



Technical Report HCSU-002

**NATURAL RESOURCES MANAGEMENT NEEDS FOR COASTAL
AND LITTORAL MARINE ECOSYSTEMS OF THE U.S.
AFFILIATED PACIFIC ISLANDS:**

**American Samoa, Guam, Commonwealth of the Northern Marianas
Islands, Republic of the Marshall Islands, Federated States of
Micronesia and the Republic of Palau**

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November 2006

This product was prepared under Cooperative Agreement CA03WRAG0036 for the
Pacific Island Ecosystems Research Center of the U.S. Geological Survey

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CITATION

Haws, M. (2006). Natural resources management needs for coastal and littoral marine ecosystems of the U.S. Affiliated Pacific Islands: American Samoa, Guam, Commonwealth of the Northern Marianas Islands, Republic of the Marshall Islands, Federated States of Micronesia and the Republic of Palau. Hawai'i Cooperative Studies Unit, Technical Report HCSU-002. University of Hawai'i at Hilo. 399 pp.

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Executive Summary

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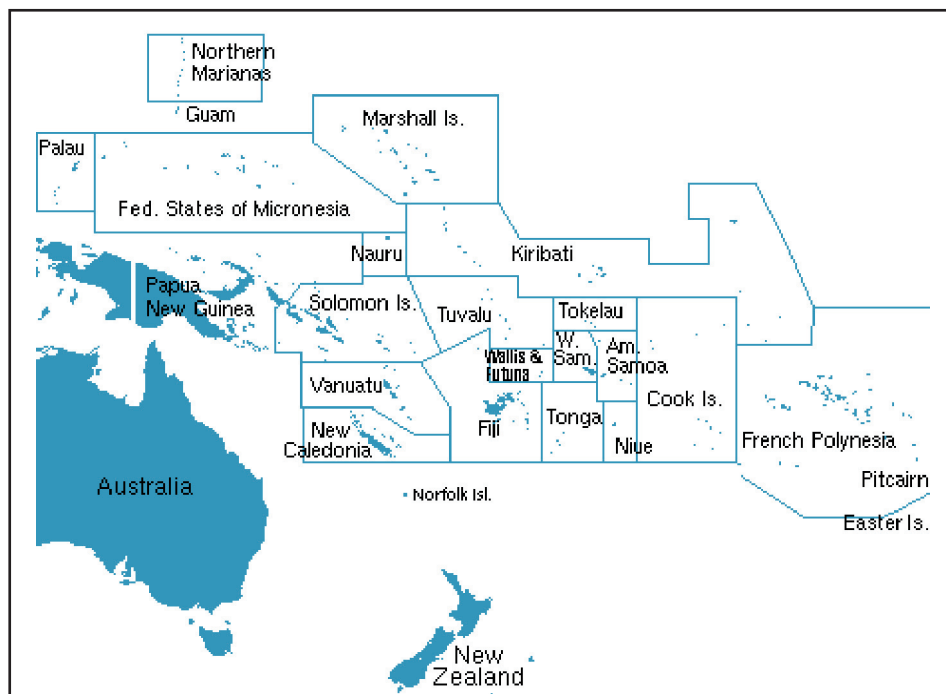
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EXECUTIVE SUMMARY

BACKGROUND AND JUSTIFICATION

This report presents a summary of the research and management needs for natural resources of the U.S. Affiliated Pacific Islands. These islands include three island groups which are affiliated politically with the U.S., Commonwealth of the Northern Marianas, Guam, American Samoa and three independent nations which are freely affiliated with the U.S, the Republic of Palau, Federated States of Micronesia and the Republic of the Marshall Islands. This work is intended to orient the U.S. Geological Survey Pacific Island Ecosystems Research Center's (PIERC) biological research to support management of natural resources in coastal and littoral marine ecosystems (CLME) in Hawaii and the U.S. Affiliated Pacific Islands. Although the focus of PIERC is on natural resources under stewardship of the Federal government and its local partners (including National Parks, United States Fish and Wildlife Services (USFWS) Refuges, National Oceanic and Atmospheric Administration (NOAA) sanctuaries and reserves, State reserves and protected areas), research and management activities may be conducted in any Pacific basin location that provides information essential to management and conservation of CLM ecosystems. Moreover, science may address issues that span the waterline, that is, research may be required in both terrestrial and aquatic habitats in order to fully describe, understand, and predict the impact of resource management and usage on various components of the marine and coastal ecosystems.

Figure 1. Map of Oceania



U.S. Federal Programs have taken leading and partnership roles in research and management of natural resources since the end of WWII when the U.N. designated these island areas as Trust Territories. The federal agencies' presence and scope of work varies considerably between the island groups, with the highest level of presence and activity in Guam, American Samoa and the Commonwealth of the Northern Marianas Islands (CNMI) where the U.S. Fish and Wildlife Service (USFWS), Department of Interior, NOAA, USGS, U.S. Coral Reef Task Force, various agencies of the United States Department of Agriculture (USDA), Federal Emergency Management Agency (FEMA) and others play very similar roles to those executed within the U.S. in partnerships with local institutions. The same agencies are also active in the independent nations of the Republic of the Marshall Islands (RMI), Federated States of Micronesia (FSM) and Palau, although to a lesser extent and with local agencies perhaps tending to assume more of a leadership role. One key distinguishing feature between the two groups of islands is the existence of refuges, sanctuaries, parks and protected areas falling under jurisdiction and management of U.S. federal agencies in the three territorial island groups. Flora and fauna is also protected under U.S. regulations such as the Endangered Species Act. The independent nations lack these federally protected areas, and U.S. jurisdiction over flora and fauna comes into play only when importation to the U.S. or its territories occurs.

Additional information about natural resource management programs in western Pacific can be found at the following websites:

- The Office of Insular Affairs <http://www.doi.gov/oia/>
- The International Coral Reef Initiative <http://www.icriforum.org/>
- The U.S. Coral Reef Task Force <http://www.coralreef.gov>
- The U.S. Fish & Wildlife Service <http://www.fws.gov/pacific/>
- The U.S. Forest Service <http://www.fs.fed.us/psw/ipif/>
- The National Park Service <http://www.nps.gov/pwro/piso/>

It should be noted that the U.S. manages a number of small Pacific Islands including Palmyra, Baker, Howland and Jarvis Islands as well as Johnston and Rose Atolls and Kingman Reef through inclusion in the Pacific/Remote Islands National Wildlife Refuge Complex (USFWS). These areas are not covered in this report.

The U.S. relationship to these islands is also influenced by the long-term presence of U.S. military bases at Guam and Kwajalein, RMI. The military is occasionally present at the other islands (e.g. ship transit, Engineer Battalion-Civic Action Team). The U.S. Army Corps of Engineers is currently active in several areas, including Palau. Significant numbers of island residents serve in the U.S. military. As part of its environmental stewardship, the U.S. military assesses and manages potential impacts related to its activities. One long-standing issue is the fate of the nuclear-affected islands of the Marshall Islands contaminated by 57 atomic bomb tests and the fates of their peoples, flora, fauna and environments.

The U.S. and the Pacific Islands are also linked through shared economic, cultural and environmental matters in the region due to their common stakeholder populations. Immigration from the Pacific Islands to the U.S. has been high after WWII since residents have the right of free entry and work. Significant numbers of Pacific Islanders live in Guam and Hawaii, and increasingly at continental U.S. locations. Most of the islands also have fairly large populations of U.S. citizens originating from the States who have strong influences on environmental issues. Movement between geographic locations is fluid; cultural and economic ties are strong and affect resource management on both sides of the Pacific. Hawaii and Guam in particular are affected by the presence of Pacific Islanders, a fact recognized by additional economic support from the U.S. government for health, education and other services provided to immigrants. Environmental awareness, economic development and resource management initiatives must take into account the inextricably linked relationships of the peoples of the Pacific and U.S. into account.

APPROACH

This paper focuses on the Central and Western Pacific, which includes Guam, Commonwealth of the Northern Mariana Islands (CNMI), American Samoa, and the Freely Associated Republics of Palau and of the Marshall Islands (RMI), and the Federated States of Micronesia (FSM). Natural resources specialists with ample expertise and experience were selected from each island location to collect relevant information and draft each chapter. The selected specialists are:

Elizabeth Matthews (Palau);
Bill Raynor (FSM);
Nicole Baker and Maria Haws (RMI);
John Gourley (CNMI);
Alison Palmer (Guam); and
Jody Authur and Fatima Sauafea (American Samoa);

Each chapter addresses the history, current status, trends, uses and threats of major coastal resources including terrestrial, freshwater, marine and near-shore habitats. Species of concern are also identified including those of particular economic importance. Abiotic aspects of each island group are also characterized. Major resource management issues are identified and discussed, as well as key aspects of knowledge management and governance issues. Research and capacity building areas needing attention are clearly identified.

THE CHALLENGE

The region covered in this study encompasses a geographic area of approximately 3 million square miles with thousands of islands of diverse cultures, environments and physical environments and a high degree of biodiversity. This area is approximately twice the size of the continental United States. Six territories or countries are involved with a total population of nearly half a million permanent residents and a “floating” population of tourists and other visitors of at least 300,000 annually. Each island group

possesses one or more distinct cultures. Both Polynesian and Micronesian cultures are found within this geographic extent as well as diverse immigrant populations with many languages and dialects being spoken.

The degree of development also varies widely ranging from modern, internationally connected cities such as Saipan to the most remote and isolated atoll communities rarely visited by outsiders. A large number of uninhabited islands provide refuges for fauna and flora. It is a challenge to fully characterize such diverse resources spread over such a large geographic expanse, much of which has only occasionally been visited or documented by scientists. The complexities of culture, language and geo-political relations further complicate efforts to succinctly characterize and study this unique region.

Despite the seeming disparities between islands, this work attempts to identify common trends, tendencies and threats which endanger the natural resources and quality of life for island residents, as well as identifying opportunities where PIERC or other institutions could effectively act to support natural resources management for conservation of native biodiversity.

A common emerging theme is the increased vulnerability of Pacific Islands. While most islands have been considered to be relatively inaccessible or underdeveloped, and therefore somewhat protected from the environmental threats wreaking havoc in other parts of the world, the findings presented here make it clear that the historical trend has always been towards increased extraction whenever the opportunity presents itself upon contact with other cultures. This trend is rapidly accelerating as even the most remote islands are no longer wholly shielded from the effects of globalization.

While research and management capacity also have increased over time, this increase in capacity generally lags behind the need to urgently address threats to ecosystems and the human communities that rely upon them. Although increased awareness of the need for natural resources management and the capacity for local institutions to meet this need are rapidly growing, there is still an over reliance on external sources of expertise. This results in an overabundance of short-term studies and assessments, but insufficient development of local, resident experts and long-term studies and monitoring efforts. There also has been an over-emphasis on research for science's sake rather than issue-driven research, or the "translation" or application of science to tangible management efforts. Additionally, funding for research and management efforts comes largely from external sources and is apt to be fleeting, unstable and insufficient to meet long-term needs. Information accessibility and management is always an issue in this field, but is exacerbated by the isolation of the islands and the geographic distances, technological capabilities, language and cultural differences separating stakeholders, scientists and managers.

SUMMARY

When surveying the field of research for natural resources management, it is a temptation to say that gaps exist in all areas. What the eight authors found is while there are a few topics for which research and management efforts are intensive and well-directed, but that most topics are only sporadically researched and most often only on a short-term basis. In-depth and long-term studies or management efforts are rare in the region. Geographic coverage of particular themes is generally very patchy. The depth and extent of research and management for a particular topic varies greatly by country. Some islands, particularly the remote coral atolls, have almost non-existent scientific records. Research agendas, management efforts and available funding are most often driven by a single individual or a small group, rather than having been the result of an institutionalized, persistent mandate. Integrated approaches are rare and there is need for holistic and multidisciplinary approaches such as integrated coastal zone management.

Below is a brief summary of major points organized by the categories of topics considered in the report.

Habitats, uses, trends and threats

Of particular note was the refutation of the authors' common *a priori* hypothesis that coral reefs habitats, fauna and flora would be the best researched and managed, and therefore a survey of this topic would find fewer gaps and issues than for other fields. While coral reefs maybe relatively well studied compare to other habitat types in the Pacific Islands, tremendous gaps exist and the reefs of entire island complexes have received almost no scientific attention. Most surprisingly, even well known and heavily impacted islands such as the nuclear-affected islands of the RMI have not been the topic of sustained coral reef research for over thirty years. Also, the amount of effort devoted to coral reef research varies greatly between countries. For example, Palau is distinguished by a long history of coral reef research and conservation, while the RMI has a relatively sparse record. In essence, scientists and managers have little information on the status and issues associated with much of the region's coral reefs.

Generally there is reason to be concerned with the status and future of coral reefs in this region. Not only does climate change and sea level rise pose major threats, anthropogenic changes are occurring in most areas with little or no control or monitoring being exerted. In particular, over-fishing, extraction of other marine resources, water quality, coastal erosion and solid waste issues were found to be causing growing impacts on almost all islands. Coral bleaching is becoming ubiquitous around the region. There is much that occurs "under the radar screen" throughout the region.

Terrestrial habitats (forests, grasslands, savannas), particularly those of the high islands such as American Samoa, Guam and CNMI are relatively well characterized and are the focus of some of the few long-term monitoring and management efforts in the region. Even so, much of the remaining forests are critically threatened by a variety of activities. Many major islands such as Chuuk have fewer research or management

efforts for terrestrial habitats in progress. The situation on atolls is much worse; few atolls have been thoroughly researched even once, much less monitored on a regular basis. To some extent this is due to the isolated nature of many atolls.

Trees and forests are being lost at a rapid rate. On high islands such as Pohnpei, managers recognize this trend and are working to stem the tide through creation of community-based forest reserves. In other cases such as outer island forestry resources, little is known and much has probably already been lost.

Freshwater habitats are common mainly on the high, larger islands. On Guam, CNMI and American Samoa, these habitats are better understood and more carefully monitored, largely as the result of efforts to assure the quality of potable water. Much less is known about freshwater habitats on other islands such as Pohnpei, or on atolls, where freshwater habitats are rarer, but crucially important. Freshwater everywhere is becoming more scarce and more in demand by both humans and other biota.

Among the least known habitats and perhaps most threatened, are the brackish water habitats (estuaries, mangroves, taro pits, wetlands). Fringing mangroves, sandy beaches, inter-tidal areas and seagrasses are subject to research in only a few scattered cases, and management efforts are largely focused on mangroves in a few locations. These fringing and near-shore habitats may be in the process of being irrevocably lost without their nature and importance ever being fully understood. This process is exacerbated by climatic and anthropogenic changes. Throughout the Pacific environments which were traditionally used for agriculture such as wetlands depressions and taro pits, are being lost as customary knowledge and interest in agriculture fades away.

Species of concern

Every island has a long list of species that are threatened, endangered or rare. With the exception of the Territories, there are few species management plans developed or implemented. Of particular interest are many species of seabirds, turtles and marine mammals, which being migratory are of regional concern. Habitat protection for these species is also nearly absent. All islands are threatened by invasive plants and animals. With a few rare exceptions such as the Brown Tree Snake, few management or control plans have been attempted or are effective. The independent nations of the FSM, RMI and Palau may be in the most dire straits as they lack the protection of the U.S. Endangered Species Act, are not signatories to CITES and have fewer resources dedicated to issues related to threatened and invasive species. Additionally, these nations face the greatest geographic and logistical challenges to assessment and management of species of concern.

Abiotic Aspects

Nearly every island group has problems with water quality and coastal erosion, although the magnitude of these problems is generally not well known due to a general lack of extensive monitoring programs or geographic information systems except in Guam and American Samoa. There is general concern that coastal erosion and impacts from

climatic events such as hurricanes will worsen with global climate change and sea level rise, for which the islands are generally ill-prepared. Disaster management and preparedness require better research and implementation of civil defense systems.

Major resource management issues

Although growth rates are slowing throughout the Pacific, growth still averages 2% with as high as 44% of some island populations (e.g. RMI) being under 18 years of age. High rates of immigration to some islands increase residential rates. Increasing populations coupled with generally poor education, health status and social services are fundamentally affect resource management issues. National demographic trends such as immigration from outer islands to capital islands to continental areas also exert an influence.

Geographic isolation, poor transportation and lack of communication also impact research and management, although often representing a double-edged sword. While isolation and lack of accessibility may serve to keep some areas pristine, they also lend themselves to enabling poaching, destructive fishing and other poor practices. Isolated communities often have poor ability to defend themselves against natural or anthropogenic threats to their resources and are particularly vulnerable to global or regional impacts such as sea level rise. They may also be more subject to exploitation or manipulation by outsiders wishing to extract valuable resources. Transportation has improved in recent years to the point where research and management efforts are now possible, although perhaps with difficulty, in many previously inaccessible areas. Communication has improved drastically over the last 10 years with internet and expanded phone service. New needs, but also opportunities, for resources management are therefore arising.

Fisheries management was cited as a major issue for all parts of the region. These islands host national and international fleets of pelagic fishers-there is concern for the status of the regional stocks and the ability of individual or groups of nations to monitor and oversee fisheries fleets. Near-shore and lagoon fisheries are crucial for the well-being of most of the islands populations, but anecdotal evidence and the rather sparse existing data suggests declines in most species and the increase of destructive fisheries practices. There is generally insufficient data collected for most near-shore and lagoon fisheries to appropriately manage the fisheries, even when sufficient institutional capacity exists to do so. Enforcement is another area that requires further strengthening to protect resources.

The Pacific Islands are experiencing a development boom spurred by growing populations, improved transportation, communication and investment. Development is largely unplanned and unmanaged thus causing impacts through coral harvesting, sand mining, dredging, construction of erosion-provoking structures, increased extraction of other resources, water pollution and increase in solid wastes.

Most authors cited the key role of customary law and tradition in past and future management efforts, as well as the richness of local knowledge, but expressed concern that indigenous knowledge is being lost faster than it can be fully documented and harnessed to better understand and manage resources.

Information and management

As demonstrated by this report, there is abundant information available to researchers and managers although it is often patchy, insufficient for some topics, and often difficult to access or systematize for decision-making purposes. Critical gaps exist for most of the key topics needed, but sufficient information is usually available to make basic management decisions. More damaging to management efforts than lack of data is the need for better awareness raising, improved education in the sciences and a general trend towards a “brain drain”. At the same time, the news is not entirely bad. Although many talented, young professionals remain overseas after completing their education, a good number are returning and assuming leadership positions in conservation and management. More are needed, as is support to enable local professionals and leaders to be more effective. There is also a need to better integrate research, information management and traditional systems of management and leadership. Some technical tools such as GIS are beginning to become available, but some locations still lack the hardware, databases and competency to use improved technologies. These are all but absent in the more remote locations.

Governance Issues and Capacity Building

Governance is a complex and usually sensitive topic in the Pacific Region. Multiple layers of responsibility, oversight, and accountability, entwined traditional leadership systems, state or atoll governments, national government agencies, U.S. Federal agencies and international bodies. This has led to overlapping jurisdictions, contradictions, disincentives and gaps in management. Additionally, policy and regulatory frameworks may not exist for some topics. In many cases, insufficient resources reduce the ability to apply or enforce existing laws. While the territories are covered by U.S. federal regulations, the independent nations are still developing and refining their laws. Enforcement is a key topic in all areas and capacity is generally low. There is a general consensus that the situation may be improving as Compact Funds are more tightly controlled and as maturing governments begin to enforce accountability measures. Governance and accountability will, however, continue to be key to resource management for some time. The effectiveness and accountability of some U.S. federal agencies has also come under scrutiny.

There is a common belief that a key part of improving governance and the active participation of all stakeholders in management, is the need for capacity building and outreach. Skill building and awareness raising was cited by all authors as a fundamental necessity and nearly every possible theme was cited as material for this. Among the top capacity building needs listed were:

- Basic and applied sciences such as marine biology, environmental sciences, geography, forestry, tropical agriculture;
- Fisheries management, particularly community-based fisheries management;

- Water quality and other ecosystems monitoring;
- Resource management;
- Resource economics;
- Environmental education;
- Law enforcement;
- Human resource management;
- Coastal management;
- Urban and regional planning;
- Endangered species and habitat management;
- Information management;
- Geographic Information Systems;
- Establishment and management of MPAs;
- Policy development;
- Strategic planning, monitoring and evaluation;
- Project management/ budget and work plan preparation;
- Aquaculture and other sustainable livelihoods; and
- Disaster preparedness and planning.

Research and Management Needs

A prime opportunity to strengthen research and management in the Pacific is fostering and supporting local institutions and professionals to take leadership roles and assuring that adequate resources are available so they can be effective. This can be done through partnerships, training, mentoring, development of sustainable financing and creating enabling conditions to encourage young people to enter and succeed in natural resources careers. The contributing authors suggested very similar priorities for research and management which are listed below (not in order of priority). A key consideration is that research efforts related to the following topics should be developed in close partnerships with local government, NGOs and stakeholder groups using the partnerships as a vehicle for enhancing local capacity.

- Long-term studies, assessments and monitoring of all habitats;
- Monitoring and preparedness for impacts of global climate change and sea-level rise;
- Expansion of research to geographic areas and topics that have been previously neglected, particularly for remote areas;
- Improvement of research facilities and support systems for researchers and managers;
- Need for integrated approaches to management such as development of Integrated Coastal Zone Management initiatives;
- Fisheries assessments and community-based fisheries management plans for near shore and lagoon fisheries;
- Assessments for species of concerns and species/habitat management plans;
- Mitigation for invasive species;
- Characterizing and monitoring of coastal processes;

- Improved management and planning for development processes;
- Environmental education at all levels of society;
- Improved knowledge management systems and hardware;
- Preservation of traditional knowledge;
- Integration of customary and scientific knowledge and management approaches;
- Increased stakeholder awareness and engagement in management processes;
- Development and support for local, national and regional law enforcement, particularly with reference to fisheries;
- Establishment of MPAs, forest reserves and other forms of habitat protection and accompanying management plans developed with local communities;
- Support for development of alternative livelihoods (e.g. aquaculture and eco-tourism), improved energy efficiency and smart growth;
- Re-engagement with environmental issues related to nuclear testing and current military uses;
- Development of self-funding and sustainable funding sources to reduce dependency on external sources;
- Increased emphasis on the socioeconomic and cultural aspects of natural resources management; and
- Resolving issues related to governance such as policy, regulation, implementation and accountability.

**Natural Resources Management Needs for
Coastal and Littoral Marine Ecosystems of:**

Palau

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BACKGROUND AND INTRODUCTION

Regional context and resources

The Republic of Palau is located in the tropical western Pacific Ocean. Palau is the most western of the Caroline Islands group, and is part of the area called Micronesia. Micronesian islands have a particularly high rate of endemism and are known for the diversity of species. The region is listed as a biodiversity hotspot by Conservation International (Conservation International 2004).

The Republic of Palau is composed of two primary sets of islands (see Map 1), the Main Palau Islands extend from 6°53' to 8°12' N and from 134°08' to 134°44' E. The Southwest Islands are located up to 600 km from the main islands and are at 2°59' N to 5°21' N and from 131°49' to 132°13' E. Palau is relatively close to Southeast Asia, especially the Philippines and Indonesia, and as a result shares some of the flora and fauna of Southeast Asia that has not dispersed through the rest of the Micronesian islands. For instance, Palau is the easternmost extent of the range for saltwater crocodiles and dugong in the region. It is also a seasonal home for many species of birds that migrate through Southeast Asia. In addition, Palau is just outside the eastern edge of the IndoPacific global center of coral biodiversity - a roughly triangular area that encloses the Philippines and Indonesian islands. Within the triangle there are from 500 to 600 species of coral; the number of species decreases with distance from this center. Palau has approximately 425 species identified to date (TNC 2002) while Guam, further to the east, has just over 300 species of corals.

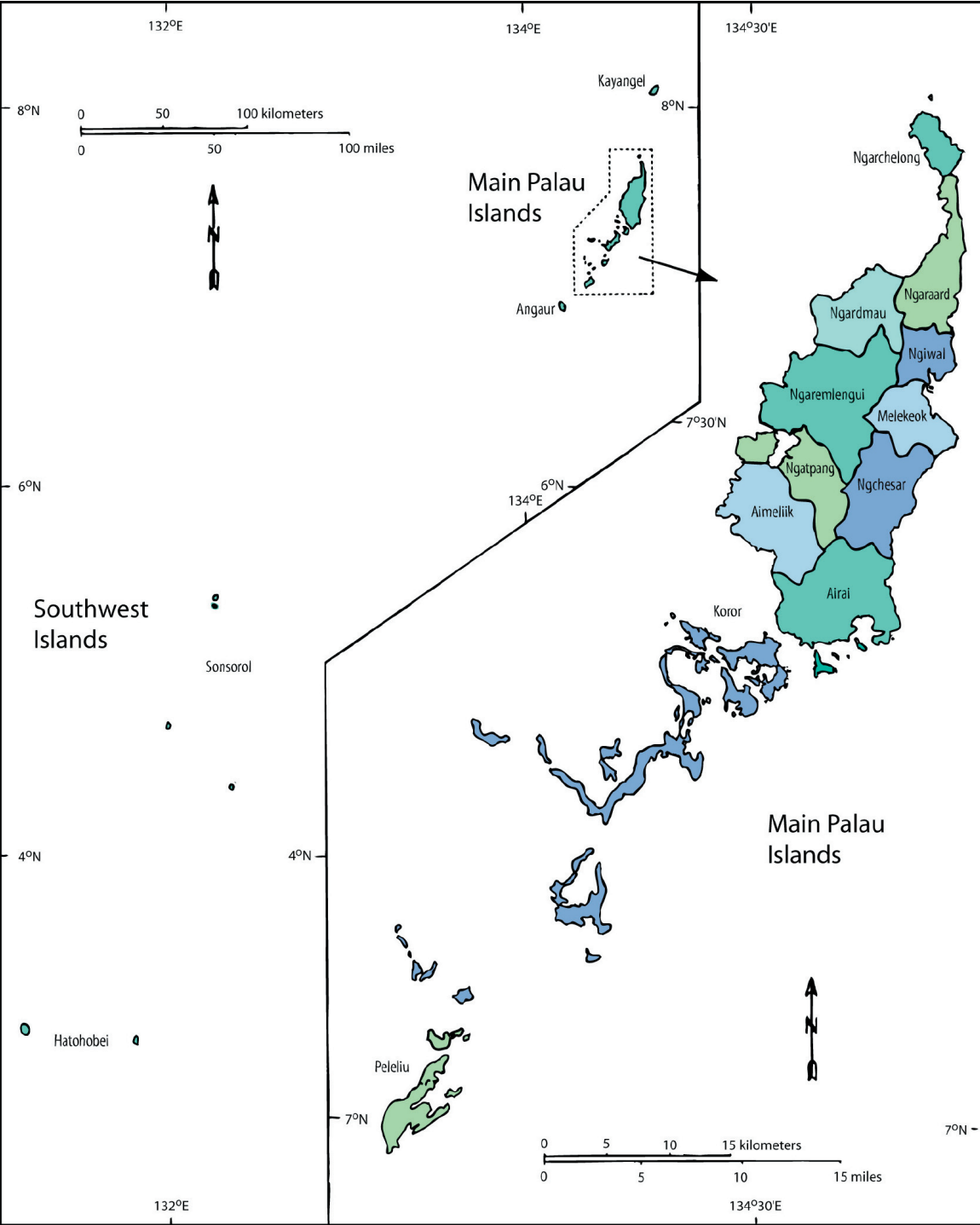
Palau's climate is tropical and humid. There is little seasonal variation in temperature. The mean daily temperature is 81°F (27°C) and the average relative humidity is 82%. Rainfall averages 150 inches (381 cm) per year. July is generally the wettest month and February and March are the driest. Surface winds vary seasonally: trade winds from the northeast and east prevail from November to May and southwest winds prevail from June to September (Maiava 1994). Palau is fortunate to be slightly off the track of typhoons and is not directly affected by typhoons as often as other nearby islands (especially Yap, Guam and Taiwan). However, every few years Palau is hit by a significant typhoon that causes damage to infrastructure, housing and the environment. In 1967, Typhoon Opal, one of the most destructive typhoons ever to hit Palau, caused widespread damage to crops, trees, housing and infrastructure and in 2001, storm surges from Tropical Storm Utor caused severe coastal erosion, landslides and damage to water, sewer and communications systems (ROP 2002).

National resources

The Republic of Palau is an archipelago composed of more than 550 islands, that stretches for 435 mi (700 km) from Ngeruangel atoll in the north to Helen Reef in the south. Only 12 of Palau's islands are currently inhabited. The land area of Palau is approximately 160 mi² (414 km²) while there is about 425 mi² (1,100 km²) of lagoon in the Main Palau Islands alone.¹ Palau's Exclusive Economic Zone (measured 200 miles from the coast) is more than 233,000 mi² (approximately 604,000 km²) (TNC 2002; FAO 2002). See Map 2.

¹ The number of islands and land area varies in each report. These numbers are taken from a compilation of Nature Facts assembled by The Nature Conservancy. The goal of that publication was to collect the most reliable information and statistics and update them as more accurate information becomes available.

Map 1: Location of Palau and the sixteen states of Palau.



Map 2: Protected areas of Palau.



The hundreds of islands that make up Palau are of four types and combinations of those types: reef and atoll, high limestone, low platform, and volcanic (US Army 1956). This great diversity of island types creates great variability of habitat and environment from one place in Palau to another. It also makes Palau one of the most biologically diverse groups of islands in Micronesia.

Table 1. Island types of Palau*

Reef and atoll	High limestone	Low platform	Volcanic
Kayangel	Rock Islands	Peleliu	Babeldaob
Ngeruangel		Angaur	Ngerkebesang
Ngemelis			Malakal
Helen			Western Koror
Southwest Islands			

*Note: some islands contain elements of more than one island type.

Palau is composed of two principal groups of islands: the Main Palau Islands (including Kayangel, Babeldaob, Koror, Ngerkebesang, Malakal, the Rock Islands, Peleliu, Angaur and their associated islets) and the Southwest Islands (Sonsorol, Merir, Fana, Pulo Ana, Hatohobei and Helen atoll). Often in the following discussion, information is provided only for the main Palau islands. The Southwest Islands are geographically, culturally and linguistically distinct from the main Palau islands. The Southwest Islands are remote, both from the main islands and from each other. As a result, some studies and surveys that have been conducted in the main islands of Palau did not include the Southwest Islands. There is, however, a substantial body of information specifically related to the Southwest Islands.

Scientists who conducted the soil survey in the main islands of Palau (excluding Kayangel) in 1980 determined that there are about 18 different kinds of soils in Palau. The soils have a wide range of texture, drainage, depth and fertility. Five general kinds of landscapes and their associated soils were characterized.

Table 2. Characteristic soils of main islands of Palau (USDA 1983).

Category	Characteristics	% of study area
soils on volcanic upland	range from shallow to very deep and support tropical forest and savanna plants	70
soils on bottomlands	very deep, poorly drained and support marshes, swamp forest, taro patches and mangrove forest	18
soils on marine terraces	very deep, poorly drained and support savanna plants and subsistence agriculture	6

Category	Characteristics	% of study area
soils on limestone	shallow, well-drained and support forest and brush	5
soils that formed in coral sand	very deep, excessively drained and supports coconuts and atoll forests	1

The major habitats found in Palau are: upland and coastal forests, savanna and grasslands, freshwater habitats, estuaries, marine lakes, nearshore habitats and coral reefs and lagoons. These will be discussed more completely in the following section.

Table 3. Habitat types in Palau

Habitat	Description	Distribution
Upland and coastal forests	Upland forests, swamp forests, limestone forest, atoll forests, mangroves	Almost all islands, but especially developed on Babeldaob, Ngerkebesang, Rock Islands, Peleliu, Angaur, Merir, Hatohobei
Savanna and grasslands	Deforested open areas dominated by grasses, ferns, shrubs and Pandanus	Babeldaob, Ngerkebesang
Freshwater habitats	Rivers, streams, lakes, cultivated and wild taro patches	Babeldaob, taro patches on all inhabited islands
Estuaries	Brackish water bodies at the point of freshwater egress to ocean areas	Ngaremeduu Bay, Airai Bay (Babeldaob)
Marine lakes	Enclosed and semi-enclosed saltwater lakes	Some Rock Islands
Nearshore habitats	Mudflats, seagrass beds, sandy beaches	All islands
Coral reefs and lagoons	Barrier reef, atoll reefs, fringing and nearshore patch reefs, shallow reef flats and lagoon patch reefs	All islands; lagoons are prominent around Kayangel, Babeldaob, Koror, Peleliu and Helen

HABITATS, USES, TRENDS AND THREATS

Upland and coastal forests

Characterization

Currently about 75% (approximately 31,260 ha) of Palau is forested. This estimate, based on vegetation maps digitized from 1976 aerial photographs, includes the major forest habitat types found in Palau: upland, swamp, limestone, atoll and mangrove forests (Cole et al. 1987; TEI 2004; TNC 2002). Palau's upland forest occurs primarily on Babeldaob, Malakal, Koror and Ngerkebesang islands. Babeldaob Island contains the largest amount of upland forest in Palau. These forests are the most extensive and diverse of any in Micronesia and include many endemic species. They are important habitats for birds and bats. Swamp forests occur just inland of the mangroves and along streams. They are found throughout Babeldaob, and remnants exist on Peleliu and Angaur. Limestone forests occur on Peleliu and Angaur. A special subcategory of limestone forests occur on the high limestone Rock Islands of Koror and Airai. Limestone forests contain a number of endemic species. Atoll forests occur towards the interior of large uninhabited atolls and along sandy and rocky coasts of the higher islands. They are behind the strand, but mixed with strand species. Mangroves occur on the south and west coasts of Babeldaob, a few areas in the Rock Islands, on Peleliu, Kayangel (planted) and in Merir in the Southwest Islands. Approximately 80% of Babeldaob's coastline is mangrove forest. Mangroves are important habitats for birds, bats, crocodiles, fish and invertebrates (especially mangrove crabs and mangrove clams), and are important nurseries for fish.

Table 4. Upland and coastal forest types in main islands, Palau*

Type	area (acres)*	% of total forest	Distribution
Upland	54,095	70	Babeldaob, Koror, Ngerkebesang
Mangrove	11,634	15	Babeldaob, Koror, Ngerkebesang, Peleliu, Angaur, some Rock Islands
Swamp	4,152	5	Babeldaob, Koror, Ngerkebesang, Peleliu, Angaur, some Rock Islands
Limestone	3,045	4	Peleliu, Angaur
Rock Island limestone	2,758	4	Rock Islands of Koror and Airai
Other	1,182	2	Includes plantation, Casuarina, palm forests throughout Palau
Atoll	383	0.5	Kayangel
Secondary vegetation	1,796		Throughout, but especially on Peleliu and Angaur
Agroforest	2,740		Along coasts and near villages

* Adapted from Cole 1987. Note these numbers do not include forests of the Southwest Islands.

Historic and current status

The exact present extent of Palau's forests is unknown, as current vegetation maps are not available and estimates are based on vegetation maps created with aerial photographic data from 1976 and 1983. Current vegetation or land use coverages are not available. There are several series of aerial photographs that could be used to create base maps from which to calculate land use changes (including forest loss). Pat Colin of the Coral Reef Research Foundation has been taking aerial photographs of the construction of the Compact Road on Babeldaob Island. This is the most recent set of aerials photographs available for Palau.

Description of uses

Historically, Palau's forests were used for sources of building materials and medicines. Palauans selectively cut trees for canoes, houses and firewood. All of the present savanna is believed to have been forested before being cleared for farming. Under the Japanese administration from 1914 to 1944, extensive areas of Babeldaob Island were cleared for farms. Some of these previously farmed areas appear to be reverting to forest (Endress and China 2001). Today Palau's forests are used much less extensively, although medicinal plants are sometimes collected and birds and bats are hunted. There is little commercial forestry. Five sawmills operate for locally harvested trees. However, imported woods are increasingly common and often cheaper than Palau's native woods.

Much of the original swamp forest of Palau had at one time been converted to taro patches. In recent history, taro production patterns have been changing. As a result many of those taro patches are returning once again to swamp forest vegetation. This trend has not been quantified.

Atoll forests on inhabited islands have mostly been converted to coconut plantation or agroforestry.

At one time, Palauan villages were established behind stands of mangroves and inland on hills to protect villagers from dangerous raids by warriors from other villages. Mangroves were important sources of firewood and other woods that were used for building materials. Channels through the mangroves were maintained to keep transportation passages clear. Today, the mangroves are not used nearly as extensively as they were in the past, as other materials now substitute for the products taken from the mangroves. Many of the mangrove channels have become overgrown as they are no longer maintained as transportation channels. The mangroves are often cut and filled to create more land for building. Mangroves remain important habitat for mangrove crabs, which are an important commercial and subsistence species. A few women maintain mangrove clam (*Anodontia* sp.) collection sites and sell the clams or bring them home for family consumption.

Trends

There have been recent measures to protect upland forests as a means to protect some drinking water sources. Currently three forested watersheds are under some form of local protection: Ngerikiil (source of drinking water for 80% of Palau's population); Lake Ngardok and the associated wetlands and forest in Melekeok state (watershed for the relocated National Capitol scheduled to open in late 2005); and Mesekelat Conservation Area in Ngchesar state. Also, trees cannot be cut from Rock Island forests under state law.

However, much of the forested areas of Palau are unprotected and are under threat of being cleared as development spreads throughout the islands (PCS 2002; Golbuu et al. 2003). Swamp forests, in particular, are one of the most threatened forest habitats in Palau.

Much of the alignment of the Compact Road being constructed around Babeldaob Island is coastal, some of it directly through mangroves. An estimated 0.25 km² of mangrove has been directly cut and filled in order to construct the Compact Road (TEI 2003). Sometimes, the mangroves are killed because water flow and circulation are blocked by the road. A significant, though undocumented, loss of mangroves has resulted from the inevitable filling of adjacent mangrove areas along a road. As has occurred in other areas in Palau (most visibly in Koror and Airai), once a road is cut through the mangroves, the remaining mangroves abutting the road are slowly filled in a piecemeal fashion. In Palau mangroves are classified as water rather than land and are not under private ownership. Throughout the states, mangroves are under state ownership (as are all resources from the coast to 12 miles) and can be leased to individuals if the state allows. Once leases are approved for mangrove areas, they are usually cut and filled. The Environmental Quality Protection Board regulates cutting and filling of mangroves and issues permits for individual projects, but does not calculate cumulative loss of mangroves on a national level.

Some states have begun to protect local mangroves. For instance, state law prohibits the cutting, filling or destroying of mangroves along the entire west coast of Ngaraard state on Babeldaob Island. However, small-scale traditional uses are allowed. A newly proposed protected area would extend this protected mangrove south into Ngardmau state. Two mangrove areas in Airai state are reserved for traditional uses only, and were set aside as mitigation for local development projects. In addition, the Papago Resort in Airai was ordered to develop public access and an educational program about mangroves on their property as partial payment for illegal clearing of mangroves during construction of the resort. The Resort now uses the resulting boardwalk, dock and interpretive signs as part of its tourist facilities and invites local school groups to tour the area.

The mangroves of the three states adjacent to Ngaremeduu Bay (Ngaremlengui, Ngatpang and Aimeliik) were originally included within the boundaries of the Ngaremeduu Conservation Area (NCAP 1999). At the time, these mangroves made up more than 40% of all mangroves in Palau. Ngaremeduu Conservation Area is one of the national mitigation areas for road construction required under the Compact of Free Association with the US. Unfortunately, conflicts between local, national and international (US) levels have led some people to propose the withdrawal of a portion of the mangrove areas from the Conservation Area. This issue is currently under negotiation and discussion.

Major threats

The major threats to Palau's upland and coastal forests are:

- forest loss and fragmentation due to poor land use planning and piecemeal development (especially with road construction on Babeldaob Island);
- invasive animal and plant species;
- uncontrolled fires; and
- hunting of forest species (especially birds and bats).

Savanna and grasslands

Characterization

Savannas and grasslands occur on Babeldaob and Ngerkebesang islands. These areas support ferns, grasses and low shrubs. Tall shrubs (bamboo which was introduced and is becoming invasive, and Pandanus) are widely scattered throughout the grasslands. Savannas and grasslands are important habitats for many species of native and migrating birds.

Historic and current status

These areas are sites of old forests that were cleared for farming or mining or by fires. Some may be of natural occurrence, however, the open grasslands existing today are maintained by constant burning that destroys much of the vegetation and degrades the soil. Many of the savannas and grasslands are the sites of terraces built by ancient populations (about 1000-1500 years BP) (Lucking 1981). These terraces are still clearly visible in Palau's landscape today. Many savannas on Babeldaob are areas that were farmed or used for military purposes by the Japanese.

Description of uses

Savannas and grasslands are important sites for the collection of medicinal plants. They are also claimed for small-scale farming. In Babeldaob, along the Compact Road, many savanna areas have been used as places to stockpile gravel and other material for road construction. Increasingly housing is being built on the open grasslands, especially in those hillside areas with a view.

Trends

Grasslands and savannas may be increasing due to widespread and periodic burning. This is becoming apparent in places along the Compact Road. The areas become more degraded supporting less diversity of plant species. Barren areas open up within the grasslands as the soil becomes more degraded. The true extent of fires is not known, nor is the amount of forest that is lost along the edges of burned savannas.

Major threats

Fire is the principal threat to diversely vegetated grasslands. Fire changes the composition of plants and soil on the savannas. Disturbed areas are recognizable by large areas of fern that chokes out all other species. Invasives are gaining hold in savannas and grasslands as well - including cogon grass. Savannas are disturbed habitats that continue to degrade due to lack of or insufficient vegetative cover to protect the soil from erosion. Some people characterize savannas as a transition habitat created by human interference, and believe that native forest species would colonize the savannas if the soils were allowed to regenerate and they were free from burning. Thus the savannas could revert back to forested land if soils could be regenerated and fires prevented.

Freshwater habitats

Characterization

The freshwater habitats found in Palau are swamps, lakes, reservoirs and streams (Bright 1979). Swamps are the most widely distributed freshwater system in Palau and are found on all island types except the raised limestone Rock Islands. There are three subtypes of

swamp in Palau: *Pandanus* swamp (the largest being in Melekeok), cultivated swamps (taro patches, known as *mesei* in Palauan), and non-cultivated manmade swamps (formed from bomb craters left after WWII or phosphate mining). Palau has two lakes and both are on Babeldaob Island: Lake Ngardok in Melekeok (15 ha) and Ngerekall in Ngaraard (0.35 ha). Lake Ngardok is the largest freshwater lake in all of Micronesia. These lakes have a high content of humic substances and are characterized by low productivity, low pH and low rates of bacterial metabolism. The lakes are important habitats for insects, crustaceans, molluscs, fish, toads and crocodiles. Palau has several reservoirs, the largest is the Ngerimel River Reservoir in Airai, the source of drinking water for 80% of Palau's population. Other reservoirs are pits that were mined for phosphate in Peleliu and former fuel storage pits on Malakal Island. The reservoirs are relatively eutrophic. No fish were observed in studies conducted in the 1970s, possibly due to occasional oxygen depletions. There are more than 15 streams of more than 5 km in length on Babeldaob Island, and several small streamlets on Koror, Ngerkebesang and Malakal islands. These are important habitats for native and endemic fish, invertebrates and plants.

Description of uses

Freshwater streams and lakes on Babeldaob Island are important sources of drinking water for Palauan communities. The Ngerikiil River in Airai supplies 80% of Palau's residents with freshwater. Lake Ngardok in Melekeok is another important drinking water source and will become a secondary source of water for the new houses and offices that will open once the National Capitol Relocation project is complete (scheduled for late 2005). Cultivated swamps are extremely important for taro production in Palau. Taro (especially *Colocasia esculenta* and *Alocasia macrorrhiza*) is a staple crop and an important element in the customary exchange of food and services among clans (Del Rosario and Esguerra 2003b).

Trends

Women in the more urbanized areas of Palau are abandoning wetland taro production in favor of dryland plantings (PCS 2002). However, in some areas, especially where access to land has increased on Babeldaob Island, there appears to be a trend towards increasing wetland taro production. These trends and patterns have not been quantified in Palau.

Major threats

The major threats to Palau's freshwater ecosystems are filling for road and other construction; water loss due to leaks in the distribution system (the largest source of loss); water loss due to overuse (for instance, some women claim their taro patches are running dry in Ngerkebesang as a result of the heavy use of water by the Palau Pacific Resort); pollution (agricultural runoff and dumping); and sedimentation (from road and other construction).

