishing practices and a retention of local knowledge.

Palau

Palau's coral reefs have not been mapped. The Palau International Coral Reef Center (PICRC) was created to enhance coral reef knowledge for more effective management and conservation. PICRC has established 14 permanent sites on shallow reefs to monitor corals, coral recruitment, and fish, and surveys close to 200 non-permanent sites. The Palau Conservation Society is active in conservation, and collaborates on monitoring and assessment programs with the Coral Reef Research Foundation, Palau Community College, the Environmental Quality Protection Board (EQPB) and the Marine Resources Division. The Nature Conservancy has an office on Palau, and works with the other agencies and organisations on coral reef conservation. Palau has substantial expertise and was recently supported by a monitoring grant from NOAA. PICRC functions as a Node of the GCRMN to assist other countries in the MAREPAC group, and an Education and Outreach Program has involved 3,030 students and about 14,000 visitors since the opening in January 2000.

Palau has a total of 13 established MPAs. In 1956, the Rock Island Management and Preservation Act designated certain areas of the Rock Islands as reserves and others as tourist activity areas. This was Palau's first MPA. The total area of Palau's coral reefs protected by no-take zones is 65.3 km² or 3.9% of the extent of the country's coral reef area.

CONCLUSIONS AND RECOMMENDATIONS

All countries and states are partners in MAREPAC, which aims to coordinate activities and avoid duplication of effort, fill gaps in areas of need and use time and financial resources efficiently and wisely. There is a need for a forum for states to present their priorities for monitoring and plan future directions. There is considerable expertise across the region and this needs to be harnessed in a coordinated manner to assist all states and raise the capacity in-country for more effective coral reef monitoring and conservation.

American Samoa

The coral reefs in American Samoa have been recovering from natural stresses, but the fisheries resources have not been recovering. The recovery of the corals will be enhanced if there are healthy populations of grazing and herbivorous fishes. These have been lost due to overfishing on Tutuila. Other major factors causing serious harm are reduced water quality near populated areas, and destruction of turtle nesting beaches.

- There is a need to expand coral reef monitoring efforts, but focus the objectives. Most monitoring efforts so far have been ecological in focus, but there is a need to address the questions faced by coral reef managers: 'Is overfishing occurring'; 'Is sediment from poor land-use practices harming the reef'. Consequently, monitoring programs must clearly identify the intended user of the data, and the parameters to measure to provide the information. A monitoring program in American Samoa should be: achievable with local staff, although off-island expertise may be needed; sustainable even with staff changes; comparable to other programs; and open to community input and management.
- Improved land-use practices are needed to slow the impacts that are currently damaging water quality. Some progress has been made in Pago Pago Harbor, but the coral reefs there have not fully recovered nor is swimming safe or fish uncontaminated. Fish and sediments in the harbour need to be tested for toxicity at regular intervals.
- A regional network of MPAs needs to be created to protect coral reef resources across the region. For example, tagging data show green sea turtles nest in American Samoa and migrate to both Fiji and Tahiti to feed.
- A recent ban on scuba-assisted fishing has been established, but there is a need for monitoring of its effects. The ban appears to have been enforced and the lack of large fishes indicates that time is required to show results. Village-based management and monitoring of reef fisheries resources should be encouraged.

CNMI

The CNMI has established a long-term marine monitoring program to provide data for conservation efforts.

- There is a need to ensure that agencies collaborate to collect and analyse monitoring data within a monitoring program that has sound objectives and establishes repeatable protocols for data collection, storage and analysis. An interagency team should be established to assess methods and design a workable monitoring program.

- Although there are adequate staff resources to start a long-term monitoring program, additional training is required to ensure continuity. Training is required in data collection, data analysis and quality control, as well as training in identification of marine flora and fauna.
- The CNMI should attempt to Rapid Ecological Assessments for the populated southern islands to identify long-term monitoring sites and implement the monitoring program. Data can then be used to recommend additional marine protected areas on Tinian and Rota.

Guam

The coral reefs of Guam continue to decline because of activities from the land. There are adequate monitoring and research data to identify the problems and suggest corrective measures. For example, there have been disturbing reductions in coral recruitment indicating that reef recovery is threatened in areas impacted by typhoons, COTS, and earthquakes. Community education initiatives have increased awareness and the political will to address reef decline. However, there is far more to be done in these areas. Overfishing is still a concern, but 5 Marine Reserves is a positive step.