Marine Habitats

Coral reefs and lagoons

Characterization

Palau is known for its diverse and spectacular coral reefs. The reefs and their associated organisms are the most studied ecosystems in the country, and have attracted many scientific studies over the years. The complexity and configuration of Palau's islands have resulted in a system of extremely diverse coral reefs and lagoons. General descriptions of these ecosystems do not do justice to their complexity. The following is a very brief overview of Palau's coral reefs and lagoons. A much more complete and informative coverage for Palau's main islands is given by Colin (2004).

Shallow barrier reefs create a large lagoon that extends off the north, west and south of much of the main islands of Palau. The barrier reef system is about 260 km long, with its greatest length extending from north of Babeldaob to Peleliu, a distance of about 170 km (Colin 2004). The barrier reef contains at least 15 major gaps or breaks, as well as some broader areas of reef subsidence. Channels within the barrier reef are important for navigation. Many of these channels are places where some species of reef fish aggregate to spawn. Grouper spawning aggregations on Palau's barrier reefs have been the focus of several studies in the past 20 years and are a focus of current marine conservation activities in several states (Johannes et al. 1999). The barrier reef also contains three basins, numerous caverns, some of which have openings on the reef face as well as the reef flat above (the Blue Holes). Many of Palau's most spectacular and visited dive sites are located along the outer barrier reef south of Koror, in an area near the Ngemelis Islands.

Atolls, oceanic islands and oceanic banks are other outer reef environments. Palau has three atolls: Kayangel and Ngeruangel in the north and Helen Reef in the Southwest Islands. Kayangel and Helen reef are typical atolls, with small islands and reefs surrounding a shallow sandy lagoon. Ngeruangel is more complex. Ngeruangel appears to be an atoll itself, but is actually the southern extent of a much larger "sunken" atoll to the north, Velasco Reef (Colin 2004). The atolls are important nesting sites for green and hawksbill turtles. The reefs are all historically important fishing spots, though now Ngeruangel and Helen are restricted conservation areas. Angaur Island and the Southwest Islands are oceanic islands, with a narrow reef shelf along their edge that drops sharply to deep ocean. One oceanic bank, Hydrographer's Bank, is located between Peleliu and Angaur at 23 m below the surface.

The barrier reefs of the main Palau islands enclose a series of lagoons that cover approximately 1,100 km² (TNC 2003). Most depths within the lagoon are 30-45 m. Within the lagoons are a complex of shallow fringing and nearshore patch reefs (around Babeldaob island), shallow reef flats (Rock Islands and Peleliu) and lagoon patch reefs (Colin 2004). These environments are closely associated with seagrass beds, covered in the previous section. The lagoons and associated reefs are primary habitat for reef fish, invertebrates, algae, as well as dugongs, sea turtles and saltwater crocodiles. Palau's reefs and lagoons are home to more than 1,300 known species of reef fish, 3,300 species of invertebrates (including

more than 400 species of hard corals), 10 species of seagrass, 7 marine reptiles, and 250 species of algae (TNC 2002). The marine environments of Palau support the local tourism industry, subsistence and commercial fisheries, in addition to being a strong component of Palau's culture and heritage.

Historic and current status

Through history, Palau's reefs were rich, abundant and relatively pristine. Some reefs were damaged occasionally by shipwrecks, the first being the British *Antelope* which ran aground in 1783 on Ulong Island. Some major alterations to the reefs and lagoons occurred under the German administration in the early 20th century, with the dredging of the German Channel through the southern barrier reef and the coastal infrastructure that was built for phosphate mining in the Southwest Islands. The German Channel still supports very few benthic marine communities (Colin 2004). Palau was the headquarters for the Japanese Administration in the Pacific before and during World War II. Numerous seawalls, dredged areas, landfill and coastal infrastructure were built by the Japanese administration in both the main and the Southwest islands. In addition, bombing during the war resulted in countless explosions in the lagoons, lost unexploded ordinance as well as numerous sunken ships and airplanes that physically damaged the reefs and leaked oil into the lagoons.

Perhaps the most important event in recent years was the coral bleaching that occurred as a result of elevated sea surface temperatures in 1998. Almost one-third of Palau's coral colonies died, with mortality reaching 100% on some outer reef slopes (Richmond et al. 2002). Soft corals, giant clams and ascidians also bleached in 1998. Since 1998, on-going coral reef monitoring programs have indicated that recovery is occurring, but is slow (Richmond et al. 2002).

Description of uses

Marine resources have been a vital source of protein for the people of Palau for centuries. Marine turtles, dugong and crocodiles have been hunted in Palau. Hundreds of fish and invertebrate species are still important food sources. These fish and invertebrate species support an extensive semi-subsistence economy throughout Palau. Many women collect marine invertebrates such as clams, sea cucumbers and crabs from nearshore reef flats, seagrass beds and mangrove areas. Men catch dozens of species of reef fish, as well as octopus, squid, mangrove crabs and giant clams. They often have motorized boats and are able to fish both inside and outside Palau's extensive barrier reefs. Southwest Islanders became particularly adept at deep ocean fishing outside of their fringing reefs. Traditionally, the reef and lagoons served as learning grounds to pass traditional knowledge about the tides, moon phases, and the behavior of marine life from one generation to the next. Rights of passage for young men often depended upon their skill as fishermen. Men acquired status and power by their levels of skill and knowledge about fishing and navigation. At times traditional chiefs were selected because of their knowledge of all natural resources. These men were responsible for wise management of the local resources, and had the authority to open and close fishing seasons and fishing grounds.

Today, Palau's coral reefs and lagoons support local subsistence and commercial fisheries. These are discussed more extensively in the next section. The reefs and lagoons are also

the basis for Palau's dive tourism industry. Tourism is one of Palau's principal industries. In 2003, more than 67,000 people visited Palau and in the first nine months of 2004, more than 80,000 people arrived (PVA 2004). The major tourism markets are Taiwan (45% of visitors) and Japan (38% of visitors). The remaining visitors are from North America, Europe, Australia, New Zealand and various Pacific island countries. Palau's reefs are major tourist attractions and Palau is home to several world renowned dive sites. A recent exit survey indicated that approximately 85% of Palau's Japanese, North American and European visitors scuba dive, while only 22% of those from Taiwan dive. However, overall about 55% of the total visitors dive while in Palau. The remaining 45% snorkel, visit the Rock Islands, see WWII relics, visit Babeldaob Island and/or engage in sportfishing activities, among other activities (Cesar et al. 2004). All of these activities are reef and lagoon related.

Major threats

The major threats to coral reefs and lagoon environments in Palau are:

- tourism (boat traffic, trash, physical damage, anchor damage)
- fishing (overharvest, destructive methods, boat traffic)
- crown of thorns starfish
- bleaching and climate events
- storms
- land-based impacts (sedimentation, pollution)
- sand mining and coral dredging
- invasive species

Estuaries

Characterization

Ngaremeduu Bay, in western Babeldaob, is the largest bay and estuary in Micronesia. Three river systems feed into the bay: Tabecheding, Ngatpang and Ngermeskang. The Ngermeskang is the longest river in Micronesia (Maragos 1992). The bay is shallow with broad mudflats and is lined by dense mangrove. In 1992, 44% of Palau's mangroves grew around Ngaremeduu Bay. In addition, most major terrestrial and nearshore ecosystems occur within the watersheds, shores or offshore habitats of the bay. Offshore habitats support a rich coral reef fishery. The nearshore area is an important habitat for mangrove crabs, mangrove clams and other invertebrates. In 1992, approximately half of Palau's mangrove crab landings came from the bay (Maragos 1992). Saltwater crocodiles were once abundant in the bay, but populations were severely reduced by hunting in the 1970s.

Historic and current status

Ngaremeduu Bay was set aside as a conservation area by the three states that share its resources: Ngeremlengui, Ngatpang and Aimeliik. It was also recognized nationally as one of the conservation area set asides for the Compact Road construction project.

Description of uses

Ngaremeduu Bay is a locally important area for subsistence and small-scale commercial

fishing. Mangrove crabs are the primary catch in the Bay. Small-scale ecotourism is being promoted in the Bay. Other uses, most recently caged fish farming, are being developed in the Bay (although technically outside of the conservation area). A preliminary resource assessment is being conducted by Palau Conservation Society to collect known information about local resource and land uses in one area of the Ngaremeduu Bay watershed (Ngatpang state).

Major threats

The major threats to the bay are similar to those of other nearshore habitats in Palau, especially sedimentation from poor land use practices and road construction. Unpublished data collected by the Marine Conservation and Protected Area Program at the Bureau of Marine Resources indicates a 25% increase in sediments in the Bay in the past five years (MCPA 2004). Additional threats include mangrove loss from coastal dredging and construction. For instance, in 1990, 35 acres of mangroves in Ngatpang were lost when the construction of a dock blocked adequate drainage.

Marine lakes

Characterization

There are 28 saltwater lakes within some of the limestone islands of Palau. These marine lakes are unique and relatively isolated ecosystems with little seasonal or annual variation. Some are directly open to the lagoon, some are connected by tunnels in the islands through which saltwater flows and some are completely enclosed by the island. “No two lakes are identical in abiotic or biotic content or structure” (Hamner 1994). Thirteen of the marine lakes contain an anoxic layer of hydrogen sulfide. Some of the lakes contain endemic species, such as jellyfish or gobies, and some are home to young crocodiles. The most famous of the marine lakes is Jellyfish Lake (Ongeim’l Tketau), so named because of the large population of *Mastigias sp.* jellyfish that inhabits the lake.

Historic and current status

The marine lakes and their unique organisms have been studied and characterized since 1978 (Burnett et al. 1989; Hamner 1994; Dawson et al. 2001; among others). Recent studies have focused on the physical parameters of the lakes and monitoring of *Mastigias* populations (Martin et al. 2001).

Description of uses

Jellyfish Lake (Ongeim’l Tketau) is one of Palau’s most visited tourist attractions. As many as 300 people a day have been counted at the lake (Olkeriil 2004). Koror State has banned tourist access to all other marine lakes because of their sensitivity to stress. Scientific research and monitoring to document species in the lakes are currently being conducted by the Coral Reef Research Foundation. Palauans occasionally hunt bats or birds at the lakes.

Major threats

The primary threats to the marine lakes are damage from tourists, climate changes and invasive species. Tourism is growing in Palau. In 2004, there were significantly more tourists visiting the country and most of these tourists visit Jellyfish Lake. Although many

tour groups are advised of the sensitivity of the site and tour agencies implement low-impact strategies (such as not using fins), some tourists have been observed throwing the jellyfish or otherwise creating disturbances in the lake. There is also concern about the potential impacts of suntan lotion in the water. In addition, all of the jellyfish medusae in Jellyfish Lake disappeared in 1999 after the sea surface temperature rise and subsequent coral bleaching event in 1998. They have since returned to former levels of abundance, due to the recovery of the benthic polyp stage (Martin et al. 2001). Invasive species are another threat to these unique environments. In 2004, an invasive species of anemone was recorded in Jellyfish Lake. This anemone is being monitored by the Coral Reef Research Foundation.

Nearshore habitats

Characterization

Sandy beaches, mudflats and seagrass beds are the most predominant nearshore ecosystems. The associated nearshore patch reefs will be discussed in the following section on coral reefs (see below). Sandy beaches line some of Palau's islands. The beaches of Kayangel, Ngeruangel Atoll, northeastern Babeldaob, some of the Rock Islands, Peleliu, Angaur and all of the Southwest Islands are most well developed. Many of these beaches are important nesting sites for green and/or hawksbill turtles. They are also habitat for land crabs, numerous molluscs and other invertebrates. The landward side of Palau's beaches are also prime nesting habitat for the Micronesian megapode. Major seabird rookeries are located on the beaches of Ngeruangel and Helen Atolls. The beaches of the Rock Islands are vital to the tourist industry.

Mudflats can be found in the lagoons of the larger islands, such as Babeldaob, Ngerkebesang and Peleliu. The mudflats in Ngaremeduu Bay in western Babeldaob are quite developed.

Seagrasses occur in all shallow, flat, marine environments and often intermix with corals, so it is sometimes difficult to distinguish distinct seagrass habitats in Palau (Colin 2004). Nevertheless, seagrass beds occur throughout Palau, and are especially well-developed around Babeldaob Island (all areas, but especially extensive on the west coast), some areas of Koror's southern lagoon, northeast of Peleliu and around the Southwest Islands (especially Hatohobei, Helen and Merir) (Maragos et al. 1994a and b). Ten seagrass species have been found in Palau (Coles and Kuo 1995). Seagrass beds are important habitat for fish (wrasses, some lethrinids, and rabbitfish), invertebrates (sea cucumbers, anemones, urchins and crabs) and many forms of epiphytic bacteria, algae and fungi. They are feeding areas for dugong, sea turtles, herbivorous fish and important nurseries for many species of reef fish and invertebrates. These areas support coastal fisheries productivity. They also help to stabilize sediment and maintain water quality.

Description of uses

Nearshore habitats are very important in Palau for subsistence and commercial harvest. Women, in particular utilize these habitats for subsistence and semi-subsistence collection of sea cucumbers, urchins, molluscs, crabs and small fish (Matthews and Oiterong 1991).

Trends

There is a general, though unquantified, trend towards degradation of nearshore habitats around Palau. Anecdotal information from Palauans knowledgeable about the status of these areas over time, from the production of Environmental Assessments for various coastal development projects (notably those associated with the construction of the Compact Road), and from daily observation all indicate a general decline in many nearshore habitats and the species they support. This is particularly true in those areas undergoing the most rapid development and change: coastal areas of Babeldaob Island.

Major threats

Nearshore habitats are among the first marine environments to be hit by detrimental impacts from land-based activities. In Palau, sediment reaches nearshore areas from construction activities and is transported by streams (especially on Babeldaob island). Increasingly, paved areas and new roads with good drainage systems are redirecting runoff from the land and concentrating its impacts in some nearshore areas. Excess sedimentation can quickly smother and overwhelm the nearshore habitats. Airai Bay, in southern Babeldaob, has suffered from excess sedimentation from poorly contained earth moving activities along the Ngerikiil River that empties into the bay (Golbuu et al. 2003; Victor 2004). These activities include an increase in unsustainable agricultural practices, the construction of the Compact Road, the expansion of the international airport runway and the dredging of a boat channel. Pollution from fertilizers, pesticides, household chemicals, fish waste and oil spills in nearshore areas are unquantified, although are of potential impact in the urbanizing areas around Koror and southern Babeldaob.

Nearshore habitats are also impacted from the seaward side from dredging and long-term sand mining activities. Habitat loss has occurred due to dredging, especially in many of Babeldaob's coastal areas. Aimeliik, Airai, Koror, Melekeok, Ngaraard, Ngarchelong, Ngatpang, Ngchesar and Ngiwal all have coral dredging operations that supply fill to the Compact Road. The habitat loss associated with these sites has not been accurately quantified, however, TEI (2003) estimated that about 1 km² of nearshore fringing reef (the estimate included seagrass beds and mudflats) has been lost as a result of these dredging activities in the past two years. No assessments have been made of the impacts of sand mining operations.

Palauans believe that increased boat traffic in shallow areas is detrimental to the seagrass beds and the species they support. Many people believe that planktonic larvae and juveniles are killed by boat engines as they travel quickly through shallow nearshore areas. While physical damage to the seagrasses and sediment from boats or jet skis that hit shallow bottom may in fact occur, the extent of damage from boats is not known.

Finally overharvest of species is an ongoing threat to the nearshore habitat. Sedentary nearshore invertebrates are particularly sensitive to overharvest, as they are relatively easy to collect in large quantities. Women are most concerned about apparent declines in sea urchins (*Tripneustes gratilla*), several species of sea cucumbers, the blue swimming crab (*Portunus pelagicus*) and many kinds of bivalves in areas where they once were abundant (PCS 2003). Recent surveys in Airai indicate serious declines in the numbers of invertebrates in areas locally known as "hotspots" for collection (Kitalong 2005). Other

species such as rabbitfish which spend much of their lives in and around seagrass beds, have shown declines in the numbers that aggregate to spawn. This decline is probably due to overharvest during their seasonal spawning aggregations, as well as to sedimentation and pollution (Kitalong 2005).

SPECIES OF CONCERN

Endemic species

Micronesian islands have high levels of endemism. These species are particularly vulnerable and many are listed in the tables above. The true extent of this endemism is unknown in Palau. There are 11 species and 9 sub-species of birds known to be endemic in Palau (TNC 2004). A recent survey of forests in Palau identified 200 rare and endemic tree species (TEI 2004). Surveys of land snails have shown high endemism especially in upland and Rock Island forests (Rundell 2005). Four species of freshwater fish and 10 lizards are known endemics. An inventory of insects is currently being conducted in Palau as a collaborative effort between the Belau National Museum and The Nature Conservancy, and will help to determine the level of insect endemism. There appears to be less endemism in the marine environment due to the flow of ocean currents that disperse planktonic larvae over great distances. However, there are 6 known endemic marine fish and one endemic chambered nautilus (Colin 2004).

Endangered and threatened species

As in many other island areas, many species in Palau have a relatively low tolerance to change and stress. Palauan birds and animals had few native predators before the arrival of man, and did not develop defensive mechanisms to protect themselves. For instance, many Palauan seabirds lay their eggs in poorly protected nests or on the ground. Traditionally Palauans exploited local resources, sometimes quite heavily. Although they occasionally developed mechanisms that worked to control the harvest of some species, over-harvest did occur. Today harvest levels have increased due to commercialization, improved technology and gear, as well as increased access to more habitats.

The distribution and status of many of the species in Palau, especially terrestrial species, are poorly known and understudied. Plants, insects, terrestrial invertebrates and freshwater species are least known. At the same time, negative human impacts on habitats, continued harvest and deleterious affects of climatic events, both in Palau and in the region, have increased the threats to more and more species. There is a fear that endemic species could be lost before they are even known to exist.

Currently, there are 111 species in Palau that are listed on the IUCN Red List of Threatened Species (see Table 5). This list contains many species, especially terrestrial gastropods (land snails) for which there is insufficient data to determine whether they are indeed threatened. However, they have been listed because of the high probability that they are endemic, possibly even endemic to a very particular island or location, and threatened by loss of native habitat. There are other species in Palau that may be threatened as well, but have not yet been added to the IUCN list. Some of these are listed in Table 6. These lists will continue to be refined as more information becomes available.

Table 5. Species in Palau on the IUCN Red List of Threatened Species (IUCN 2004).

* “National law” indicates that national legislation exists in Palau to protect this species. Effective enforcement of such laws, however, is often a problem.

Scientific Name	Common Name	Comments*
<u>Mammals</u>		
<i>Pteropus pilosus</i>	Large Palau fruit bat	Extinct
<i>Emballonura semicaudata</i>	Pacific sheath-tailed bat	Endangered
<i>Pteropus mariannus</i>	Marianas fruit bat	Endangered regionally but not considered threatened in Palau
<i>Dugong dugon</i>	Dugong	Vulnerable; national law
<i>Macaca fascicularis</i>	Crab-eating macaque	Introduced and invasive (esp. on Angaur)
<i>Stenella longirostris</i>	Long-beaked dolphin	Least concern
<i>Lagenodelphis hosei</i>	Fraser’s dolphin	Data deficient
<i>Feresa attenuata</i>	Pygmy killer whale	Data deficient
<i>Grampus griseus</i>	Grey dolphin	Data deficient
<i>Mesoplodon densirostris</i>	Blainville’s beaked whale	Data deficient
<i>Mesoplodon ginkgodens</i>	Ginkgo-toothed beaked whale	Data deficient
<u>Reptiles</u>		
<i>Eretmochelys imbricata</i>	Hawksbill turtle	Critically endangered-nesting population; national law
<i>Chelonia mydas</i>	Green turtle	Endangered-nesting population; national law

Scientific Name	Common Name	Comments*
<u>Birds</u>		
<i>Gorsachius goisagi</i>	Japanese night-heron	Endangered-migrant
<i>Megapodius laperouse</i>	Micronesian megapode	Endangered-national law
<i>Caloenas nicobarica</i>	Nicobar pigeon	Near threatened-national law
<i>Ducula oceanica</i>	Micronesian imperial-pigeon	Near threatened-national law
<u>Fish</u>		
<i>Cheilinus undulatus</i>	Humphead wrasse	Endangered-national law
<i>Epinephelus lanceolatus</i>	Giant grouper	Vulnerable-national law
<i>Nebrius ferrugineus</i>	Tawny nurse shark	Vulnerable
<i>Rhynchobatus djiddensis</i>	Whitespot giant guitarfish	Vulnerable
<i>Stegostoma fasciatum</i>	Leopard shark	Vulnerable
<i>Thunnus obesus</i>	Bigeye tuna	Vulnerable
<i>Urogymnus asperrimus</i>	Porcupine ray	Vulnerable
<i>Echinorhinus cookei</i>	Prickly shark	Near threatened
<i>Epinephelus coioides</i>	orange-spotted grouper	Near threatened
<i>Epinephelus fuscoguttatus</i>	Brown marbled grouper	Near threatened-national law
<i>Gallicolumba canifrons</i>	Palau ground-dove	Near threatened-national law
<i>Megazosterops palauensis</i>	Giant white-eye	Near threatened-national law
<i>Plectropomus leopardus</i>	leopard coral trout	Near threatened-national law

Scientific Name	Common Name	Comments*
<i>Carcharhinus amblyrhynchos</i>	Gray reef shark	Least concern
<i>Carcharhinus longimanus</i>	Oceanic whitetip shark	Least concern
<i>Carcharhinus melanopterus</i>	Blacktip reef shark	Least concern
<i>Eleotris melanosoma</i>	Broadhead sleeper	Least concern
<i>Galeocerdo cuvier</i>	Tiger shark	Least concern
<i>Hexanchus griseus</i>	Bluntnose sixgill shark	Least concern
<i>Isurus oxyrinchus</i>	Shortfin mako	Least concern
<i>Prionace glauca</i>	Blue shark	Least concern
<i>Triaenodon obesus</i>	Whitetip reef shark	Least concern
<i>Cephalopholis boenak</i>	Chocolate hind	Least concern
<i>Aetobatus narinari</i>	Spotted eagle ray	Data deficient
<i>Hippocampus denise</i>	Denise's pygmy seahorse	Data deficient
<i>Manta birostris</i>	Manta ray	Data deficient
<i>Thunnus alalunga</i>	Albacore tuna	Data deficient
<u>Invertebrates</u>		
<i>Marine</i>		
<i>Tridacna derasa</i>	Southern giant clam	Vulnerable-national law
<i>Tridacna gigas</i>	Giant clam	Vulnerable-national law
<i>Hippopus hippopus</i>	Bear paw clam	Least concern-national law
<i>Hippopus porcellanus</i>	China clam	Least concern-national law
<i>Tridacna maxima</i>	Small giant clam	Least concern-national law
<i>Tridacna squamosa</i>	Fluted clam	Least concern-national law

Scientific Name	Common Name	Comments*
<i>Assimineea palauensis</i>	marine gastropod	Data deficient
<i>Birgus latro</i>	Coconut crab	Data deficient
<i>Kubaryia pilikia</i>	marine gastropod	Data deficient
<i>Omphalotropis cheynei</i>	marine gastropod	Data deficient
<i>Omphalotropis mutica</i>	marine gastropod	Data deficient
<i>Omphalotropis striatapila</i>	marine gastropod	Data deficient
Freshwater		
<i>Paludinella vitrea</i>	freshwater gastropod	Data deficient
Terrestrial		
<i>Partula calypso</i>	land snail	Endangered-endemic
<i>Partula leucothoe</i>	land snail	Endangered-endemic
<i>Partula thetis</i>	land snail	Endangered-endemic
<i>Aaadonta angaurana</i>	land snail	Data deficient
<i>Aaadonta constricta</i>	land snail	Data deficient
<i>Aaadonta fuscozonata</i>	land snail	Data deficient
<i>Aaadonta irregularis</i>	land snail	Data deficient
<i>Aaadonta kinlochi</i>	land snail	Data deficient
<i>Aaadonta pelewana</i>	land snail	Data deficient
<i>Diplommatina alata</i>	land snail	Data deficient
<i>Diplommatina aurea</i>	land snail	Data deficient
<i>Diplommatina crassilabris</i>	land snail	Data deficient
<i>Diplommatina gibboni</i>	land snail	Data deficient
<i>Diplommatina inflatula</i>	land snail	Data deficient
<i>Diplommatina lamellata</i>	land snail	Data deficient
<i>Diplommatina lutea</i>	land snail	Data deficient

Scientific Name	Common Name	Comments*
<i>Diplommatina pyramis</i>	land snail	Data deficient
<i>Diplommatina ringens</i>	land snail	Data deficient
<i>Hungerfordia pelewensis</i>	land snail	Data deficient
<i>Nesopupa eapensis</i>	land snail	Data deficient
<i>Palaina albata</i>	land snail	Data deficient
<i>Palaina dimorpha</i>	land snail	Data deficient
<i>Palaina dohrni</i>	land snail	Data deficient
<i>Palaina moussoni</i>	land snail	Data deficient
<i>Palaina patula</i>	land snail	Data deficient
<i>Palaina platycheilus</i>	land snail	Data deficient
<i>Palaina pupa</i>	land snail	Data deficient
<i>Palaina pusilla</i>	land snail	Data deficient
<i>Palaina rubella</i>	land snail	Data deficient
<i>Palaina strigata</i>	land snail	Data deficient
<i>Palaina striolata</i>	land snail	Data deficient
<i>Palaina wilsoni</i>	land snail	Data deficient
<i>Palaua babelthuapi</i>	land snail	Data deficient
<i>Palaua margaritacea</i>	land snail	Data deficient
<i>Palaua minor</i>	land snail	Data deficient
<i>Palaua ngarduaisi</i>	land snail	Data deficient
<i>Palaua straminea</i>	land snail	Data deficient
<i>Palaua wilsoni</i>	land snail	Data deficient
<i>Palline notera</i>	land snail	Data deficient
<i>Paludinella semperi</i>	land snail	Data deficient
<i>Pseudopalaina polymorpha</i>	land snail	Data deficient

Scientific Name	Common Name	Comments*
<i>Pupina difficilis</i>	land snail	Data deficient
<i>Semperdon kororensis</i>	land snail	Data deficient
<i>Semperdon uncatius</i>	land snail	Data deficient
<i>Semperdon xyleborus</i>	land snail	Data deficient
<i>Succinea philippinica</i>	land snail	Data deficient
<i>Videna electra</i>	land snail	Data deficient
<i>Videna oleacina</i>	land snail	Data deficient
<i>Videna pagodula</i>	land snail	Data deficient
<i>Videna pumila</i>	land snail	Data deficient
<u>Plants</u>		
<i>Aglaia mariannensis</i>	tree	Vulnerable
<i>Parkia parvifoliola</i>	tree	Vulnerable-endemic to Babeldaob
<i>Pericopsis mooniana</i>	Nandu wood (tree)	Vulnerable
<i>Horsfieldia palauensis</i>	tree	Least concern-endemic

Table 6. Other species in Palau believed threatened (adapted from CI 2004).

Scientific Name	Common name or group	Comments
<i>Artamus leucorhynchus</i>	White-breasted wood swallow	
<i>Caprimulgus indicus</i>	Jungle nightjar (bird)	
<i>Cettia annae</i>	Palau bush warbler	endemic
<i>Colluricincla tenebrosa</i>	Palau morningbird	endemic
<i>Erythrura trichroa</i>	Blue-faced parrotfinch	
<i>Gallinula chloropus</i>	Common moorhen	
<i>Myiagra erythropis</i>	Palau flycatcher	endemic
<i>Porphyrio porphyrio</i>	Purple swamphen	
<i>Ptilinopus pelewensis</i>	Palau fruit dove	endemic
<i>Pyrroglaux podargina</i>	Palau owl	endemic
<i>Rhipidura lepida</i>	Palau fantail	endemic
<i>Crocodylus porosus</i>	crocodile	small population; considered a dangerous pest
<i>Aglaia palauensis</i>	shrub	
<i>Avicennia alba</i>	mangrove plant	
<i>Ceriops tagal</i>	plant	
<i>Cinnamomum carolinse</i>	plant	
<i>Cinnamomum pedatinervium</i>	plant	
<i>Garcinia matudai</i>	tree	endemic
<i>Gulubia palauensis</i>	palm	endemic
<i>Ptychosperma palauensis</i>	tree	
<i>Rhizophora lamarkii</i>	plant	
<i>Terminalia crassipes</i>	plant	
<i>Terminalia samoensis</i>	plant	
<i>Xylocarpus moluccensis</i>	mangrove tree	

Economically important species

Fishing

Palauans have long depended upon the rich local marine resources for sustenance. Today those resources are the basis of commercial enterprises. Fisheries comprise the second largest source of revenue in Palau. In 2003, 90 longline and 31 purse seine boats from China, Japan and Taiwan were licensed to fish for tuna in Palau's waters. Table 7 lists the recorded 2003 catch of the longline fleet.

Domestic fisheries are somewhat complex and difficult to quantify in Palau. The domestic fisheries are composed of fishing and invertebrate collection for local markets and restaurants, for informal and village markets, for customary and other events (funerals, festivals, sporting events), for family consumption, and for export to family members abroad. In addition, fish and invertebrates are often processed, cooked and sold throughout the country. "Bentos" (lunch-sized packages) containing a complete meal of such items as fried fish, rice, eggs and salad are sold in many local stores. Data is collected on the commercial sale of fish and some invertebrates in the larger local markets. For example, Table 8 shows the weight and value of fish and invertebrates based on market receipts submitted to the Bureau of Marine Resources for 2002. More than 450,000 pounds with a market sale of \$637,000 for many species of reef fish and invertebrates were recorded through these receipts.

This is a fraction of the total catch, as many of the smaller markets (where a wide variety of other species from sea cucumbers to sea turtles, as well as processed bentos, are sold) are not regularly monitored. Studies have documented the extent of some of these small-scale fishing activities. Women, in particular, are involved in many small-scale, semi-subsistence activities. Women sell many species of sea cucumbers, molluscs, crabs, urchins and anemones in small local markets throughout Palau (Matthews and Oiterong 1991; Lambeth 1999). Women also cook a large amount of what they sell. Due to the difficulty and variety of venues, sales through smaller commercial markets, village stores, restaurants, informal markets and special order direct from the fisherman or woman are also not monitored.

Live reef fish and invertebrates (ornamentals and food fish) have been exported sporadically from Palau since 1990 (Graham 2001). The ornamentals were shipped to the United States and the live food fish (primarily groupers, snappers and humphead wrasse) to Hong Kong. In the peak year (1994-1995), Palau exported at a rate of 25 mt/yr of live food fish to Hong Kong. The industry became unpopular in Palau because of local complaints about using reef fish to feed the live fish, concern over the impacts on spawning aggregations of grouper and dissatisfaction with the use of foreign fishermen rather than local fishermen (Graham 2001). Recently a new live fish export company has been accused of very similar actions by the community of Ngaremlengui, where it was originally welcomed. In addition, the company has been caught fishing in two marine protected areas: Ngaremeduu Bay Conservation Area (near where it was licensed to fish) and Ngeruangel Reserve (approximately 25 miles north of where it was permitted to fish).

Table 7. Catch by longliners in 2003 (Sisior 2004).

Species	Catch (metric tonnes)
Bigeye tuna	598
Yellowfin tuna	1,144
Black marlin	1
Blue marlin	51
Striped marlin	3
Swordfish	12
Other	26
Total	1,835

Table 8. Domestic fish catch 2002 - from local market receipts (Bureau of Marine Resources).*

Category	Weight (lb)	Value (\$)
Assorted Reef Fish	253,173	315,655
Surgeon and Unicornfish	81,035	119,515
Parrotfish	26,061	34,969
Wrasses	23,877	36,007
Tuna and Mackerels	13,071	10,841
Mangrove crabs	12,162	50,769
Rabbitfish	11,839	17,098
Groupers	11,600	16,504
Snappers	9,683	9,755
Emperors	7,339	7,669
Jack, Scad, Trevally	2,552	2,736
Lobster	2,332	8,498
Rudderfish	2,217	2,346
Herring, Sardines, Sprats	969	979

Category	Weight (lb)	Value (\$)
Goatfish	945	1,052
Milkfish and Mullet	942	1,092
Billfish	797	723
Barracuda	578	638
Mojarras	227	195
Dolphinfish	144	115
Rays	75	56
Squirrelfish and Soldierfish	59	66
Sweetlips	5	4
Total	461,687	\$ 637,292

*Data concerning the catch of the Japanese purse seine fleet, which is allowed to transport and offload catch in Japan, are not included in the tables above because of differences in reporting requirements. The Japanese purse seine fleets only report their catch if requested by the National government. This does not appear to be routinely done.

Hunting

Hunting of birds and bats is also economically important on a small scale in Palau. No studies have been done to quantify the exploitation of Micronesian pigeons (*Ducula oceanica monacha*), which are the most commonly hunted bird in Palau. Although it is illegal to hunt pigeons, there is still an active local black market, with birds selling for as much as \$20 apiece (Matthews, pers. obs.). Wiles found that Palau was the major exporter of fruit bat (*Pteropus mariannus pelewensis*) to Guam from 1976 to 1994, with more than 150,000 bats exported in that time period (Wiles et al. 1997). Currently the only limitation on export of fruit bats is the requirement for a CITES permit from the importing country (if that country is a signatory of CITES²). Preliminary assessments from a recent bird and bat survey indicate that Palauan bat populations still appear to be healthy (Wiles, pers. comm. 2005).

Farming

Much of the agricultural products in Palau are imported. Production of fruits and vegetables dropped threefold from 1996 to 2001 as a result of increased imports (SAGRIC 1996). However, there is the impression locally that commercial farming, especially in Airai, is increasing. In addition, there is a vibrant and important informal agricultural sector, which is mostly the realm of women who tend taro patches and agroforestry plots. In 1996, the Informal Employment and Sustainable Livelihoods Program (IESL) estimated that the non-

² Most countries with direct flights to Palau are members of CITES (US, Japan, Philippines, China (Taiwan)). However, Federated States of Micronesia is not a signatory to the Convention. Thus listed species, including fruit bats, can be transported legally between Palau and Yap with no permits.

commercial agricultural sector was double the commercial sector (IESL 1996). Much of this produce is sold in small local markets scattered throughout Palau. The most important locally farmed crops are taro, tapioca, sweet potato, cucumbers, pumpkin, betelnut and a variety of tropical fruits.

Aquaculture.

Palau has a long history of aquaculture. The following table outlines some of the major aquaculture initiatives in Palau undertaken by the Japanese administration (1920-1943), American administration (1970-1990) and Palau National Government (1990s). Palau may be particularly renowned for its efforts rearing giant clams and the establishment of a giant clam hatchery in the 1970's which served as a model for hatcheries in other countries.

Table 9. Aquaculture projects in Palau (adapted from Oiterong 2003).

Year	Species	Comments
1920	Black-lip pearl oyster	
	Silver or gold-lip pearl oyster	imported
1931	Trochus	transplantation trials
	Sea cucumber	
1935-1936	Japanese pearl oysters	imported
1936-1943	Giant clams	studies
	Trochus	
	Edible oyster	
1970	Hawksbill turtle	headstarting
	Rabbitfish	
	Crocodiles	
	Pearl oyster	
	Baitfish	
	Shrimp	
	Prawn	

Table 9. Aquaculture projects in Palau (adapted from Oiterong 2003). Cont.

Year	Species	Comments
	Mullet	
	Milkfish	
	Sponges	
1973	Giant clams	7 species
	Trochus	
	Oyster	
	Saltwater and freshwater prawns	
	Milkfish	
	Rabbitfish	
1990s	Grouper (coral trout)	

Aquaculture has been promoted in Palau as an effective way to replenish diminished marine stocks of fish and invertebrates. However, there is little evidence that this is an effective strategy. In fact, most species that have been reared through aquaculture in Palau to date, with the exceptions of Black-lip pearl oysters, giant clams and rabbitfish, are either imported species, wild caught juveniles that are then grown-out or species that are not locally threatened. New aquaculture facilities are now being constructed in Ngatpang to raise milkfish (imported fry) and eventually shrimp in an area that formerly was a mangrove.

Aquaculture projects are regulated through several agencies and require a number of permits, including environmental impacts, cultural/historical impacts and import of marine species. In order to assist people who may be interested in starting an aquaculture project, a multi-agency task force has created a packet of information that includes a checklist of required permits and information from the Small Business Development Center on costs and associated risks. The Small Business Development Center has also conducted a workshop on how to start an aquaculture business. A workshop on the regulatory aspects of aquaculture was held (hosted by PCS) in 2003 with participants from local agencies, University of Hawaii-Hilo, NOAA and the College of the Marshall Islands. Future advancement with aquaculture would require efforts that are able to meet the permitting requirements and be economically feasible.

Culturally important species

Several marine species are valued for non-commercial or cultural reasons in Palau. Some of the larger marine species have particular cultural value, especially sea turtles, dugong, sting rays, humphead parrotfish and humphead wrasse. Taro is another species that is an important element of the traditional food exchange system. In addition, many species of schooling fish such as rabbitfish, unicorn fish and surgeonfish have local importance for subsistence and semi-subsistence purposes. Other species are popular mainly for their subsistence uses. These include sea urchins, giant clams, sea cucumbers and many species of small fish.

Sea turtles in Palauan culture

The shell of the hawksbill turtle (*Eretmochelys imbricata*) is the source of one form of women's money in Palau, an oval tray called toluk. Women both give and receive toluk. Toluk is given to women by their husband's clan to pay for food preparation services performed for a traditional custom. Toluk is made by special craftsmen who place heated pieces of shell into molds. Once the shell has hardened it is carved and polished. Hawksbill shells are also a highly valued source of material for jewelry such as earrings and bracelets. Wearing several turtle shell bracelets (klilt) was once a sign of wealth. Today, anyone can buy turtle shell jewelry. It is sold in many shops around Palau, especially those catering to tourists.

Fishermen say that large turtles are becoming scarcer. As a result, the toluk that is currently being made tends to be thinner and smaller than older pieces. Older, larger toluk are more valuable than newly made toluk. Although it is not possible to place a true monetary value on a traditionally valued item, some of the older pieces of toluk may be worth more than \$1000. Women are keeping the older pieces of *toluk* out of circulation. Instead of giving away their more valuable pieces, women are buying cheaper, smaller *toluk* to exchange. They keep the older, more valuable pieces for emergencies, such as an important funeral, when there is no choice but to give away the very best pieces.

Turtle meat, especially that of the green turtle (*Chelonia mydas*), is a popular food. It is seen as a high-quality, inexpensive source of protein, and is especially important in the diet of Southwest islanders. At one time, turtle meat was reserved for special occasions, such as the inauguration of a chief. Although it is not required for these feasts, turtle meat adds to an event's prestige. Turtle is also served at more traditional feasts and celebrations. Today it is possible (during the open season) to buy turtle meat for lunch in local markets.

Dugongs in Palauan culture

Dugongs (*Dugong dugon*) are one of four animals (dugong, shark, stingray and sea turtle) that symbolize the strength and values of Palau's traditional leadership system (Palau Society of Historians 1998). Traditionally, one of three dugong bones was used to make a bracelet (called *olecholl*): skull or forehead was for the *rubaks* (chiefs) of lowest rank, the mid-section of the head was for the head *rubak* and the vertebrae between the head and neck was for men who had distinguished themselves by some brave deed (Krämer 1917). A great deal of pain accompanied the placement of one of the vertebrae bracelets on the wearer's wrist - the bones in the hand or fingers were broken and skin was torn off

as the bones were too small for most men's hands. Wearing such a bracelet was a sign of prestige and high rank. Today the bracelets have lost much of this traditional prestige and are occasionally seen worn as accessories by young women.

The dugong was also used symbolically in the inaugural feasts of the four highest ranking *rubaks* in the form of large dugong-shaped sweets made from Tahitian almonds (*miich*) mixed with coconut syrup. These sweets, called *debechel miich el mesekiu* or *Debechellir ar Rubak*, were very large and took many days to prepare. They were brought to the *bai* to be divided symbolically among the *klobak* (highest chiefs) (Palau Society of Historians 1998). This practice continues for the inaugural feasts of the high chiefs in some areas in Palau to this day (previously published as Matthews 2003a).

Terrestrial species

Perhaps the most culturally important terrestrial species is taro (*Colocasia esculenta* and *Alocasia macrorrhiza*). Taro is traditionally raised by women in converted wetlands called *mesei*. Taro patches are important habitats for birds and several species of medicinal plants. *A mesei a delal a telid* (the taro patch is the mother of our breath) is a local saying that indicates the importance of taro to life in traditional Palau. Taro is an essential item in the exchange of food between families. Recently, there have been shifts in taro production, although the extent of these changes has not been documented. Dryland produced taro and giant taro (*brak*, *Alocasia macrorrhiza*) are sold more often than they were in the past. In addition, some women now hire foreign male workers to work in their taro patches, once a realm primarily of women. Previously young, unemployed women were hired to do this work. Thus, young women are not as active in the *mesei* as they once were, nor do they have the same cultural responsibilities as they once did (PCS 2002).

Invasive Species

Palau's native and endemic species are threatened by invasive species that outcompete or prey upon local species. Invasive species present perhaps one of the most serious threats to Palau's native biodiversity (CI 2004). A national taskforce was created to develop a strategy for managing existing and controlling the introduction of invasive species in Palau (ROP 2004). Invasives have been brought into the country knowingly or have been introduced accidentally. One species of native vine (*Merremia peltata*) occurs naturally in clearings in the forest, but has become more invasive as increasing forest clearing due to construction has expanded its habitat. The threat of invasive species increases as Palau imports more products and services from around the world. Ornamental plants, many of which are invasive in Palau, are increasingly popular. These plants can harbor invasive insects, amphibians and disease, or act as invasives themselves. There is a constant threat of the introduction of the brown tree snake (*Boiga irregularis*) on airplanes and ships that arrive from Guam, where it has almost completely destroyed local bird populations (Wiles et al. 2003). The construction of the Compact Road around Babeldaob Island has also helped the spread of invasive plants around Palau, as several new species were introduced as seeds in soil on construction vehicles. In addition, many of the more invasive plants are spreading as more land is cleared along the road, opening up native forest to more light and conditions conducive for active growth (ROP 2004).

Table 10. Ten of the most invasive plants in Palau (TNC 2004).

Common Name	Scientific Name	Palauan Name	Description
African Tulip-Tree	<i>Spathodea campanulata</i>	Orsachel kui	A large tree with showy orange flowers that outgrows native trees and forest plants.
Chain of Love	<i>Antigonon leptopus</i>	Dilngau	This spreading shrub with sensitive leaves and thorns is a serious weed in tapioca and vegetable farms.
Siam Weed	<i>Chromolaena odorata</i>	Ngesngesil	This widespread shrub is a fire hazard in grasslands and a serious weed in tapioca and vegetable farms.
Mile-A-Minute	<i>Mikania micrantha</i>	Teb el yas	A very fast growing vine with arrowhead-shaped leaves that grows over trees and kills them. It is a serious weed in taro patches, and tapioca and vegetable farms.
Merremia	<i>Merremia peltata</i>	Kebeas	A native vine with heart-shaped leaves that grows over trees and kills them.
Giant Sensitive Plant	<i>Mimosa diplotricha</i>	Mechiuaiu	This very thorny spreading shrub with sensitive leaves is a serious weed in tapioca and vegetable farms and in grasslands.
Cogon Grass	<i>Imperata cylindrica</i>	Kasoring	A thick growing grass that shades out all other plants. It is a fire hazard in grasslands and a serious weed in tapioca and vegetable farms.
Koster's Curse	<i>Clidemia hirta</i>	Kui	This is a shrub that can outgrow native trees and other plants in the forest understory.
Bronze-Leaved Clerodendrum	<i>Clerodendrum quadriloculare</i>	Kleuang	This tall shrub has large leaves that are purple on the underside. It can outgrow native trees and plants in the forest understory.
Blue Trumpet Vine	<i>Thunbergia grandiflora</i>	Bung el etiu	This is a fast growing vine with large blue flowers that grows over trees and kills them.

The known list of introduced and invasive animals continues to expand. Currently, invasive animals that have become established in Palau include:

- giant African snail (*Achatina fulica*)
- cane toad (*Bufo marinus*)
- monitor lizard (*Varanus sp.*)
- Pacific, Norway, Himalayan, roof and ship rats

- house mice
- Asiatic musk shrew
- crab-eating macaques (*Macaca fascicularis*)
- pigs
- dogs
- cats
- sulphur-crested cockatoo (*Cacatua galerita*)
- eclectus parrot (*Eclectus roratus*)
- Nile Tilapia (*Oreochromis niloticus*)
- marine hydroid (*Eudendrium carneum*)
- marine anemone

Wild dogs, cats, pigs, monitor lizards and rats are serious threats to nesting birds and turtles. The crab-eating macaques are considered a nuisance on Angaur, where they damage crops. Cockatoos eat the hearts of native palms, however, the extent of damage is unknown. Introduced insects and fungi, especially those damaging to crops and fruit trees, have increased in recent years. The Palau Bureau of Agriculture has a program to control fruit flies and coconut beetle and has issued warnings about other insect pests such as mealy bugs.

ABIOTIC ASPECTS

The Republic of Palau is composed of hundreds of low-lying islands, many with sandy beaches and/or highly erodable soil. Increasing development can have detrimental impacts in such a small, vulnerable place. The abiotic characteristics that have a bearing on coastal resource management include: soil erosion, coastal erosion, water quality, human activities and climate-related impacts.

Soil erosion

The most pressing and widespread abiotic concern in Palau is soil erosion. The soils are highly erosive causing the majority of the water quality problems in rivers, streams and nearshore coastal waters. This affects coral reefs, seagrass beds and fisheries, as well as drinking water. In Airai Bay, terrigenous mud that flows into the bay from rivers after heavy rain, is killing corals and is causing a phase shift from coral to algal dominance (Golbuu et al. 2003). Soil erosion is not just a problem in the rivers and nearshore waters where the soil ends up as sediment, but is also the major problem for land management and productivity in Palau (DeMeo 2005).

Coastal erosion

Little is known about the extent of coastal erosion in Palau. No erosion assessments have been conducted, although there is a general concern about the loss of area from many of Palau's shoreline. For instance, many of the beaches in the Rock Islands and along

the eastern coast of Babeldaob have noticeably eroded in recent years. The Southwest Islands have also been subject to coastal erosion, and some archeological sites on Tobi have suffered (Hunter-Anderson 2000). Some of the erosion is marked by the dead and toppled trees that once grew along the edges of the beaches.

Water quality

The Environmental Quality Protection Board (EQPB) monitors water quality in Palau, and has determined baseline standards for both freshwater and marine areas based on EPA water quality standards. EQPB's capacity to continuously monitor water quality throughout Palau is limited. As a result, marine water quality is measured in only a few areas around Palau. A program to monitor freshwater quality is sporadic, and only a few parameters are routinely measured (temperature, turbidity, pH, nitrogen and coliform level). There are no on-island laboratories equipped to measure levels of organic pollutants, oil or heavy metals. Water samples can be sent to labs in Guam or other areas for analysis, but this is prohibitively expensive and rarely, if ever, done. There are increasing threats to water quality from increased uses of pesticides, fertilizers and cleaning products (bleach and detergents), many of which drain from farms, households and laundries directly into streams. EQPB regulates the pesticides and fertilizers that can be legally used in Palau, and many of the more toxic chemicals that have been banned in the US are banned in Palau. However, there are cases of pesticides being transported illegally into Palau and other Pacific areas from Asia and sold to farmers (G. Sahara, pers. comm.). No studies have been done to assess the pesticide and fertilizer content in rivers in Palau, especially in those areas such as the Ngerikiil River in Airai state where commercial farming is rapidly increasing along the river.

There are a few known cases in Palau of the use of (Matthews, pers. obs.) or explosives to catch fish or other marine life. Explosives, obtained from relics of World War II or created with locally purchased materials, have been used to stun schools of fish. There are unconfirmed reports of the use of cyanide and bleach to stun fish as well. There are recent rumors that some spearfishermen may swim trailing leaking bottles of bleach to ward off sharks. No studies have been conducted in Palau to determine the extent or impacts of these practices.

Human activities

Human activities that utilize or have altered abiotic resources include: phosphate and bauxite mining; dredging for coral and sand; limestone and basalt quarrying; warfare; fires; and coastal construction.

Mining

The major mining operations established in Palau were the phosphate mines on Angaur, Peleliu, Sonsorol and Hatohobei that operated between 1907 and 1935, and a bauxite mine in Ngardmau state on Babeldaob Island in the 1930s (Hezel 1984; Hunter-Anderson 2000; Rechebei et al. 1997). None of these mines are currently operating, however some have created significant and lasting change in the local environments. The phosphate mines in Angaur, Peleliu, Sonsorol and Hatohobei were started under the German administration and continued under the Japanese. The largest was the Angaur mine. In 1911 there were

more than 1300 laborers (some imported from the Southwest Islands, Yap, Guam, China and India) at the mine. That same year, Angaur phosphate provided 76% of Germany's total export value from all of its Pacific island colonies (Hezel 1984). There is much less information on the bauxite mine in Ngardmau. This mine was started under the Japanese administration, and in 1938, 30,000 tons were shipped to Japan for the production of aluminum. The American administration closed the mine in 1944 after discovering that the quality of ore was so different from American sources that aluminum could not be extracted in US plants without extensive modifications (Rechebei et al 1997).

The phosphate mining operations left pits throughout Angaur and Peleliu that have mostly filled with water. In Angaur some of these pits have become crocodile habitat. The mining operations destroyed traditional taro patches and historical sites in the Southwest Islands. However, the currently active taro patch in Tobi is on the site of the old phosphate pits. In Ngardmau, the bauxite mining areas are still degraded, unvegetated and continue to be a major source of sedimentation into the local rivers and ocean.

Dredging

Nearshore dredging operations collect sand or corals for construction, or dredge to clear navigation channels. There is one sand dredging operation in Koror. Coral and other substrate is dredged from several sites, especially around Babeldaob Island. Five primary sites around Babeldaob (in Aimeliik, Ngaraard, Melekeok, Ngchesar and Ngiwal) provide fill for the construction of the Compact Road. Environmental Assessments were conducted prior to the dredging operations to discern possible impacts and also to recommend actions to minimize impact. There is on-going monitoring of these dredging operations to ensure minimal impacts. There are also several other non-road associated dredge sites owned by private companies. These are less well monitored. By their very nature, and by the number of dredge operations in sensitive habitat, impacts to the nearshore environment are occurring. While no studies have been conducted on the cumulative impacts of these dredge sites, anecdotal information collected from people living in the communities nearby indicates that many seagrass beds have become degraded, corals are suffering from sedimentation and some important nearshore invertebrates and fish are more difficult to find (PCS 2002). It is unknown what the impacts of these activities are on species that are not important for local consumption.

Quarrying

In Palau, there are five private operations that quarry basalt or limestone for construction: basalt is quarried from Babeldaob Island at Ngaremlengui and Melekeok and from Malakal Island in Koror; limestone is quarried from two Rock Islands in Airai and Koror. Koror state legislation prohibits mining in any of the Rock Islands of Koror except those connected by roads. Airai has no such legal protection. No quarrying sites that have been started in Palau have yet closed. However, two of the operations are becoming depleted and new sites that have been proposed are two Rock Islands in Airai and one in Koror. The quarries have literally removed large portions of the islands on which they operate, in some cases entire hills are now gone. Some companies have plans for revegetation of the sites once they are closed. However, local residents are concerned with the extent of erosion and

sedimentation that originates at some of the sites, especially on Babeldaob Island (PCS 2002). One assessment estimated 1.5 km² of forest land has been lost on Babeldaob Island alone as a direct result of quarries that are in operation solely for collecting rock for use on the Compact Road (TEI 2003). There is an ongoing debate about whether it may be more beneficial to import rock and aggregate from off-island in order to minimize the loss of Palauan land. No comprehensive studies have been done to assess the impacts of Palau's quarrying operations or to analyze the economic costs and benefits of so many local quarrying sites.

Warfare

Intense warfare occurred throughout Palau during World War II. The fighting was most intense in the main Palau islands. However, Merir, Sonsorol and Tobi in the Southwest Islands were occupied by both Japanese and American troops. The heaviest fighting and hence environmental destruction occurred on islands of Peleliu, Angaur, Koror and Babeldaob. Peleliu, in particular, was bombed so extensively during the American air strikes of 1944, that it was completely devoid of vegetation. Most of the Palauans from Angaur and Peleliu had been resettled on Babeldaob Island by the Japanese administration, so Palauan casualties on these islands were minimal. However, once the Japanese military bases on Peleliu and Angaur were destroyed, the American tactic was to cut off supply lines to the Japanese troops. As a result those Palauans and Japanese living on Babeldaob Island suffered amazing hardship. For an entire year, daily air raids prevented farming and fishing, forcing people to conduct these activities at night. Many people died of starvation and disease (Nero 1989; Rechebei et al. 1997). Once the war was over, people who had been relocated were settled back onto their home islands of Peleliu and Angaur, but the islands were completely unrecognizable. Reconstruction began throughout Palau. However, the extensive infrastructure and development that the Japanese had built up in the previous 30 years (including roads, airports, government buildings, schools, hospitals and farms) that at one time had supported a cosmopolitan population of 40,000 in Koror, was completely destroyed by the American assault. Serious reconstruction under the American Trust Territory administration never fully materialized, so remnants of Japanese projects are still visible throughout Palau (Nero 1989). In 1999, forty-five years after the war had ended, residents of Angaur and Peleliu were still requesting assistance to assess the fertility and status of the soil on their islands. They were concerned that their islands had not recovered from the bombing during WWII and that rehabilitation of the soil was necessary. The USDA sponsored two soil assessments of the islands and concluded that the limestone soils on both islands were naturally poor, didn't hold nutrients well and that the vegetation had returned completely to the islands (USDA 2000a and 2000b). These reports recommended mulch and compost as ways to increase the fertility of the naturally poor soils. Finally, one other remnant of WWII that still lingers in Palau, is unexploded ordinance. Careful surveying is needed before any digging or clearing is done throughout the islands, as there is still the chance of accidentally finding live bombs. For example, this occurred late in 2004 when some workers accidentally set off a bomb while clearing land in Koror. The explosion caused damage to a power transmission station, knocking out electricity for hours.

Fires

People in Palau set fires to rid already farmed land of weeds, to burn grass or branches that have been cut, to ease access to areas for hunting and to control insect pests. Some fires are also simply the result of arson. Many people believe that fires enrich the quality of soil thus making it more productive for farming. While small and controlled fires may be somewhat beneficial, often the fires burn out of control, especially in months with little rain. Wildfires are not monitored systematically in Palau. In addition, they are only contained if they are close to Koror and threaten a house. Many of the plants that are able to survive fires or that quickly sprout once an area has been burned, are invasive species. It is possible that much of the native vegetation of the savannas and grasslands in Palau is being replaced by more invasive, non-native species. The plants on the boundaries between upland forest and savanna are also unable to withstand fires. It is not known how much, if any, of the upland forest is being lost to fires, nor to what extent the species of the savannas are changing as a result of fires. In fact, some scientists speculate that savannas would not exist if not for occasional fires. However, it is apparent that large areas that have been recently burned contribute significantly to erosion and sedimentation problems, especially around Babeldaob Island.

Coastal construction

As discussed throughout this report, construction projects, especially the new construction of the Compact Road and the relocation of the National Capitol, have had significant impacts on the abiotic environment of Palau. However, coastal areas in Palau have been subjected to major construction projects for at least 80 years. Construction began in earnest with the Japanese administration, as Japan was interested in developing and extracting the resources of their colonies. One of the first things the Japanese administration did was to build a road system throughout the islands. After the roads, other development followed: cement and stone houses, large administrative centers, electricity, telephones, radio, medical dispensaries, schools, railroads (for transporting material from the mines), factories and other production facilities, seawalls, fishing ports, docks and airports (Rechebei et al. 1997). Large new areas of land were created with fill. Preparation and fortification for WWII involved considerable additional coastal construction. As a result of the bombing campaigns of WWII, much of this construction was destroyed or severely damaged. However, remnants are scattered throughout all islands of Palau. There are many Japanese roads still in use, several buildings exist (for instance, the Supreme Court in Koror is an old Japanese building), pieces of the old seaplane ramp and communications towers litter the waterline at Meyuns, and some offices of the Ministry of Resources and Development are located where seawalls and other structures once supported a port. Since the war, new coastal construction activities have added to the alteration of Palau's coastline. Causeways link the three main islands of the state of Koror (including a few nearby Rock Islands), a bridge spans the channel between Koror and Babeldaob (the largest bridge in Micronesia), the alignment of the Compact Road required mangroves to be cut and filled, fishing docks and piers cut off flow to inner mangrove areas, and artificial beaches have been created along the water near several hotels in Koror. No comprehensive studies have been attempted to assess the changes in nearshore habitats or currents as a result of any of these projects.

Climate-related impacts

Palau's islands are low lying and vulnerable to climate-related impacts such as storms, typhoons, droughts, coral bleaching and sea-level changes. A preliminary vulnerability assessment found almost all systems of Palau sensitive to the impacts of climate change:

- coastal margins, including lagoons, reefs, marine ecosystems and fisheries;
- freshwater and terrestrial ecosystems;
- water resources;
- agriculture and forestry;
- tourism;
- communications and human health; and
- infrastructure (ROP 2002).

A stark reminder that climate-related impacts can have significant and long-lasting impact was the severe coral bleaching event that occurred in Palau in 1998. Hard and soft corals and some other invertebrates (such as giant clams) bleach when their symbiotic zooxanthellae algae are expelled as a result of stress. Under mild bleaching events, corals can generally recover. However, in 1998, sea surface temperatures in areas around Palau were elevated to 30°C and above for five months (normal sea surface temperatures range from 27-30°C). Afterwards, about one-third of Palau's hard coral colonies had bleached and died, and as much as 100% of the colonies on some outer reef slopes were dead (Richmond et al. 2002; Colin 2004). Some species were particularly hard hit, and many reefs around Palau are nowhere as vibrant or diverse as they were before the bleaching. *Acropora sp.*, soft corals, and giant clams are noticeably missing from sites where they were once abundant. Recovery is occurring, but has been slow (Richmond et al. 2002). There is a concern that outbreaks of crown-of-thorns starfish (which prey upon *Acropora sp.*) could devastate those remaining *Acropora* colonies in Palau. No comprehensive studies have been conducted to monitor or assess the impacts of the bleaching event on local fisheries or on the recovery of corals and other species around Palau. In addition, no studies have been conducted to monitor sea-surface temperature impacts in other habitats, such as seagrass beds. However, one program sponsored by The Nature Conservancy is assessing how to protect those reef areas that appear to be more resilient or resistant to bleaching than others.

MAJOR RESOURCE MANAGEMENT ISSUES

The major issues regarding resource management in Palau are: (1) the sensitivity and limitations of island habitats; (2) unplanned and inappropriate development; (3) culture, change and resource uses; and (4) roles of governing systems. Other issues, such as limited local capacity and data gaps, are important as well, but are discussed more fully in following sections. The issues described in this section are interrelated and influenced by each other. There are interacting biological, cultural, social and economic elements to each of these issues. Each is an issue for all of Palau's ecosystems, although certain ecosystems and habitats are influenced more or less than others. Those habitats that are most influenced by a particular issue, or where that issue is most influential in resource management, will be highlighted in the discussion that follows.

Sensitivity and limitations of island habitats

Challenges

Islands, by their very nature, are small, vulnerable to change and relatively isolated. Palau is a small island country, with limited land area, but with a very high diversity of marine and terrestrial ecosystems. These ecosystems support a high level of endemism and biodiversity for such a limited space. Palauans have adapted to the limited land area, and have become experts at exploiting the sea. Much of Palauan social structure, culture and traditional resource use practices could be interpreted as responses to the limitations inherent in living in an island environment. A small population with limited technology have generally had limited impact on the abundant resources. Even with advances in technology that have increased the range and extent of exploitation, until relatively recently, people took the apparently limitless resources for granted.

Modernization has altered many traditional, social and environmental structures and the limitations of Palau's island habitats are becoming much more clear. Many marine resources now appear to be in steady decline. Nearshore habitats are severely altered. Invasive plants are spreading. The islands themselves appear to have shrunk as transportation has improved: powerful motorboats and improved roads have increased access to many areas that were previously inaccessible. As the numbers of second-hand imported cars, trucks and buses have increased in recent years, so have problems of traffic, deterioration of roads and air pollution.

All land is owned by individuals, clans, states or the national government; foreigners are not allowed to own land. State-owned land can be leased, however these areas are limited. Mangroves, which are not considered to be land are under the jurisdiction of the states (as are all marine resources). Many states grant leases to individuals for mangrove areas, which are then cut and filled to create new land. This is occurring with greater regularity as development spreads throughout Babeldaob. Land ownership and limitation of land also creates challenges with regard to siting major infrastructure, such as sewage treatment facilities and landfills. Often, environmental assessments are conducted to determine appropriate sites for such facilities. However, because of land ownership and other social issues, the sites that are eventually selected may not be the best environmentally appropriate sites. This sets the stage for future environmental problems, as well as for costly mitigation. Land fills and dumps have often been sited away from local communities in those areas where people do not want to live, such as on the edges of mangroves or wetlands. These dumps are unsanitary, generally unmanaged, more numerous and have grown considerably as the amount and quality of solid waste has changed.

Invasive species are another threat to the sensitive environments of Palau. With increased international trade and transport, the risk of new and invasive introductions increases.

Opportunities

The size and limitations of Palau also create opportunities for management. Island-wide and ecosystem-based management initiatives are possible in Palau because of the small physical scale. Interactions between terrestrial and marine environments can be relatively quickly ascertained because distances are small. Palau makes an ideal coastal laboratory

in many ways. In addition, the size of Palau creates an atmosphere in which ideas and successes can spread quickly. For instance, the creation of a nature trail in one conservation area has increased interest in similar projects throughout the country. If a few people are trained in such skills as trail building, park management and maintenance, they can become the local experts to help people in other locales. Difficulty, however, remains in the lack of manpower, expertise and funding. Capable people can become overwhelmed with the demands placed on them to duplicate their successes.

Unplanned and inappropriate development

Challenges

Palau signed a Compact of Free Association with the United States in 1994, thus becoming an independent nation. Since independence, the rate of development in Palau has increased, some of which may be considered inappropriate in reference to the scale and “fit” of the development in the local context. Much of the development is associated with the construction of the Compact Road and the relocation of the National Capitol on Babeldaob Island. However, other development and growth is occurring as well. The tourism sector is expanding into Asian markets. In the past three years, direct air routes have been initiated between Palau and Taipei, Manila, Seoul, and several Japanese cities. Plans exist for several golf courses, new airports, a Free Trade Zone with an associated manufacturing district, hotels in previously undeveloped areas such as Kayangel, retirement complexes for wealthy expatriates, aquaculture facilities and oil exploration.

Many of these projects are implemented at the state or local level. However, most states do not have effective development plans or the capacity to develop and implement plans, to help guide local development. Nor is there much effective coordination at the national level. National development plans were written to help guide Palau’s future, but in actuality much of the authority over decisions is made at the state or more local level. In addition, although Palau has some good environmental regulations, enforcement is difficult and underfunded. There are no building codes and cumulative impacts of development projects are not assessed at a national level. As a result, development is occurring on an *ad hoc* and piecemeal basis throughout the country. For instance, on Babeldaob Island, an area of 410 km² (158 mi²), there are three proposed golf courses, plans for a Free Trade Zone, two proposed botanical gardens to feature non-native tropical species, plans for large-scale farming, two planned fish culturing facilities, seven ocean thermal energy conversion plants (OTEC), as well as the National Capitol relocation and new Compact Road. Many of these projects may not materialize for various reasons. However, they are an indication of the kinds of development being proposed haphazardly in a relatively small place.

Opportunities

Many opportunities exist to create new and innovative approaches to development. By blending the traditional and locally appropriate building styles with modern techniques and technologies, a uniquely modern Palauan style could develop. Alternative technologies could be explored so that Palau was less dependent upon imported oil and gas. Community visioning exercises have been initiated in order to lay the foundation for future state-level land use planning initiatives.

Culture, change and use of resources

Palauans have a traditional culture and local knowledge base that are strongly tied to natural resource uses and habitats. Traditional culture was based on a hierarchy of clans and villages with well-defined roles and responsibilities. Exchanges of valuables and food were important to maintaining and strengthening relationships among clans and families. Resource management regimes evolved for many species and some habitats, primarily as a means of controlling access to valued resources and guaranteeing a local supply of food and materials (Johannes 1978). However, political and economic changes have had significant impacts on the effectiveness and strength of some aspects of the traditional systems. Conflicts between modern and traditional economic, social and value systems have become more apparent. However, certain elements of Palauan culture are still very strong and influence how and why resource use decisions are made. In Palau, resource use and management is affected by culture and social and political changes in several ways: (1) changes in values, technology and management authority have altered how people utilize resources; (2) commercialization is leading to increases in certain resource uses and a need for improved management; (3) traditional practices are used less often, although they have not yet been completely lost; and (4) although Palau appears on the surface to be a modern society guided by non-indigenous norms, culture and tradition operate very strongly, sometimes in opposition to non-Palauan resource management attempts.

Challenges

It is unclear to what extent the changes leading away from traditional lifestyles and governance have altered resource uses and management. It is also unclear how much culture and tradition affect how resources are used in Palau. However, there are several recent examples of how social factors influence resource use and management decisions. For instance, traditionally in Palau's main islands, serving sea turtles at a feast was a sign of prestige and helped to mark the importance of an event. Often sea turtles were reserved for important community events, such as feasts for the community (*mur*), or when one community visited another (*klechdaob*). In 1999, a draft management plan for Ngeruangel Reserve in Kayangel state included a section banning the taking of sea turtles from the Reserve because of apparent declines in the number of green sea turtles. However, the inauguration of the state governor and legislature always involves a feast featuring sea turtle meat. In order to comply with the national closed season (which occurs during the time of the inauguration), and to protect the population of nesting turtles on Ngeruangel, the people of the state of Kayangel decided to only allow turtles to be taken from the reserve for the inauguration, and to limit that number to four. In addition, a reminder to comply with national laws was added as well (TNC 2000). Finally, the inauguration was rescheduled to a time when the national season to hunt turtles was open in order to comply with the national law. It was decided that the presence of sea turtle meat at the inauguration was too important to ban outright. Decisions such as these, that are ruled by cultural and social factors, must be considered in resource management in Palau.

On an individual level, it appears that local knowledge of sustainable resource uses and practices still exists in many areas, but people are using these practices less frequently (PCS 2003). At times, government and regional programs have encouraged the use of non-

traditional methods. For instance, traditional farming practices that utilize native plants as mulch and fertilizers are changing in favor of practices that require chemical fertilizers. Fishermen rarely follow seasonal or lunar cycles of reef fish or fish with selective gear, in favor of non-selective gears and increasingly the use of fish finders. They can now save time and money by catching larger amounts of fish less often. Their excess catch can be frozen for future use, rather than just used to fill their immediate needs. There has also been an apparent increase in the number of customary events, so there is an increased need for some food items, such as fresh fish.

Opportunities

Culture presents a firm foundation upon which to build conservation and resource management regimes in Palau. The Palau Conservation Society, for instance has been working with some local communities to set up conservation areas based upon the traditional idea of a *bul*. A *bul* is a traditional, temporary ban of the use of a resource declared by local chiefs and their female counterparts. The women or chiefs can lift the ban if the resource shows signs of recovery or can keep it in place for longer periods. This approach has been successful in some areas (such as Ebiil Conservation Area in Ngarchelong) and has led to long-term community-based conservation interest. It has been more difficult in other areas where conservation areas have been set up for only very limited duration, with limited environmental benefits. However, PCS, local government agencies and local communities are exploring other ways of linking cultural values and norms with conservation of natural resources. For instance, protecting historical and cultural sites may be an appropriate and powerful means of protecting habitats in Palau. This approach is being used successfully by the state of Koror for management of some areas within the Rock Islands. There are other exciting possibilities and partnerships being explored between environmental and cultural/historical organizations in Palau.

GOVERNANCE

Challenges

Palau has several layers of governance that can occasionally seem to be at odds with each other: national, state and traditional. There is a national constitution, as well as 16 state constitutions. Each of the state constitutions describes the ways traditional leadership will be represented in that state government, if at all. The national government and its ministries have relatively clearly designated roles, as do the states, but negotiation may be required to reach agreements between the various government agencies. Often the national government and states work very independently. In addition, the national and state governments have taken over many of the roles that were once those of the traditional leaders. Roles in the governing systems are not always clearly defined. As a result, projects may become stalled because of lack of clear leadership. Traditional leaders have responsibilities to their clans and villages, and have authority over activities at a local level. However, the actual authority of traditional chiefs may lessen outside of state or village bounds (Graham and Idechong 1997). As a result, people from other states may not fully respect traditional authority or decrees away from their homes. Foreigners pose another challenge, as they often unfamiliar with the traditional rules in a community or what may be considered proper uses of local resources by Palauans.

Opportunities

The different levels of governance can work in harmony and can provide a strong framework for resource management at many levels as long as the roles and responsibilities of each level are clear. Palauans, with great foresight, wrote the traditional leadership into national and state constitutions, so that it would not be lost. At the national level, the Traditional Council of Chiefs serves an advisory function on matters of custom. At the state level, there is a range of traditional and elected leadership, which varies by state. In terms of resource management, the states and traditional leaders working together could provide the most effective system of management (Graham and Idechong 1997). The national government can support state and local efforts through technical or financial assistance. There are exciting partnerships developing that are examples of increasing cooperation among the different governing systems. For instance, a partnership is forming among four states, traditional leaders and the national Department of Fish and Wildlife Protection, with the assistance of the Palau Conservation Society, to discover ways to share resources to monitor and enforce environmental and conservation regulations in those states.

Status of knowledge and information base for management

Sources of information

In Palau there are a wide variety of sources of information that are useful for resource management. Some of the sources are old, out-of-date or difficult to find. However, for the most part, there is a wide range of useful information.

Geographic information of Palau exists in the form of several series of aerial photographs: 1930s, 1946, 1976 and 1994. These photographs are spread throughout the region, in Palau, Hawaii and Saipan. A complete set of geographically referenced photos does not exist in Palau. More recent aerial photographs have been taken by Pat Colin of the Coral Reef Research Foundation. He has been taking aerial photographs, especially of Babeldaob Island (along the Compact Road) and of reefs and lagoons of the main Palau islands. He has limited coverage of Peleliu and Angaur. The Office of PALARIS (Palau Automated Land and Resource Information System) is the national depository and developer of GIS for Palau. PALARIS has created databases and GIS coverages of soils, elevation, reefs, roads, and hydrography based on USGS topographic maps of the main Palau Islands from 1984. A vegetation coverage from these base maps is currently being completed. No base maps of the Southwest Islands exist. Palau has access to Landsat imagery and has recently purchased Quickbird imagery. This data is available to entities outside of national government through special request and nominal fees.

Rainfall and climate data is collected by the Weather Service. However, the data is not available in electronic form. Census data is collected by the Office of Planning and Statistics (OPS) every ten years. In addition, OPS produces a Statistical Yearbook for Palau that is a compilation of statistics from many important areas, such as fisheries, tourism, health and education.

There is limited water quality and sedimentation data for some of Babeldaob Island's freshwater streams. The data is collected by the Capital Improvement Program (CIP) and Environmental Quality Protection Board (through USGS assistance). For large-scale

development projects, some water quality data is collected by consultants as part of the EIS process. In addition, the Palau Conservation Society and USDA Natural Resource Conservation Service have begun to collect a limited amount of sedimentation and stream data for the Ngerikiil watershed.

In preparation for the construction of the Compact Road, a comprehensive Environmental Impact Study was completed in 1997 (US Department of the Army 1997). The EIS, which was conducted only for those areas through which the alignment of the road itself would go on Babeldaob Island, is composed of several studies that provide some useful information for management. Appendices include: water quality, air quality, noise quality, botanical, biological, coastal, marine, estuarine, freshwater wetland, and archaeological investigations, as well as social and economic impact assessments. In addition, since 1999 more than 50 Environmental Assessments have been conducted for projects associated with the construction of the Compact Road, such as borrow pits, gravel and fill storage areas, access roads and other secondary projects that were not included in the original EIS because they are not directly associated with the alignment of the road. These EAs give a picture of the habitats that have been lost due to construction of the Compact Road. However, there is no formal compilation of the results of these secondary studies, and no assessment of the true environmental or social impacts of the Compact Road construction has been made.

There are also EISs and EAs, of varying usefulness and quality, that have been conducted for other proposed development projects, such as a proposed golf course in Airai state, the construction of hotel complexes, new aquaculture facilities and the expansion of the causeways in Koror state. In recent history, EIS or EAs have not been conducted for several construction projects. This has resulted in instances of sedimentation and erosion that were not subject to the usual containment measures required under Palauan law (Matthews, pers. obs).

Research and Assessment Efforts

Early research in Palau was conducted by the Polish anthropologist Johann Kubary in the late 1800s. He documented building construction, fishing implements and methods and many other aspects of daily life in Palau. His three volume ethnography, originally written in German, has been translated into English (Kubary 1889). A German anthropologist, Augustin Krämer, studied the peoples of the Western Pacific from 1908 to 1910. He produced a five-volume ethnography documenting Palau's material culture; governance; customs; language; geography; and everyday practices such as cooking, fishing, hunting and farming (Krämer 1917). The original documents are in German, but some sections have been roughly translated into English. Annaliese Eilers compiled an ethnography of the peoples of the Southwest Islands that was conducted by researchers on the same expedition (she herself never visited the islands). She produced four volumes, one each on Merir, Pulo Ana, Sonsorol and Tobi (Eilers 1935). These volumes contain a wealth of information, however must be used with caution. The expeditions typically stayed only a few days in each location, so much of the interpretation of social systems and customs are speculation at best (Buschmann 1996).

In 1937, Japanese researchers developed the Palau Tropical Biological Station. Until 1944, scientists conducted extensive marine and coastal surveys of Palau's reefs, hydrography, marine biology and potential for aquaculture. A few agricultural and insect surveys were also conducted. The results of these studies were written in Japanese, some with English abstracts. Recently, Japanese scientists associated with the Palau International Coral Reef Center have indicated that they will translate some of these documents into English.

Some studies on fish, turtles and insects were conducted by American scientists during the 1950s and 1960s when Palau was a Trust Territory of the United States. The 1970s and 1980s saw a surge in fisheries and aquaculture related research projects, as U.S. and Japanese fishing and aquaculture interests in the western Pacific increased. Many notable Ph.D. dissertations and books were written about Palau during this time. Some works of particular interest to resource managers are by Black (1981), Johannes (1981), Masse (1983, 1989), McCutcheon (1981), McKnight (1968, 1969) and Nero (1987).

In recent times, the most active period for research was in 1991 and 1992, when several significant studies were sponsored by the Division of Marine Resources. Rapid Ecological Assessments (REA) were conducted by teams of scientists for the Southwest Islands (Maragos 1994a), main Palau islands (Maragos 1994b) and Ngaremeduu Bay (Maragos 1992). These REAs provide a substantial baseline for marine and coastal habitats and species in Palau. Other studies that were conducted through the Division of Marine Resources at that time include surveys of sea turtles (Maragos 1991), crocodiles (Brazaitis 1993), dugong (Marsh 1992), Ngerukuid Reserve (Seventy Islands) (Birkeland 1990), women's role in nearshore fisheries (Matthews and Oiterong 1992), among others. A comprehensive Fisheries Profile was also completed at this time (Nichols 1991).

Other marine-related studies and on-going monitoring activities include:

- coral reef and fish monitoring program at the Palau International Coral Reef Center;
- marine lakes monitoring at the Coral Reef Research Foundation;
- a new turtle conservation and monitoring program based at the Bureau of Marine Resources;
- conservation area baseline and monitoring data collected by Palau Conservation Society, Marine Conservation Area Program of the Bureau of Marine Resources, Koror state, and others;
- fisheries data collected by the Bureau of Marine Resources (reef fish and some invertebrates) and by the Bureau of Oceanic Fisheries Management (tuna and by-catch)³; and
- studies on such topics as tuna; live reef fish trade; grouper spawning aggregations; tourism impacts; local perceptions about turtles, crocodiles and dugongs; subsistence fishing in the Rock Islands; and community perceptions on the state of local biodiversity initiated by partnerships of NGOs and state and national government agencies.

³The fisheries data is somewhat incomplete, and is generally not analyzed extensively.

Several significant terrestrial studies have been conducted in Palau as well. The USDA Soil Conservation Service conducted a soil survey in 1979 to 1980 (USDA 1980), a vegetation survey was done in 1988, and a forest bird survey was conducted in 1991 (Engbring 1992). The bird survey was repeated in 2005 and the others may be repeated in 2006. Much of the terrestrial work that has been done in Palau has been conducted in the past five years. DeMeo and the USDA Natural Resources Conservation Service have produced soil and/or watershed assessments for five areas in Palau: Ngaremeduu Bay (1999), Angaur (2000a), Peleliu (2000b), Ngerikiil watershed (2005), and Lake Ngardok Nature Reserve (2004). A forest inventory is currently being conducted by the US Forest Service. The Palau Conservation Society and The Nature Conservancy sponsored a rare and endemic plant survey in late 2004. The Nature Conservancy is also supporting an insect inventory. The Belau National Museum is working with partners to develop a natural history collection. An herbarium of native and endemic plants is being created as part of this effort.

The Palau Community College Cooperative Research and Extension has been collecting information on important agricultural and medicinal plants in Palau. As a result of this research, PCC-CRE has produced a series of informative booklets on Palauan medicinal plants, taro, sweet potatoes, tapioca and cucumbers (Del Rosario 2001; Del Rosario and Esguerra 2003 a and b; Esguerra and Rengil 2000).

Other programs also have relevant information about natural and cultural resources. The Bureau of Arts and Culture has conducted archeological studies, collected oral histories and mapped historic sites. A resource use study and a series of community consultations were conducted as background information for Palau's National Biodiversity Strategy and Action Plan (NBSAP) (TEI 2002; PCS 2002 and 2003). The University of Oregon sponsored graduate students to work as short-term technical assistants in Palau from 1990 to 1999 under the Micronesia Program. These students produced several valuable studies, plans and reports on topics such as tourism, conservation, women's fishing and waste management. Finally the School for Field Studies was based in Ngaraard state in 1995. Students conducted brief studies of local resources and resource uses.

CAPACITY FOR RESEARCH AND MANAGEMENT

Institutional capacity

Historically, Palau has relied on outside researchers and institutions to conduct needed resource assessments and surveys. A general lack of local capacity to carry out many kinds of marine research still exists, however, significant strides have been made to build local research capacity. For instance, in 2001 the Palau International Coral Reef Center (PICRC) was built. Today PICRC has an on-going coral reef and fish monitoring program in Palau; has helped build capacity in the Federated States of Micronesia for reef monitoring; provides support for international scientists to conduct research in Palau; maintains collections of hard coral, marine algae and fish; assesses sedimentation on coral reefs; and is developing georeferenced databases of important marine habitats. PICRC has begun to direct its research more at resource management needs, and has initiated research associated with Marine Protected Areas.

The local capacity to conduct terrestrial or more general coastal research is not so strong, as there is no central terrestrial or coastal research center. The Palau Community College - Cooperative Research and Extension has limited capacity to conduct terrestrial research, and focuses on small-scale freshwater aquaculture and agricultural extension projects. Currently there is no center for coastal management in Palau.

The Ministry of Resources and Development has limited capacity to manage Palau's marine and coastal resources. The Ministry includes such important offices as the Bureau of Marine Resources, (mandated to manage fisheries and marine resources), the Forestry Section (mandated to manage forest, including mangrove, resources) and the Office of PALARIS (Palau's GIS). However, the Ministry has limited human and financial capacity and infrastructure to implement its programs.

Non-governmental organizations (Palau Conservation Society and The Nature Conservancy) and semi-government agencies (Palau Community College and Palau International Coral Reef Center) strive to fill the gaps that occur in resource management in Palau. These institutions have sponsored and conducted research needed for resource management, have helped to identify and establish protected areas, have worked with partners to develop management plans and policies, and have worked to build capacity in local communities and states for more long-term, sustainable use, monitoring and management of resources. Recently PCS and TNC have focused efforts more heavily on terrestrial and coastal environments, as that is where research and management needs are most pressing. Much of this work has centered on the main islands of Palau. In the Southwest Islands, an important NGO partner is the Community Conservation Network who works with Tobi state to manage Helen Reef.

Finally there is no central library, or web archive in which to conduct literature-based research. The Palau Community College has the most extensive (though not up-to-date) collection of materials. Smaller collections of materials are housed at PICRC, Belau National Museum, various government agencies, Coral Reef Research Foundation, The Nature Conservancy, Palau Conservation Society, USDA Natural Resource Conservation Service, and others. A six-CD set of scanned reports, books, documents and photos related to Palau's marine environment and culture was compiled by David Sapio when he was a Peace Corps volunteer with PICRC in 2003. This remains the most complete archive of marine and coastal information in Palau. However, because of copyright issues, these CDs are for use only in local libraries.

Individual/professional capacity

Palau has a very small population: in 2000 the total population was 19,129 (5,920 of whom were non-Palauan residents). As in many other small island developing states, this limited human resource base has serious implications. There are very few people working in resource management in Palau, and the issues are as extensive as in any other developing country. A very few people (possibly not more than 30) are involved in almost every aspect of research and resource management in Palau. Among Palauan students there is generally a limited interest in resource management or environmental sciences as a career. Those students who do go into the field can usually find higher paying jobs outside of Palau.

In addition, there are limited opportunities available in the few research or management facilities that exist, and only recently has there been an upsurge in resource management related jobs in Palau. As a result, there is a serious lack of qualified Palauans to conduct research or to work in resource management. There are some expatriates working in areas related to resource management, but these positions are generally poorly paid. Palauan students have been encouraged and sponsored to pursue studies in marine biology, natural resource management and GIS. There are now many qualified Palauans with expertise in marine biology or mapping. However, similar success has not yet happened in terrestrial or coastal fields of study. For instance, PCS has not been able to fill a position for a Palauan with terrestrial conservation expertise, because of the lack of qualified candidates. It is particularly important for Palauans to fill some of these positions, as there is a need for the ability to work with local Palauan communities.

Research and management priorities often follow outside funding and program priorities. The David and Lucile Packard Foundation, The Nature Conservancy, NOAA, USDOJ, Japanese Overseas Cooperative Assistance, South Pacific Regional Environment Programme (SPREP) and Food and Agriculture Organization (FAO) are currently the major sources of funding and/or technical assistance for coastal research and resource management in Palau. These organizations are generally responsive to local needs and try to develop their programs with significant local input, however, they still drive the projects. Aside from assistance specifically related to watershed management and more recently, to birds, it has been very difficult to obtain significant funding for terrestrial related research and management.

Gaps in critical information

The following is a list of key topics where critical information is not being collected, or has not been collected extensively:

- ✦ nearshore currents and small-scale circulation patterns;
- ✦ patterns of recovery from coral bleaching;
- ✦ impacts of coral bleaching on fisheries;
- ✦ seagrass beds (ecology, biology, distribution, health);
- ✦ mangroves (ecology, biology, distribution, health);
- ✦ forests (ecology, biology, distribution, health);
- ✦ linkages between and among marine and terrestrial ecosystems;
- ✦ terrestrial and marine species inventories (including a complete vegetation inventory);
- ✦ distribution of rare and endemic plants (trees, orchids, fungi, etc.), insects, birds, terrestrial invertebrates, freshwater fish;
- ✦ extent of endemism in terrestrial and marine ecosystems;
- ✦ distribution and impacts of introduced and invasive species;
- ✦ status of species important in nearshore and offshore fisheries;
- ✦ quantity and description of fish and non-fish by-catch in the offshore fishery;
- ✦ gaps in fisheries data: tuna, highly migratory fish, reef fish and invertebrates (land crabs, lobster, molluscs);

- ✦ uses and status of nearshore invertebrates (urchins, sea cucumbers, crabs, molluscs);
- ✦ local and regional population dynamics and migratory patterns of sea turtles;
- ✦ fish population dynamics and migration patterns;
- ✦ life histories of native species with potential for aquaculture (reef fish, land crabs, mangrove crabs, coconut crabs, swimming crabs, sea cucumbers, molluscs);
- ✦ accurate, long-term information related to climate change: sea level and temperature changes, flooding, droughts, frequency and damage from storms, coastal erosion, changes in terrestrial and marine habitats and communities;
- ✦ extent of damage caused by fires;
- ✦ cumulative impacts of development projects;
- ✦ impacts of dredging and sand mining on nearshore habitats;
- ✦ sediment loading and hydrology of rivers;
- ✦ quantity and extent of pesticide, fertilizer, detergent, bleach and other chemical contamination in rivers;
- ✦ rainfall patterns and distribution throughout Palau;
- ✦ short- and long-term land use changes (assessment and mapping);
- ✦ population and demographic trends;
- ✦ socioeconomic impacts of development and conservation projects;
- ✦ cultural and social changes that are impacting the environment;
- ✦ mechanism by which key resource management decisions are made at different scales;
- ✦ documentation of traditional management and sustainable resource use practices;
- ✦ documentation of traditional fishing and farming techniques;
- ✦ impacts and effectiveness of conservation activities and legislation; and
- ✦ impacts of human immigration and migration on resource uses and management (including the outmigration from Southwest Islands to Koror).

All geographic areas of the main islands and the Southwest Islands of Palau are understudied.

Information management

Traditionally in Palau, access to and control of information was a source of power. For example, those people who knew the secrets of medicinal plants or the migration patterns of fish, could partially control access to those resources by controlling access to information about them. The knowledge was considered family property and was handed down to someone in the family who was trusted to use the knowledge and resources appropriately. While much has changed in Palau and access to information has increased considerably, remnants of information control still exist. Perhaps this is one reason there is no central library, depository or clearinghouse for information related to resource management, as specific information is held by many agencies and individuals. The information is thus very dispersed throughout Palau and it can be difficult to understand comprehensively what exists, what research has been done or who has access to the information.

There have also been many instances over the years when foreign scientists have conducted research in Palau and then vanished with the data. Reports or published papers are not returned to the country, taxonomic collections are housed in and owned by institutions outside of Palau, and people in Palau have neither access to nor knowledge of the results of the studies. In addition, some Palauan co-researchers have not been acknowledged or compensated in any way for their contributions to the scientific work of visiting researchers. As a result, although there is an understanding of the need for research, there is often a feeling of distrust for visiting researchers. Many contemporary scientists are conscious of the need to return information to the country in which it was collected, as well as to acknowledge the contributions of local researchers, however there still is work that needs to be done to correct this problem.

There is a significant amount of information relating to Palau that is spread throughout the Pacific or in need of translation. For instance, Kubary's, Krämer's and Eiler's ethnographies from the late 1800s and early 1900s are still in need of thorough translation from the original German. As mentioned earlier, a lot of valuable information was collected by Japanese scientists in the 1930s and 1940s and little of that information is available in English. There are several series of aerial photographs located in offices in Hawaii, Saipan and Palau. These series need to be copied and georeferenced so land use changes can be measured. There may also be additional historical and scientific information about Palau archived in other countries (especially Germany and Japan) that is not known of in Palau.

There are efforts to make information more accessible. For instance, one mandate of the Office of PALARIS (National GIS) is to become a depository for geographically referenced data, such as monitoring data. PALARIS staff have been conducting intensive database management and GIS training courses in order to build capacity in agencies and organizations throughout Palau in order to meet this mandate. However, there has been limited success in creating the GIS clearinghouse, as much of the data remains with the agencies where it is collected.

Perhaps one of the greatest recent achievements to increase accessibility to information, is the 6-CD compilation of scanned reports, documents and books related to Palauan culture and the environment that were created by Peace Corps volunteer Dave Sapio in 2003 while working at the Palau International Coral Reef Center. The scanned documents are stored on the computer at the research library of PICRC, and are accessible to anyone who uses the library. In addition, copies of the CDs were provided to members of MAREPAC (Marine Resources Pacific Consortium) making them accessible in several other offices in Palau as well. Most individual libraries in Palau were visited and many of the major documents related to marine and coastal resources, as well as many cultural resources in Palau were scanned. The goal is for MAREPAC members to continually update the collection as new reports become available.

Finally, there have been many focused studies and several resource management plans written, but few serious attempts to integrate or compile the information in a meaningful and accessible manner. The notable exceptions are the Rapid Ecological Assessment reports (Maragos et al. 1992, 1994a, 1994b), a new report on marine environments of Palau (Colin 2004), and a bird book compiled in 1988 (Engbring 1988). Aside from the field guide to

birds, no field guides have been written specifically for Palau. In fact, field guides specific to the Micronesian region as a whole are scarce, especially for terrestrial species and habitats. Regional information is available about reef fish (Myers 1991), IndoPacific corals (Veron 1986), marine invertebrates (Colin and Arneson 1995) and wetland plants (Stemmermann 1981). In addition, several books aimed at the tourist market contain a popular treatment of many environmental subjects in Palau. Quite a few of these books and guides are currently out-of-print.