- Enforcement of existing laws and environmental regulations is required.
- Improvements to erosion control programs are needed to reduce the land-based stresses on coastal reefs.
- Recovery of Guam's reefs will only occur with improvement in coastal water quality that allows natural recovery to occur. A balance needs to be found between continuing development of the traditional, urban, military and tourist sectors, and the conservation of the coral reefs, which are a key component of the local economy.

Federated States of Micronesia

The reefs within the FSM are in relatively good condition. However, land-use practices on the high islands are a concern and urban developments and agriculture have caused reef damage, which is expected to increase. Also reef fisheries on some islands have been over-exploited, and damaging fishing practices have been reported in Chuuk Lagoon.

- There is a need for integrated watershed management through improved coordination of management activities among the states. Currently some agencies have overlapping responsibilities.
- Improved monitoring of the coral reefs and assessments of fisheries resources are needed to counteract the over-optimism about developments, especially needed are data on how the fisheries respond to current levels of exploitation.
- Education and programs involving the community need to be expanded to increase awareness at all levels of the need and benefits of fisheries management and conservation via the establishment of MPAs.
- There is a need for improved enforcement of State fishery laws by police or conservation officers and patrols are required in MPAs to ensure that conservation objectives are attained.
- Mechanisms for the prevention of ship groundings and especially the timely removal of ships, with penalties applied for damage to the reefs, need to be applied state and national level.

Marshall Islands

At present, the coral reefs of the Marshall Islands are in good condition. While the two atolls used for the nuclear testing program experienced unique stresses, the reefs of the RMI as a whole have escaped the extensive damage seen in other parts of the world. The remoteness of many of the atolls and the fact that the country as a whole is relatively isolated has helped to keep down many potential impacts to the reefs. However, this isolation also leaves the reefs vulnerable to illegal or semi-legal exploitation. Moreover, increased globalisation and the pressures to change from traditional subsistence economy could easily alter the present situation and allow at least some of the stresses discussed before to become serious threats.

- There is need for further training in coral reef monitoring and management to bring the Marshall Islands to the same level as other 'countries' in the region.

Palau

- Regular assessment and monitoring of Palau coral reefs is required for effective coral reef management, so that problems can be detected earlier and effective remedial strategies can be developed. It is essential that results of monitoring programs be disseminated early and widely. It is essential that the community be informed as part of an awareness raising program. The Palau Community College is recommended as the repository for the data and the mechanism to involve the public.
- There is a need to develop school curricula from elementary to post secondary stages that incorporate environmental issues and concerns, especially on coral reefs, which are so important for Palau. This should be extended to community outreach programs targeted at policy makers, traditional and political leaders and villagers.
- There is a need to monitor reef fisheries catch levels and trends so that effective management of coral reef fish resources can be implemented. Currently, only two fish markets in Koror provide landings data to the Marine Resources Division. This needs to be expanded to include catch data from all fish markets, as well as gathering data on the type of fishing gear used, numbers of fishers and time spent fishing.
- A collaborative program should be established between all the agencies and organisations involved with coral reef monitoring and management. The first step is to form a strategic planning group, then set priorities and areas of focus for each group/area and focus on problems that can only be solved through cooperation.

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ICRAN

JALUIT ATOLL MARINE CONSERVATION AREA, MARSHALL ISLANDS – ICRAN DEMONSTRATION SITE

The atolls of the Marshall Islands run north and south in two parallel chains called Ratak, eastern chain, and Ralik, western chain. Jaluit Atoll lies in the southern end of the Ralik island chain and includes 91 islets with a total land area of only 11.4km². The islets form a ring around a shallow lagoon and 4 deep passes connect the lagoon to the open ocean. Over 250 species of reef fish and 4 species of mangroves inhabit the atoll along with several species of turtles, whales and dolphins.

Jaluit Atoll has a resident population of about 2,500 people, primarily on 6 of the 91 islets. Primary subsistence activities, including harvesting of giant clams, trochus, many finfish species, oysters and turtles, are considered unsustainable. In an effort to alleviate these problems, the Jaluit Atoll Conservation Area was established in 1999 under the Marshall Islands Environmental Protection Agency and in partnership with GEF and SPREP.

Ecological Monitoring: A survey of Jaluit's marine resources conducted in early 2000 showed that trochus and sea cucumber stocks were low due to unregulated harvesting. To allow their recovery, a ban on harvesting these species was recommended in 2000. For other locally used marine resources, a long-term monitoring system needs to be put in place and seasonal harvesting introduced to prevent overexploitation.

Socio-economic Monitoring: No details received.

Coral reefs are **80%** of the natural resources.

Ecological Monitoring is **planned**.

Socio-economic Monitoring is not **planned**.