Education and research institutions

Palau Community College is the only local institution of higher education. The College is developing a research and extension facility for agriculture and freshwater aquaculture in Ngaremlengui state on Babeldaob Island, though current capacity is still limited. Affiliated with the College, but operating separately, the Palau International Coral Reef Center (PICRC) has marine research and educational facilities. The Center is newly established and has built its capacity for local and regional work in the past couple of years. PICRC's Scientific Advisory Board is composed of imminent coral reef and marine scientists from around the world who conduct research in Palau. PICRC also offers facilities for other visiting scientists to conduct research in Palau. The Center has begun to increase its involvement in marine resource management issues, and is embarking on several studies aimed at marine protected areas. The Coral Reef Research Foundation (CRRF) is a non-profit research institute that maintains a laboratory in Palau. CRRF has been creating collections of sponges and other invertebrates, monitoring the marine lakes, assisting Koror State with conservation area monitoring, and creating a catalog of aerial photographs, among other projects.

There are a few significant working relationships with regional institutions. Over the years, scientists at the University of Guam have partnered with local institutions to conduct important inventories of marine species and habitats, as well as to develop a watershed monitoring study. There has been sporadic contact and collaboration with the University of the South Pacific (USP) in Fiji and the College of Micronesia.

Traditional and local knowledge

Palau is renowned for the extent of traditional and local knowledge about the marine environment. This was popularized by Johannes' work with master fishermen from Ngaremlengui and Tobi in Palau in the 1970s (Johannes 1981). Women maintain a wealth of knowledge and medicinal plants, taro and other crops. Palauans still maintain a significant store of traditional and local knowledge about many terrestrial and marine habitats, species and ways to utilize them. However, this knowledge is poorly documented and much of it is in danger of being lost.

As mentioned earlier, Palauans, especially knowledgeable elders, are sensitive about sharing important information with people who are strangers to them. Knowledge was traditionally closely guarded by families and was not freely accessible to all. Even within the family, only some people were trusted to hold knowledge and information. There has been much recent interest in collecting information from community people about their perceptions and knowledge of local resources. For instance, the Palau Conservation Society has been

involved recently in several studies aimed at collecting local knowledge on crocodiles and dugongs, and is beginning a survey on uses of marine turtles. In addition, PCS staff have also interviewed people throughout Palau about their knowledge about local issues related to biodiversity conservation as part of the National Biodiversity Strategy and Action Plan (PCS 2003a and 2003b). Other surveys are being conducted by other organizations, as well: PICRC, Public Health, students from the College, and others. During some of these interviews, it became apparent that Palau has a very small population. This is especially true on Babeldaob island, where population size is only several hundred per state. In some places, people have been overwhelmed by the numbers of surveys that have been conducted in their village while other communities (notably the Southwest Islanders) have been under-surveyed. In addition, the results of the studies are rarely presented back to them. There are still many important information gaps, especially in the lack of documentation of local knowledge and management practices. Therefore, it is critical for scientists to be sensitive to local perceptions on research, to design studies with as much local involvement and benefit as possible and to be willing to communicate information and results back to the local communities in a timely manner.

Governance related to natural resource management

As in many countries, governance related to natural resource management is spread over many agencies and groups. In Palau, this dispersion of resource management authority is further complicated by the existence of both a traditional system and an democratically elected system of governance, as well as the influence and existence of foreign government agencies and regional or international programs. At times there can be confusion over how these systems interrelate, and often roles and responsibilities need clarification. In addition, the values and practices that support the traditional system, which is based on a relatively strict hierarchy of clans and villages, can be opposed to the more egalitarian and individualistic ideals of the democratic government. However, Palau has a very rich and long history of resource management that is at the heart of both traditional and modern forms of governance. The challenge in Palau is to effectively use both traditional and democratic styles of government to meet development goals while maintaining a healthy environment.

General overview

Resource management is complicated in Palau, and throughout Micronesia, by the complex history of the islands. Complications stem from the layers of administration that have been in place over the years. A traditional system was overlaid with a Japanese administration, which was replaced by an American Trust Territory administration, which eventually was replaced by a conditional independence. Each of these layers has influence on resources and resource management issues to the present day.

From 1914 to 1944, Palau was administered by the Japanese government. Palauans received differential treatment in many spheres of life during the Japanese administration. Palauan children received only minimal education and they were being trained to be laborers. Local customs and language were suppressed in favor of Japanese customs and language. Over the 30 years that Japan controlled the islands, much had changed: modern conveniences

and technologies had been introduced; an elaborate and well-maintained infrastructure had been built; and four colonies on Babeldaob Island for permanent Japanese settlers were built (on the Ngeremeskang River, on the southern coast of Airai, at Lake Ngardok, and on the Tabecheding River). Some Japanese men married Palauan women and settled into the society. By 1939, there were 30,000 Japanese, Okinawan and Korean civilians living in Palau, and only 5,000 Palauans.

World War II dramatically undid all of that. Much of the elaborate infrastructure that had been built by the Japanese was destroyed by the war. In addition, many people were killed and families were broken. The United States military controlled all of the Micronesian islands that were under Japanese mandate by 1945. Once the United Nations was established after World War II, some of the islands of Micronesia (Palau, Saipan, Yap, Pohnpei, Truk and the Marshalls) became the Trust Territories of the Pacific Islands, with the United States assigned to administer authority.

One of the first responsibilities of the new administration under the Trusteeship was to set up self-governing institutions. In Palau, this meant replacing the Japanese government with a new one styled after the American system. Sixteen established municipalities were recognized (which later became states). These local municipalities would be run by District and Assistant District Chiefs working with a Council of “nobles.”

The Trust Territory Administration grappled with how to rebuild Palau after the War. The pre-war economy was based on the large number of Japanese permanent residents, and the new Administration decided that it was not realistic to rebuild to that extent. One of the major issues of rebuilding issue was redistribution of land. The Japanese had considered most of Babeldaob as “state” land. Peleliu and Angaur, from which the local Palauan population had been relocated, were also considered government land. After the war, additional public land was set up under the Trusteeship. By 1955, about 73% of the total land area was considered “public” lands. The Palauan leaders wanted the public land to be returned to the council of chiefs of each municipality so they could facilitate the redistribution of land to villages and individuals. The complicated process of determining claims and registering lands remain major issues in Palau (Pulea 1994).

For over 20 years, Palau struggled internally and with the United States to define its political status. This struggle was complicated, at times violent and has had lasting repercussions. Palauans wrote and rewrote their Constitution, but had difficulty reconciling some of its clauses with the Compact of Free Association supported by the United States and some influential Palauans. During these difficult times, Palau’s first President was killed, the father of an outspoken lawyer was killed, a prominent women’s leader’s house was bombed and tensions within Palau escalated. Finally, in 1994, Palauans voted to accept the Compact of Free Association and thus the last district of the Trust Territory of Pacific Islands became the Republic of Palau.

Since 1994, the Republic of Palau has enacted several key pieces of legislation related to resource management and the environment. In addition, Palau has become signatory to regional and international conventions that also govern resource management. Finally, trade has opened with Taiwan, China, Japan, Philippines, Korea and the European Union. This

increased presence in the regional and international stage, has added to the responsibilities as well as the opportunities for increased resource management in Palau.

Traditional system of governance

The following brief description of Palau's traditional system of leadership for the main islands of Palau is based on the work of the Palau Society of Historians (1997). No comparable description has been completed yet for the governing system of the Southwest Islands. Traditional governance in Palau's main islands is based on a sophisticated hierarchy of villages or hamlets (*beluu*). Each *beluu* holds ten or eleven ranked titles for the men and a complementary set of titles for female counterparts. The titles are the property of the clans. Each clan has the authority to appoint someone to bear its title. Generally, the elder females who are members of the clan through matrilineal descent, have the authority to assess and recommend who will hold a title that is available because of death of the title holder. Traditionally each title held specific responsibilities that the titleholder must perform. The men who held the titles (*rubaks*) as a group were called the *klobak*. This group had the power and authority to rule over the *beluu*, and governed the use of its resources.

The basic values that were upheld by the traditional authority and system were:

- respect and honor (*omengull ma omeluu*)
- praise or appreciation (*odanges*)
- compassion (*klechubechub*)
- cooperation and communication (*klaiuerenges*)
- good or right conduct and character (*kldung*)
- unity (*odekial a reng*).

Traditionally there were relationships and alliances between the *beluu*. The relationships between the *beluu* and the *kebliil* were maintained and strengthened through customs and exchange of valuables and food. The relationships were also supported or broken through competition and warfare. The most important of these alliances was the one between the two half-heavens (*bitang ma bitang el eanged*). One of these halves followed Paramount Chief Ibedul of Koror and the other followed High Chief Reklai of Melekeok.

Table 11. States associated with each of the half-heavens (*bitang ma bitang el eanged*)

States following Reklai	States following Ibedul
Kayangel	Ngardmau
Ngarchelong	Ngaremlengui
Ngaraard	Ngatpang
Ngiwal	Aimeliik
Melekeok	Koror
Ngchesar	Peleliu
Airai	Angaur
	Sonsorol
	Hatohobei

Another important means of categorizing alliances was based on the legend of the Children of Milad. Her children were the first Palauans and they became the four corner posts of Palauan society. These children are Ngaremlengui, Melekeok, Aimeliik and Koror.

The traditional system continues to operate in subtle ways, especially in matters of protocol. The hierarchy of places is important, and lists of states often follow the traditional hierarchy. If a series of meetings or workshops are scheduled in the states of Palau, the traditional order of invitation and visits should be maintained as much as possible (starting at Kayangel heading towards the south). It is also important to show proper respect for people of high rank or position. Finally, it is always necessary to gain permission and acceptance from the traditional and elected leadership for any studies or activities that may be associated with their state or village.

STATE AND NATIONAL GOVERNMENT AGENCIES

State governments

The sixteen state governments (Table 12) are based on traditional groupings of villages and the municipalities that had been created under the Trusteeship. Each state has a Constitution, a Governor and a state government composed of a varying array and number of positions. Often the traditional leadership of Palau works through the state government. The level of authority granted to the traditional leadership is defined in the state constitution. In Article 1, Section 2 of the Palau Constitution, Palauan states have “exclusive ownership of all living and non-living resources, except highly migratory fish, from the land to twelve nautical miles seaward.” States can enact laws that limit resource uses within their boundaries, as long as those regulations do not conflict with national law. The majority of conservation areas and reserves in Palau have been initiated at the state and local levels. Some states (Kayangel, Ngarchelong, Melekeok, Koror, Sonsorol and Hatohobei) have at least one Conservation Officer on staff. The duties of this position vary with the local circumstances, but often include monitoring, maintenance and education. However, many states have little capacity or funding for the majority of resource management responsibilities. The exception is Koror state, where the state government is the most developed of the sixteen. Koror State Department of Conservation and Law Enforcement is a well-developed and well-respected model in Palau. The Department is responsible for management, maintenance and monitoring of the Rock Islands of Koror, among other responsibilities.

Table 12. States of Palau, in order of population (OPS 2000)

State	Total population	Palauan population
Koror	13,303	8,873
Airai	2,104	1,378
Ngaraard	638	383
Peleliu	571	542
Ngaremlengui	367	303
Ngarchelong	286	271
Ngatpang	280	224
Aimeliik	272	230
Ngchesar	267	251
Melekeok	239	213
Ngardmau	221	203
Ngiwal	193	178
Angaur	188	176
Kayangel	138	132
Sonsorol*	39	6
Hatohobei*	23	4
TOTAL	19,129	13,367

*Note: Most Southwest Islanders live in Koror. They are citizens of Palau. However, most consider their ethnicity to be Micronesian rather than Palauan as their language and culture are more closely tied to Yap than to the main Palau islands. As a result the “Palauan” population of the SW Island states appears to be very small.

National government

The National Government and its ministries administer a wide range of programs related to terrestrial and marine resource management and are beginning to coordinate state activities. The Palau National Constitution and the Palau National Code guide the national

government and its programs. The Second Constitutional Convention is currently being convened and will result in several proposals to amend the Palau National Constitution. It is not yet known how this may affect resource management or government structure in Palau.

In 1949, a staff entomologist (Robert Owen) was hired by the Trust Territory administration to coordinate a program to control an outbreak of coconut rhinoceros beetle (*Oryctes rhinoceros*) that was causing severe damage to coconut plantations in Micronesia. He also began to oversee problems related to soil conservation, forestry, marine resources, botany and physical and biological problems for the Trust Territory islands. Eventually, offices for different environment and natural resource-related programs opened throughout the Micronesian islands. In Palau, the office evolved into the Department of Conservation and Entomology. This Department was responsible for all aspects of conservation and conservation law enforcement. The office and its duties were split among several ministries and agencies in 1999 after Chief Conservationist (Demei Otobed) retired (Otobed 2003). At the present time in Palau there is no overarching home for coastal management, resource management and environment related programs. At times this has led to difficulty in coordination and administration of programs and policies. Currently, the principle offices and ministries responsible for resource management activities in Palau are the following.

Office of the President

Office of Environmental Response and Coordination (OERC)

The Republic of Palau established the Office of Environmental Response and Coordination (OERC) in 2001 to coordinate the programs associated with the Republic's responsibilities related to internationally identified and funded environmental initiatives, such as global climate change, biodiversity, desertification and land degradation. The OERC is mandated to develop a broad and coordinated planning approach to issues of environmental response that integrate governmental environmental programs into Executive Branch environmental response planning.

Ministry of Resources and Development

Bureau of Marine Resources

The Bureau of Marine Resources' primary responsibilities are managing and developing fisheries resources and aquaculture development. They are responsible for operation of the Palau Mariculture Demonstration Center (PMDC), which is well known for its research work on the propagation and culture of giant clams. They also administer the Marine Conservation and Protected Areas Program (MCPA) and are responsible for managing and monitoring the Ngaremeduu Bay Conservation Area.

Bureau of Agriculture

The Bureau of Agriculture is responsible for the promotion, exploitation, development and conservation of the terrestrial resources of the Republic including forestry, agriculture, mineral and other land based resources, and ocean ecosystem resources. Forestry management at the Bureau is housed within the Forestry Section. This section prepares management plans and directions for forestry management activities for native forests, plants, watersheds and

mangrove forests. The section also oversees programs that address problems or threats from plant diseases, wildfire, noxious weeds and erosion; manages forestry extension programs and forestry activities to protect wildlife, with an emphasis on birds and fruit bats; and conducts environmental education programs directed at preserving forests.

Bureau of Oceanic Fisheries Management

The Bureau of Oceanic Fisheries Management is responsible for managing and monitoring oceanic fisheries (especially tuna fisheries) in Palau. It is currently being administered by the Director of the Bureau of Marine Resources.

Bureau of Lands and Surveys

The responsibilities of the Bureau of Lands and Surveys are to advise the Minister of Resources and Development and represent the Republic on all technical matters related to land issue and registration. The Director coordinates logistical support to the Land Court and its sixteen State Land Registration Offices, the Palau Public Land Authority and the sixteen State Public Land Authorities, national government ministries, state governments and other programs or activities involving the use of eminent domain. The Bureau contains the Division of Surveying and Mapping that performs official land and geodetic surveys and re-surveys as deemed necessary for the identification and description of all public and private lands, and the Division of Land Resource Information that conducts an ongoing and thorough inventory of the Republic's land and mineral resources above the high water mark and other areas of specific interest below the high water mark. As part of the land resource inventory, the division also classifies and maps land formations for vegetation, soils and minerals.

PALARIS

Palau Automated Land and Resources Information System (PALARIS) is the National Geographic Information System or GIS. The office uses the most updated and modern computer technologies to digitally map and analyze resources within Palau. Data gathered goes into the Natural Resource Information Database. This data can be used to track habitat changes, monitor loss as well as protection of water, soil, vegetation and cultural resources over time and provide crucial information for the decision-making process and monitoring of sustainable development planning.

Ministry of Justice

Division of Fish and Wildlife Protection

Fish and Wildlife Protection enforces laws relating to regulated plants and animals. The Division enforces the Marine Protection Act (PNC Title 24) and other national laws related to conservation and resource uses.

Division of Marine Law Enforcement

Division of Marine Law Enforcement is responsible for marine surveillance of the Republic's territorial waters and its 200-mile Exclusive Economic Zone. The division enforces all laws and regulations related to fishing, environmental protection and illicit narcotic trafficking.

Office of the Attorney General

The AG's Office is responsible for providing legal services to the Republic, including the prosecution of criminal and civil cases on behalf of the Republic. The AG's Office represents and advises all agencies, divisions and ministries of the executive branch on legal matters; provides legal services to the procurement officers; drafts, reviews and certifies government contracts; reviews legislation as requested by the President; processes petitions for corporate charters, including the registration of foreign corporations.

Ministry of Community and Cultural Affairs

Bureau of Arts and Culture

The Bureau of Arts and Culture (BAC) is a semi-government agency that protects and preserves the historical and cultural resources of the Republic of Palau for both present and future generations. Activities include conducting archaeological surveys, promoting site registration, restoration, and interpretation and implementing oral history and ethnography documentation to ensure that traditional knowledge is preserved. Numerous reports and documents are published annually and are available to the public.

Environmental Quality Protection Board

The Environmental Quality Protection Board is a semi-governmental agency created in 1981. Its mission is to ensure for all persons in Palau safe, healthful, productive, and aesthetically and culturally pleasing surroundings, and to attain the widest range of beneficial uses of the environment without degradation, risk of health and safety, or other undesirable and unintended consequences. EQPB issues permits for activities that require earth moving or the cutting or filling of mangroves. EQPB inspectors monitor both fresh and marine water quality, the use of pesticides and other hazardous materials. The EQPB partners with USGS on developing water quality programs and conducts seminars and conferences to educate youth and the general public in environmental conservation issues.

Palau Public Land Authorities

The Palau Public Land Authority (PPLA) was established under the Palau National Code to manage public lands, i.e., "those lands situated within the Republic which were owned or maintained by the Japanese Administration or the Trust Territory government... and such other lands as the national government has acquired or may hereafter acquire for public purposes" (35 PNC Section 101). The PPLA's goal is to return public lands to individuals, clans or lineages, with the remainder of the land transferred to State Public Land Authorities. The PPLA has the power to receive and hold title to public lands; to administer, manage and regulate the use of public lands and income there from; to administer a program for homesteading on public lands; to sell, lease, exchange, use, dedicate for public purposes or make other disposition of public lands; and to use eminent domain or to acquire land by negotiation (PCS 1999).

Semi-government agencies

Belau National Museum

The Belau National Museum has been in operation for forty-eight years and is the oldest museum in Micronesia. The museum's primary focus is preserving the rich cultural heritage of Palau with research in natural history and the complex links between culture and natural resources. Through extensive and expanding exhibits and other community outreach programs, the museum shares knowledge and research with the public. The Museum is currently developing a Natural History section, that will include an herbarium, other collections and educational displays.

Palau Community College - Cooperative Research and Extension

The Cooperative Research and Extension (CRE) arm of the College conducts projects in agriculture, aquaculture, family and consumer education, natural resources and environmental education. CRE operates the Agricultural Experiment Station (AES) at Ngaremlengui on Babeldaob Island. Currently CRE is working with the Bureau of Marine Resources on several small-scale experimental aquaculture projects.

Palau International Coral Reef Center

Palau International Coral Reef Center (PICRC), a non-profit semi-government organization, was established in 2001 in order to create a self-sustaining center for marine research, training, and educational activities in Palau. Through marine research at their professional research facilities and aquarium, PICRC educates the public about ecological, economic, and cultural importance of coral reefs. PICRC's current areas of focus are coral biology, marine protected areas and sedimentation.

Non-governmental organizations

Coral Reef Research Foundation

The Coral Reef Research Foundation (CRRF), founded in 1991, is a non-profit organization incorporated in the State of California and the Republic of Palau whose purposes are to increase knowledge of coral reefs and other tropical marine environments to allow intelligent conservation and management decisions. CRRF conducts both basic and applied marine research. CRRF research programs focus on: (1) dynamics of the marine environment as it relates to conservation decisions, (2) limits of species diversity, community distribution and biogeography and (3) monitoring with respect to short to long-term environmental and climate changes.

Palau Conservation Society

Palau Conservation Society (PCS) was founded in 1994 and is dedicated to the preservation of Palau's unique natural environment and the perpetuation of its conservation ethic for the economic and social benefit of present and future generations. PCS works closely with local and traditional communities, local government, international agencies and the international scientific community. PCS has been working closely with states throughout Palau to help establish, maintain and monitor marine and terrestrial conservation areas and reserves. Much of PCS's early work focused on protecting the marine environment. Recently, PCS developed two inter-related strategies: one focused on marine conservation and the other

on terrestrial conservation (with a special focus on Babeldaob Island). With its partners, PCS has developed a watershed protection program, and is beginning to build the basis for effective state and local land use planning with a community visioning program. PCS is also the Micronesian affiliate of BirdLife International.

Palau Federation of Fishermen Association

The Palau Federation of Fishermen Association (PFFA) is a body that brings Palau's state fishing cooperatives and their members together.

The Nature Conservancy

The Nature Conservancy's (TNC) goal is to preserve the plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. The Conservancy's work in the Micronesia began in 1990. The Conservancy maintains offices in Koror, Palau and Kolonia, Pohnpei.

US programs

USDA Natural Resource Conservation Service provides technical assistance in conservation planning typically for farmers and land use decision makers. NRCS provides leadership in natural resource management but does not have a financial assistance or cost share program available in Palau.

USDA Forest Service provides assistance to support forest management in Palau in the form of several programs which are financially and technically supported by USFS remotely and conducted through the Palau Bureau of Agriculture Forestry Section. Hawaii- and Yap-based foresters have provided a considerable amount of technical assistance in Palau. A small grants program, the Urban and Community Forestry program (U&CF), is run through the Forestry Section. This program funds small-scale locally based activities that enhance or protect forests and agroforests of Palau. The U&CF program has assisted state nurseries to establish native tree propagation programs to enable community based re-vegetation activities; has helped develop and maintain the Lake Ngardok Nature Reserve, one of Palau's few terrestrial conservation areas and a Wetland of International Importance under the Ramsar Convention; and has supported the development of a database of information on native and endemic trees.

US Peace Corps has had a presence in Palau since 1966. Over the years Peace Corps volunteers have worked on a variety of resource management related projects. Among these are small-scale aquaculture development, science education and conservation area management. Recently the US Peace Corps in Micronesia have begun to focus many of their projects to help improve coastal and resource management. As a result volunteers with experience and interest in topics such as watershed management, environmental studies and protected area management and monitoring have been placed with agencies, NGOs and states throughout the country.

The Department of the Interior maintains an office in Palau. DOI funds several resource management projects in Palau, including support for PALARIS and for building community support for land use planning.

Other US-based programs

The Palau Community College administers the National Land Grant program. Land grant funds some of the activities and programs at the Cooperative Research and Extension arm of the college. Several national government agencies, semi-government agencies and NGOs in Palau receive funding and technical assistance for resource management activities through USGS, NOAA, NMFS, USFWS, and USFS, among others. Some of the projects and funding are related to assessing and minimizing the impacts of the construction of the Compact Road.

International and regional bodies

Over the years, Palau has hosted several agriculture and fisheries development projects through the Food and Agriculture Organization (FAO), UNDP and UNEP. Recent projects have been initiated through the World Bank (economic valuation of resources) and the European Union (energy development). Japan International Cooperative Agency (JICA) has an office in Palau, and has supported Palauan agencies and schools with many technical and education volunteers over the years. New international aid and technical assistance programs are being established by New Zealand, Australia and Republic of China (Taiwan).

The regional bodies relevant to resource management in Palau are the Secretariat for the Pacific Community (SPC), South Pacific Regional Environment Programme (SPREP), Forum Fisheries Agency (FFA) and SOPAC. These regional bodies have sponsored studies and assessments in such fields as coastal fisheries development and management, conservation area management, waste management, and policy development.

Existing policies, regulations and agreements

Local and state

Traditionally, states and villages had tenure over the local resources and outsiders were not allowed access without permission. Over time this tenure, especially the well-developed marine tenure system of the past, has weakened. Today, policies and regulations related to resource management and control at the local and state level often operate in some combination of traditional and state law. For instance, some states have set aside conservation areas through traditional *bul* (a temporary ban on the use of a resource). Sometimes these restrictions are then written into state laws. See Map 2. Other states do not utilize the traditional system to set up conservation areas, but start by writing state regulations. The state of Koror has the most elaborate and far reaching set of state regulations regarding resource uses. Koror has drafted a comprehensive management plan for the Rock Islands, which includes zoning of the area for multiple uses. This plan is awaiting approval of the Koror state legislature.

Some states have regulated the use of certain species, often when similar restrictions do not exist at the national level. For instance Koror, Peleliu, Angaur and Ngiwal all have limitations on the harvest of land crabs, a species important for small-scale commercial and subsistence uses. And Hatohobei state is starting to regulate the transport of marine turtles from the state to the main Palau islands.

Very few states have attempted to develop master land use plans or have implemented any zoning regulations. Koror state has implemented a zoning plan. There is no expertise on island to assist the states with land use planning. A few states have master plans. In addition, the Association of Governors hired an internationally based consulting firm to create master plans for each of the 16 states. As a first phase to the project, the consulting firm produced a series of constraint maps for each state based on the available data and consultations with state representatives and local consultants. The funding has not yet been secured for the second or third phases of this project.

National

Some of the most relevant policies and regulations regarding resource management at the national level are:

- An act that established EQPB and EQPB's set of regulations for protecting the quality of air, water and land resources;
- Endangered Species Act (regulations and list of species has not been adopted);
- Limitations of taking of turtles and their eggs;
- Control of sponge harvesting;
- Control of black-lip mother of pearl harvesting;
- Conservation of dugongs;
- Regulations regarding trochus collection (which is only open for collection for a one-month season once every 3-5 years);
- Illegal methods of capture, including a ban on using poison or dynamite;
- Conservation of birds - no birds can be hunted except red junglefowl, collared kingfisher, purple swamphen and sulfur-crested cockatoo;
- Prohibition on moving monkeys from one island to another;
- Plant and Animal Quarantine Act;
- Marine Protection Act (1994) - establishes seasons and size limits on some reef fish and invertebrates; bans the collection of aquarium fish; sets gear restrictions (such as a ban on fishing with scuba gear);
- Foreign fishing laws;
- Legislation demarcating Ngerukuid Islands Wildlife Preserve (1956) and Ngerumekaol Spawning Area (1976) as protected areas;
- Protected Areas Network Act (2004) - repeals the Natural Heritage Reserve Act; encourages national support for protected areas that are set up by states and local communities; and
- Legislation that bans foreign fishing boats from taking reef fish, turtles, rays sharks or marine mammals; bans the use of steel leaders (to minimize by-catch of sharks).

International

Prior to 1994, while still technically a Trust Territory, Palau shared many of the same international obligations as the United States. In 1994 Palau entered as an independent nation into the United Nations. Since then, Palau has independently become signatory to a number of international conventions related to resource management and uses. These include Framework Convention on Climate Change, Convention on Biological Diversity, Convention to Combat Desertification and Land Degradation, Ramsar Convention on Wetlands, Convention on International Trade of Endangered Species (CITES) and the International Whaling Commission, among others. The administrative and reporting requirements for these conventions are coordinated through the Office for Environmental Response and Coordination or the Ministry of Resources and Development.

Palau has entered into foreign fishing agreements with Japan, Taiwan and China. These countries have license to fish for tuna and other pelagics in Palau's EEZ. The agreements are negotiated and regulated under the Foreign Fishing Laws of PNC Chapter 1.

Customary laws and resource use and management

Although the traditional governance systems have weakened after centuries of foreign occupation and administration, many elements of the system are still operating in Palau. The Palau National Constitution recognizes the importance of the traditional system and its laws. Under the Constitution, statutes and traditional law hold equal weight. In the case of conflict between statute and traditional law, the statute prevails only if it does not conflict with the underlying principles of traditional law (Graham and Idechong 1998; Pulea 1994). A Traditional Council of Chiefs (*Rubekul Belau*) is composed of the 16 top ranking *rubaks* from each state. The primary duty of the Council of Chiefs is to advise the President on issues of customary law and practice. Leading the Council of Chiefs are Paramount Chief *Ibedul* of Koror and High Chief *Reklai* of Melekeok.

Palau's state constitutions were written to include and recognize traditional laws. The states have chosen a range of levels of integration of traditional and elected governing bodies. In many areas the state governments have provided a means of empowerment of traditional leaders and the states appear to be exerting more control over the uses of local resources (Graham and Idechong 1997).

Coordination and collaboration

As mentioned earlier, there is no overall Ministry of the Environment in Palau, so national programs are spread among a variety of ministries. Coordination and collaboration among the agencies can be difficult. Over the past 5 years several coordinating bodies have been created to help increase coordination and collaboration among and between national and state government, NGOs and other entities. These groups are composed of member organizations that meet monthly to discuss issues of concern. They are:

- Marine Resources Pacific Consortium - Palau (MAREPAC)
- Palau Natural Resources Council (PNRC)
- National Environmental Protection Council (NEPC)

MAREPAC is a consortium of government agencies, research institutions, education, NGOs and private companies with an interest in marine resources. MAREPAC members meet monthly to discuss current and on-going projects. The consortium has developed a five-year plan and prioritized projects and issues in order to fill some of the gaps in data collection, monitoring and conservation. Priorities include mangroves, coral reef monitoring protocols, and collection of appropriate reference literature and reports. Members often collaborate on projects.

The Palau Natural Resources Council (PNRC) is composed of government agencies, research institutions, education, NGOs and private companies with an interest in terrestrial resources. PNRC members have developed a detailed action plan, coordinate on projects and committees are set up to combat difficult resource management issues. One of the most active groups within the PNRC is the committee working on invasive species.

The Palau National Environmental Protection Council (NEPC) is a body established by Executive Order. Members include government agencies, NGOs and others working on all aspects of environmental protection and resource management. Meetings are often attended by high level representatives. The goals of the NEPC are to advise the President on important matters related to the environment and resources, and to review policies and strategies. The NEPC was also set up to review large development proposals before they had been approved by the government. To date, this Council has not had the opportunity to review any major proposals.

In addition, informal partnerships and collaborative work improve communication among the different entities. For instance, several partners are working to improve the condition of the Ngerikiil River watershed, the source of drinking water for 80% of Palau's population. This watershed is in an area of especially fast growth, with residential areas and farms spreading throughout the area. The state of Airai, USDA Natural Resources Conservation Service, Palau Conservation Society, Palau International Coral Reef Center and others have been conducting studies, resource assessments and developing strategies to improve the water quality through reducing sedimentation.

Trans-boundary ecosystems

The issues that transcend the geographic limits of Palau are management and enforcement of licensed and unlicensed foreign fishing fleets; the activities in other countries that impact locally important species (i.e., sea turtles nest in Palau but migrate throughout the region); and the increased threat of introduced invasive species.

Taiwan, China and Japan are licensed to catch tuna in Palau's waters. However, enforcement is weak and occasionally unlicensed boats, especially from the nearby Philippines and Indonesia, are caught in Palau's EEZ. This occurs most often in the more remote locations such as off the coast of Angaur and around the Southwest Islands. In addition, the licensed boats are occasionally caught fishing in nearshore areas not open to them (i.e., less than 12 miles from the coast). There has also been an increase in shark finning, an activity that new legislation is attempting to control. Finally, although a few Palauans have been trained, there is no active fisheries observer program and by-catch is generally not monitored.

Several locally important species have large regional migratory ranges. Green and hawksbill turtles, tuna, other pelagic fish and some bird species spend much, but not all of their lives in Palau. Local protection programs can only go so far if the species are not protected outside of Palau.

Finally, with increasing international shipping by air and sea, as well as increases in imported goods, plants and food from around the world, there is the growing risk of importation of invasive species. This is discussed in more detail in an earlier chapter.

Stakeholder involvement

More efforts are being made to increase the range of stakeholder involvement in resource management in Palau. Public hearings are held on important national projects, such as the relocation of the municipal land fill. Environmental Impact Statements for large development projects are open to public review. Consultations are being held more frequently to gain input from local community members on important issues such as climate change and biodiversity. The process, however, has room for improvement. It is not customary in Palau to speak openly about some issues, especially if the views are in opposition to a project being proposed by a more senior or titled person. In addition, some people, such as many women, will not speak publicly at such fora. Written comments are not commonly used in Palau, where communication is based on oral tradition.

Financing for resource management

Resource management is funded through a wide range of grants from foundations and international government agencies (such as NOAA), international treaties, bilateral agreements, regional organizations and local government funds. There are few examples of sustainable financing. However, a portion of the permit fees visitors pay for use of the Rock Islands is used to fund Koror state conservation programs. The Nature Conservancy is working with the national government to discover appropriate sustainable financing mechanisms that could be used to fund more conservation and resource management programs. Developing a national environmental trust is one option that has some local support.

Existing strategies, plans and related tools

Several significant strategies and plans have been written to guide environmental and resource management policies and activities in Palau. These include:

- Comprehensive Conservation Strategy (1991)
- National Environmental Management Strategy
- 2020 National Master Development Plan
- Mangrove Management Plan
- Sustainable Tourism Plan
- Waste Management Plan
- National Biodiversity Strategy and Action Plan (NBSAP) (currently under legislative review)

In addition, conservation area management plans have been developed for several marine and terrestrial conservation areas: Ngaremeduu Bay, Ngardok Nature Reserve, Ngeruangel Reserve and Rock Islands (under legislative review).

Overall, these plans are well thought out and contain many useful recommendations. A few of the plans have been used to guide policy and activities. Implementing some of the plans has been challenging, however. For instance, the Mangrove Management Plan has not been implemented to date. Occasionally there is insufficient input by key decision-makers or community members in the development of the plan, so there is not enough buy-in by those who should carry out the recommendations of the plan. Often the difficulty lies in the lack of funding allocated to implement the recommendations.

Major issues and gaps

Overall, Palau has a well-developed system of agencies, plans and policies for natural resource management at many levels (traditional, state, national and international). At times complications arise as a result of confusion about jurisdiction and roles at the different levels. For instance, national officers enforce national fishing and hunting laws (such as the illegal taking of turtles), however, they only document and report violations of state laws (such as the illegal entry into state conservation areas) (Gavitt 2003). Often the states do not have the capacity to enforce their own laws or to manage local resources. Recently there have been several encouraging attempts to increase the coordination and cooperation between and among state and national enforcement officers and programs.

Some national and state environmental laws are confusing, contradictory, or in-need of review. For instance, a review of the Marine Protection Act is needed to determine if appropriate size limits and seasons have been set.

There is no national land use or development plan, no building codes have been adopted, and no overall vision has been proposed for the country that has significant support of the states and local communities. Palauan states have considerable autonomy, and often act independently. However, few states have created appropriate land use or development plans of their own. As a result, unplanned development is occurring quickly especially in Koror and throughout Babeldaob Island in areas made more accessible by the construction of the Compact Road. Action is needed now to help direct the development, so that the Palauans of the future will continue to live with and know firsthand the rich and abundant natural resources of their homeland.

Acknowledgements

This chapter was greatly improved by the suggestions and comments given by Robin DeMeo (USDA Natural Resources Conservation Service Palau Field Office), Bernadette Keldermans (Palau Conservation Society), Ann Kitalong (The Environment, Inc.), Eric Kutter (Palau Department of Fish and Wildlife, volunteer), Dr. Joel Miles (Palau Office of Environmental Response and Coordination), Ilebrang Olkeriil (Koror State Department of Marine Conservation and Law Enforcement), Dr. Andrew Smith (The Nature Conservancy), Thomas Taro (Palau Community College - Cooperative Research and Extension) and Victorio Uherbelau (Palau Conservation Society, Board of Directors). The author wishes to thank Tiare Holm and all staff of the Palau Conservation Society for their assistance, patience and good humor. This chapter does not represent the views of the Palau Conservation Society. Any omissions or mistakes are the fault of the author alone.

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**Natural Resources Management Needs for
Coastal and Littoral Marine Ecosystems of**

**The Federated States of Micronesia
(FSM)**

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INTRODUCTION AND BACKGROUND

The Federated States of Micronesia is a young nation derived from part of the former United Nations Trust Territory of the Pacific Islands (TTPI). It is allied with the United States through a Compact of Free Association initiated in 1986. The FSM became a full member of the United Nations in 1991.

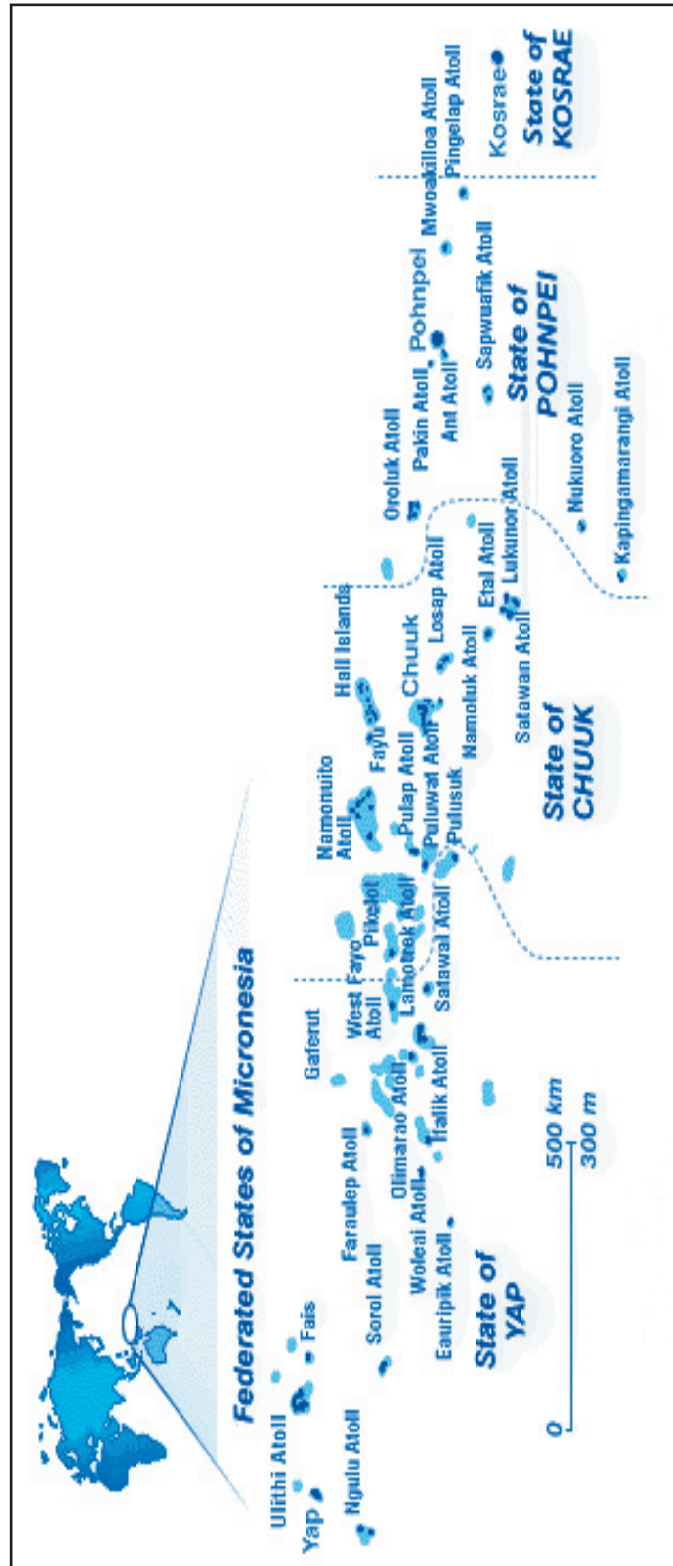
The FSM is made up of the Central and Western Caroline archipelago, and consists of the four states of Kosrae, Pohnpei, Chuuk and Yap (see Figure 1). With an Exclusive Economic Zone that extends from approximately 1 degree S to 14 degrees N latitude and 135 to 166 degrees E longitude, this nation of small islands (271 sq. mi. total land area) extends over an ocean area of approximately 2,978,000 sq. km. There are 30 high islands, one raised coral island and 33 atolls whose individual islets bring the total number of islands to over 600. These islands range from islets barely above sea level to the high island of Pohnpei which reaches 791 meters above sea level. The total population recorded in the 2000 census was 107,008, with a distribution of 50.5% in Chuuk State, 32% in Pohnpei State, 10.5% in Yap State and 7% in Kosrae State.

The per capita GDP for the FSM in 2002 was \$2,165. The FSM economy is basically made up of subsistence farming, wholesale and retail and government services as its main activities. Government services dominate the economy at 43% of GDP with expenditures totaling \$129 million in 2002. This is supported mainly by the Compact of Free Association with the United States.

At one time Micronesians were almost completely dependent on the natural resources of their islands for their daily lives. As human populations grew, so did their impact on natural resources. Species have been lost and ecosystems damaged by the dense populations of the FSM's past. At the same time, the people of the FSM have adapted to living with limited island ecosystems. Micronesian cultures incorporate practices having conservation value and thus served to buffer people's impact on the environment. The cultural and technological adaptations to living with island ecosystems are an important heritage of the past and an asset for the future.

Today the population of the FSM is growing rapidly, and patterns of resource use are changing. New technologies enable people to have a much greater impact on the natural environment, and commercial markets encourage greater exploitation of natural resources. Infrastructure developments such as roads and unsustainable agricultural practices have led to deforestation. For example, on Pohnpei island the reduction in the area of native upland forest from 42% of the total vegetation cover in 1975 to only 15% in 1995 is attributed largely to clearing to plant sakau (kava or *Piper methysticum*). This general degradation of land and water resources as populations grow and people increase natural resource exploitation activities as they shift towards a cash economy has resulted in increased erosion and sedimentation, with soil being deposited in rivers and eventually making its way out to cover and suffocate mangroves, sea grass beds, and coral reefs.

Figure 1. Map of the Federated States of Micronesia



The availability of off-island markets has resulted in unsustainable exploitation of resources. Examples include the former unsustainable harvest of fruit bats from Yap to Guam and the unsustainable boom in the export of mangrove crabs from Pohnpei and Kosrae. The commercial demand for reef fish has resulted in the decline of traditional controls over access to this resource in all islands. Stocks of inshore reef fish have declined in all state centers. The availability of a cash market has also encouraged destructive fishing methods such as the use of dynamite and chlorine products. Turtles are also highly endangered throughout the islands due to overharvest and a breakdown in traditional management and protection.

Other major environmental issues in the FSM include the growing combined impacts of climate change and poor land management, including increased shoreline and beach erosion, seawater intrusion into coastal swamps and taro patches, coral bleaching, and other negative impacts. In addition, pollution, both from growing solid waste and human and animal wastes, impact both biodiversity and public health.

Regional context and resources

The oceanic islands of the Federated States of Micronesia, formerly known as the Caroline Islands, in the western Pacific, are home to some of the most biologically diverse forests and coral reefs in the world. The proximity of Micronesia to the Indo-Malay region and the relative nearness between the islands themselves enabled the high islands in the region to act as bridges for the migration of terrestrial and marine species. However, the islands are far enough apart that populations became isolated and in some cases new species were formed. As a result, the total number of species decreases from Yap in the westernmost reaches of the FSM to Pohnpei at the eastern edges, but the proportion of endemic species increases.

The geology of the islands of the FSM is extremely diverse, with relatively large, high volcanic islands interspersed between small, nearly flat atolls. Environmental factors vary throughout the FSM. Yap is unique in the FSM in having metamorphic rock and associated soils resulting from uplift of the ocean floor (plate tectonics), as well as old volcanic soils. Islands to the east are younger and are made up of limestone (atolls) and on Pohnpei and Kosrae, volcanic basaltic rocks and associated soils. Larger islands can accommodate more species, and high islands like Pohnpei and Kosrae have different environmental conditions with elevation. Atolls have limited variation in habitats but are of different sizes and lie in different rainfall regimes. Yap is closer to Southeast Asia and New Guinea, while the islands of eastern FSM are more isolated from large landmasses that serve as sources of flora and fauna.

FSM is also located just north of the equator and in the Pacific's Intertropical Convergence Zone (ICTZ), an area of extremely high rainfall and humid tropical conditions. Rainfall is highest in the east reaching up to 6,400 mm/yr in Kosrae in the easternmost Caroline Islands, while the island of Yap in the west has a notable dry season. The country is located to the south of the major tropical typhoon tracks which ravage the Northern Marianas, Philippines and other neighboring countries. The overall result is a high diversity of plant and animal species within a relatively small land area.

WWF recognizes two major terrestrial ecoregions fully located within the FSM:

Carolines Tropical Moist Forest

Mature vegetation on the high volcanic islands in the *Carolines Tropical Moist Forest* ecoregion is dominated by broadleaf tropical forests. These high islands were probably almost completely forested at one time, with small patches of savanna. Much of the lowland vegetation has since been modified from its original state by humans. On Pohnpei Island, the largest island in the ecoregion, and Kosrae, well-developed mangrove forests and freshwater swamp forests still exist in coastal areas.

Pohnpei and Kosrae have the only remaining patches of montane cloud forest in Micronesia. The forests are unusual because they are amongst the lower elevation cloud forests in the world, starting around 450 meters in elevation (Raynor 1993). Endemism is high, in part because the islands are relatively close to the floristically rich Southeast Asia region and partly because of their isolation and age. A unique type of coastal swamp forest dominated by the endemic *Terminalia carolinensis* is found only on Kosrae.

Twenty-four species of reptiles (e.g., skinks and geckos) and amphibians, including four endemics, with one endemic genus, are found in the Caroline Islands (Dahl 1986). The island's fruit bats (*Pteropus marianus*, *P. molosinus*, *P. insularis*, *P. phaeocephalus*), the latter three being restricted to the Carolines, are all threatened by habitat loss and commercial hunting for export to Guam. Eighteen restricted-range species of bird occur in the Carolines (Statterfield et al. 1998). Thirteen species are endemic to the ecoregion, including the Chuuk monarch (*Metabolus rugensis*), the Pohnpei fantail (*Rhipidura kubaryi*), the Pohnpei mountain starling (*Aplonis pelzeni*), and the Pohnpei lory (*Trichoglossus rubiginosus*). Among the 29 recorded bird species on Pohnpei, 24 make extensive use of the upland forest habitat. On the island of Tol in Chuuk, one of the world's most endangered rainforests with over 25 endemic species of plants and birds found nowhere else in the world survives precariously on the peak of Mt. Winipot. The moist cloud forests of Pohnpei and Kosrae are also home to over 30 species of tree snails (Raynor 1993).

Yap Tropical Dry Forest

The flora of the *Yap Tropical Dry Forest* ecoregion appears to be an attenuated version of that found in neighboring Palau. Little is known of the original vegetation of the area, but the islands are thought to have been mostly covered with broadleaf deciduous forests. Today, forests cover about 40% of the total land area and have been divided by Falanruw et al. (1987) into 3 main forest types: upland (mixed broadleaf forest), swamp, and mangrove. Another 26% of the land area is used for agroforestry, or tree gardens. The upland forests are of low stature with no conspicuous stratification. Yap's forests support a few endemic plant species, mostly genera represented in Palau, including *Drypetes yapensis*, *D. carolinesis*, *Trichospermum ikutai*, *Hedyotis fruticosa*, *Timonius albus*, and *Caesaria cauliflora*. A boxlike shrub, *Myrtella bennigseniana*, is endemic to the savanna environment of Yap and Guam (Mueller-Dombois and Fosberg 1998). Yap contains three strict endemic bird species, a monarch (*Monarch* sp.) and two white-eyes (*Rukia* sp., *Zosterops* sp.) as well as four additional restricted-range bird species (Stattersfield et al. 1998, Pratt et al. 1987). The Yap flying-fox (*Pteropus yapensis*) is endemic to the islands (Flannery 1995), though some

consider this a subspecies of *Pteropus mariannus* (Mickleburgh et al. 1992). The species is considered Endangered due to hunting and typhoons (Hilton-Taylor 2000).

Caroline Islands Ocean, Reefs and Lagoons

Although a marine ecoregional analysis of the FSM has not yet been undertaken, the ecoregional planning process considered the ocean, reefs and lagoons located within the two terrestrial ecoregions delineated by the WWF. The exclusive economic zone of the FSM comprises 1,149,508 square miles. The islands of FSM exhibit a great diversity of types, from high volcanic islands with fringing and barrier reefs to coral atolls, including Chuuk lagoon, one of the world's largest (823 mi²/3130 km²) and deepest (60m/200 ft) lagoons. The FSM is located at the outer edges of the world's "bull's-eye" of coral and fish biodiversity. The country's 2,700 sq. miles of lagoons and coral reefs, along with those of Palau and the Marshall Islands, is estimated to harbor ***a greater diversity of corals, fishes, algae and invertebrates than the floras and faunas of Florida, Puerto Rico, the U.S. Virgin Islands, the Gulf of Mexico and Hawaii combined*** (US Coral Reef Task Force, 2000).

The FSM is located in the heart of the world's largest tuna fishery, and offshore waters contain rich stocks of yellowfin, bigeye, skipjack, and other species of fish. The FSM's marine environment comprises an enormous and largely unexplored resource. The FSM also provides a haven for some of the healthiest remaining populations of many globally threatened species including the Hawksbill turtle (*Erytmochelys imbricata*) and the Green Turtle (*Chelonia mydas*). Several small islands adjacent to the atoll of Ulithi in Yap State make up the largest documented green turtle rookery left in the insular Pacific. In addition, some of the healthiest remaining intact sea bird colonies are found in the remote outer islands of the FSM. The world's deepest ocean (> 7 miles deep), located along the southern extent of the Marianas trench, is located within the FSM between Yap and Chuuk States.

National and State resources

Tropical rainforest

Three types of upland broadleaf forest and two types of palm forest are found in the FSM.

Characterization

Montane Cloud Forest is found above 450 meters on the main islands of Pohnpei and Kosrae, with largest extent in the former. These occurrences are the lowest-elevation cloud forest in the world. Above 2000 feet on Pohnpei, the trees are stunted (typically 10-20 feet, sometimes more), whereas on Kosrae the vegetation is dominated by a scattered layer of trees (*Elaeocarpus caroliniensis*, *Cyathea* spp., and *Astronidium kusaianum*) and ferns (*Nephrolepis*, *Gleichenia linearis*, *Davallia*, *Lycopodium*) and other genera. On the highest, wind-blown summits of Pohnpei, trees reach only 4-5 feet in height. *Cyathea ponapensis*, *Gynotroches axillaris* are typical dominants, but *Astronidium ponapense*, *Garcinia ponapensis*, *Ilex volkensiana*, *Cinnamomum sessilifolium*, *Elaeocarpus kerstingianus*, *Glochidion*, *Syzygium caroliniense*, *Rapanaea caroliniensis* and *Camposperma* all attain dominance in some areas (Raynor 1993).

Upland Broadleaf Forest is found on all of the main islands. In Kosrae, upland forest covers the island's steep slopes and occurs throughout the uplands. *Camptosperma brevipetiolata*, *Horsfieldia nunu*, *Ficus*, *Neubergia celebica*, *Eugenia stelechantha* and *Elaeocarpus caroliniensis* are dominants. The most extensive remaining upland forests in the FSM exist on Pohnpei, where the type occurs throughout the uplands from 1000-2000 feet in elevation. Dominant species in this forest type include *Camptosperma brevipetiolata* and *Elaeocarpus caroliniensis*, with *Parkia korom*, *Palaquium karrak*, *Myristica insularis*, *Cinnamomum carolinense*, *Ficus tinctoria*, *Barringtonia racemosa*, *Terminalia caroliniensis* and *Cynometra ramiflora*. In Chuuk, broadleaf forest occurs mainly as small, relatively inaccessible stands located on mountaintops and rocky ridges. Dominant species include *Clinostigma caroliniensis*, *Ficus prolixa* var. *caroliniensis*, *Parinari laurina*, *Garcinia ponapensis* var. *trukensis*, *Cynometra yokotai*, *Dysoxylum abo*, *Pentapthalangium carolinense*, *Schefflera krameri*, *Flacourtia rukam* var. *micronesica*, *Randia carolinensis* and other species. The broadleaf forests of Yap have been greatly modified from their original condition, but higher quality examples include *Camptosperma brevipetiolata*, *Semecarpus venemosus*, *Buchanania englerana*, and *Pterocarpus indicus*.

Yap island also has some stands of **Riparian Forest** (*loway*), which is found growing in savanna areas associated with steep ravines. This is a moist, broadleaf evergreen forest on moist soils, adjacent to streams, often richer in species than forests on drier and upper slopes. The forest often merges with savanna or upland/lowland forest on upper slopes, and swamp forest on lower coastal bottomlands. Dominant species include *Trichospermum ikutai*, *Commersonia bartramia*, *Camptosperma brevipetiolata*, and *Rhus taitensis*.

Two types of palm forests are found in the FSM. The first is **Clinostigma Palm Forest**, a community type endemic to Pohnpei. The dominant species is also endemic to Pohnpei. Palm forests of pure or nearly pure native *Clinostigma* palm are found at higher elevations on Pohnpei. Kotop (*Clinostigma ponapensis*) is the most common species between 450 and 600 m (1470-1970 feet) elevation and attains a height of 25-30 m (80-100 feet). The heart of palm from this species is edible, and the *Clinostigma* palms seed profusely under natural condition, making them very resilient under the natural disturbance regime of tree windfall. *Ptychosperma hosinoi* and *P. ledermanniana* are also present. The heart of palm from this species is edible.

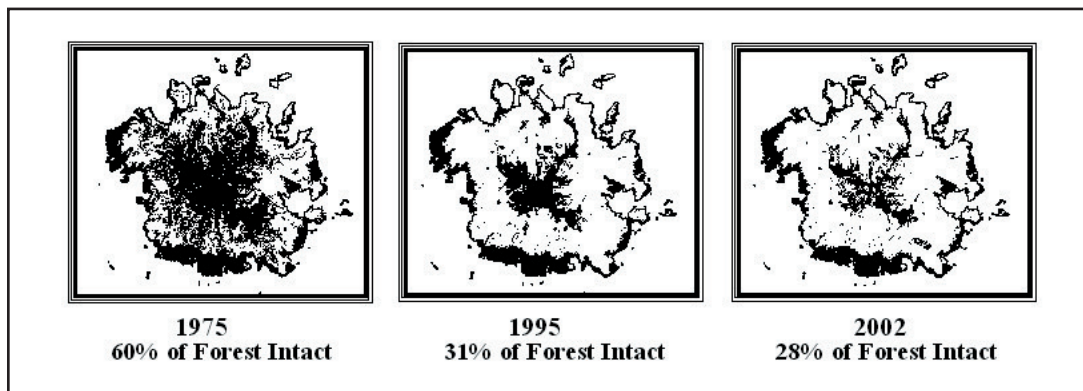
The second palm forest type is **Ivory Nut Palm Forest**, found only in Pohnpei and Chuuk. On both islands, ivory nut palm forest is dominated by the ivory nut palm (*Metroxylon amicarum*) and is commonly located at the edge of wet areas (including rivers and streams) and often forms pure stands. The nut is commonly used to produce carved handicraft items.

Historic and current status

Probably all of the high islands of the FSM were at one time covered with broadleaf and palm forests. However, the relatively small size of island forests combined with thousands of years of human habitation has led to a reduction in size and general degradation. Forests are most degraded on Chuuk, where damage from WWII and subsequent population pressures have taken the greatest toll. Yap forests have also been greatly impacted by “slash and burn” agricultural methods. Forests on Pohnpei and Kosrae, by virtue of steeper

topography and larger land size *vis-à-vis* human populations, are generally more intact. Data on forest status is most complete for Pohnpei island, where aerial photography and vegetation mapping between 1975 and 2002 has dramatically documented conversion of native forest for agriculture and homesteading. Data indicates that in only 27 years (1975-2002), about 12,000 hectares of Pohnpei's intact native forests had been heavily disturbed or destroyed; indeed, between 1975 and 2002, the area of upland forest alone was reduced from 18,800 hectares to 10,500 hectares (Figure 2)(Newsome et al. 2003).

Figure 2. Forest conversion on Pohnpei Island, 1975-2002



While the decrease in area of native forest in Pohnpei has been exacerbated by upland shifting sakau culture, forests of the other three states of the FSM have also been subjected to other serious impacts including: bulldozing for development activities, storms, drought, wildfires, invasive species and shifting agriculture. Only remnants of native forest remain in Chuuk and Yap. These forests are generally in less accessible places, such as the tops of mountains in Chuuk, small in area, and more valuable for their ecological services and genetic heritage than for economic exploitation.

Uses

The rich biodiversity of the FSM's broadleaf and palm forests have served the inhabitants of the islands for thousands of years. Micronesians make use of the forest plants for medicine, food, building materials, and cultural ornamentation. Birds have provided food to local islanders. Micronesians depend on a number of these species for subsistence and income (Raynor 1993; Falanruw 1987 a & b, 2002). In addition, the forests of Pohnpei provide important watershed benefits, storing, filtering, and slowly releasing water into the island's numerous springs, streams and rivers, while protecting the island's lowlands, lagoon and reef from sedimentation and degradation.

Major threats

Upland rainforest types in the FSM have evolved under high rainfall and periodic high winds and typhoons, and thus are resilient to these natural disturbance regimes. However, as on other islands, FSM forests evolved in the absence of both humans and their livestock. Montane cloud forest is rapidly broken down by the trampling, rooting or browsing of large animals, as it originated in the absence of such animals, and the component trees

are not able to withstand these disturbances. Upland broadleaf forest also is susceptible to grazing animals, though the high rainfall regime of the main FSM islands limits the ability of ungulates to thrive in a feral state. Pigs, however, have gone feral in many high island forests, and a small population of introduced deer survives in Pohnpei's upland forest (Wiles et. al. 1999). Cats and rats have also gone feral and posed an unknown threat to endemic and native birds and other fauna. Forest disturbance also opens up areas to growth of invasive plant species. But by far the largest threat to the remaining forests of the FSM is agricultural clearing and homesteading.

Agroforest

Characterization

When the vegetation of the FSM was first mapped by the US Forest Service in the early 1980's, a type of forest was found that could not be typed as wild forest because it was mostly made up of food-bearing trees and other useful and ornamental species planted by people around residences, homesteads and villages (Falanruw 2002). The type was labeled as "agroforest" to signify the combination of agriculture and forestry practiced in Micronesia. This was probably the first time that the U.S. Forest Service mapped this forest type. Scattered coconut trees and breadfruit trees are indicators of agroforests, and some wild species may be present. The type varies throughout Micronesia. In Pohnpei it depicts areas from early to late stages of shifting agriculture, as well as settled homesteads. In Chuuk the type consists largely of areas dominated by coconuts and breadfruit on sloping land. In Yap the type represents long established tree garden/ taro patch systems involving landscape architecture to manage water flow through the system. While agroforests are most extensive (57%) on the mapped islands of Chuuk, they are most diverse on Yap.

Historic and current status

Agroforests were developed over thousands of years and have slowly evolved as Micronesians have developed or brought in new crops and cultivars over hundreds of years. Together with native forests and marine habitats, agroforests have traditionally provided a wealth of material goods, food, ornaments, medicines and other products that have made life possible on the islands. Aerial photography over the last two decades have shown agroforest area to be increasing on all islands, but work by some researchers (Raynor 1987; Falanruw 2002) suggests that agroforests and the local knowledge that sustains them are on a slow decline as cultural practices decline and Micronesians increasingly turn to paid labor and imported foods.

Major threats

The biggest threat to the FSM's agroforests is the steady loss of plant and traditional cultivation knowledge and neglect as Micronesians increasingly turn to western food imports and paid labor.

Savanna/grasslands

Characterization

Although generally considered a degraded habitat type, **Fern/Sedge Savanna** is fairly common throughout the high islands of the FSM, especially in Yap, where this habitat makes up over a third of the main islands' habitat. Grasslands or savanna occur on soils of generally infertile, poorly drained clays, and are believed to be the result of the destruction of forest vegetation by fire, generally human-induced. In the western Carolines, some areas of native savanna are characterized by a peculiar and interesting aggregation of species of plants which varies from island to island. Plants characteristic of this type include *Miscanthus floridulus*, *Heteropogon contortus*, *Dimeria*, and other small grasses; many sedges, principally species of *Fimbristylis*, *Scleria*, *Rhyncospora*; ferns and related plants, such as *Gleichenia linearis*, *Lycopodium cernuum*, *Cheliantes tenuifolia*, *Lygodium scandens* and *Blechnum orientale*; shrubs and herb, such as *Geniostoma*, *Eurya*, *Melastoma malabathricum*, *Pandanus*, *Myrtella benningseniana*, *Glossogyne tenuifolia* and others. Several Micronesian endemic plants occur only in this habitat type. In addition, it is important for a number of other species (e.g., short-eared owl) that persist in the FSM.

Historic and current status

Grasslands and Fern-sedge Savanna are generally considered the result of human-induced burning and gradual erosion of topsoil. Fern-sedge Savanna especially are found in degraded sites with little soil, and periodic fire, usually the result of uncontrolled agricultural burning escaping into surrounding habitats. Grasslands are generally found on areas of deeper soils, and are also maintained by fire. In the absence of fire, or in some areas, grazing pressure from introduced ungulates like deer (Pohnpei only), goats and cattle, grasslands eventually can reestablish as secondary forest in most areas where they occur.

Uses

Fern-sedge savanna is generally considered a relatively unimportant habitat by Micronesians. Some medicine species are found in the savanna, and ferns are sometimes used as head ornaments and other ornamental uses. On Pohnpei, hunters burn the savanna to attract introduced deer from surrounding forest habitat and make it easier to shoot them.

General trends over the last 50 years

Generally, fern-sedge savanna and grassland both are slowly increasing as a result of burning, agricultural clearing and homesteading, and development activities like road-building. These habitats are then maintained and further expanded by periodic burning, especially during drought years associated with the La Niña.

Major threats

The only major threats to savanna/grasslands are homesteading and other development activities. Periodic burning actually helps maintain this habitat type, although it does threaten some of the characteristic fauna that makes use of savanna/grasslands for hunting and nesting, especially the Short-eared Owl on Pohnpei.

Freshwater habitats (rivers, streams, lakes)

Characterization

Due to abundant rainfall, freshwater habitats are common throughout the FSM, especially on high islands where water tables are generally high and soils impede rapid infiltration.

Freshwater Stream/rivers are characteristic mainly in the eastern Caroline high volcanic islands of Pohnpei and Kosrae where perennial streams and rivers exist due to high rainfall and lack of a defined dry season. Particularly in Yap, stream flow is intermittent especially in drought years. Freshwater streams and rivers are habitat for a rich array of fauna and flora. Recent studies by Nelson et. al., (1997) revealed that species of decapod crustaceans and amphidromous gobies are found in high numbers in the headwater streams as well as the rivers in Pohnpei. Maciolek et. al. (1987) reported 5 different families of fish in the Nanpil River on Pohnpei. Buden (2001) reported 5 gobies species, three of which were endemic to Pohnpei. From Yap, four species of freshwater fish were recorded. One species, (*Oreochromis mossambicus*) is known to be introduced. Lobban (1989) recorded 41 green algae, 2 red algae, 13 blue-green algae, 2 red algae, 3 mosses and 10 angiosperms in unstable habitats of small ponds and small streams found in Yap, Micronesia. Maciolek (1987) reported 3 families of Decapod crustaceans and 2 families of snails from the streams of Pohnpei. Buden (2001) identified and reported two species of *Macrobrachium* (Palaemonidae) and three atyid shrimp (Atyidae) species.

Swamp Forests are amongst the most threatened of native freshwater habitat types in the FSM. Found in Kosrae, Pohnpei, and Yap, swamp forest occurs where soils are inundated with fresh or brackish waters. Swamp forests are important for both the materials they provide and for their ecosystem services which include serving as silt traps, buffering fresh water resources and quality, and contributing to the health of mangrove systems. In Kosrae, swamp forests are dominated by *Terminalia carolinensis* to 100 feet in height, with other trees including: *Horsfieldia nunu*, *Barringtonia racemosa*, *Hibiscus tiliaceus*, *Nypa fruticans*, and *Neubergia celebica*. In Pohnpei, swamp forests are found in low-lying freshwater areas inland of the mangroves, in river bottoms, and elsewhere where the water table is high. Species common along rivers include *Heritiera littoralis* and *Cynometra ramiflora*; in boggy areas, *Terminalis carolinensis*, *Camptosperma brevipetiolata*, *Pandanus cominsii*, and *Barringtonia racemosa* are dominant. In Yap, swamp forest occurs in similar habitats as described elsewhere, and is dominated by *Dolicandrone spathacea*, *Heritiera littoralis*, *Pongamia pinnata*, *Cynometra ramiflora*, *Dalbergia candenatensis*, *Derris trifoliata*, and *Acrostichum aureum*; *Barringtonia* is common in wetter areas. Swamp forests along rivers are dominated by *Barringtonia racemosa*, *Hibiscus tiliaceus*, *Semecarpus venenosus*, *Inocarpus fagifer*, and *Ficus tinctoria*.

Another common freshwater habitat is **Coastal Freshwater Marsh**, found in all four states. Coastal freshwater marshes are generally located slightly above sea level, often landward of mangroves, or in more inland areas. Most are vegetated with extensive patches of *Phragmites* however others include patches of sedges, and in Yap, *Hanguana malayana* and *Eriocaulon sexulare* var. *micronesicum*. In Pohnpei and Chuuk the ivory nut palm commonly grows at the edge of marshes with species of sedges and other herbaceous growth. Extensive patches of *Phragmites* marsh occur in the lowlands of Chuuk.

On Pohnpei island, another type of freshwater habitat, **Montane Perched Freshwater Swamp**, occurs only at high elevations. The typical swamp vegetation is dominated by sedges (*Thoracostachyum pandanophyllum* and others), grading into swamp forest of *Metroxylon amicarum* and *Hibiscus*, with drier areas dominated by *Cyathea nigricans* and *Clinostigma ponapensis*. At Nahna Laud (elevation 750m), *Clinostigma* is an emergent species to 30 feet high; main canopy to 10 feet high. Endemic *Pandanus patina* forest is also found in this swamp area at Nahna Laud.

Historic and current status

Historically, Micronesians generally made limited subsistence use of swamp forests, other types of more easily accessible forest being available. During the Japanese occupation (1918-1945) swamp forests species, especially *Terminalia carolinensis* on Pohnpei and Kosrae and *Callophyllum* on Yap, were logged extensively for lumber and other products. After 1945, swamp forests slowly recovered but development activities in the last few decades, especially circumferential road construction, have either directly destroyed or improved access for harvesting much of the FSM's remaining swamp forests. As a result, swamp forests and coastal freshwater marsh are mostly degraded in all FSM high islands where they exist, mainly through conversion to agriculture (mostly *Cyrtosperma*) taro cultivation. In addition, a number of swamp forests and marshes have been filled in the process of coastal development, especially for roads and houses.

Uses

Traditional uses of swamp forest tree and plant species for building materials, canoes, and medicine were numerous. *Terminalia carolinensis* is a preferred tree for canoe bodies in Kosrae, and also can be used for house construction. However, even prehistorically, many swamp forests and marshes were converted for *Cyrtosperma* cultivation.

General trends over the last 50 years

Swamp forests in particular have declined substantially as populations have grown and roads have expanded access to all coastal areas. In Kosrae, 13 distinct *Terminalia carolinensis* swamp forests existed only decades ago, only one (Yela Valley) is still in an intact condition. The rest have been converted to agriculture in the past two decades as the circumferential road has been expanded around the island. The fate of coastal marshes has followed a similar trend.

Major threats

Swamp forests and coastal marsh are under heavy pressure from road construction and conversion to taro patches. It is important to maintain enough area of swamp forest in the especially high and wet islands of Kosrae and Pohnpei to maintain their ecological functions. The swamp forest type in Chuuk and Yap has largely been disturbed and converted to *Phragmites* marsh and taro patches.

Brackish water habitats (wetlands, coastal lagoons)

Characterization

Brackish water marsh occurs only in Pohnpei in the FSM. These two marsh areas are located within larger areas of mangrove, and may be the result of inadequate tidal flow in the area which has precluded normal mangrove development. One particular area, Nan Panilap is a 14.6 ha herbaceous peat land located on the south side of Pohnpei island. The site is dominated by herbaceous vegetation and is surrounded by a large stand of mangroves. The site appears to have supported mangroves recently, as there is 20 cm of herbaceous peat on top of 1 m of mangrove peat, which is overlying coral rubble. The transition from mangrove to herbaceous could have been caused by fire, as pieces of burnt wood at the transition from mangrove to herbaceous peat are abundant (Chimner 2004).

Dwarf Mangrove Forest is another rare brackish water habitat that occurs in a few places in the FSM, mainly within very large stands of mangrove extending from 1/2-1 mile out from the coast. This type of habitat is reportedly especially common in Palau where there is little soil on top of coral substrate (Ewel, personal communication). In Kosrae, there is a small patch by the mouth of the Yela River. Generally, mangroves (primarily *Rhizophora*, and to a lesser extent *Sonneratia*, grow in this dwarf form when they have little access to nutrients. These areas may have some wildlife value in that they provide valuable habitat for benthic organisms and fish.

Atoll Inland Mangroves, considered a subtype of mangrove forests, are found in inland depressions which allow vegetation to tap the water lens on some islets of certain FSM atolls (e.g., Alei Islet on Puluwat Atoll). These depressions have a conduit to the oceans which bring in salt water during high tides. These forests may be comparable to what F.R. Forsberg called “mangrove depressions” on the Marshall Islands. On Puluwat Atoll, the mangrove depression is dominated by *Bruguiera gymnorrhiza*. There is some thought that these may have been planted by humans in prehistoric times, however, this has not been proven.

Historic and current status

Brackish water habitats, perhaps due to the relative poor site status in which they are found, have not been as negatively affected by humans as have other habitats. Although, little data exists, it appears brackish water habitat types have remained stable in area over the last several decades.

Uses

Brackish water habitats, with the exception of some wood products from atoll inland mangroves, are not very productive, and thus are not of much use to local inhabitants. Some medicines are extracted from plants in the area, and on Pohnpei, dwarf mangroves are considered to be habitat for deer and some bird species.

Major threats

No major threats are known for these habitats.

Coastal forests including mangrove

Characterization

Due to the geological age of the islands and the development of fringing and barrier reefs, the most common coastal forests in the FSM are **Mangrove Forests**. Extensive mangrove forests are found in all 4 states, on the main islands and to a limited extent on atolls. Diversity of mangrove species ranges from 14 species in Yap to 10 in Chuuk, Pohnpei and Kosrae. This is the natural vegetation of tropical, salt-water mud flats. Mangrove swamps in Micronesia are not so extensive or well developed as in the subcontinental region farther west. Considerable areas exist around all the high islands in the Carolines in the form of narrow fringes along many stretches of coastline and in filled lagoons (as in Kosrae). Principle tree species include *Rhizophora mucronata*, *R. apiculata*, *Bruguiera gymnorhiza*, *Sonneratia alba*, *Xylocarpus granatum*, *Lumnitzera littorea*, *Barringtonia racemosa*, *Heritiera littoralis*, and *Exoceria agallocha* (Table 1). At the mouths of a few of the large rivers and for a short distance upstream, are found pure stands of *Nypa fruticans*. An interesting impoverishment of the mangrove flora takes place as one goes east from Palau. Subtypes include mangrove depressions (in atolls of the Carolines), *Nypa* swamps, and *Acrostichum* swamps.

Mangrove forests thrive along the intertidal shorelines of estuaries and river mouths. Mangroves provide rich nurseries for many species of crabs, lobsters and fishes. They also provide nesting sites for birds which also feed on the fishes, crabs and other prey in this habitat. Mangroves protect against wave damage and coastal erosion. They serve as a filter buffer on the effects of runoff sedimentation and pollution. In developing nations such as FSM, they are a source of fuel wood and woodcarvings. Economically important species that inhabit the mangrove area include crabs, (e.g. mangrove crab, *Scylla serrata*), mullets, rabbitfish and species of snappers.

In the FSM's numerous atolls and some coastal areas on Kosrae and reef islands of the other FSM high islands where mangrove does not occur due to poor reef development, **Atoll/Beach Forest** is common. Atoll/Beach forest is an association of species generally occurring along sandy and coralline coasts. The forest habitat generally consists of a characteristic set of pantropical trees, shrubs, and herbaceous species. Woody species become taller and better formed towards the interior of larger and wetter uninhabited atolls, and consists of mesophytic species such as *Pisonia grandis* and *Calophyllum inophyllum* in the upper canopy and *Guettarda speciosa* in the lower canopy. Many atoll forests in the FSM have been converted to coconut plantations, breadfruit and other agroforest species over the last several hundred years. On smaller islets, the phreatophytic atoll forest can't develop due to lack of a freshwater lens. Beach forest is found on sandy or rocky coasts of low and high islands. Species commonly found in atoll forests include an outer fringe of shrubby *Scaevola taccada*, *Tournefortia argentea*, and *Sophora tomentosa*.

The last type of coastal forest occurring only peripherally in the FSM is **Limestone Forest**. This vegetation type, which is more common in the Marianas and Palau, occurs on the raised limestone island of Fais and has not been described.

Table 1. Main species of mangrove trees in the FSM (From Falanruw 2002)

Main species of mangrove trees	Kosrae	Pohnpei	Chuuk	Yap
<i>Avicennia alba</i>				X
<i>Bruguiera gymnorrhiza</i>	X	X	X	X
<i>Ceriops tagal</i>				X
<i>Dolichandrone spathacea</i>				X
<i>Excoecaria agallocha</i>			X	X
<i>Heritiera littoralis</i>	X	X	X	X
<i>Lumnitzera littorea</i>	X	X	X	X
<i>Nypa fruticans</i>	X	X	X	X
<i>Rhizophora apiculata</i>	X	X	X	X
<i>Rhizophora X lamarkii (hybrid)</i>	X	X	X	X
<i>Rhizophora mucronata</i>	X	X		X
<i>Rhizophora stylosa</i>	X	X	X	X
<i>Scyphiphora hydrophyllacea</i>				X
<i>Sonneratia alba</i>	X	X	X	X
<i>Xylocarpus granatum</i>	X	X	X	X
Total number of species	10	10	10	15

Historic and current status

Mangrove forests were generally well-appreciated by Micronesians in prehistoric times, both for their importance as nursery areas for fish and other marine species, as well as their role in coastal protection. Atoll beach forests also were maintained both for their numerous products as well as for their role in coastal protection and stabilization. During the German period (1898-1914), extensive areas of atoll/beach forests were converted to coconut plantation. Much of the existing vegetation on FSM atolls is still highly impacted from this era, although as the price of copra has declined and coconut plantations have been neglected, atoll forest is making a comeback on many islands.

During the Japanese occupation (1914-1945), mangrove forests were logged extensively for construction wood and tannin production. After 1945, most cutting activities stopped, and mangrove forests, again subjected to subsistence use only, have regenerated in most areas. Mangrove forest in Chuuk lagoon were severely damaged by massive oil spills as a result of the destruction of the Japanese fleet there in 1944, and some mangrove areas have never recovered fully. Where coastal forests and mangroves have been destroyed or highly degraded, coastal erosion, sedimentation in the adjacent lagoon, and other negative consequences are well known and understood by most local inhabitants, so in general mangrove forests and atoll beach forests are being protected and maintained in most areas.

Uses

Mangrove forests provide a host of products for coastal inhabitants, the most important which are building materials and firewood. In Kosrae especially, mangrove wood is the preferred firewood for cooking, which has led to some problems of over cutting in more accessible areas.

General trends over the last 50 years

Aerial photography and anecdotal evidence has shown that mangrove forest area has been relatively stable over the last 50 years, except in the vicinity of urban areas, where mangroves have been filled and otherwise degraded as a result of development efforts (Trustrum 1996; Falanruw et. al., 1987a and b; Maclean et. al. 1987).

Major threats

Throughout the FSM, mangrove forests are under threat from roads altering the flow of freshwater, dredging operations, oil spills, overharvesting for firewood and other threats. It is important to develop mangrove management programs and to protect adequate areas of mangroves in order to maintain their ecosystem services, which far outweigh their value as timber.

Nearshore habitats

Characterization of each habitat type

Rocky shores are characteristic features of areas of high wave energy. In the oceanic atolls, this habitat is usually located on the ocean side of the islands. Small crabs and mollusks are usually associated with this type of habitat. Brown algae (*Ectocarpus sp.*) often grow on the rocks sprayed by seawater from the breaking waves. At high tide, these rocky shores become a popular feeding ground for fishes that forage the shoreline in search of food (Edward 2002).

Estuaries occur on most FSM high islands. An estuary is defined as the environment that inhabits the lower part of a river where the freshwater and marine environments interchange. Characteristics are wide variations in salinity, turbidity, currents, and to a lesser degree temperature, a wide range of habitats and associated flora and fauna, high productivity, and high susceptibility to damage, especially terrestrial run-off. Estuaries are utilized by many species for reproduction and nursery sites for juvenile animals (reef fish, etc.). Common

fish species in this area include the mullets. The seagrass *Enhalus acoroides* is common. Micro-atoll *Porites* corals are often also common, which provide suitable habitat for many fish species. The algal species of *Halimeda* may also be found. This area is important to many marine species as a nursery and feeding grounds (Edward 2002).

Sea Grass Beds are an important habitat found beyond the mangrove forest. Sea grass roots help stabilize the sediment and their leaves provide shelter and food to many organisms as well as a source of detritus, which is a very important food source for many inhabitants of the coral reefs. Sea grass beds also function to lessen the current and serve as a nursery ground for some invertebrates and fishes. At high tide, large carnivorous fishes such as species of *Carangidae*, *Lethrinidae*, *Serranidae* and *Lutjanidae* roam the sea grass beds to hunt for food. Some species of parrotfishes also use the sea grass as food. Crustaceans and mollusks are also common in this area of the reef flat. Occasionally, species of *Porites* corals with flat tops may be found. *Anadara* shells are also commonly found. Several species of sea cucumbers and urchins also are common inhabitants of sea grass beds. Sea cucumbers use the sandy bottoms of the sea grass beds to filter food materials for their survival. When the weather and the water conditions are appropriate, jellyfishes are found in abundance.

Historic and current status

Estuaries and sea grass beds, by virtue of their proximity to the shore, have been the marine habitats most highly impacted by human activities. Sedimentation from land-based agriculture, burning and other activities have degraded these habitats on all islands with human habitation. However, until fairly recently, sedimentation and other land-based pollution has been of a level that estuaries and sea grass beds have been able to survive and thrive. Increased population and agriculture, forest conversion, and other development activities (especially sand mining and dredging), and resulting sewage and runoff, have had substantial negative impacts on estuaries and sea grass beds throughout the FSM, especially in the vicinity of urban centers.

Description of use by humans

Micronesians have a close association with the ocean, which is evidenced by the congregation of villages and communities along the coastline. They depend on the ocean to supplement their diets with protein. People's daily schedule is divided between tending small farms, (planting yams, bananas and other staple crops) and fishing in the ocean for fish and shellfish. Fishing was a shared responsibility of both men and women. Women were generally tasked with the collecting of sea cucumbers, shells, and crabs from the mangroves or on the reef flats immediately beyond the mangrove forest and net fishing to catch small fish on the reef flat.

General trends over the last 50 years

Estuaries especially have been highly impacted by greatly increased run-off and sedimentation from land-based activities over the last several decades. Circumferential road construction, forest clearing, and coral dredging have combined to pollute and degrade most estuaries on inhabited islands to the point where many no longer provide the ecosystem services (fish

nursery, feeding grounds) that they did previously. In Pohnpei in previously dredged areas where berms were removed, there was an increased abundance of some seaweed, corals, fish and invertebrates, but only after more than 10 years of inactivity (Tissot et al. 1998).

Major threats

The sources of degradation of estuaries are varied and numerous, the most serious being sedimentation and pollution from land-based activities. Dredging and construction of causeways with insufficient openings for current and tidal flow have also further degraded a number of estuaries in the FSM. Sea grass beds are threatened by sedimentation and pollution, but have been spared some of the ravages of estuaries especially where healthy mangrove forests still line the coast and can absorb land-based impacts. To a lesser extent, boat traffic (propeller damage) has had local negative impacts on sea grass beds, especially along regular transportation routes in lagoons. Storms and wave action particularly those resulting from typhoons occasionally impact sea grass beds, as does increased freshwater runoff (Maragos 1997, Wilkinson 1998).

Coral reef

Characterization

Coral reef biodiversity and complexity is high within the reefs of FSM and this diversity diminishes notably from west to east within the region. Using stony corals as an example, approximately 400 species are recorded in Palau, 300 from Chuuk, 200 from Pohnpei and 150 from Kosrae (Maragos 1997). It is estimated that the FSM has 300 species of corals, over 1,000 species of fish and 1,200 species of mollusks (Edward 2002).

Coral reefs are very important to the people of FSM. Fish and invertebrates are harvested from the coral reefs and serve as the main source of protein in the local diet. Coral reefs also provide other products that are essential for human survival such as building materials and medicines. Coral reef communities may vary among the various island types but generally they all possess the following communities in the order from land towards the ocean: fringing reef flats, lagoons, barrier reef flats and reef slopes. These communities constitute the intertidal zone.

Fringing reef flats are located in the extreme upper subtidal portion of the reef. Reef flats can range in width from a few meters to a few kilometers. Reef flats can further be subdivided into three main zones. The inner reef flat retains some water during the lowest tides. Microatoll formations, flat-topped heads of massive Porites corals are commonly found here. Meadows of sea grasses are also common feature of inner reefs of high islands. Several species of pomacentrids inhabit coral heads in this area of the reef flat.

The outer reef flat is pavement-smooth topped with many blocks of dead coral rocks brought on to the flat from the reef margin during storms. This area is usually covered with a film of filamentous algae which at high tide becomes the grazing ground for the herbivorous fishes.

The third part of the reef flat is the lagoonal reef slope, which is normally porous and provides great habitat for many corals. Fish are also abundant in this area as they use corals for food and shelter. The coral populations may be abundant but coral diversity is lower than that of the outer reef slope.

The **lagoon** is the area enclosed by the low tide line of the inner edge of the barrier or atoll reef flat. It contains numerous patch reefs which may range from a small piece of coral to a massive pinnacle that is topped with reef flats and islands. In some areas of the lagoon, pinnacles are elongated forming interconnected reefs that form small pools. These shallow pools are favorite living areas for many fishes, corals and invertebrates. Planktivorous fishes use the lagoonal water column as their feeding and breeding grounds. In the shallow areas of the lagoon, the commonly found corals are large colonies of *Porites*. Species of *Halimeda* are also commonly found on the sandy shallow lagoon bottoms. Examples of abundant corals found in reef platform and lagoon reef habitats include species in the genera *Porites*, *Acropora*, *Pocillopora*, *Montipora*, *Favia*, *Favites*, *Astreopora*, *Millepora*, *Acanthastrea*, and *Stylophora* (Holthus et al. 1993).

*The **barrier reef flat** is the area of the reef containing a veneer layer of sand in some areas to reef pavement bottoms in others. It contains micro-atoll formations near the seaward edge showing that it is exposed at low tide. This area harbors sea cucumbers such as the commercial *Actinopyga mauritiana* and other species of holothurids. In the same area, species of brown seaweeds are seasonally seen. These brown algae are mainly the *Sargassum* sp. and *Turbinaria ornata*. Large blocks of coral commonly litter the reef pavement, mainly pushed up from the reef slopes by typhoon waves after being wrenched out of the reef. On the lagoonal margin of the reef flat where the area may be submerged, there is an abundance of algae, especially the browns and the greens. In some areas, the species of *Halimeda* and *Caulerpa* dominate. Coral species may include *Porites* and some species of *Acropora*.*

The **outer reef slope** is the portion of the seaward reef that slopes into deep waters. It is a fairly steep slope with moderate to high coral cover. The diversity and abundance of corals as well as fishes is greatest along promontories and other areas exposed to tidal currents. Below the depth of the reef slope, coral cover decreases rapidly and branching corals are replaced by plate like forms. In the atolls, the reef slope on the leeward side of the island is always an abrupt drop to a platform and a gradual slope into the oceanic waters. The windward sides, on the other end, have a very gradual slope that is covered by reef structures such as grooves and buttresses. The reef slope represents the area of the reef with the highest diversity.

Historic and current status

The coral reefs of the FSM are generally considered to be in good to excellent condition, with percent live coral cover ranging from 15-70% (Birkeland et al. 2002; Abraham et al. 2004). Coral reefs are especially in excellent condition in the outer islands where human disturbance is low. With the growing population of the FSM, the demand on the exploitation of marine resources for both subsistence and commercial purposes is causing increased degradation of coral reefs, especially the vicinity of urban areas.

Uses

Coral reefs provide extensive fishery resources to local communities for subsistence and small-scale commercial sale and these are significant sources of protein and key to a healthy diet. Both men and women fish the reefs, although methods of fishing vary by island and between sexes. In Kosrae, women are still actively involved in net fishing to catch small fish on the reef flat. In Pohnpei, women are more involved in using a hook while standing in the seagrass bed at high tide and catching fish by tossing a baited hook several feet. Pohnpeian women still engage in picking sea cucumbers, shells, and crabs from the mangroves or on the reef flats immediately beyond the mangrove forest. In Chuuk and Yap, women are involved in a somewhat unsustainable harvest process called gleaning where rocks on the reefs are turned over and whatever is suitable for eating is picked (Edward 2002). The tourism industry depends heavily on coral reefs for diving and snorkeling, especially on the main islands. Dredging of coral reefs provides the fill material for road construction and other development.

General trends over the last 50 years

Traditionally, village and island chiefs regulated who could access reefs, when, how, and for what species, but over the last several decades, reef access has become more open. Fishing gear has become more sophisticated, and modern boats and motors have given fishers greater access to the reef. In addition, flashlights have made destructive night fishing easy for all to participate in. All these have contributed to a rapid depletion of the marine resources. Reef fish surveys conducted in Kosrae and Yap in the 1990s (Graham 1991; Wilson and Hamilton 1992) indicated that these resources may be overharvested. More recently, studies show that although percent live coral reef cover remains fairly high, fishery resources appear to be heavily impacted in certain areas, such as Chuuk lagoon (Birkeland et al. 2002; Abraham et al. 2004). More comprehensive and quantitative information on the status of the reefs of the FSM will become available with the recently implemented coral reef monitoring programs in Pohnpei and Kosrae and those planned for Yap and Chuuk. Today fishermen, especially those dependent on the inshore fisheries for subsistence income, are complaining about declining fisheries. Both the government and non-government organizations have begun marine education and environmental awareness programs to help educate the people to improve the management of their reefs. In all the states of the Federated States of Micronesia, Marine Resources departments have been installed to deal with marine affairs. Unfortunately, these departments are generally short of funds and personnel needed to deal with the contemporary threats to the FSM's coral reefs.

With in the last decade, in an effort to protect, preserve and manage the marine resources, a move to establish Marine Protected Areas (MPA) has begun. These areas are set up as "no take" areas where no one is allowed to fish or extract marine products. Pohnpei is ahead of the other islands in establishing these MPAs. Both Chuuk and Yap are still depending on their traditional ownership systems to manage the marine resources although these States, too are now moving towards establishing MPAs.

Major threats

The sources of degradation of coral reefs are varied and numerous. Unfortunately, most of the coral reefs subject to human use are located near human settlements and are suffering damages significantly reducing their value. In the Federated States of Micronesia, the leading causes of environmental impacts to coral reefs are sewage and runoff, forest cutting (especially mangrove deforestation), sand mining and dredging. Other causes contribute but at lower levels and this may include destructive fishing such dynamite fishing, ship groundings and marine construction activities.

In addition, there are many natural disturbances to the reefs of the FSM however, most have little effect on the region as a whole and do not cause major long-term damage to the reefs. The major stresses to the reefs are storm and wave action particularly those resulting from typhoons (cyclones, hurricanes), outbreaks of biological predators such as crown of thorns starfish, urchins and predator gastropods, various coral diseases, increased sea water temperature (El-Niño Southern Oscillation) events, and freshwater runoff (Maragos 1997; Wilkinson, 1998).

Species of concern

The biodiversity of the FSM has not been thoroughly documented as previous survey work has been limited and existing literature is scattered. The inventory and monitoring of the biodiversity of the FSM is integral to a thorough understanding and appreciation, and should be a part of future conservation efforts. Terrestrially, over 1,239 species of ferns and flowering plants have been described in the FSM. Approximately 782 species are native, including about 145 species of ferns, 267 species of monocots and 370 species of dicots. Each state of the FSM has its own outstanding features and biodiversity treasures. Kosrae has magnificent swamp forests dominated by endemic *Terminalia carolinensis* and *Horsfieldia nunu* trees. Pohnpei has the most endemic species in the FSM. Chuuk is also high in endemics and has some of the most endangered native forests in the FSM. Yap has the most diverse mangroves and agroforests in the FSM. Over 457 species of plants, including many food plants have been introduced to the FSM. The percentage of introduced plants varies between the states with introduced species comprising 22% in Kosrae, 40% in Pohnpei, 37% in Chuuk and 39% in Yap. Some of these introduced species have become invasive pests that have spread out of control. The spread of invasive species is a continual threat due to increased movement of people and machinery between the islands, and needs to be carefully monitored and controlled (Falanruw 2002).

Native terrestrial mammals of the FSM include five endemic species and subspecies of fruit bats of the genus *Pteropus* and a sheath-tailed bat of the genus *Emballonura*. Taxonomic and biological studies of the FSM's bats are not complete. Introduced mammals include 3 species of rats, a mouse, deer, pigs, dogs, cats, and from time to time goats, rabbits and cattle, all of which can have damaging impacts on native biodiversity.

One hundred and nineteen species of birds have been reported in the FSM. These include 31 resident seabirds, 33 migratory shorebirds, 19 migratory land or wetland birds and 5 vagrant species (Engbring et al. 1990). Each State of the FSM has one or more endemic species. They include the Dusky White-eye of Kosrae and Pohnpei, Pohnpei Lory, Pohnpei Greater

White-eye, Pohnpei Flycatcher, Pohnpei Mountain Starling, Pohnpei and Chuuk Ground Dove, Truk Greater White-eye, Oceanic Flycatcher, Yap Monarch and Yap Greater White-eye. A number of the FSM's birds have become extinct or are declining in numbers.

The least understood group of vertebrates in the FSM are the reptiles and amphibians. There is one introduced amphibian (*Bufo marinus*), and over 27 species of reptiles, most of them native and at least 2 endemic. Several species of lizards have been introduced but thus far, there have been no confirmed introductions of the brown tree snake, which has decimated bird and reptile populations on nearby Guam. Recent collections in Pohnpei have yielded numerous species of land snails and 50 species of ants (Falanruw 2002).

Due to the sparse knowledge of FSM's biodiversity, an up to date list of threatened "species in peril" has not been compiled at national or state levels. Some species present in the FSM are, however, included in the IUCN Red List of threatened species as well as appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the U.S. Endangered Species Act listing of Threatened and Endangered species. The Endangered Species Act of the FSM was carried over from the Trust Territory of the Pacific Islands and is incomplete. Threatened terrestrial native habitat of the FSM includes cloud forest, remaining areas of native forest, native fresh water marsh and riverine systems, swamp forest, and critical areas of mangrove forest and uninhabited atoll seabird and turtle rookeries. Other critical areas such as sea bird roosting and nesting sites, sea turtle rookeries, coconut crab islets and fruit bat roosting sites should also be considered for protection.

A number of FSM animal and plant species are of particular concern due to their reported or perceived status as endangered or threatened (Table 2.)

Table 2. Animal and plant species of concern in the FSM. Source: IUCN Redlist.

IUCN rankings:

- EX – Extinct
- EW – Extinct in the wild
- CR – Critically endangered
- EN - Endangered
- VU - Vulnerable
- NT – Near Threatened
- LR – Lower risk – conservation dependent
- DD – Data Deficient

Species	Common Name	Location	Status	Notes
Terrestrial Species				
<i>Birds</i>				
<i>Anas superciliosus</i>	Gray Duck	Chuuk lagoon	IUCN Red List - VU	Endemism to Chuuk at the subspecies level
<i>Aplonis pelzelni</i>	Pohnpei mountain starling	Pohnpei	IUCN Red List – CR	Endemic to Pohnpei. Likely extinct. Habitat is forest, with most records coming from native rain forest
<i>Asio flammeus ponapensis</i>	Ponape short-eared owl	Pohnpei	None	Endemic to Pohnpei. Found in a variety of habitats including grasslands, savannas, small forest openings and forest edges – principally along the coastal lowlands. Considered very rare in Pohnpei. Distinguished from <i>A.f. flammeus</i> by size; taxonomic validity questionable.
<i>Collocalia inquieta</i>	Micronesian swiftlet	Kosrae, Pohnpei, Chuuk	IUCN Red List None	Range of species includes FSM, and the Marianas – extinct in Guam and Rota. Roosts and breeds in caves, but forages over forests and open habitats. Susceptible to habitat destruction and alien species in caves. Taxonomy questionable – some consider the Caroline Island race as distinct from the Marianas race (<i>C. bartschi</i>).

Species	Common Name	Location	Status	Notes
<i>Coracina tenuirostris</i>	Cicada Bird	Chuuk and Pohnpei	None	Two endemic subspecies occurring in the FSM - <i>C.t. inseperatum</i> (Pohnpei), and <i>C.t. nesiotis</i> (Chuuk).
<i>Ducula oceanica</i>	Micronesian imperial-pigeon	Chuuk	IUCN Red List – NT	Endemic to Micronesia – Palau, Yap, Pohnpei, Chuuk and Kosrae, and the Marshall Islands; extirpated from Kiribati. Habitat canopy of well-developed, high island montane forests is preferred, although it occurs in an array of habitats, including secondary forests, mangroves, and atoll/beach forests.
<i>Ducula oceanica teraokai</i>	Micronesia Imperial Pigeon – Chuuk	All FSM States	IUCN Red List - NT	Extremely rare Chuuk subspecies of the <i>Ducula oceanica</i> .
<i>Gallicolumba xanthonura</i>	White-throated ground dove	Yap	IUCN Red List - NT	
<i>Gallicolumba kubaryi</i>	Caroline Islands Ground Dove	Chuuk, Pohnpei	IUCN Red List - VU	Endemic to Chuuk and Pohnpei. A bird of dark, montane forests, sometimes in openings. Declining and rare due to introduction of cats and other factors.
<i>Metabolus rugensis</i>	Chuuk monarch	Chuuk	IUCN Red List - EN	Endemic to Chuuk - found on all or nearly all of the high lagoon islands as well as some of the outer reef islets. A bird of large patches of primary forest, and large mangrove stands. Extremely rare due to loss of native forests and other factors.

Species	Common Name	Location	Status	Notes
<i>Monarcha godeffroyi</i>	Yap monarch	Yap Island	IUCN Red List – NT	Endemic to Yap – widespread and common there in virtually all forest types, including mangrove. Most abundant in brushy draws, mixed second-growth, and along forest edges. Protected as the state bird of Yap.
<i>Rukia longirostra</i>	Long-billed white-eye	Pohnpei	IUCN Red List – NT	Endemic to Pohnpei. Found in the upland interior forests, using both palm and broadleaf forests; rarely uses agroforests; not recorded in mangroves.
<i>Rukia ruki</i>	Chuuk greater white-eye	Chuuk lagoon	IUCN Red List - CR	Endemic to Chuuk. Has one of the most restricted ranges of any species in the country - recorded only from the Faichuuk group, Tol South, Onei, Pata, and Polle. Mostly confined to native forest, particularly the rich and well-developed forest at upper elevations of Tol South. However, found in non-native habitats.
Bats				
<i>Emballonura semicaudata</i>	Polynesian sheath-tailed bat	Chuuk and Pohnpei	IUCN Red List – EN	Once widespread and common in Polynesia and Micronesia, but has declined significantly. Has gone extinct in Guam, Anatahan, Tonoas, Viti Levu. Found on Weno, Pohnpei, Tol within the FSM. Considered abundant on Chuuk’s main islands.

Species	Common Name	Location	Status	Notes
<i>Pteropus insularis</i>	Chuuk flying fox		IUCN Red List – CR, CITES I	Endemic to the islets/atolls of Chuuk Lagoon – Tol Island in particular, but also Ruo, Otta and likely others. Most of the forests on the islands where it lives have been cleared, with remnants surviving on mountain tops.
<i>Pteropus mariannus</i>	Marianas flying-fox	Yap outer islands	IUCN Red List – EN, CITES I, U.S. ESA, and Yap State law	Mostly occurring in the Marianas, but also Sonsorol and Ulithi in FSM.
<i>Pteropus molossinus</i>	Pohnpei flying-fox	Pohnpei	IUCN Red List – CR	
<i>Pteropus phaeocephalus</i>	Mortlocks flying-fox	Chuuk outer islands	IUCN Red List – CR, CITES I, endangered	Endemic to the Mortlocks – likely Losap, Namoluk, Eatl, Lukunor and Satawan.
<i>Pteropus ualvus</i>	Kosrae flying fox	Endemic to Kosrae	IUCN Red List – EN, CITES, U.S. ESA	Considered by some to be a subspecies of <i>Pteropus mariannus</i> . IUCN ranks are based on listing under <i>Pteropus mariannus</i> .
<i>Pteropus yapensis</i>	Yap flying fox	Endemic to Yap	IUCN Red List – EN, CITES I, U.S. ESA, and Yap State law	Considered by some to be a subspecies of the Marianas flying fox.
Mollusks				
<i>Partula emersoni</i>	Pohnpei tree snail	Endemic to Pohnpei	IUCN Red List – CR	A species of tree snail highly endangered from introduced parasitic flatworms and the predatory <i>Euglandina</i> snail.

Species	Common Name	Location	Status	Notes
<i>Partula guamensis</i>	Pohnpei Tree snail	Endemic to Pohnpei	IUCN Red List – CR	A species of tree snail highly endangered from introduced parasitic flatworms and the predatory <i>Euglandina</i> snail.
<i>Partula martensiana</i>	Kosrae tree snail	Endemic to Kosrae	IUCN Red List – CR	A species of tree snail highly endangered from introduced parasitic flatworms and the predatory <i>Euglandina</i> snail.
Reptiles				
<i>Emoia arnoensis arnoensis</i>	Arno Atoll skink	Kosrae	IUCN Red List - DD	Found within FSM on Kosrae and Arno Atoll (of the Marshall Islands).
<i>Emoia ponapea</i>	Pohnpei Island skink	Pohnpei Island	None	
<i>Perochirus scutellatus</i>	Giant Micronesian gecko	Yap and Pohnpei outer islands	None	
Plants				
<i>Metroxylon amicarum</i>	Ivory Nut Palm	Pohnpei and Chuuk	IUCN Red List – VU	
<i>Parkia korom</i>	Kurum	Endemic to Pohnpei	IUCN Red List – VU	
<i>Semecarpus kraemeri</i>	Chuuk poison tree	Endemic to Chuuk	None	This species is only found within a small remnant forest on Mt. Winipot on Tol Island.
<i>Cyathea spp</i>	Tree ferns	FSM High Islands	CITES	
Cycadaceae	<i>Cycads</i>	Yap	CITES	All parts except seeds, seedlings, propagated plants.

Species	Common Name	Location	Status	Notes
<i>Heritiera longipetiolata</i>	Looking Glass tree		IUCN Red List - VU	
<i>Euphorbia spp.</i>			CITES	
<i>Swietenia mahagoni</i>	Mahogany		CITES	Introduced in the FSM.
<i>Nepenthes spp.</i>	Pitcher plants		CITES	All parts except seed, seedlings in vitro, cut flowers or artificially propagated.
<i>Orchidaceae</i>	Orchids		CITES	
Freshwater Species				
<i>Lentipes sp.</i>	Pohnpei Stream Goby	Pohnpei and Kosrae streams	None	Endemic to Pohnpei. An undescribed species. Locally common in sections of Nanpil River, and recorded elsewhere – once in the Lehn Mesi and once from a stream in Kosrae. Most of the specimens were taken at 200-300 m.
<i>Sicyopterus eudentatus</i>	Pohnpei Mountain Goby	Pohnpei	None	Endemic to Pohnpei. The rarest of the endemic mountain gobies – known from a total of 18 specimens (17 from the Nanpil-Kiepw River and 1 from the Senipehn River – all between approximately 100-200 m.
Marine Species				
Fish				
<i>Cheilinus undulatus</i>	Napolean wrasse	All FSM reefs	IUCN Red List – EN	A top-level predator of coral reef systems.
<i>Epinephelus lanceolatus</i>	Giant Grouper		IUCN Red List – VU	

Table 3. Environmental Systems, Stresses and Sources. Source: Blueprint for Biodiversity Conservation in the Federated States of Micronesia Workshops, 2002.

Systems	Stresses	Sources
<p>Forests Native flora and fauna; natural resources; traditional medicines; cultural resources</p>	<ul style="list-style-type: none"> • Habitat destruction • Habitat fragmentation • Spread of exotic species • Altered composition/ structure 	<ul style="list-style-type: none"> • Inappropriate land-use sources • Lack of land-use plans • Lack of protected area system • Development and infrastructure activities • Fires • Limited quarantine practices
<p>Watersheds and Streams Drinking water; irrigation; stream/freshwater fauna; waterfalls-tourism sites; endangered species</p>	<ul style="list-style-type: none"> • Sedimentation • Nutrient loading • Contamination • Changes in flow patterns 	<ul style="list-style-type: none"> • Inappropriate land-use practices • Lack of land-use plans • Development and infrastructure activities • Pesticide and fertilizer misuses • Quarrying • Waste disposal
<p>Coastal Wetlands Mangroves; marine resources nursery; endangered species; coastal protection; cultural resources</p>	<ul style="list-style-type: none"> • Habitat destruction • Habitat fragmentation • Habitat disturbance • Resource depletion • Sedimentation 	<ul style="list-style-type: none"> • Development and infrastructure activities • Over-harvesting of marine resources • Reclamation and dredging • Waste disposal • Non-point source pollution • Limited area in protected areas
<p>Coral Reefs and Lagoons Coastal protection; marine resources; tourism; endangered species; cultural resources</p>	<ul style="list-style-type: none"> • Habitat destruction or conversion • Habitat fragmentation • Habitat disturbance • Resource depletion • Habitat loss through bleaching 	<ul style="list-style-type: none"> • Development and infrastructure activities • Over-harvesting • Reclamation and dredging • Waste disposal and pollution • Tourism activities • Soil erosion and sedimentation • Climate change (coral bleaching) • Incomplete protected area network

Species	Common Name	Location	Status	Notes
<i>Manta birostris</i>	Manta Ray	All FSM States	None	The world's largest ray, it occurs singularly or in small groups in surface or mid-waters of lagoons and seaward reefs, particularly near channels at times of outgoing tides.
<i>Plectropomus leopardus</i>	Coral Trout	All FSM islands	IUCN Red List – NT	Particularly vulnerable during annual spawning aggregations (Feb –Apr).
Molluscs				
<i>Hippopus hippopus</i>	Bear Paw clam	All FSM islands	IUCN Red List – LR	
<i>Tridacna gigas</i>	Giant Clam	All FSM islands	IUCN Red List – VU	Locally extinct on some islands – heavily overharvested.
<i>Tridacna maxima</i>	Small Giant Clam	All FSM islands	IUCN Red List – LR	
<i>Tridacna squamosa</i>	Fluted Clam	All FSM islands	IUCN Red List – LR	
Reptiles				
<i>Chelonia mydas agassizii</i>	Pacific Green Turtle	All FSM islands	IUCN Red List – EN, CITES II, U.S. ESA	
<i>Eretmochelys imbricata</i>	Pacific Hawksbill Turtle	All FSM islands	IUCN Red List – CR, CITES, U.S. ESA	
<i>Dermochelys coriacea</i>	Leatherback sea turtle	Yap and Pohnpei	CITES	Known from at least Yap and Pohnpei.
<i>Lepidochelys olivacea</i>	Olive Ridley sea turtle	CITES		Reported from Yap (Falanruw 1975).

Invasive Species

Invasive and alien species are arguably the major threat to Pacific biota and native ecosystems, and nearly all the globally threatened species in the FSM are threatened by alien invasive species. Ever since humans first colonized islands of the FSM up to 3,000 years ago, introduced plants and animals have had a significant impact on native biota. The early Micronesian colonists deliberately introduced a number of plants and animals for food, medicines, building materials and ornamentation. Some of these deliberate introductions, and other species that were introduced accidentally, became pests. Examples include pigs, dogs and Pacific rats (*Rattus exulans*). However, following European colonization from the mid 19th Century onwards, hundreds more species were introduced, many accidentally. Now, in the FSM, there are more introduced flora and higher vertebrates than native species and the nation is full of examples of alien species that have become serious pests.

The classic example of the impact of an introduced predator, is the brown tree snake (*Boiga irregularis*). In the past 40 to 50 years, this predator from the Papua region has caused the extinction of nine of eleven native species of forest birds and the apparent extinction of three skink species and two species of gecko on Guam. The snake has now spread to Saipan and there are serious fears that if the snake were to spread to the FSM it would cause similar devastation.

The most widespread introduced animals currently present in the FSM are goat (*Hircus capra*), pig (*Sus scrofa*), dog (*Canis familiaris*), cat (*Felis catus*), pacific rat (*Rattus exulans*), norway rat (*Rattus norvegicus*), ship rat (*Rattus rattus*), and mouse (*Mus musculus*). Rats are particularly serious pests and consume a wide range of prey including fruits, seeds, insects, snails, lizards and birds, including eggs and nestlings. Pigs, goats and cattle cause habitat disturbance by eating tree seedlings and thereby slowing forest regeneration and reducing native plant diversity. Both dogs and cats prey on seabirds and land birds particularly surface nesting species, while cats also prey on skinks and geckos. The impact of feral animals on bird populations received attention by Buden (2000) who compared bird surveys that were conducted in 1983 and 1994. Buden (2000) suggested that cats and rats were largely responsible for a 65-80% decline in most species of birds. Other species reported from parts of FSM include Rusa deer (*Cervus timorensis*), *Rattus tanezumi* (Flannery 1995), monitor lizard and the red junglefowl (*Gallus gallus*) (Buden 1996). The monitor lizard (*Varanus indicus*) was introduced in the hope that it would control rats. It became established and is reported to have become common and widespread but now is relatively scarce and restricted to a few areas on Pohnpei and Kosrae. The Cane Toad (*Bufo marinus*) is present on Pohnpei and many of the other islands in FSM. Its introduction is said to have been made in the hope of controlling the monitor lizard! It is also believed to be contributing to mosquito control in the FSM, and therefore is probably still being activity distributed.

Arthropods are the most numerous invasive species on islands and ants probably pose the greatest arthropod threat to conservation in the Pacific. The potentially most damaging ant invaders include the bigheaded ant *Pheidole megacephala*, the long legged or crazy ant *Anoplolepis longipes*, the Argentine ant *Lineopthema humile*, little fire ant *Wasmannia auropunctata* and others. Characteristics of ants that make them so destructive include the

formation of large, non-competitive multi-queen colonies, the ability to hitchhike readily, highly aggressive behavior and the limited number of effective control options. Introduced ants have decimated all lowland native vertebrates and invertebrates such as crabs, snails and aquatic and semi-aquatic invertebrates by predation, direct competition and by creating favorable conditions for other invasive biota.

Introduced land snails have decimated native snail species on many islands in the FSM. The high islands have the highest snail diversity, and are therefore at greatest risk from introduced snail species. The carnivorous rosy wolf snail, *Euglandina rosea*, was introduced to control another introduction, the giant African snail (*Achatina fulica*), but has unfortunately decimated native land snails. On Pohnpei the flatworm *Platydemus manokwari* was also introduced to control the Giant African snail and has also impacted native species. Neither of the two introduced biological control agents appears to be effective control of *A. fulica* populations.

Hundreds of plants have been introduced to islands of the FSM and several have become serious threats to native habitats of the nation. The impacts of invasive plants on native flora and vegetation include decreased dominance of native species, decreased overall species richness, fewer vertical tiers of plants, and a lower range of biodiversity overall. Many of the invasives are heliotropic and are more successful than native species in forest clearings from where they may spread into the forest. The spread of invasive plants has been hastened by habitat degradation on islands from typhoon damage or agricultural activity. Some of the most aggressive weedy invaders include the following:

- trees and shrubs: African tulip tree (*Spathodea campanulata*), wild tamarind (*Leucaena leucocephala*), red sandalwood tree (*Adenanthera pavonina*), *Lantana camara*, *Clerodendrum*, *Psidium guajava* spp. (guava), *Chromolaena* sp., and the giant sensitive plant (*Mimosa invisa*);
- the climbing vines *Merremia peltata*, *Mikania micrantha* and *Coccinia* spp;
- the grasses *Paspalum*, *Imperata*, and *Pennisetum* spp;
- the creeping herbs *Costus* sp. and *Wedelia trilobata*.

Other potentially destructive alien invaders include introduced fishes, amphibians and crustaceans which can impact on native biodiversity by altering habitats, competing for food and living space, introducing pathogens, hybridization with native species and socio-economic and environmental impacts.

Major resource management issues

At one time Micronesians were completely dependent on the natural resources of their islands for their daily lives. As human populations grew, so did their impact on natural resources. Species have been lost and ecosystems damaged by the dense populations of the FSM's past. At the same time, the people of the FSM have adapted to living with limited island ecosystems. Micronesian cultures incorporate practices having conservation value and thus served to buffer people's impact on the environment. The cultural and technological adaptations to living with island ecosystems are an important heritage of the past and an asset for the future.

Today the population of the FSM is growing rapidly, and patterns of resource use are changing. New technologies enable people to have a much greater impact on the natural

environment, and commercial markets encourage greater exploitation of natural resources. Infrastructure developments such as roads and unsustainable agricultural practices have led to deforestation. An example that was cited earlier on Pohnpei island is the reduction in the area of native upland forest from 42% of the total vegetation cover in 1975 to 15% in 1995 which is attributed largely to clearing to plant sakau (kava or *Piper methysticum*). This general degradation of land and water resources as populations grow and people increase natural resource exploitation activities as they shift towards a cash economy has resulted in increased erosion and sedimentation, with soil being deposited in rivers and eventually making its way out to cover and suffocate mangroves, sea grass beds, and coral reefs.

The availability of off-island markets has resulted in unsustainable exploitation of resources. Examples include the unsustainable harvest of fruit bats from Yap with export to Guam and the unsustainable boom in the export of mangrove crabs from Pohnpei and Kosrae. The commercial demand for reef fish has resulted in the decline of traditional controls over access to this resource in all islands. Stocks of inshore reef fish have declined in all state centers. The availability of a cash market has also encouraged destructive fishing methods such as the use of dynamite and chlorine products. Turtles are also highly endangered throughout the islands due to overharvest and a breakdown in traditional management and protection.

Other major environmental issues in the FSM include the growing combined impacts of climate change and poor land management, including increased shoreline and beach erosion, seawater intrusion into coastal swamps and taro patches, coral bleaching, and other negative impacts. In addition, pollution, both from growing solid waste and human and animal wastes, impact both biodiversity and public health.

In 2002, during the development of the “*Blueprint for Biodiversity Conservation in the Federated States of Micronesia*”, a series of workshops were held in each FSM State. As part of the workshop, participants were asked to rank threats to the areas of biodiversity significance that were identified in each State. The combined results of the survey identified and ranked nine threats as particularly pervasive as follows: overfishing and overhunting, coastal erosion and sea-level rise, water pollution, erosion/sedimentation, incompatible commercial development, destructive harvesting, invasive species, dredging/mining of sand and coral, landfill/dumping. Major impacts on habitats are summarized in Table 3.

Overfishing and overhunting was identified as the most urgent and important threat across marine and terrestrial habitats in all states. This threat has been fueled for the last three decades by a combination of high population growth. For example, the FSM population growth rate was estimated at 3 percent for 1980-1989, one of the highest in the world (FSM DEA 2002a). At the same time, there has been a general slow-down of the local economy over the last several years brought on by step-downs in the amount of funding provided to the FSM from the US through the Compact of Free Association. While total new jobs for each five-year period between 1970 and 1995 ranged between 1,000 and 2,800 jobs, employment between 1996 and 2001 showed virtually no growth, moving from 15,304 jobs in 1996 to 15,392 in 2001 (FSM DEA 2002a).

The public reaction has been two-fold. First, population growth has almost stopped since 1997 due to an estimated 2,000 FSM citizens a year leaving the islands to take up residence in Guam, Saipan, Hawaii and the mainland US to find the jobs there that are not available to them at home (Hezel 2002). At the same time, however, those remaining in the FSM have been forced to make greater use of the natural terrestrial and marine resources to “make ends meet”, and it is these people who dynamite coral reefs in Chuuk, hack through the watershed so they can plant sakau on Pohnpei, and cut down mangrove in Kosrae for firewood. These people – who have elected to remain in FSM when so many others have left, the people who have not even moved into town to compete for the few jobs to be had there – are by default the guardians of the land. But they also stand to be its main despoilers.

Status of reef fisheries in the FSM

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% (Richmond et. al. 2002). 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.

Most (873 of 1,125 species) of the fish in the FSM are reef-associated, however catch and export data are limited. However, fisheries operation may be substantial – the gross value of FSM fisheries in 1998 was estimated at US\$86.4 million (Richmond et. al. 2002). The FSM earns about US\$18-24 annually from licensing fees for foreign fishing vessels fishing for tuna in its waters. Chuuk has the largest commercial export of reef fish. Destructive fishing practices, including the use of explosives taken from WWII wrecks, have caused localized reef damage, especially in the Chuuk lagoon. Pohnpei also exports a substantial amount of fish and crab, although exports were shut down for a time around the 2000 cholera outbreak. Fish export from Yap and Kosrae is limited and mainly for personal and family use. Sea cucumber exports have been attempted in both Yap and more recently in Pohnpei, but both states currently have banned export until further studies are done about the sustainability of the fishery.

The National Government also has an inshore fisheries management agency within the Department of Economic Affairs, but duties are limited to coordination of fisheries assistance activities within the nation and representing the FSM in regional and international meetings. The College of Micronesia has staff trained in marine resource assessment and monitoring, and periodically works with the various fisheries/marine resource management agencies throughout the FSM to improve monitoring of coral reefs. There is also regional cooperation under the Marine Resources Pacific Consortium (MAREPAC), funded by the US Department of the Interior to increase local and regional capacity for assessment and monitoring. The Palau International Coral Reef Center is also conducting active research and education programs and is coordinating coral reef monitoring in the region for the

GCRMN. They are attempting to take a larger coordinating role in the region, and are also working with regional governments to develop standardized monitoring protocols to allow data to be compared and rolled up regionally. In general, the capacity of the FSM’s government and non-government agencies to monitor and manage their reefs is improving, but more progress is needed before adequate areas are protected as no-take reserves.

Although monitoring and other activities have been going on sporadically for a number of years, in general coral reef and fisheries data are scarce. Some FSM shallow-water coral reef and associated benthic habitats have been mapped over the years, but mainly around major population centers. In the 1980s, coastal resource inventories and atlases have been prepared for Pohnpei, Yap, Kosrae, and Weno Island in the Chuuk lagoon. These are now somewhat outdated but still useful for baseline information. Coral reef and fisheries monitoring is the responsibility of the State fisheries/marine resource management agencies, and the monitoring methodology used is determined by the agency staff. Often data is not properly stored or analyzed and much data has been collected uselessly over the years. Because of the multitude of different methods being employed in the various states, it is nearly impossible to roll up monitoring data to the national level with any accuracy (Table 4).

Table 4. Examples of on-going coral reef and fisheries monitoring activities in FSM States.

State	Focus	Description
Pohnpei	Population surveys of 22 species of commercially and/or culturally important fish and invertebrate species	CSP and Marine Development Unit set up fish and invertebrate monitoring sites around five of Pohnpei’s MPAs – methods employed – twenty minute long swim technique and fifty meter belt transect.
Pohnpei	Spawning aggregation site monitoring	CSP and Marine Development Unit have been monitoring the Black Coral SPAGS for years (2001-2003) – Method employed - one hundred twenty foot transects (five dives at the new moon and full moon, twice a month for six months of the year).
Pohnpei	Coral cover	CSP and Marine Development AIMS line intercept transect at ten sites around Pohnpei in the outer islands (Mwoakilloa and Pingelap).
Kosrae	Reef fish population monitoring at five sites around the island.	Division of Marine Resources, along with volunteer assistance from Kosrae Village Resort (and KCSO PCV since 2002), has been monitoring certain fish populations since 1994 as part of their coral monitoring program through Reef Check International. Four twenty meter transect lines, at five meters apart, are rolled out in a linear pattern from end to end.

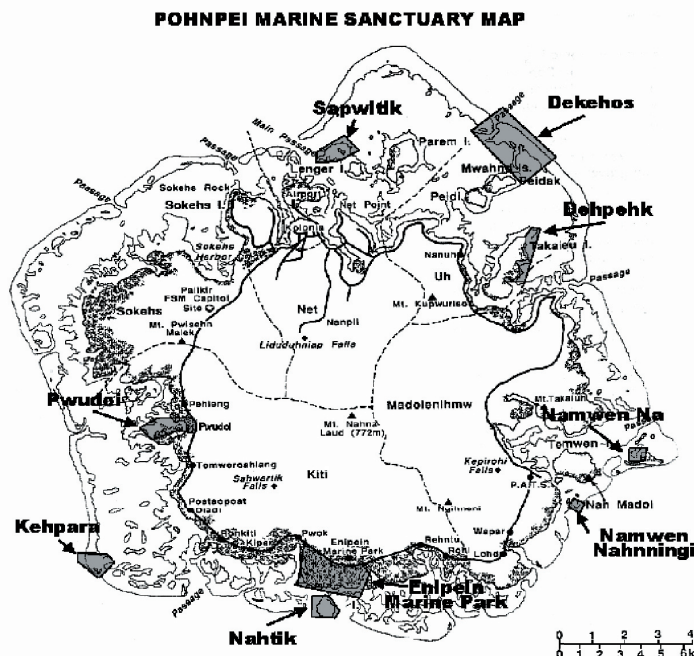
Kosrae	Coral cover monitoring at five sites around the island.	Division of Marine Resources, along with volunteer assistance from Kosrae Village Resort (and KCSO PCV since 2002), has been doing coral monitoring through Reef Check International. Four twenty meter transect lines, at five meters apart, are rolled out in a linear pattern from end to end.
Kosrae	Invertebrate population monitoring at five sites around the island.	Invertebrate are also part of the Division of Marine Resources Reef Check International monitoring project since 1994. Sea cucumbers, sea urchins, trochus, and giant clams are the major invertebrate species monitored using the same transect line method as the fish population and coral cover studies.

One method of fisheries management that is gaining acceptance in the FSM is the establishment of marine protected areas. Although reefs were traditionally controlled and protected by chiefs and other traditional leaders, this protection has broken down to various degrees in recent years, especially in the more populated State centers. The establishment of a Protected Areas Network is a high priority under the recently completed National Biodiversity Strategy and Action Plan (NBSAP). The NBSAP sets a clear conservation objective under the major theme of ecosystem management:

“A full representation of the FSM’s marine, freshwater, and terrestrial ecosystems are protected, conserved, and sustainably managed, including selected areas designated for total protection.”

Pohnpei State passed legislation in 1999 establishing 9 MPAs. Although the “top-down” legislation was mostly rejected by local communities at first, concerted efforts by the Conservation Society of Pohnpei and the Pohnpei Division of Marine Development have led to the establishment of five community-led reserves. In Yap, where villages still own their reefs, four communities have put forward potential MPA sites as part of the FSM International Waters Project funded by the UNDP and supported by SPREP. Efforts by the Kosrae Conservation and Safety Organization and the local government in Kosrae’s Utwe-Walung Park have also built substantial community support for the establishment of an MPA within this important site. The FSM National Government joined 187 other nations in approving the Plan of Work on Protected Areas developed at the Seventh Council of the Parties (COP) of the Convention on Biodiversity (CBD) meeting held in Kuala Lumpur in 2004. Through the Plan of Work, the FSM has agreed to establish a fully representative, effectively managed and sustainably funded protected areas network by 2010 for terrestrial areas and by 2012 for marine areas. See Figure X for the MPA currently being managed.

Figure 3. Marine Protected Areas of Pohnpei. Courtesy of the Conservation Society of Pohnpei.



In December 2004, a number of local partners signed a National Implementation Support Partnership (NISP) agreement pledging to collaborate and support the implementation of the Programme of Work (PoW) on Protected Areas. The NISP provides an overarching framework for establishing a national protected areas network in the FSM. Signatories to the FSM NISP include the Government of The Federated States of Micronesia, the State governments (key partner agencies include the Chuuk Environmental Protection Agency, the Yap Department of Resources and Development, the Pohnpei Department of Lands and Natural Resources, and the Kosrae Island Resource Management Agency), the College of Micronesia – FSM, the Micronesia Conservation Trust, FSM Visitors Board, The Nature Conservancy, Conservation Society of Pohnpei, Kosrae Conservation and Safety Organization, and the Yap Community Action Agency. Over the next two years, the partners will be working together to build a consensus for a nationwide protected areas network in the Federated States of Micronesia, begin network design, and work with the Micronesia Conservation Trust to ensure sustainable financing for the network.

Coastal Erosion and Sea-Level Rise, including increases in storm surge and saltwater intrusion into freshwater ecosystems, are being experienced across the FSM, especially in the low coral atoll islands. Unwise construction of sea walls, jetties and other poorly planned coastal infrastructure during the first ten years (1986-1996) of the Compact, when large amounts of money were spent on infrastructure development, has further exacerbated coastal erosion in several areas. The anticipated rise in sea levels of between 20-100 cm over the next 50 years (FSM, 1999) will further exacerbate the situation, to the extent that many coral atoll islands may become uninhabitable to humans and unviable as natural terrestrial systems. Climate change is likely to have significant impacts on marine biodiversity (Buddemeier 1993; Wilkinson 1999). Sea level rise will affect turtle nesting

beaches, low-lying seabird colonies, and mangroves, to name some of the more obvious casualties. In addition, other anticipated climate change impacts anticipated for the FSM include reductions in rainfall, more frequent droughts and increased tropical storms and typhoons (FSM, 1999).

Water pollution, including human and animal waste is a serious threat to coastal and marine inshore areas, especially in on high volcanic island population centers where people live in over-crowded conditions with only minimal sewage treatment. Cholera outbreaks have occurred.

Erosion/Sedimentation from land-based activities, both **incompatible commercial development** and agricultural and other activities under taken by private landowners, is degrading freshwater and coastal/marine areas on all islands. With the projected further reduction in the local economy under Compact II, there will probably be less home construction and road-building - the two major causes of earth-moving and disturbance; this should mean less damaging effects of excavation on slopes and access to ecologically fragile areas. There will also be less clamor for rapid and large-scale economic growth—in the form of resort hotels, golf courses, garment factories, etc.—regardless of the social and environmental cost. With the option to go abroad to earn a living, economic development may seem less urgent than it once did (Hezel 2002).

Destructive harvesting, in particular the use of dynamite and/or poisons in fishing, is a major threat to marine environments in Chuuk, and to a lesser extent on other islands. Harvesting practices for forest products have also become more destructive, e.g., traditionally many forest products were harvested using sustainable means, but now harvesters strive for maximum yield with little thought for the future.

Invasive species are a growing threat, especially in terrestrial areas. Much of the information available on the status of invasives in Micronesia has been documented by Meyer (2000), Cowie (2000) and Atkinson & Atkinson (2000) in their technical reports to the South Pacific Regional Environment Programme (SPREP) Invasive species technical review and draft regional strategy. The isolated insular nature of the FSM's islands makes them highly susceptible to invasive plant and animal species, and these species (e.g., rats, cats, and parasitic snails) are believed to be a factor in most of the species and community targets that are considered rare and/or endangered. Many plants and animals have been introduced in the last 150 years, and with regular air and sea connections to neighboring island nations/territories with well-documented invasive species problems (e.g., the Brown Tree Snake on Guam), the threat of invasive species will only increase.

Dredging/mining of sand and coral, especially on high islands in the state centers, has had a serious impact on coastal environments and coral reefs. Besides directly destroying the immediate surroundings, increased turbidity kills corals and other invertebrates and leads to a sharp drop in biodiversity.

Landfill/dumping is a major threat as islanders are adopting western packaged food and beverages and other products (refrigerators, cars, air conditioners, etc.) Solid wastes on all islands are a major eye-sore, source of pollution, and breeding ground for rats, flies, and mosquitoes.

Table 5. Principal Sources of US Public Funding Available to the FSM
 FAS=Freely Associated States

Source of Funding	Funding Type	FFY'05 Approximate Funding levels	Geographic Application
DOI-Compact of Free Association with the FSM/Environment Sector	Allocation ¹	\$2.3M	FSM
DOI-Office of Insular Affairs Management Grants	Allocation Allocation	\$350K \$150K	Guam, CNMI FAS
DOI-Office of Insular Affairs Marine Resources Pacific Consortium (MAREPAC) Funds	Allocation	\$100K	FAS, Guam, CNMI
National Fish and Wildlife Foundation (NFWF)	Grants ²	\$500K (NOAA funds)	FAS, Guam, CNMI
NOAA/National Ocean Service-Coral Reef Monitoring	Allocation	\$100K/ea \$10K-\$20K/ea	Guam, CNMI FAS
NOAA International Coral Reef Conservation	Allocation	\$400K	FAS and territories (and other regions internationally)
NOAA General Coral Reef Conservation	Grants	\$600K	FAS, Guam, CNMI
USFS—State and Private Forestry	Allocation	\$300K \$200K \$100K \$600K \$500K	FSM Palau RMI Guam CNMI
USFWS, Pacific Islands Office, Marine and Coastal Programs	Grants	\$250K	FAS, Guam, CNMI

¹ While a specific level of funding is guaranteed to an entity/country, proposals or spending plans are usually required to access those funds.

² With grant funding, no specific regional allocation is made, and entities compete with all other applicants for funding.

Status of knowledge and information base for management

Sources of information, databases and studies for management

The biodiversity of the FSM has been studied extensively, however, data is widely scattered and not comprehensive. No national biodiversity database exists, however, two institutions – the College of Micronesia Library and the Micronesian Seminar Library have made intensive efforts to identify and collect research publications pertaining to the FSM. In addition, the National Government, in partnership with the College of Micronesia, are in the process of launching a web-based National Clearinghouse Mechanism (CHM) with the following goals:

- Promote and facilitate cooperation to effectively implement the NBSAP and Biodiversity Strategy and Action Plans for Chuuk, Yap, Kosrae and Pohnpei.
- Promote and facilitate technical and scientific cooperation between FSM and other countries, organizations and institutions.
- Develop a national mechanism for exchanging and integrating information on biological diversity.
- Develop the necessary human and technological network.

Other databases which include information on the biodiversity of the FSM are also freely accessible on the internet. The IUCN Red List of Threatened Species is the most comprehensive, apolitical global approach for evaluating the conservation status of plant and animal species. The current IUCN list can be accessed at <http://www.redlist.org>. This site provides a database that can be searched online. It lists 88 species from the FSM under different categories.

Information in plant invasive species in the FSM is available through the Institute of Pacific Islands Forestry Pacific Island Ecosystems at Risk (PIER) database (<http://www.hear.org/pier/index.html>). The PIER project has compiled reference information on exotic plant species of known or potential threat to Pacific island ecosystems. Included are plant species that are threats to natural or semi-natural ecosystems of all types. Information is also included on species that are agricultural weeds or invaders of other highly disturbed sites.

Research efforts of significance

The B.P. Bishop Museum has digitized the valuable Island Bibliographies and Supplements by Sachet and Fosberg (1955, 1971) and updated the bibliography through about 1998. More recently, the Bishop Museum has received a grant with The Nature Conservancy from the MacArthur Foundation to fund the development of species richness maps for corals, fishes and mollusks. They also have another grant to develop comprehensive checklists of vertebrates and vascular plants of Micronesia.

Another activity that relates to the biodiversity of the FSM is the PABITRA network of the Ecosystem Division of the Pacific Science Association Task Force on Biodiversity. This effort has been in process since 1994 and has resulted in annual meetings on Asian and Pacific biodiversity. In 1998, a Pacific-Asia Biodiversity Transect (PABITRA) was initiated. Two branches of this transect are planned for the FSM. The fifth PABITRA workshop was held on Guam in 1993 but there was no participation by the FSM.

Institutional and individual capacity for research and management

Institutional and individual capacity for research and management has improved significantly over the last few decades, especially in the marine sciences. The College of Micronesia's FSM National Campus (<http://www.comfsm.fm/>) is the foremost research institution in the nation, and several of the instructors at the college also perform biological research and surveys alone or with their students. A marine laboratory, the Marine Environmental Research Institute of Pohnpei (MERIP) was established as part of the Ponape Agriculture and Trade School (PATS) on Madolenihmw Bay. Although PATS has recently closed, MERIP continues operation as an autonomous NGO. It has wet labs, dry labs, boat and dive facilities, aquaculture demonstration farms (sponge, pearl, giant clams, corals) and other research needs. Previously utilized primarily for aquaculture research, is it now open to visiting scientists for other research purposes. The Conservation Society of Pohnpei (CSP) also conducts marine and terrestrial research and has some facilities, particularly diving and boating equipment. CSP also hosts visiting researchers.

Most research, however, is still performed by off-island graduate students/scientists and institutions either in partnership with local scientists and agencies or alone. Currently, the FSM National Agriculture Unit of the Department of Economic Affairs issues permits for bringing plants, animals and plant products and animal products into and out of the FSM. The FSM States issue permits for interstate traffic. The Agriculture Unit also collaborates with the FSM National History & Archives Unit of the Department of Health, Education and Social Affairs in the research application process, especially if related to agriculture. Researchers apply for entry permits from FSM Immigration and include a research proposal that is reviewed by the Unit with a resulting recommendation to be returned to Immigration. In the past, most foreign researchers have worked in the areas of archeology, geology, geography and the social sciences. Recently, however, researchers in the life sciences have become more prevalent. The current research proposal load has begun to overwhelm the Unit, and this has led to increased collaboration with Department of Economic Affairs and the State governments to review proposals. The decision for approval now rests with the States. There are a lot of gaps in the current research approval process, and issues include the lack of expertise to review proposals and a lack of coordination between States and the National Government, exacerbated by the fact that visitors can come for 30 days without a permit. The review process also requires some improvement and monitoring after the permit is issued.

Information Gaps

There are a number of data gaps that were identified during the recently completed National Biodiversity Strategy and Action Planning process. Geographically, the FSM's outer islands are much more poorly studied than the main high islands. The FSM's outer islands are highly dispersed over a million square miles of ocean, and transportation and communication are sporadic and unreliable. As opportunities arise, it is highly recommended that biological inventories be conducted on all the outer islands.

Key topics that need more data collection include the following:

- the biology and threats to freshwater aquatic habitats
- biology of the open ocean, including the biology of the deepest part of the Marianas trench, which falls within the FSM
- the origin, dynamics and role of fire in savanna grasslands
- characteristics of forest types in the FSM, especially species differences due to elevation and gradient
- particular research on forest remnants on Chuuk including species recovery plans for extremely rare plants and animals existing only on a few mountain tops in the Chuuk lagoon
- further demarcation of marine communities, currents and larval dispersal, and general health and viability
- habitat needs and current status of the six distinct endemic species of flying foxes in the FSM, including recommended actions for management
- research into the biology and role of endemic tree snails in native forests and recommendations for avoiding extinction

GOVERNANCE

State and National government agencies

Because of the government structure of the FSM federation with a National Government and four semi-autonomous State governments, each of the four States have their own constitutions along with the FSM constitution. This structure makes it a prerogative of each State to enact their own legislation in line with their powers as mentioned in the FSM Constitution to address the threats to or conserve biodiversity. At the state level there are also municipal ordinances and traditional precedents but these are not included as part of this preliminary report.

The source of the National Government's authority to regulate is the FSM Constitution. The Constitution clarifies the National and State Governments' roles in implementing the FSM's obligations under the Convention on Biological Diversity. The FSM Constitution explains that a power that is expressly delegated to the national government, or a power that is of such an "indisputably national character as to be beyond the power of a state to control, is a national power." A power that is not expressly delegated to the national government or prohibited to the states is a state power. The FSM Constitution also sets out powers that are expressly delegated to the FSM Congress. There are many powers listed, but the important ones for purposes of this strategy document include the power to:

- ratify treaties;
- regulate foreign and interstate commerce;
- regulate navigation and shipping, except within lagoons, lakes, and rivers;
- regulate the ownership, exploration, and exploitation of natural resources within the marine space of the FSM beyond 12 miles from island baselines;
- promote health by setting minimum standards;
- coordinating state activities relating to foreign assistance; and
- providing training and assistance to the states.

Responsibility for environmental issues is shared between the FSM National Government and the individual FSM States. This sharing of responsibility has at times resulted in legislation that appears duplicative at the State and National levels. It has also resulted in gaps in legislation and areas in which the location of responsibility between the State and National Governments has been unclear.

The State and National Attorneys General at one time formulated a tentative Joint Opinion regarding State and National jurisdiction over certain environmental issues. This Opinion, though not signed, concludes that the protection of ecosystems, such as reefs and mangrove swamps, is the responsibility of the States; agriculture, forestry and watershed protection in general are regulated by the States, although the National Government has regulatory authority if any aspect of these areas has a clear effect on foreign or interstate commerce or concerns the public health. The States take the lead role in ensuring that development is avoided in vulnerable areas and ensuring that critical natural systems are protected. Most of the States have made efforts to control development and manage natural resources through the creation of land use plans, coastal zone plans, legislation and regulations. The National Government provides guidance and technical assistance to the state, when needed and requested, on matters related to planning, economic development, natural resources, fisheries, and the environment.

Because the FSM was a UN Trust Territory previous to becoming independent, the FSM Constitution provides that a statute from the Trust Territory era continues in effect except to the extent it is inconsistent with the FSM Constitution or is amended or repealed. When the first official codification of the laws of the FSM was completed in 1982, the preface to the Code acknowledged that the Code included many laws that were arguably within the exclusive jurisdiction of the states. The committee reviewing the Code determined that such questions would be better answered by time, court decisions and congressional action. Time, court cases and congressional action have in fact clarified the role of some of these provisions.

The institutional structure for implementing activities in line with the international environmental conventions in the FSM and for implementing activities supporting legislation and regulations outlined previously, is complex at both the National government level as well as within each of the four States of the FSM. The primary agencies, committees, and NGOs are listed in the table below. Other agencies and NGOs not listed are also involved but to a lesser degree. The Committees and Council are established primarily to improve coordination and ensure integration across sectors. Most of these committees and councils have cross-sectoral representation. Some government agencies are tasked with dual and the sometimes apparently conflicting roles of maximizing utilization of the same resources they are expected to conserve. The four States implement projects and programs and are supported by the national level.

There is a fairly strong and rapidly growing NGO sector in the FSM. Three NGOs stand out in particular – the Conservation Society of Pohnpei in Pohnpei, the Kosrae Conservation and Safety Organization in Kosrae, and the Yap Community Action Program in Yap. Each of these organizations has strong community ties and conducts community outreach programs around a variety of environmental issues. These organizations are becoming increasingly

involved in State and National planning and implementation activities, and all have a high capacity to plan and implement proposals.

On the other hand, the CBO sector in the FSM is still evolving and varies from State to State. Both Pohnpei and Yap enjoy strong traditional leadership, and villages are headed up by traditional chiefs who exercise some to a great deal of authority over the village's development and conservation activities. In addition, both States have State-wide traditional leader councils which meet regularly and influence State policy. The churches, especially the Catholic and Protestant faiths, hold a large measure of authority and church leaders are very influential in determining village policy, especially in those islands without a formal traditional chief structure (Kosrae and Chuuk). Many youth, men and women's groups also exist throughout the nation, mainly affiliated with the churches.

U.S. programs

Under the Compact of Free Association, the FSM is considered an independent nation, and as such is not eligible for a number of Federal Programs. The most plentiful and visible U.S. funding coming to the FSM is funneled through the Department of Interior and is linked to the Compact of Free Association that the U.S. has entered into with FSM. The Compact agreement has a relatively small portion of environment sector funding (health, education, and infrastructure receive the lion's share). In FSM, that represents about \$2.3M in FY '04. Compact funding flows through the respective national governments, and is used mainly to support government staffing and other operational needs; at this point it does not yet reliably address the conservation needs and natural resource management challenges outside the public sector.

There are a number of U.S. federal resource agencies that direct funding to Micronesia and/or have a physical presence in the region. A key funder of governmental entities and NGOs is the National Oceanic and Atmospheric Administration (NOAA), the principal source of coral reef protection funds in the U.S. and a key player in the U.S. Coral Reef Task Force, a body formed as the result of a late 1990's initiative by President Clinton. The USDA Forest Service also contributes substantial funds to the FSM, through programs authorized in the Farm Bill. This USFS money comes in the form of a fairly reliable annual allocation to the FSM, channeled through the state foresters in each State. The Department of Interior-Office of Insular Affairs (DOI-OIA) has been a reliable source for funding for coral conservation work, partly because the current proposal process is quite straightforward, and funding can be granted quickly. Contributing funding, but in smaller amounts, are the USFWS and USDA's Rural Development Program. (See Table 5 for a matrix of key U.S. funding to Micronesia).

Beyond these more established sources of assistance, there are other programs that fund regional conservation efforts, and still others that could be cultivated, including the National Science Foundation, Department of Defense, Department of Transportation, Center for Disease Control, Health and Human Services, and others. Collectively, U.S. federal funding programs are capable of providing significant resources to the region.

International and regional bodies

The FSM, as an independent nation, is a party to a number of international environment conventions.

A number of regional and international bodies operate with in the FSM in the area of natural resource management, including the South Pacific Regional Environment Programme (SPREP), United Nations Development Programme (UNDP), United Nations Food and Agriculture Program (FAO).

Non-government organizations

Conservation Society of Pohnpei

The Conservation Society of Pohnpei (CSP) was founded in 1998 as TNC's primary non-governmental partner in Pohnpei, Federated States of Micronesia. CSP is a unique NGO on the island given its mission of terrestrial and marine conservation and management. Its activities include public awareness and community outreach, marine and terrestrial resource management, and conservation policy development.

In 1999 and 2000, TNC sent an organizational development specialist, Ellen Grant, to Pohnpei to help this fledgling organization build its capacity. In 1999, Ellen spent two months in Pohnpei helping the Board and staff establish an institutional framework for CSP. Ellen also helped hire Willy Kostka as Director of CSP, a position he has filled very successfully since then. In 2000, Ellen returned to Pohnpei for two weeks to assess progress since her last visit a year ago, train the new Office Manager (Meileen Albert), develop a local fundraising plan, and assist with drafting a proposal for the Packard Foundation's Organizational Effectiveness Program.

Cathy Kidman spent six weeks in the summer of 2001 working with the staff and Board of CSP to address gaps identified by Ellen Grant the previous year. Cathy also developed and conducted a Board Exchange between CSP and the Palau Conservation Society, an exercise that proved extremely effective in helping the Board of CSP come to consensus at a subsequent retreat on several important issues of governance. Ms. Kidman observed: "A further item to note, in a broader context, is the lack of capacity building support for NGO's in the region, and its potential impact on the success of CSP. Over and over again the Board and staff stated that their partner organizations and agencies "need this training". The lack of vision, leadership and organization among CSP's many community partners directly impacts the ability of CSP to move forward with conservation efforts. It also means that partners are not able to provide CSP with the decisions or resources needed to move forward. Out of necessity, CSP has taken on an objective of building the capacity of partner organizations and agencies in order to meet their own conservation goals. This is a critically important objective for the region.

Additional trainings provided to CSP since that time include:

- Jolie Sibert, June 2002: fundraising
- Andy Walker, August 2002: Institutional assessment, financial sustainability, board development

Kosrae Conservation and Safety Organization

The Kosrae Conservation and Safety Organization was chartered in July 15, 1998. The group's mission is "to mobilize the people of Kosrae to protect and improve our island environment." Since its inception, the KCSO has been involved in a number of successful conservation projects including the review of a proposed foreign investment project to extract reef fish for the aquarium trade (State government denied the permit) and the Reef Protection Project (includes mooring buoys and monitoring). In 2002, at the urging of the Conservancy, the KCSO Board of Directors was expanded to include nine individuals representing many stakeholders including the public and private sectors, church, legal system and communities - both local and expatriate residents. Together, the new Board determined that the organization should take a much stronger and pro-active role in local environmental issues. The Board hired their first employee, Andy George, in late 2002, and with the help of Willy Kostka, Executive Director of the Conservation Society of Pohnpei, and Patricia Leon, then MIC Coordinator, the group developed a three year strategic plan. The KCSO is focusing their activities in the following three areas:

1. Solid Waste Management/reduction/recycling.
2. Environmental Awareness at the community level.
3. Improving the management of our terrestrial and marine environments.
4. Working with local state leaders to develop and improve environmental policy and legislation.

KCSO with the wide support of the local communities, the State and Municipal governments, Department of Education, Development Review Commission, Kosrae Visitors Bureau, and the local radio and T.V. stations has already began to implement a variety of actions to create environmental awareness. These actions include: a newsletter, website, producing videos to be shown on the cable T.V public channel, "conservation minute" radio spots, community cleanups, boy scout involvement, school visits, field trips, and curriculum development for grades 1-3.

Policies, regulations and agreements

A significant body of environmental law exists in the FSM, and the nation as a whole exhibits a growing legislative commitment to natural resource management and environmental protection.

National Level

At the national level, the source of the National Government's authority to regulate is the FSM Constitution. The Constitution clarifies the National and State Governments' roles in the day to day management of the nation's environment as well as in implementing the FSM's obligations under the various international conventions.

Article VII of the FSM Constitution provides that three levels of government are recognized in the FSM: national, state and local.

Article VIII of the FSM Constitution then sets out the **powers** of the National Government, relative to the powers of the other two levels of government. The FSM Constitution explains that a power that is **expressly delegated** to the national government, **or** a power that is **of such**

an “**indisputably national character as to be beyond the power of a state to control**”, is a national power.” (Article VIII, sec.1). However, a power that is not expressly delegated to the national government or prohibited to the states, is a state power. (Article VIII, sec. 2)

Article IX of the FSM Constitution sets out powers that are expressly delegated to FSM Congress. There are many listed, but the important ones for purposes of our discussion include:

- the power to ratify treaties (section 2(b));
- the power to regulate foreign and interstate commerce (section 2(g));
- the power to regulate navigation and shipping, except within lagoons, lakes, and rivers (section 2(h));
- the authority to regulate the ownership, exploration, and exploitation of natural resources within the marine space of the FSM beyond 12 miles from island baselines (section 2(m)); and
- the authority to promote health by setting minimum standards, coordinating state activities relating to foreign assistance, providing training and assistance to the states. (section 2(r)).

Again, a power that is not expressly delegated to the national government or prohibited to the states, is a state power. (Article VIII, sec. 2)

Article XV of the FSM Constitution provides that a statute of the Trust Territory continues in effect except to the extent it is inconsistent with the Constitution or is amended or repealed.

FSM Code Title 23 – Resource Conservation – Marine Resources

Title 23 has two chapters, one addressing marine species protection and a second addressing endangered species of plants and animals.

Chapter 1, “Marine-Species Preservation,” prohibits the use of certain destructive fishing practices, such as the use of explosives and poisons or chemicals to catch fish or other marine life. It also places time and size limitations on the taking of hawksbill turtles, green turtles, sea turtles, trochus and black-lip mother of pearl oyster shell, and prohibits the taking or molesting of artificially planted sponges.

Under Section 105, no hawksbill turtles or sea turtles may be taken or intentionally killed while on shore and no eggs may be taken. No hawksbill turtle may be taken or killed except whose shell is at least 27 inches, measured over the top of the carapace shell lengthwise. No green turtle may be taken or killed except whose shell is at least 34 inches when measured over the top of the carapace. No sea turtle of any size may be taken or killed from June 1 – August 31 or December 1 - January 31. Sea turtles and their eggs may only be taken for scientific purposes, when permission is specifically given.

Under Section 107, black-lip mother of pearl oyster shell cannot be taken from August 1 – December 31, and must be at least 6 inches in minimum diameter to be taken. There is an exception for takings for scientific purposes.

Section 109 prohibits anyone from intentionally interfering with the growth of trochus in the Trust Territory waters, except as provided in Chapter 1.

Section 110 gives the district administrator, with the advice and consent of the High Commissioner (former Trust Territory titles), the authority to designate and vary open seasons during May through September for such periods of time as deemed advisable for the harvesting of trochus. Certain reefs and sections of reefs may be declared closed, even during open season, and open season may vary in different areas or islands. Notices of open seasons must be filed with the clerk of court.

Section 115 of Title 23, which was added by Public Law 4-71 in 1986, prohibits the commercial taking or killing of marine mammals, including porpoises, whales, seals and dugongs.

Section 116 establishes a penalty not to exceed six months, or a fine of not more than \$100 or both, for violations under Chapter 1.

FSM Code Title 23 – Resource Conservation – Endangered Species Act

Chapter 3 of Title 23, entitled the “Trust Territory Endangered Species Act of 1975,” provides for the protection of species of plants and animals that are threatened with, or in danger of becoming extinct. Chapter 3 declares the indigenous plants and animals of the Trust Territory to be of aesthetic, ecological, historical, recreational, scientific, and economic value, and states that the government’s policy is to foster the well-being of these plants and animals and to prevent the extinction of any species.

Section 306 prohibits any person from taking, engaging in commercial activity with, holding possession of, or exporting any threatened or endangered species of plant or animal listed by regulation. “Threatened species” means a species that is likely to become an endangered species within the foreseeable future through all or a significant part of its range. “Endangered species” is defined as any species which is in danger of extinction throughout all or a significant part of its range.

Exceptions to these prohibitions are provided for certain subsistence uses, for exports for scientific uses under a permit, and for exports of species that are the product of controlled farming.

Section 313 gives authority to the Director of Resources and Development for the Trust Territory for the establishment of conservation and research programs aimed at conserving endangered and threatened species and to acquire land or aquatic habitats for the conservation of resident endangered or threatened species.

Section 314 prohibits the importation of endangered species listed by the Convention on International Trade in Endangered Species (CITES), which may be listed by regulation under the Act. The FSM is not a party to this convention, although the International Plant Protection Convention, 1951, and CITES were applicable within the Trust Territory prior to November 1986, when the FSM signed its Compact of Free Association with the United States.

Section 315 of the Act prohibits the importation of exotic plants and animals except by permit, to prevent ecological upsets, to prevent competition with indigenous plants and animals, and the possible introduction of serious or devastating diseases.

Under Section 316, the government may confiscate any endangered species of plant or animal, or any weapon, gear, or vehicle used in violation of the Act.

Finally, under Section 317, violators are exposed to a fine of up to \$10,000, a term of imprisonment of up to one year, or both.

The *Fish, Shellfish and Game: Endangered Species Regulation (Adopted)*, which became effective in the FSM through adoption of the Trust Territory Endangered Species Act of 1975, sets forth a list of endangered species throughout the former U.S. Trust Territory and the geographical ranges in which they can be found. This list includes the following species with ranges in what is now the FSM: blue whale, sperm whale, Truk Micronesian Pigeon, Nightingale Reed-Warbler, Truk Greater White-eye, Ponape Mountain Starling, Hawksbill Turtle, Leatherback Turtle, Truk Palm and Truk Poison Tree.

FSM Code Title 24 – Marine Resources

Title 24 is intended to promote the conservation, management and development of the marine resources of the FSM within the 200 mile exclusive economic zone, to generate the maximum benefit for the nation from foreign fishing, and to promote the development of a domestic fishing industry.

The Micronesian Fisheries Authority, or MFA, negotiates and enforces foreign fishing agreements, and issues fishing permits. The MFA research section collects data on tuna caught within FSM waters and uses these data to monitor the sustainability of the FSM's tuna fisheries. These data also yield information on other species caught and on by catch.

Title 24 is currently being revised. The new fisheries bill will include provisions that are intended to bring the FSM into compliance with international conventions addressing the conservation and management of marine resources in the exclusive economic zone. The new bill directs the Authority to ensure that management measures are based on the best scientific evidence available and to apply a precautionary approach to the FSM's fisheries resources.

In the new bill, the Authority is authorized to:

- assess the impact of fishing, other human activities and environmental factors on target stocks and species belonging to the same ecosystem or associated with or dependent upon the target stocks;
- adopt conservation and management measures for species belonging to the same ecosystem or associated with or dependent upon the target stocks, so that populations of these species do not become seriously threatened;
- minimize pollution, waste, discards, catch by lost or abandoned fishing gear, and impact on associated or dependent species, and in particular endangered species, through measures that may include the development and use of selective, environmentally safe fishing gear and techniques;

- protect biodiversity in the marine environment;
- take into account the interests of subsistence fishermen;
- collect and share data concerning fishing activities, including catch of target and non-target species and fishing effort and information from national and international research programs;
- promote and conduct scientific research; and
- implement and enforce conservation and management measures through effective monitoring, control and support for the FSM maritime surveillance program.

The Authority is authorized to determine the total allowable level of fishing with respect to any stock of fish subject to Title 24, and may establish allocations of allowable catch, or acceptable levels of fishing effort. These allocations may include restrictions on vessel type, gear type, seasons of operations, areas in which the fishing can take place, or any other restriction relevant to fisheries conservation and management.

FSM Code Title 25 – Environmental Protection

Title 25, Section 610(6) of the FSM Code authorizes the Environmental Protection Board to establish a permit system for the discharge of any pollutant in the air, land or water, or for the conduct by any person of any activity, including the operation, construction, expansion, or alteration of any installation, which results in or may result in the discharge of any pollutant in the air, land or water.

Section 702 requires the National Government and its agencies to submit an environmental impact statement prior to taking any major action significantly affecting the quality of the human environment. The requirement applies to any such action funded in any part by the National Government or its agencies.

The *FSMEPA Earthmoving Regulations*, enacted in 1988 pursuant to Section 610(6), require all persons engaging in earthmoving activities to first acquire a permit. Under the law, permits are issued by the Secretary of the Department of Health, Education and Social Affairs, although in practice these permits are issued by the responsible agency in each state. The earthmoving regulations prohibit the release of funds, equipment, materials, or a building permit to anyone engaged in earthmoving activities without a permit. Earthmoving activities include activities which involve moving, depositing or storing of soil, rock, coral or earth and activities of a continuous nature that disturb or alter the land, such as dredging or quarrying. These activities on reefs or in lagoons also fall under these regulations. Most agricultural, construction and development activities require an earthmoving permit under these regulations. Each state has either adopted the national earthmoving regulations into state law, or applies the national regulations directly.

The *FSMEPA Environmental Impact Assessment Regulations*, enacted pursuant to 25 F.S.M.C. 702, apply to the National Government and to projects funded in whole or in part by the National Government. These regulations require the Secretary of the Department of Health, Education and Social Affairs to submit an environmental impact statement (EIS) prior to the initiation of any action which will significantly affect the quality of the human

environment. Effects may be ecological, aesthetic, cultural, historical, economic, social or health related and may impact land use, population density, air water or natural systems.

FSM Code Title 22 – Quarantine Control

Under Title 22, Section 410 of the FSM Code, all animals and plants or parts thereof, including seeds, fruits, vegetables, cuttings, etc., entering or transported within the FSM are subject to inspection by agricultural quarantine inspectors and may be refused entry into or movement within the FSM if they are known to be, or are suspected of being, infected or infested with disease or pests.

All aircraft and vessels or their cargoes, including baggage, ship's stores, and ballast, that either enter or move within the FSM, are subject to inspection by agricultural quarantine inspectors to enforce quarantine controls and regulations. It is a crime (petty misdemeanor) for anyone to interfere with or refuse to submit to the inspections authorized by Section 410.

Title 22, Section 413 of the FSM Code provides that materials that are brought into the FSM illegally, or that are transported within the FSM illegally or in a manner inconsistent with quarantine regulations, may be seized and destroyed, or seized and returned their place of origin, depending on the pest risk involved.

The FSM's Plant and Animal Quarantine regulations were amended in June, 2000 and contain detailed provisions regarding import restrictions.

FSM Code Title 26 – Historical Sites and Antiquities

Chapter 2 of Title 26 establishes the Institute for Micronesian History and Culture. The Institute is responsible for the oversight, identification, conservation and protection of historical properties and cultural attributes within the FSM. Title 26 requires the Institute to review all development proposals brought to its attention for possible adverse impacts to cultural resources. The Institute is then required to take all steps reasonable and necessary to determine the nature and magnitude of the impact and to eliminate or mitigate any harmful effects. In practice, these duties are performed by the Office of Historic Preservation, which works closely with the historic preservation offices in each State.

The Office of Historic Preservation reviews research proposals that are submitted in connection with requests for research entry permits. The Office requests that prospective researchers sign a "Permit and Agreement" for Sciences and Humanities Research in the FSM with the FSM National Government, through the Division of Archives and Historic Preservation Office. Researchers are asked to provide a short description of the project and its title, whether they propose to conduct research, experimentation, documentation, promotion, or others, to state the period over which their research will occur, to report in writing to the FSM Division of Archives and Preservation at least twice during the course of their projects and to provide copies of preliminary reports and final reports to the Historic Preservation Office of the State within which the research is conducted and to the National Office. Upon completion of the project, the Project Coordinator is to furnish the State with a duplicate original and a copy of the finished work, including reports, photographs, sketches, drawings, pointing, motion pictures, images, video tapes or recording audio tapes or recordings.

Under the agreement, the parties agree that the FSM National Government and the State within which the research is conducted shall share the rights in and authority to reproduce, publish, display or exhibit the finished work product of the project in any manner of the Nation's choosing. But there is no protection for the contents of the report, just for the report itself.

FSM Code Title 50 -- Customs and Immigration

Those entering the FSM are required to obtain an entry permit. Research permits are one category of entry permit issued. The FSM Office of Historic Preservation reviews all requests for research permits.

Title 50, Section 103(8) of the Customs Act provides that researcher's entry permits are issued for research in the fields of endeavor that the President deems in the best interest of the citizens of the FSM. The President must receive permission from the place the researcher intends to stay before granting permission to enter the FSM. The President may also attach conditions or restrictions to researcher's entry permits.

The FSM's entry permit application asks for information on the applicant's "purpose of entry, description of business to be transacted, names and address of company, firm or business you represent and products or services involved, and names and addresses of persons or firms to be contacted (in detail)." Permit applications must be accompanied by a statement that the facts set out are true and correct to the best of the applicant's knowledge and belief and that the entrant understands that throughout the period of the visit he or she is subject to the rules, regulations and laws of the FSM.

The difficulty with law, as written, is that it no entry permit is needed for visits of up to 30 days. Those who enter on visitors permits are able to obtain extensions of up to 60 days, and U.S. citizens may enter for up to one year, until the expiration of the Compact.

FSM Code Title 35 – Copyright

The FSM Constitution expressly provides for intellectual property matters, and delegates to the FSM Congress the power to regulate patents and copyrights. Title 35 of the FSM Code is titled "Copyrights, Patents and Trademarks." However, while Title 35 has a chapter addressing copyrights, no legislation has yet been developed in the areas of patents and trademarks.

Existing copyright protection extends to "original works of authorship fixed in any tangible medium of expression from which they can be perceived, reproduced, or otherwise communicated, either directly or with the aid of a device." These categories of authorship include literary works; musical works and accompanying words; dramatic works and accompanying music; pantomimes and choreographic works; pictorial, graphic and sculptural works, motion pictures and other audio visual works; and sound recordings.

Significantly, copyright protection does not extend to any "idea, procedure, process, system, method of operation, concept, principle, or discovery, regardless of the form in which it is described, explained, illustrated or embodied in the work of authorship."

Protection for published works exists when on the date of first publication, one or more of the authors is a national or a domiciliary of the FSM or is a national or a domiciliary of a

country that is a party to a copyright treaty to which the FSM is also a party. 35 F.S.M.C. 102(4)(a). The FSM has not yet entered into any copyright treaties with other nations. Title 35 permits the President to extend copyright protection on a case-by-case basis yet to authors from other nations that extend similar protection to FSM authors.

The owner of a copyright has the exclusive right to reproduce the copyrighted work, to prepare derivative works based upon the copyrighted material, to distribute copies of the copyrighted work to the public by sale, transfer or lease, and for audiovisual work, to perform the copyrighted work publicly and to display the copyrighted work publicly.

There is a provision for fair use and limitations on exclusive rights that are to be set forth in regulations. No regulations have yet been drafted.

Public Law 7-116 - National Food Safety Act

Public Law 7-116 addresses the importation of food that is adulterated or misbranded. The law establishes a cooperative system between the Secretary of Department of Health, Education and Social Affairs (HESA) and the appropriate State department or agency in administering a food safety program.

If a state has enacted and is implementing food safety standards covering the areas of labeling, packaging, sanitation, food inspection for purity, quality and fitness for human consumption, and other areas of food safety covered in the act, the State only has to meet the minimum standards set out in the act and its regulations. The Act applies to advertisements, articles, food, labeling, and sales intended for interstate and foreign commerce and to food articles imported into the FSM.

Coordination and collaboration between government, NGOs and other entities and community stakeholders

After the 1999 FSM Economic Summit, the FSM President's Council on Sustainable Development (SD) was reconstituted and revitalized (including NGO participation for the first time), and the SD Secretariat was established in the FSM Department of Economic Affairs. However, in recent years, the Council has met irregularly and has also suffered from a lack of credibility with the States due to transportation and communication challenges of getting State representatives to actively participate. When funding has been available, the National government has made efforts to send State government representatives to international meetings or training with or in behest of the National government. The most successful example of cooperation and coordination amongst different levels of government as well as NGOs and the private sector was the recent (2003) completion of the nation's National Biodiversity Strategy and Action Plan. To develop the NBSAP, a national task force partnered with State task forces and through two national workshops and intensive state consultation processes, produced a truly national action plan. The State governments and NGOs are completing State BSAPs to specify how the States will implement the national goals set out in the NBSAP.

Financing for resource management

The Micronesia Conservation Trust, formally established in 2002, is the FSM's main source of in-country funding for biodiversity conservation. The Trust is currently overseeing ten

grants to NGO, government and community organizations, and is working on building an endowment of US\$20 million over the next 5-10 years. The MCT came about as the result of a lengthy and highly participatory process with its origins in the FSM National Biodiversity Strategy and Action Plan (NBSAP). MCT evolved from a series of community and government meetings as a vehicle for distributing funds available for biodiversity and environmental conservation projects to groups which might not otherwise have access to them while improving local capacity to manage projects and project monies. A Steering Committee of public and private professionals and activists in the field consulted with advisors from the Nature Conservancy (TNC) and local conservation organizations in order to develop a structure appropriate for the identified needs and capacity present in the FSM. This structure entailed the establishment of an endowment as well as the development of a “sub accounts” mechanism to allow for flexibility in conforming to external donors’ requirements and priorities.

The MCT adheres to policies and standards set out in its Articles of Incorporation and By-Laws as duly adopted and approved under the laws of the Federated States of Micronesia. It is a charitable and irrevocable corporation organized to manage and provide funds for the accomplishment of the following mission: “to support biodiversity conservation and related sustainable development for the people of FSM by providing long term sustained funding.”

The goals of MCT are to:

- Raise community awareness about biodiversity conservation and related environmental education programs
- Support the conservation of priority natural biodiversity resource areas
- Strengthen the ability of communities, community organizations, government agencies, conservation and development NGOs, and other appropriate organizations to conserve FSM’s biodiversity and sustainably manage its natural resources for the benefit of future generations
- Support biodiversity conservation advocacy

A Board of Directors consisting of nine members governs the Trust, setting policy, approving projects and promoting the work of the Trust in their respective communities. Board representation is based on the division of the FSM into two eco-regions: high islands and low islands with four directors designated from each of the eco-regions; and one Director selected from a prominent International Non Governmental Organization or Foundation.

The Board of Directors has appointed a Technical Committee comprised of eight highly respected FSM individuals recognized in areas of science related to biodiversity conservation, management, community development, research and education. The Committee assesses concept papers and full proposals and prepares recommendations for the Board of Directors for funding projects.

Strategies, plans and related tools

A number of strategies and plans have been developed over the last several years. The plan that is most comprehensive and has the largest stakeholder buy-in at this time is the National Biodiversity Strategy and Action Plan, which was completed in 2002 after a

highly participatory 2 year planning process. The planning process was undertaken by the NBSAP Panel under the President's Sustainable Development Council, and full-time Coordinator was based in the FSM Department of Economic Affairs. The Coordinator manages the planning process which consisted of a combination of statewide meetings & and focused on community workshops supplemented by literature review. The planning process culminated in a national meeting to finalize NBSAP, after which the plan was submitted to SD Council & President and approved.

The long-term vision for the FSM's environment sector stated the NBSAP is as follows:

“The FSM will have more extensive, diverse, and higher quality of marine, aquatic, and terrestrial ecosystems, which meet human needs and aspirations fairly, preserve and utilize traditional knowledge and practices, and fulfill the ecosystem functions necessary for all life on Earth.”

Further, the recommended sector goals and activities have been developed based on the following basic principles developed during the NBSAP consultation process in all four States:

- **Sovereign Rights** - The people of the FSM hold the sovereign rights over their biological diversity;
- **Community-based Approach** - The community is the basic management unit for biodiversity in the FSM – they have the right and responsibility to manage and sustainably develop their biodiversity resources for their benefit and that of future generations;
- **Traditional Heritage** - We will build upon and utilize the rich traditional knowledge and experience of our ancestors to devise and implement strategies for the sustainable stewardship of our rich natural resources; and
- **Ecological Integrity** – We will strive to maintain and improve the diversity and quality of our ecosystems, conserving our biodiversity *in-situ* while enhancing our ecosystems' capacity to adapt to change.

The NBSAP provides national goals and objective for the next five years for eleven thematic areas:

- Species Management
- Ecosystem management
- Genetic Resource Use
- Agrobiodiversity
- Ecological Sustainable Industry Development
- Biosecurity
- Waste Management
- Human Resources and Institutional Development
- Resource Owners
- Mainstreaming Biodiversity
- Financial Resources

Over the last year, each of the four States developed State Biodiversity Action Plans addressing how each entity will meet the national goals and objectives. These plans are

now being implemented using Compact Environment funds and other resources (e.g. local revenues, Micronesia Conservation Trust grants, Federal grants, foundation and private grants).

Acknowledgements

The author would like to acknowledge the FSM Department of Economic Affairs for providing a lot of reports and other materials which were used in this report. In addition, the special assistance of Dr. Katherine Ewel, now retired but formerly with the US Forest Service's Institute of Pacific Island Forestry in Honolulu, Hawaii, Dr. Margie Falanruw of the Yap Institute of Natural Science, and Ahser Edward of the College of Micronesia - FSM are acknowledged

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**Natural Resources, Management and Research Needs for Assessment
for the Coastal and Littoral Marine Ecosystems (CLMEs) of**

**The Republic of the Marshall Islands
(RMI)**

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INTRODUCTION AND BACKGROUND

The Republic of the Marshall Islands (RMI) is part of Micronesia and is one of the most isolated island groups in the world (Spenneman 1988a). This large archipelago of atolls and small islands is located 2,300 miles (3,700 km) miles from the main Hawaiian Islands, but lies only 300 miles south of Wake Island. Kosrae, part of the Federated States of Micronesia, lies about 300 miles east of Ebon Atoll. To the south, Tarawa, the capital of Kiribati is located 415 miles (668 km) from Majuro. The relative geographic isolation of the RMI has a great influence on its biota and its geopolitical relationships which affect resource use and management. Isolation, distance from developed nations and a generally low level of development has kept its resources in a relatively pristine state with a few notable exceptions. Despite the high level of marine biodiversity, and partially because of its inaccessibility, it has been overshadowed in the international scientific and conservation arenas by neighboring biodiversity “hotspots” such as Palau and Hawaii, and thus has not received the full scientific attention its unique resources and human communities might otherwise demand. Moreover, isolation has its penalties as this was a primary reason for it being chosen by the U.S. as the site for extensive nuclear testing and later, as an Intercontinental Ballistic Missile testing site (United States Army Kwajalein Atoll/Reagan Test Site). Its political relationships shaped by these uses have had ramifications for natural resources management and associated science. Similarly, the RMI’s growing political bonds, primarily with Asian fishing nations, promise to have equally significant effects on management, both positive and negative.

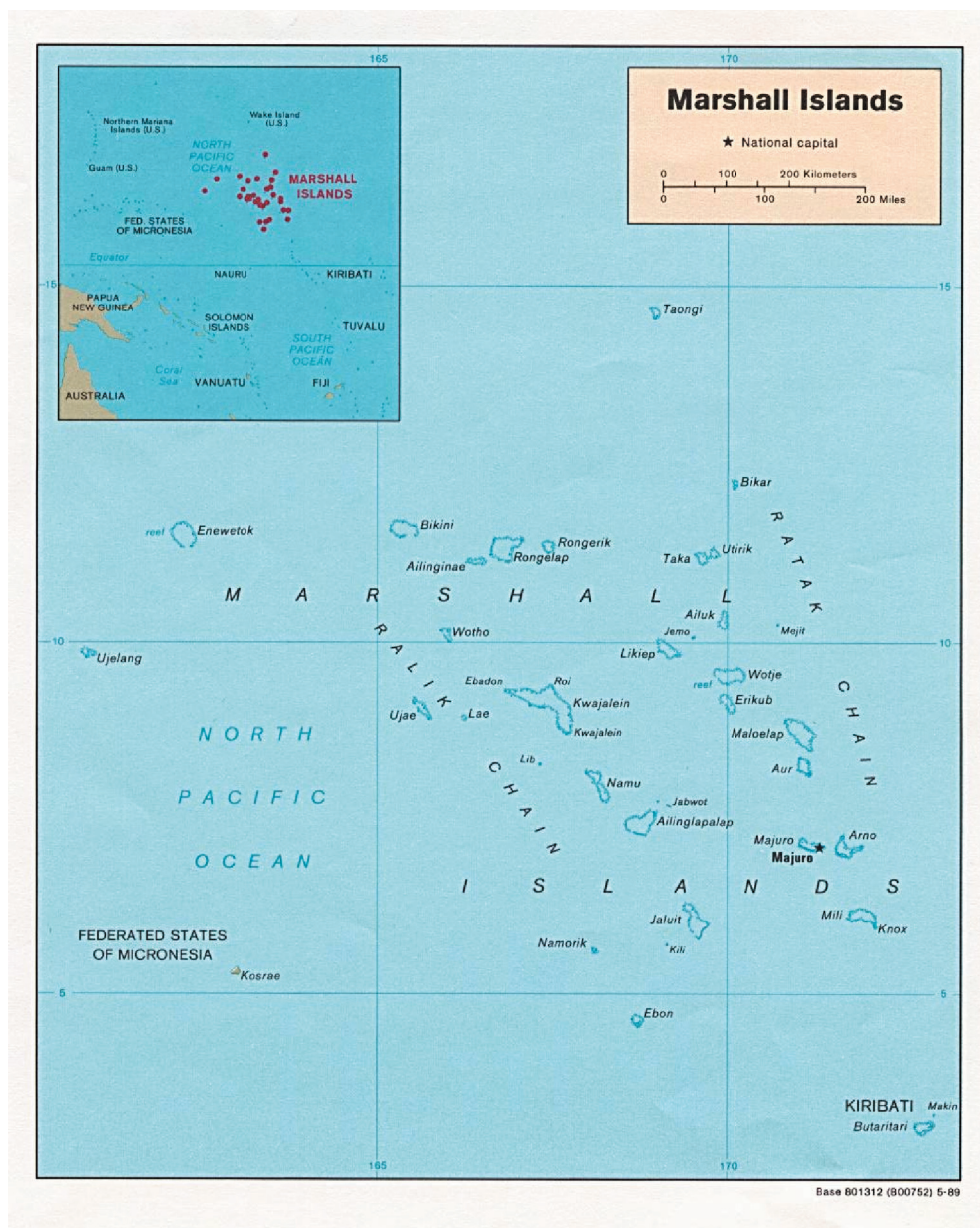
Regional Context and Resources

The Marshall Islands are believed to have been first settled about 2,000 BC by migrants from other parts of Micronesia. Traditionally the Marshallese survived by fishing, limited agriculture and collection of terrestrial-based foods such as coconuts. These islands were first colonized by the Germans in 1885 and control was later assumed by the Japanese during World War I. The Japanese ruled the islands under a League of Nations Mandate until WWII. The islands of the RMI were primarily viewed as important for extractive use, military strategic importance, and in the case of the Japanese, as a target area for Japanese immigration. After a violent interlude in WWII during which the Marshall Islands were important battlegrounds, the Marshall Islands became a United Nations Trust Territory of the Pacific Islands (TTPI) and became largely economically dependent on the U.S. With the signing of the Compact of Free Association (COFA) in 1986 and amendment of the COFA in 2003, economic assistance and services were guaranteed until 2023. The economic aid provided by the U.S. (among other nations) has had contradictory effects on development of the RMI as a nation and the use of natural resources by its residents and others.

Significant environmental and social changes accelerated after WWII. Two northern atolls, Bikini and Enewetok, became the sites of 67 nuclear tests including the largest hydrogen bomb test (Bravo) in 1957. Radioactive fallout from the multiple tests affected atolls as far south as Jaluit, although only two atolls (Rongelap and Utrik) were judged to be affected to a significant degree other than the two test sites. Inhabitants of Bikini, Enewetok and Rongelap were relocated multiple times and to date, only the inhabitants of Enewetok

have re-established a permanent settlement on their home island. Utrik was judged not to be contaminated to the degree that re-settlement was needed. The legacy of nuclear testing continues to this day and plays a major role in the lives of the Marshallese people, their relation with their land and marine resources and geopolitical relations with relations with other nations (see Major Resource Issues). The U.S. presence after WWII and joint programs for health, development and education under the COFA continued social, cultural and environmental changes in the RMI. Although Marshallese have increasingly become reliant on imports for daily needs, exploitation of natural resources has also increased due to introduction of technologies, growing population, access to markets and the presence of non-Marshallese.

Map 1. The Marshall Islands and its location within the Micronesian region.



NATURAL RESOURCES

The Republic of the Marshall Islands became an independent nation in 1979. The RMI was previously a United Nations Trust Territory of the Pacific Islands (TTPI). It is allied with the United States through a Compact of Free Association initiated in 1986, an association which continues under the Amended Compact signed in May 2004. The RMI became a full member of the United Nations in 1991.

The RMI is comprised of 29 atolls and 5 small islands totaling 181 sq. km. (about 70 sq. mi.) of land area, making it the seventh smallest nation in the world. Its islands are scattered over 500,000 square miles at 9 00 N, 168 00 E in the Central Pacific Ocean. The RMI claims an EEZ of 1.99 million km² (18,411 miles), the third largest among the Pacific Islands. These atolls make up about one-tenth of the total atoll area in the world and possess 2.49% of the world's coral cover (World Resources 2001-2002). The atolls of Majuro and Kwajalein are among the largest in the world. The island are roughly grouped in two north-south chains, the Ratak (sunrise) and Ralik (sunset). Wake Island is not part of the RMI as a political entity but lies within 300 miles of Bokak Island and may be considered to be part of the island ecosystem.

The RMI is inhabited by 68,126 persons (RMI census 2002), with most of the population concentrated on Majuro (~30,000) and Kwajalein (~10,000). Growth rate is estimated at 3.88% annually, although local net population growth is ameliorated by emigration to Hawaii, Guam and the Continental U.S. It is estimated that one in five Marshallese live outside the RMI. The GDP (1998) is \$105 million of which \$65 million comes from US Compact funds. The Asian Development Bank estimated that without Compact funds, real GDP would be about \$1200 per capita (ADB 2002). The economy is largely based on fishing and services related to fishing, shipping and supporting the U.S. military activities on Kwajalein. With the exception of tuna and other pelagic fish, few natural products are produced or exported since the decline of the copra industry. Other RMI economic activities include aquaculture (black pearls, giant clams, marine ornamentals), tourism and sports fishing.

Demographics has had and will continue having a direct effect on natural resources management. Aside from a high population growth rate, there is a trend of outer island inhabitants moving to Majuro and Ebeye since WWII, but perhaps accelerated in recent years due to the principal outer-island economic mainstay, copra production, becoming economically unfeasible. Although migration to the highly populated islands continues, outer-island populations are at all time historic highs and have most likely exceeded the local carrying capacity of some islands. Imported foods and goods make outer island survival possible. Although the outer islands are still relatively pristine, impacts from over utilization of resources are becoming noticeable and problematic. These include declines in reef fish stocks and other marine species, salinization of freshwater lenses, deforestation and wood exports (within the RMI), destructive fishing practices, increasing solid waste problems, declines or changes in traditional agriculture practices and alteration of coastlines. Outer islands also suffer from environmental issues such as storms, sea level rise, coral bleaching and drought (particularly in the drier northern islands).

The most highly populated islands of Majuro and Ebeye exhibit the same environmental trends but at exacerbated levels. The very dense populations, low educational level and lack of services such as solid waste disposal are causing impacts that are worsening.

These population centers also act as marketing centers and host non-Marshallese entrepreneurs who often support extractive activities that may impact resources in the RMI while providing little if any long-term benefits to Marshallese stakeholders. It is important to understand that many environmental issues are directly or indirectly linked to activities of non-Marshallese individuals and entities which often wield great economic, technological and political power and may significantly alter resource use patterns. There has always been a significant population of non-Marshallese at Majuro and Kwajalein, generally largely American until recently, that has driven development and introduced new technologies. It is therefore necessary to understand how non-Marshallese residents affect natural resources management when attempting to develop solutions.

While Marshallese traditionally employed customary practices for natural resource management, many of these traditions have been largely forgotten or are no longer followed. Modern pressures and opportunities such as availability of off-shore markets also provide incentives to ignore traditional practices. However, the last few years have seen a significant degree of awareness raising and efforts to revive traditional customs and institute modern resource management that may provide the means to stem or reverse negative trends. Institutional capacity is also increasing for natural resources management and research.

As for so many other island groups that have populations living off-island, one effective strategy for resource management is to include off-island populations in outreach and management efforts since these groups utilize local resources through products sent to them by relatives at home. For example, it is common to send or take fish, turtle meat, giant clams and other scarce marine resources overseas. Off-island communities also represent potential economic, educational and social strengths that can be harness for resource management efforts.

HABITATS, USES, TRENDS AND THREATS

Forests-Eastern Micronesia tropical moist forests

Note: the following section is extracted from the World Wildlife description of Ecoregions found at: http://www.worldwildlife.org/wildworld/profiles/terrestrial/oc/oc0104_full.html, prepared by Sandra Zicus; from WWF 2001.

“The World Wildlife Fund recognizes one ecoregion, Eastern Micronesia Tropical Moist Forests) of which the Marshall Islands is a part. This ecoregion comprises Wake Island, the Marshall Islands as well as the Gilbert Islands group and Nauru. The influence of centuries of human habitation, coconut planting, and violence associated with WWII on the existing vegetation should not be underestimated.

Wake is a small, isolated atoll between the Marshalls and the Northwest Hawaiian Islands. There are three vegetation types: a *Tournefortia* scrub forest with *Cordia* and *Pisonia*, a *Lepturus* grass cover with *Tribulus cistoides* and *Portulaca lutea*, and a *Pemphis* scrub margins on the lagoon side of the atoll (Herbst 1994).

The Marshall Islands border the typhoon belt, and have a wet season from May through November. There is also a north-south climatic gradient, and the climate ranges from semi-arid in the north to very humid in the south. This climatic variation is reflected in the vegetation of the islands. With the exception of the two northernmost islands, Taongi (also known as Pokak) and Bikar, the vegetation of the islands is very similar. Taongi contains the least disturbed vegetation in the Marshalls, and includes only 9 species of vascular plants (Mueller-Dombois & Fosberg 1998).

Often surviving as a windbreak, mixed broadleaf forest is the most common vegetation type in undisturbed areas of the Marshall Islands. Of low to medium stature with a closed canopy, this forest type contains only a small number of tree species, such as *Tournefortia argentea*, *Guettarda speciosa*, *Pisonia grandis*, *Pandanus tectorius*, *Allophylus timoriensis*, *Cordia subcordata*, *Hernandia nymphaeifolia*, and *Thespesia populnea*. There are also a few shrubs, and an herb layer with low species diversity that may include *Lepturus repens*, *Thuarea involuta*, *Fimbristylis cymosa*, and *Polypodium scolopendria*. A few species of epiphytes are also found in the wetter southern areas.

In the interior parts of the islands where forest still exists, there are remnants of almost pure stands of tall, clear-trunked *Neisosperma oppositifolium*, which possibly constitute a final successional stage. The dense canopy of *N. oppositifolium* creates a heavy shade, where few other species can survive. Today, these forest remnants are found only in the relatively moist northern atolls (Thomas et al. 1989).

Another monodominant community in the Marshalls is the *Pisonia grandis* forest, which was formerly very common and widespread throughout the Indo-Pacific. Up to 30 m tall, with trunks more than 2 m in diameter, *P. grandis* has a smooth pale trunk, and a soft, brittle wood. There is little or no understory or herb layer in the *Pisonia* forest, and the ground is covered with a thick brown spongy humus layer of semi-decomposed leaf litter. The trees are a favored roosting and nesting site for several species of seabirds, and the droppings from these birds causes a phosphate hardpan layer to develop under the humus in some of these areas. Other monodominant communities of *Tournefortia argentea*, *Suriana maritima*, and *Pemphis acidula* also occur in the Marshalls (Mueller-Dombois & Fosberg 1998).

The rate of endemism is low in the ecoregion due to small island areas, low habitat diversity, and harsh conditions.

Although common in temperate regions, monodominant forest communities are unusual in tropical ecosystems. They probably occur in the Marshall Islands because of the stressful environment (salt spray, periodic typhoons, etc.) and the low number of species of atoll flora (Thomas et al. 1989). *Pisonia grandis* monodominant stands are now one of rarest forest types left in the Marshall Islands, because of the ease of felling the trees and the fact that the fertile, organic-rich soil is ideal for growing coconuts (Mueller-Dombois and Fosberg 1998).

Four Secondary Endemic Bird Areas were delineated in the ecoregion by Birdlife International. Two endemic species occur, or occurred. One is the now extinct Wake Island rail (*Gallirallus wakensis*), which was last seen in 1945 and is presumed to have been eaten by the occupying Japanese forces. The other endemic is the Vulnerable Nauru reed-warbler

(*Acrocephalus rehsei*). The purple-capped fruit-dove (*Ptilonopus porphyraceus*) has been extirpated from Ebon atoll in the Marshalls (and the ecoregion), but is otherwise widespread in the Pacific (Pratt et al. 1987). In addition, the restricted-range species Micronesian imperial-pigeon (*Ducula oceanica*) is resident and the widespread but vulnerable bristle-thighed curlew (*Numenius tahitiensis*) winters in the Marshalls and Gilberts (Stattersfield et al. 1998, Hilton-Taylor 2000).

There are no native mammals in this ecoregion.

The atolls of the Marshall Islands, especially Taongi and Bikar, are extremely important as rookeries for seabirds such as great frigatebirds (*Fregata minor*), brown boobies (*Sula leucogaster*), red-footed boobies (*Sula sula*), wedge-tailed shearwaters (*Puffinus pacificus*), red-tailed tropic birds (*Phaethon rubricauda*), sooty terns (*Sterna fuscata*), white terns (*Gygis alba*), and brown noddies (*Anous stolidis*) (Thomas, et al. 1989)” (WWF 2001).

Status and Trends

There were no on-going or recent studies of terrestrial habitats found during research for this report. The most recent published material is the National Biodiversity Report (2000) which presents brief overviews of some trends. The decline of the copra industry is hypothesized to perhaps be a factor in changing terrestrial ecosystems. Copra producers regularly replant and harvest coconuts, and tend large areas of the atoll with the goal of promoting optimal growth of coconuts. This often includes clearing understory plants. When coconuts are no longer harvested and are left on the ground, food sources increase for coconut crabs, rats and other animals. The rebounding understory when copra farmers no longer clear the land may also increase habitat for some species, but may not be representative of the original growth and may include invasive plants. Copra producers also tend to visit the more remote islets within an atoll system and establish a temporary bases there during copra making, thus increasing extraction of resources from these localize areas. The recent diminishing of income from copra production also increases incentives for extraction of other resources such as fish or wood. There also appears to be renewed interest in other forms of agriculture. For example, the RMI has several unique cultivars of *Pandanus*, reputed to be among the tastiest in the Pacific. *Pandanus* is used to make a variety of food including several that were traditionally storage forms for times of food shortages. Banana and taro cultivation are also beginning to solicit more interest. Agriculture in general is increasing on Majuro, due to the promotion of gardening by a Taiwanese sponsored project. Harvest and export of wood in the outer islands for local use and export to Majuro occurs, but no information is available as to the status of this activity. Production and use of coconut oil as a biofuel has potential to help outer islands economies and reduce reliance on fuel imports.

One issue of interest is the fate of terrestrial ecosystems on the nuclearly affected islands of Enewetok, Rongelap and Bikini. Enewetok and Rongelap are in the process of re-settlement and have been subject to extensive clean up effort and infrastructure creation. Although residents are cautioned not to consume terrestrial sources of food due to lingering radiation, reports of consumption have been made. Ecosystems monitoring is merited in particular for these islands to track recovery from the major disturbances and to guide management efforts by the re-settled populations.

There are few studies of terrestrial fauna since the National Biodiversity Report. More attention is needed to document changes in terrestrial habitats and their fauna and flora.

Freshwater and brackish habitats

Freshwater habitats are generally scarce in the RMI and drinking water is a serious issue on many Marshallese islands. Most atolls have a shallow Ghyben-Herzberg freshwater lens under the surface but these are subject to depletion through overuse, reduction during drought or saltwater intrusion. Some northern atolls lack freshwater lenses. The NBR (2000) lists 6 types of freshwater or brackish habitats: inland lakes, tree holes/small freshwater reservoirs; taro pits; large artificial reservoirs; *Bruguiera* communities; and *Sonneratia* communities. Inland lakes occur on Wotje, Lekan and Kwajalein. Tree holes accumulate water on all islands and provide habitats for insects, including mosquitoes. These were used or created by the early Marshallese as a means of accumulating or storing drinking water. Most inhabited islands also have taro pits, which are becoming scarce on some islands. The only large freshwater systems are the municipal water collection areas.

Four species of mangrove are found in the RMI: *Bruguiera gymnorrhiza*, *Lumnitzera littorea*, *Rhizophora mucronata* and *Sonneratia alba* (Woodroffe, 1987). Mangrove communities are typified by *Sonneratia* or *Rhizophora* spp. growing along the intertidal zone. *Bruguiera* communities and basins (wetland depressions) tend to be found in lower-salinity inland depressions (*pat*). Distribution appears to be partially related to precipitation as *Bruguiera* is lacking in the drier, Northern islands. *Bruguiera* is believed to have been cultivated to some extent by the Marshallese for use in stabilizing coastal lines, canoe parts, wood and dye. Spenneman (1998b) postulates that *Bruguiera* and the freshwater eel (*Anguilla celebensis*) which inhabits *Bruguiera* depressions may have been imported from the East, possibly Kosrae or Pohnpei, as a “wetlands improvement package”.

The principal wetland areas in the RMI are listed by Wetlands International (2005) as:

1. A small tidal pond with mangrove-fringed channel in the centre of Majej (Mejit) Island, a low coral island in the Ratak Chain.
2. Several small stands of mangroves on Arno Atoll (Ratak Chain).
3. Mangroves in small depressions on islets in Ailinglaplap Atoll (Ralik Chain).
4. Mangroves in small depressions on islets in Jaluit Atoll (Ralik Chain).
5. A small stand of *Bruguiera gymnorrhiza* in Bikini Atoll (Ralik Chain), probably introduced by man.
6. A small stand of *Rhizophora* mangle in Enewetak Atoll (Ralik Chain), presumably introduced by man.
7. A small freshwater pond in the central depression of Ellep (Lib) Island, a low coral sand island in the Ralik Chain.
8. A small, enclosed saline lagoon in one of the two main islands in Namdrik (Namorik) Atoll (Ralik Chain).

Status and Trends

Little information is available on freshwater habitats. There is concern that as global climate change accelerates, the changes in weather patterns will exacerbate the problems already experienced by the northern islands during the dry season and other islands during El Niño years with lack of freshwater.

No recent studies of mangrove use have been conducted although anecdotal evidence exists that mangrove removal may be accelerating as urban development and infrastructure projects grow. The authors have personally observed reduction in mangrove in Jaluit due to airport causeway construction. There is also export of wood from Jaluit to Majuro but the magnitude of this export is unknown.

The RMI has only recently been participating in Ramsar activities. Jaluit Atoll has been listed as a Ramsar site based on the mangrove areas and has now passed the management plan into law.

Marine Ecosystems

Being comprised mainly of atolls and a few small islands, there is much more marine habitat to consider than terrestrial. Despite its importance to the Marshallese, its overall importance as 2.5% of the world's entire coral reef habitat and the mandate of certain U.S. Federal Agencies to assist in managing Pacific Island resources, it can be said that the marine habitats of the Marshall Islands are woefully under-studied and management in the formal sense is miniscule in comparison to the need.

Coral Reefs

All atolls and islands possess coral reefs that form the basis for human existence on these islands. Most major types of reef environments (slopes, flats, pinnacles, passes, etc.) are found among the RMI islands. Coral reef systems are a major part of all RMI atolls and small islands and can be subdivided into lagoon reefs (slopes and flats), ocean reefs (slopes and flats), pinnacle reefs, inter-island reef flats, reef passes and mid-ocean pinnacles. The coral reefs of the Marshalls are home to a high diversity of marine species, although the full magnitude of species presence, ranges, abundances and endemism is not fully known. Many of the RMI atolls are essentially unexplored by scientists although much local knowledge exists that requires documentation.

A fairly high degree of biodiversity is found for coral reef organisms and the reefs are generally in good conditions, particularly those in the outer islands. Approximately 860 species of fish, 362 coral species, 40 sponges, 1,655 mollusks, 728 crustaceans and 128 echinoderm species occur. In addition, 27 species of marine mammals and 5 turtle species have been observed (Richmond, et. al. 2002). New species continue to be identified as reef research has begun anew in recent years. A new species of coral, *Acropora rongalapensis* was found on Rongelap in 2002-2003 (Richards and Wallace, 2004), and two specimens from Namu suspected to be new species are currently under examination (Pinca, pers. comm.).

To date coral reef/fish surveys have been conducted in a sporadic manner. The earliest significant work took place just before and after the U.S. utilized the northern Marshallese

Islands as site for 67 nuclear tests between 1948 and 1958. A marine laboratory was established by the Atomic Energy Commission in 1954 on Enewetok and served as the base for lagoon studies on Enewetok and other Northern Atolls.

Extensive geophysical, biological and ecological studies were carried before and after the nuclear tests in the Northern islands yielding perhaps the most comprehensive study of coral reef atolls for their time, and perhaps even to this date. Much of this work is summarize by H.S. Ladd in “Bikini and Enewetok Atolls, Marshall Islands”, in Jones and Endean, 1973. Of particular interest was the 1951 success of efforts at Enewetok to drill nearly 5000 feet through the limestone base of the atoll to the basaltic underlayer, thus providing the first evidence to support Darwin’s theory of the formation of atolls.

Status and Trends

While RMI government agencies and resident scientists and managers are making good progress, the effort required to manage the resources of a nation with 40 remote islands with irregular transportation and communication is difficult to muster. One positive trend is that the creation of a marine science program at the College of the Marshall Islands (CMI) has attracted a core group of well-qualified marine scientists and resource managers who, with the collaboration of growing teams of professionals at Marshall Islands Marine Resource Authority (MIMRA) and Environmental Protection Authority (RMI-EPA), have ended the nearly 30 year hiatus of marine science studies. This group of professionals has not only brought increased scientific expertise, they have also worked to fund-raise, served to catalyze and coordinate efforts, and conduct outreach. In their role as teachers and mentors they aim to provide support to new cohorts of students and young professionals to enable them to enter careers in science and management. There is also increasing awareness of all major stakeholder groups that pressures on resources are increasing and that actions must be taken to understand and manage their resources.

Major threats include pollution, anchor damage, and dredging, particularly in urban areas. Over-fishing and over-harvesting of shellfish and other marine resources are threats on all atolls.

Within the last three years, coral bleaching and coral disease have begun to be documented in some areas of the RMI, although the date of first occurrence is not known. It was first noted in 2000 that the average sea temperature in the RMI was around 84 degrees F (29 degrees C), close to the upper limit where coral can persist in a healthy state (NBR 2000) but coral bleaching had not yet been observed in the RMI although bleaching events were occurring in other parts of the Pacific Islands. Temperatures recorded at Enewetok show water temperature reaching the coral bleaching temperature benchmark during the summer (June-August) period in 1985, 1987, 1989, 1992, 1993-1997, and 2001 (NOAA 2004). The first noted case of bleaching was in 2001 and occurred in a limited area of Majuro lagoon (Pinca 2002). Dr. Dean Jacobsen has begun studying patterns of bleaching and disease in coral in Majuro lagoon and ocean reefs which have intensified since, but appear to be of a much lesser degree than that observed in other areas of the Pacific Islands such as Palau. He has also documented a recent outbreak (2004) of Crown-of-Thorns (COT) starfish and accompanying coral destruction (Jacobsen 2004, pers. comm.), but preliminary

results are insufficient to determine whether the increased abundance of starfish constitutes an outbreak or indicates the need for eradication campaigns. Documentation of outer island occurrences of bleaching or COT outbreaks are sparse due to the general absence of qualified observers.

Dr. Silvia Pinca of CMI has led a series of marine surveys on 6 atolls starting in 2002 (see section on Information and Studies, below), and but has not noted coral bleaching on islands other than Majuro. One author of this report has observed a moderate degree of coral bleaching in some areas of Jaluit lagoon in 2003-2004 and extensive areas in Namdrik in August 2004 (Haws, pers. obs). Although water quality measurements were not made during the surveys in Namdrik, which were primarily for the purpose of selecting pearl farming sites, the water in the inner reaches of the lagoon seemed very warm and turbidity was high. Namdrik residents reported that coral had begun dying in 2002, that the degree of turbidity was a relatively new phenomena and that a previously uncommon orange sponge had begun covering and smothering coral in the southern part of the lagoon. This sponge was photographed but has not been identified. Namdrik lagoon is small with only a shallow pass. The population is high (~800) and multiple sources of organic pollution were noted. Fishing pressure is high and few large fish were seen. Eutrophication may be occurring in this lagoon. It is difficult to determine which atolls may be experiencing ecosystem changes and the magnitude of the changes simply because trained observers rarely if ever visit most islands and few outer island residents have an opportunity to report their observations.

Coral reefs are also threatened by destructive and illegal fishing activity. Report of destructive fishing practices are increasing although use of explosive and cyanide are relatively rare compared with other Pacific areas. Destructive fishing practices have been reported in Jaluit, Mili, Enewetok and Majuro. Further monitoring is required.

Shark finning has been an issue of concern, but mostly for pelagic sharks although there are some indications that the shark finning vessels were encroaching on the atolls' limits and perhaps even fishing in the lagoons. It was an activity of concern to coral reef ecosystems as some target sharks move between the lagoon and open-ocean areas. Sharkfinning was rampant until the major fishing company was closed down in 2004 and may have possibly affected marine ecosystems in the RMI as top predators were removed; again, documentation is lacking. The Marshall Island Billfish Club reports that billfish and ground fish such as snappers and groupers are also decreasing in size and number in Majuro lagoon which may also affect reef populations. Interviews with outer islanders reveal that fish sizes and total catch are believed to be decreasing (Berger 2003; Baker, pers. obs.; Haws, pers. obs.).

Gleaning of shallow coral reef areas is also a use which has intensified on the more populated islands. On the more remote islands, extraction may also be increasing, particularly for small molluscs such as the Ebon honey cowry (*Cypraea helvola*) and the Utrik Wut (*Melampus luteus*), which are used extensively in handicraft manufacture and found only on those islands. Ebon residents reported that shell abundances were decreasing, causing concern, particularly since this is one of the few exports from this islands (Kumabe, 1999). In 1999, Sea Grant and the College of the Marshall Islands conducted a survey of shell

resources and provide training in management methods. The RMI is also famed for several other seashell such as rare Golden Cowry (*Cypraea aurantium*) which are sold for \$50 to \$100 in Majuro to tourists. Giant clams (tridacnids) are another concern although there are three giant clam hatcheries in the RMI. Most cultured clams are exported to the aquarium trade. As in most other Pacific Islands, giant clam restocking efforts have largely failed in the RMI. Management effort may be more effective, but little concerted effort has been made despite wide spread declines in abundance. Although all species of giant clams are listed under CITES and require a permit from MIMRA for export to the US or Guam, it is common to see ice chests with frozen clam meat being taken out of the RMI by travelers. More control at the receiving ports of Honolulu and Guam might help stem this.

Seagrasses

Seagrasses are considered to be rare in the RMI. Documented seagrass beds include two (*Thalassia hemprichii*) in Ujelang and Ailinglaplap, and one in Majuro (*Cymodocea rotunda*). *Halophila minor* is reported in Kwajalein (Thomas et. al. 1989). Seagrasses are relatively little studied in the RMI (NBS 2000) and may be more extensive than documented.

Status and Trends

Very little is known about the current status of seagrasses. One report from Ebon in 2000 reports that seagrass beds were in decline and being taken over by *Halimeda* thus affecting seashell harvest, but no apparent cause was noted (Kumabe 1999).

Intertidal areas

Intertidal areas are found both on the seaward and lagoon sides of atolls. These may differ significantly in their community composition and human use. These areas are regularly harvested for shellfish and other invertebrates, with gleaning being particularly intense on Majuro and Ebeye.

Status and Trends

Although ubiquitous, very little research specific to intertidal habitats has been done since the marine surveys conducted during the Enewetok and Bikini ecological studies of the 1950's. Beaches and intertidal areas are currently threatened by urban development, erosion and contamination.

Fisheries and fisheries habitats

Principal fisheries habitats include lagoons, fringing reefs and open-ocean. Open ocean fisheries are primarily conducted by commercial fishermen and to a lesser extent by artisanal fishers who generally lack the boats, fuel and gear needed to take advantage of the pelagic fish stocks. For certain islands such as those lacking lagoons, experiencing over fishing in the lagoon or suffering from ciguatoxic fish (e.g. Jaluit), the ability to fish in the open ocean but relatively close to shore takes on a greater importance.

The RMI licenses a large number of fishing vessels and has worked actively to position Majuro as a convenient port of call for the fishing fleets to off-load catch and obtain fuel and services. Until November 2004, Majuro had a tuna loining plant; upon its closure

around 700 jobs were lost and the attraction of Majuro for landing catch decreased. The number of fishing vessels licensed in the RMI had already dropped dramatically since the heyday of 1998, falling from 385 to 238 in 2003. In part this reflects the migratory nature of the tuna fisheries, with ships following the tuna which ranges widely through the Central and Western Pacific. This also is reflected in the decrease in transshipping fees as fewer tuna are landed in the RMI.

Lagoon fishing is conducted by most male adults and many women in the RMI using a variety of vessels and gears. Most commonly small aluminum boats with outboards are used, although some islands still employ the traditional outrigger for fishing. Nets and handlines are the most common gears. Fish is a dietary staple for most Marshallese and most, particularly in the outer islands consume fish every day when it is available. Some islands such as Namdrik suffer from shortages of reef fish and have increased take of turtles as a response (Haws, pers. obs.).

Status and Trends

Aside from the marine surveys conducted by CMI and MIMRA, which do not specifically focus on fisheries habitats but rather selection of areas of high biodiversity for designation as MPA's, little work has been done to characterize fisheries habitats or monitor fish populations. Generally fisheries habitats are still largely intact except in areas where urban development, pollution or coral bleaching have affected reefs. There is a need for long-term monitoring of fisheries habitats and fish stocks.

There are two general categories of fisheries stocks in the RMI; pelagic and in-shore. The commercial pelagic fishery is mostly conducted by vessels owned and operated by foreign entities, although there is a small local fleet. The RMI has made efforts in the last 10 years to become an attractive port for off-loading and processing tuna and providing services to the fishing fleet. There is also a large merchant marine registry. Majuro has become a regional center for off-loading tuna and other pelagics, much of which is caught outside the RMI EEZ. The RMI, like most Pacific Nations, does have an observer program (although under-staffed) and keeps records of catch. The general trend in recent years is towards fewer vessels and lower landings due to the decrease in tuna stocks (MIMRA, 2004). All tuna species are considered either maximally exploited or over exploited by the Western Tuna Commission.

In-shore (within 12 miles) and lagoon fisheries are reserved for Marshallese fishers, although violations by foreign vessels do occur. MIMRA has establish landing and cold storage fisheries facilities on 6 outer islands (Arno, Ebon, Jaluit, Mili, Ailinglaplap and Namu). MIMRA transports the stored fish to Majuro and Ebeye for sale. Presence of these facilities has allowed outer island fishers to sell some of their catch and provides incentives to extract more fish. The Fish Base on Majuro oversees sales to local retailers and keeps records of the catch and sales. The manner of collecting catch data assort the fish into five categories of disparate species according to consumer preference. While total catch and weights are taken, the data is not adequate to truly monitor the status of the fisheries of those islands. The only *in-situ* fisheries monitoring effort is a joint project of MIMRA and the Japanese Overseas Fishing Corporation which is currently collecting creel data

from 5 fishers in Arno Atoll. This information has not yet been released (Haws, 2005). The Majuro Billfish Club, a sport fishing organization, has years of catch data on billfish and pelagics (e.g. marlin, swordfish, tuna) and ground fish (e.g. snappers, groupers) which have won the monthly and annual tournaments. This data has not been analyzed but could provide interesting information on trends of the target species.

The following table (**Table 1**) lists the most commonly targeted reef fishes and their current retail price if purchased at the MIMRA Majuro Fish Base. The categories are listed according to consumer preference with Category A being considered most desirable (information originally obtained from Florence Edwards/MIMRA (2004), modified by Haws with assistance from M. Trevor). Note that scientific names are not included due to the probable inaccuracy; there is a great deal of confusion as to the corresponding Marshallese, English and scientific names for many fish. The database “FishBase” (Froese and Pauly 2005) includes listing of scientific and Marshallese names; local specialist on nomenclature for Marshallese fish species, Mike Trevor, contends there is a high rate of error for their listings.

Table 1: Categories and prices of commonly consumed reef fishes by consumer preference.

Category	Species (Marshallese name)	Species (English name)	Price per pound (wholesale is quantities greater than 50 pounds)
A	Mole Bejrok Aotak Muramur	Streamline Spinefoot Rabbit fish Lowfin and Highfin Rudder unknown	Retail: \$2.25 Wholesale: \$1.75
B	Jato Jera Mon Kwi Bwilak Lojebjeb Kuban	Paddle tail snapper Squirrel fish Soldier fish Lined surgeon fish Orange spine unicornfish Highfin grouper Convict tang	Retail: \$1.85 Wholesale: \$1.50
C	Motal Kiro Jo Dijin Mejmej Berak	Dash and dot goat fish Camouflage grouper Yellowfin goatfish Spotcheek Emperor Big eye bream Orange spot Emperor	Retail: \$1.45 Wholesale: \$1.25
D	Mera Batakclaj Jojo Molmol Ael	Parrotfish (green) Unicorn fish Flying fish Mackerel scad Black surgeon fish	Retail: \$1.10 Wholesale: \$0.95
Others		Lobster Octopus	Retail: \$3.00/Wholesale: \$2.50 Retail: \$2.00/Wholesale: \$1.50

There is limited activity with collection of ornamental marine fish. One collector has been working out of Majuro for over 15 years, and a few more individuals have recently attempted to enter into collection and trade. Limited transportation from Majuro to the US and Asia have generally limited this activity. Culture of some marine ornamentals (fish and invertebrates) is promising as one large company has established fairly reliable shipping to the U.S. MIMRA is beginning a survey of marine ornamental fish in Majuro lagoon in June 2005.

Fisheries habitat and fishing

Aside from recent marine surveys (Pinca 2003-2005) which do not specifically focus on fisheries habitats but rather selection of areas of high biodiversity for designation as MPA's, little work has been done to characterize fisheries habitats. Generally fisheries habitats are still largely intact except in areas where urban development, pollution or coral bleaching have affected reefs. There is a need for long-term monitoring of fisheries habitats and fish stocks.

Agricultural and animal husbandry

Marshallese traditionally cultivated a variety of plants and trees as food sources (see Table 2). Other modern crops are also cultured.

Status and Trends

Agriculture is considered to be in a general decline in modern times, particularly on the more populated islands. However, efforts have resulted in renewed interest in agriculture such as the Taiwanese-supported gardening project in Laura, Majuro and a banana project on Namdrik. Generally locally produced food is insufficient to sustain the growing population, a partial factor in the reliance on imported foods and the resulting epidemic of nutritionally-related disease such as heart disease, diabetes and stroke. Increased agricultural effort could partially compensate for declining fisheries resources and incomes, but technical support and seed funding would be needed to make it a significant contributor in the modern context.

Approximately 21 species were also cultivated for medicinal or non-food purposes such as for use in poisoning fish (Spenneman, 2000).

Animal husbandry is generally limited to pigs and chickens. Often little food is provided to the animals since they are left free to wander and forage at will. Pigs in particular may cause environmental impacts through digging, producing erosion and contamination of water sources. On some islands, people prefer to keep pigs contained on the lagoon side of the atoll because wastes are removed by the tides. This may be a contributing factor to eutrophication of some lagoons such as Namdrik, which appears to be suffering from this problem.

Table 2. Traditional Marshallese Food Plants (Spenneman, 2000).

Scientific name	Common name	Marshallese name	Edible parts	
			Normal times	Emergency
<i>Alocasia maccrohiza</i>	Giant taro	babai	Tubers	
<i>Artocarpus mariannensis</i>	Breadfruit (w. seeds)	mä	Fruit, Seeds	
<i>Artocarpus altilis</i>	Breadfruit (no seeds)	mä	Fruit	
<i>Boehemia nivea</i>		armwe		Leaves, grated wood
<i>Cocos nucifera</i>	Coconut	ni	Nuts, Sap,	Old wood
<i>Crinum bakeri</i>	Spider lily	kieb	Roots, Stem	
<i>Cyrtosperma chamissionis</i>	Swamp taro	jaraj	Tubers	
<i>Ixora casei</i>				Grated wood
<i>Musa sapientum</i>	Banana	binana	Fruit	
<i>Pandanus tectorius</i>	Pandanus	böb	Keys (Pulp)	Keys (Seeds), Roots, Bark Sap
<i>Tacca leontopetaloides</i>	Arrowroot	makmök	Tubers	
<i>Triumfetta procumbens</i>		ata		Leaves, grated wood
<i>Wedelia biflora</i>		markubwebwe		Leaves, grated wood

SPECIES OF CONCERN

The Marshall Islands have a lower degree of terrestrial biodiversity given the more limited number of habitat types than in other Micronesian Island groups. According to the National Biodiversity Survey, there are about 700 native species of land animals and only 80 species of native vascular plants. A fairly large number of introduced plants and animals now occur. Marine biodiversity is much higher than terrestrial with over 1,000 species of fish in 157 families.

An overview of endemism is provided in Table 3 from the National Biodiversity Survey (2000). New species are still being described.

Table 3: Summary statistics of fauna and flora of the RMI (NBS 2000).

Classification	Total # species or subspecies	# native species	% native species	# endemic to RMI only	% endemic to RMI only	# endemic to Micronesia and RMI	% endemic to Micronesia and RMI	# endangered, threatened, extinct	% endangered, threatened, extinct
Vascular plants	724+	342	47%	3	0.41%	5	0.7%	-	-
Non-vascular plants	256	256?	100%	-	-	3	0.85%	-	-
Fauna	5097+	1182	23.2%	46	0.9%	76	1.49%	296	5.8%

Endangered/ Threatened Species

There are multiple species that are rare, endangered, threatened or otherwise of concern. Please note that tables (4 and 5) below do not provide an exhaustive list of species of particular concern in the RMI as there are significant gaps in the various lists and databases.

Many of these species and their status are poorly researched or updated. Sea turtles are one of the few groups that recently has received attention. NOAA commissioned a report in 2004 to assess the cultural, economic and ecological importance of sea turtles. This study, executed by Michael McCoy (2004), comprehensively reviews past efforts and presents the results of a very thorough investigation. Sea turtles have cultural importance. They form an important part of the diet mainly as an alternative to fish and for serving at cultural celebrations. Most participants in the study report that sea turtle abundance is decreasing. The report makes recommendation including efforts towards better public awareness and protection of nesting habitat, particularly on the islands of Bikar, Wotje, Taka, Jemo and Erikub. Turtles may become more threatened if steps are not taken to better manage the near shore and lagoon fisheries as turtles are the first alternative to consuming fish.

Table 4: Endangered and Threatened Species of the RMI (NBS 2000) and IUCN Redlist (2005).

Scientific Name	Common Name	Status and Comments*
Mammals		
<i>Megaptera novaeangliae</i>	Hump back whale	Vulnerable
<i>Stenella longirostris</i>	Long-beaked dolphin	Least concern
<i>Feresa attenuata</i>	Pygmy killer whale	Data deficient
<i>Lagenodelphis hosei</i>	Fraser’s dolphin	Data deficient
<i>Mesoplodon densirostris</i>	Blainville’s beaked whale	Data deficient
<i>Mesoplodon ginkgodens</i>	Ginkgo-toothed beaked whale	Data deficient
Reptiles		
<i>Eretmochelys imbricata</i>	Hawksbill turtle	Critically endangered-nesting population;
<i>Chelonia mydas</i>	Green turtle	Endangered-nesting population;
<p>Note: Sea turtles are an important special occasion food in the RMI. Loss of traditional conservation practices and the unchecked harvesting of turtles is contributing to the endangered/ threatened status. Turtle harvesting is regulated in national legislation but this is not enforced. Loggerhead (<i>Caretta caretta</i>), Pacific Ridley (<i>Lepidochelys olivacea</i>), Leatherback (<i>Dermochelys coriacea</i>) also occur in the RMI and are considered endangered or threatened, but are not included on the IUCN Red List.</p>		

Scientific Name	Common Name	Status and Comments*
Birds		
<i>Gallirallus wakensis</i>	Wake Rail	Extinct
<i>Ptilinopus porphyraceus</i>	Purple-capped Fruit-dove	Extirpated from the RMI, now found only in Kosrae.
<i>Phoebastia nigripes</i>	Black-footed albatross	Endangered
<i>Ducula oceanica</i>	Micronesia Imperial pigeon	Nearly threatened. Reported as extirpated on several atolls in the RMI and Kosrae. Still found on Arno and Mili, small population re-introduced to Majuro.
<i>Tryngites subruficollis</i>	Bluff-breasted sandpiper	Nearly threatened
<i>Numenius tahitiensis</i>	Bristle-thighed curlew	Vulnerable
<p>Note: It is thought that some parts of the Marshall Islands provide important breeding grounds for migratory bird species, however, there is insufficient data on this. (See National Biodiversity Team, 2000). Also reported and considered of concern are: Short-tailed albatross (<i>Diomedea albatrus</i>), Buller's Shearwater (<i>Puffinus bulleri</i>), Band-rumped Storm Petrel (<i>Oceanodroma castor</i>).</p>		
Fish		
<i>Cheilinus undulatus</i>	Humphead wrasse	Endangered
<i>Carcharodon carcharias</i>	Great white shark	Vulnerable
<i>Epinephelus lanceolatus</i>	Giant grouper	Vulnerable
<i>Nebrius ferrugineus</i>	Tawny nurse shark	Vulnerable
<i>Rhincodon typus</i>	Whale shark	Vulnerable
<i>Thunnus obesus</i>	Bigeye tuna	Vulnerable
<i>Urogymmus asperrimus</i>	Porcupine Ray	Vulnerable
<i>Epinephelus fuscoguttatus</i>	Brown marbled grouper	Near threatened
<i>Carcharhinus amblyrhynchos</i>	Gray reef shark	Least concern
<i>Carcharhinus limbatus</i>	Blacktip shark	Least concern
<i>Carcharhinus longimanus</i>	Oceanic whitetip shark	Least concern

Scientific Name	Common Name	Status and Comments*
<i>Carcharhinus melanopterus</i>	Blacktip reef shark	Least concern
<i>Hexanchus griseus</i>	Bluntnose sixgill shark	Least concern
<i>Isurus oxyrinchus</i>	Shortfin mako	Least concern
<i>Prionace glauca</i>	Blue shark	Least concern
<i>Triaenodon obesus</i>	Whitetip reef shark	Least concern
<i>Aetobatus narinari</i>	Spotted eagle ray	Data deficient
<i>Doryrhamphus dactyliophorus</i>	Banded pipefish	Data deficient
<i>Eurypegasmus draconis</i>	Little dragonfish	Data deficient
<i>Manta birostris</i>	Manta ray	Data deficient
<i>Syngnathoides biaculeatus</i>	Alligator pipefish	Data deficient
Invertebrates		
Marine		
<i>Tridacna gigas</i>	Giant clam	Vulnerable-national law
<i>Hippopus hippopus</i>	Bear paw clam	Least concern-national law
<i>Tridacna maxima</i>	Small giant clam	Least concern-national law
<i>Tridacna squamosa</i>	Fluted clam	Least concern-national law
<p>Note: Giant clams are an important subsistence and special occasion food in the RMI. Loss of traditional conservation “mo”, small-scale commercial operations and in some instances harvesting for illegal export are contributing to a serious depletion of clams on most atolls. There is a viable commercial ornamental clam farm on Majuro atoll with hatcheries and farms being developed on other atolls. Export by travelers largely uncontrolled.</p>		

Scientific Name	Common Name	Status and Comments*
<i>Birgus latro</i>	Coconut crab	Data deficient. Coconut crabs have been an important subsistence food in the RMI in the past, however increasing human populations, loss of “mo” and habitat loss have resulted in severely depleted populations.
Corals (various spp.)	Corals form the basis of the fragile ecosystems of the RMI. Various anthropogenic activities affect the health of the corals. A fledgling industry is developing for farmed coral for the ornamental aquarium market. Corals are a major attraction for the fledgling dive tourism industry. Recent surveys are extending the range of some species and discovering possibly new species.	Some species may be threatened. Economically important.
Terrestrial		
<i>Paludinella semperi</i>	land snail	Data deficient
Plants		
Jaluit Mangrove	Unknown	A species of mangrove was observed on a remote islet of Jaluit Atoll which is possibly a previously unidentified species.

Economically Important Species

The top species with economic importance in the RMI are listed in Table 5. Nearly all species of fish and many terrestrial plants and animals would have some social, economic or cultural role. Only the most notable in terms of commercial use or sensitive status are listed here.

Table 5: Economically important species of the Marshall Islands

Scientific Name	Common Name	Status and Comments*
Black-lipped pearl oysters	Black-lipped pearl oysters occur naturally and are being farmed for pearl production. There are viable pearl farms on Jaluit, Arno and Namdrik.	Economically important Populations very low on islands such as Mili and almost non-existent on others.
Bottom fish, rainbow runners (various spp.)	Various species of food fish provide an important subsistence food source as well as the basis for commercial fisheries on several atolls. Increasingly, evidence shows that some of the key target species are being fished at unsustainable levels (e.g. indications of reduction of stocks of rabbitfish on Arno atoll).	Economically important
Groupers (various spp.)	Groupers are an important subsistence and commercial food fish in the RMI. In addition, they are target species of the live reef food fish trade, which is known to operate in the RMI from time to time.	Economically important
Reef sharks (various spp.)	Reef shark have been fished in recent times for the Asian market in shark fins. There is anecdotal evidence from divers that their populations are being severely depleted in certain areas due to this unreported and unregulated fishing. Shark are economically important as a major attraction in the fledgling dive tourism industry.	Possibly threatened Economically important

Scientific Name	Common Name	Status and Comments*
Sea cucumber (various spp.)	While not generally used for food within the RMI, sea cucumber is known to be harvested and exported for the Asian market.	Economically important
<i>Pandanus</i> (various spp.)	The RMI is home to several rare cultivars of pandanus, which is an important subsistence food in the RMI.	Economically important
“Nin” <i>Morinda citrifolia</i>	Important plant for local medicine. Currently there is a viable small-scale commercial operation producing “Nin Juice” and it is being explored for its potential as a major cash crop for the RMI.	Economically important
Trees for wood	Although more and more construction is done using man-made materials, on the outer islands trees are an important source of timber for firewood and construction of houses.	Economically important
Coconut	For over 100 years, the copra industry was the main activity in the cash-economy. In recent years the global price of copra has dropped and this industry is now heavily subsidized by the government as an income-redistribution mechanism. Attention is now on coconut oil as an alternative fuel source and soap making.	Economically important
Breadfruit	Important plant in subsistence agriculture.	Economically important
Sport-fish (Marlin, tuna, wahoo, mahi-mahi etc.)	There is a vibrant sport-fishing industry in the Marshalls. This attracts mostly local participants, but there is a fledgling sport-fishing tourist industry.	Economically important.

Invasive Species

Invasive species were introduced either accidentally or purposely. While early Micronesian voyagers are theorized to have introduced many of the species considered “native” today, the trend of large and damaging numbers of introductions began in WWII and is believed to have accelerated since. See Table 6.

Table 6: Summary of Invasive Species of the RMI (source-NBS 2000 and personal observations of the authors).

Vascular plants	Invasive plant species causing harm in the RMI include <i>Paspalum diticum</i> , <i>Casuarina equisetifolia</i> , <i>Miconia calvensus</i> , <i>Antigonon leptopus</i> , <i>Lantana camara</i> and <i>Bidens pilosa</i> . (National Biodiversity Team, 2000)	Invasive
Animals	Over 42 invasive animal species are listed in the National Biodiversity Report (National Biodiversity Team, 2000). Species of major concern include mealybug, coconut scale, giant African snail, brown tree snake, and various species of non-native lizards. In addition, outbreaks of crown-of-thorns have been observed in recent times. Given the international debate over the processes of crown-of-thorns outbreaks, it is not known if this is a major concern.	Invasive
Fungus	There are 25 listings of pestiferous or potentially pestiferous fungus in the National Biodiversity Report (National Biodiversity Team, 2000)	Invasive
Algae	Non-native species of <i>Eucheuma</i> has been introduced for culture. Unknown if established after pilot farming studies, but has been shown to be an invasive for reef systems.	Potential invasive
Others	There are several other listings for diseases affecting agriculture, and algae and coral disease in the National Biodiversity Report.	

ABIOTIC ASPECTS

Physical Factors, Climate, Geology

All of the Marshallese islands are either atolls or low coral islands. The highest elevation is about 3 meter above sea level. The size of the atolls ranges from Kwajalein, reputed to be the largest atoll in the world, to the smallest atoll of Bikar. There are numerous small islands with five being considered large enough to name and inhabit (Lib, Jabot, Kili, Mejit, Jemo). Like all atolls, the RMI atolls were formed by coral formation on top of sinking, ancient volcanoes. Darwin's theory of atoll formation was provided with conclusive evidence in the Marshalls when cores taken from Enewetok finally penetrated depths sufficient to find basaltic rock. Marshallese atolls tend to be large, have deep lagoons and a number of scatter islets concentrated on the windward sides of the atoll.

All Marshallese islands are considered vulnerable to storms and drought due to their low elevation, small land masses and lack of freshwater sources.

The wet season is considered to be from May to November. Rainfall varies from north to south with the northern atolls being much drier than the southern; in some years the northern islands may receive little if any rainfall. Total rainfall can range from 750-1,000 mm in the northernmost atolls to over 4,000 mm on Jaluit. Rainfall is more consistent in the southern atolls and the drier northern atolls have a more restricted rainy season from September to November. Average rain days per month range between 9 in February and 14 in October.

Since some of these lack freshwater lenses, surviving droughts can be problematic for humans, animals and plants. Droughts during El Niño years have often required that desalinization equipment be taken to the outer islands. The annual rainfall appears to be decreasing with an annual mean of 137 inches in the 1960's to 129.5 in the 1990's (RMI Climate Change Website <http://unfccc.int/resource/ccsites/marshall/>).

Average temperature is 81-82 °F throughout the year, with the minimum temperature being 77 °F, and maximum monthly temperature averaging 85-87 °F degrees, with the peak temperature of 87 °F in September-October. (NOAA 2005).

Infrastructure Development, Aggregate Mining, Causeway and Seawall Construction and Land Reclamation

Since independence and the signing of the Compact of Free Association with the United States, the Marshall Islands has embarked upon extensive infrastructure development, especially at the urban centers of Majuro and Ebeye. Activities include dredging, residential and commercial construction, road building, aggregate mining and hardening of the coastline through the building of seawalls. One common method of disposing of waste is to use it to fill in shallow areas on both the lagoon and ocean sides of the atolls and use this filled area for construction. This has destroyed natural habitats in the most concentrated parts of these atolls, while less developed portions of the atolls are increasingly threatened by human encroachment and development. On the outer islands there is increasing infrastructure development including the construction of airport runways and roads, resulting in aggregate mining from the reef flats.

The relatively small amount of land means that land is at a premium, particularly in the urban centers of Majuro and Ebeye. Reef flats are commonly reclaimed as land using discarded vehicles and heavy machinery as fill. This machinery is usually not stripped of fluids before being placed on the reef flat.

The construction of causeways has occurred to significant extent on Majuro and Ebeye. This has had an unmeasured effect on the flushing of water in the lagoon. In Jaluit, a causeway has been built that directly affects the flushing of the protected Mangrove area.

The road on Majuro was paved in 1998-1999 with Japanese Aid (Saipan Tribune 2000). Although greatly beneficial to facilitating movement around the island, it has also led to an explosion in the number of cars which will lead to increased fuel consumption, pollution, traffic jams, and issues related to disposal of cars and parts such as batteries and tires. One local resident called the road the one of the worst impacts on the Majuro lagoon as the hardened surface increases rapid run-off from rain causing lagoon-side erosion and leading to more litter being carried to the lagoon. The Majuro lagoon is already literally carpeted with waste, particularly in the urbanized D-U-D area (Daritt, Uliga, Delap).

There is little data on anthropogenic or naturally occurring erosion and sedimentation processes. However, significant changes in the coastline of Majuro atoll from both types of processes can be observed from aerial photographs.

A large commercial dry dock has been proposed for construction near the Uliga dock in downtown Majuro funded by Taiwanese investment funds. The dry dock would service fishing vessels. This has prompted controversy as there is concern this would cause increased impacts to the already damaged Majuro lagoon through increased traffic, waste, erosion and other factors (C. MacClennen, 2005).

Solid and Hazardous Waste and Sewage

Rapid urbanization and the relative affluence of urban centers has given rise to serious waste and pollution problems in the Marshall Islands, particularly on Majuro and Ebeye. The waste and pollution poses many serious threats to coastal ecosystems ranging from excessive nutrient loading in the marine environment to poorly-managed landfills. Landfills are usually created by building sea-walls (open structured “gabions” of aggregate encased in wire mesh) on reef flats. These waste landfills have numerous problems. Cover material is obtained by dredging and even then is not sufficient to create a sanitary landfill. Leachate from the landfill is issued directly into the marine environment. Usually the bulk of the volume of landfill is below the high-water mark and water washes through the filled material. There is no separation of liquids, chemicals or hazardous wastes before depositing into the landfill.

There are no primary sewage treatment plants in the Marshall Islands. Raw sewage is discharged ocean-side on Majuro and lagoon-side on Ebeye. Outside the major urban centers, sanitation facilities vary but in all cases raw sewage is discharged into the marine environment or else is stored in cesspits which can leach into the marine water or into the fresh-water lenses.

Climate Change and Sea-level Rise

Climate change and sea-level rise poses a serious threat to the coastal ecosystems of the RMI. Aside from the actual impact of sea-level rise on the available land area of the low-lying atolls, the linkages between coral bleaching and temperature increase give cause for concern for the health of the coral reef and the processes of land-formation. In addition, any rise in sea-level could cause salinity in the fragile fresh-water lenses that provide water for land-based agriculture.

Nuclear testing

Although the last nuclear test in the RMI occurred over 47 years ago (in 1958 on Enewetok), the Marshall Islands continues to be affected by its nuclear legacy. The present day status of the northern islands and their people is complex and the veracity and significance of many of the statements and claims made in reference to nuclear testing can be difficult to evaluate. *The purposes of the following discussion is not intended to necessarily validate or negate any of the claims made by any parties, but to provide a brief summary of historical events and present an overview of issues, perceptions, and debates that may affect natural resources management or those working in these areas.*

Nuclear tests were conducted at two northern islands, Enewetok and Bikini; residents were relocated prior to testing. Inhabitants of Rongelap, 150 km away were affected by fallout to the extent that its people had to be evacuated after a few days. Rongelapese returned in 1957 after being assured of the safety of living on Rongelap, but were then re-evacuated with assistance by GreenPeace after symptoms of radiation exposure and lack of adequate living conditions continued. Rongelap is only now beginning to be resettled. Enewetok was re-settled in 1980 after an extensive clean-up costing \$218 million. Bikinians have delayed resettlement due to their judgment that funding was insufficient for clean up efforts that would be required to mitigate unsafe conditions (Bikini Atoll Website, 2005). Utrik atoll was also significantly affected by fall out but was not evacuated.

Affected residents of the four islands have been subject to a host of medical problems, particularly thyroid abnormalities, cancer (Simmons 2005) and birth defects (Eknilang 1995). In reference to the latter, many Marshallese cite the occurrence of birth defects among people exposed to radiation but no scientific documentation of this exists. The Nuclear Tribunal has allowed claims for the birth of mentally retarded children under certain circumstances (Nuclear Claims Tribunal 2005). Residents of the four nuclear-affected islands are eligible for compensation for damages related to medical conditions possibly linked to nuclear testing under Section 177 of the Compact of Free Association which provides for compensation to affected persons over the 15 years of the Compact.

The Marshall Islands Nationwide Radiological Study was a comprehensive radiological monitoring program conducted throughout the Marshall Island from 1989 to 1995 to assess past and present radiological levels and the health status of exposed individuals, with a focus on the four nuclear-affected islands. A summary of this study can be found at http://radefx.bcm.tmc.edu/marshall_islands/ (Simons, 2005), as well as in the official report made to the governments of the U.S. and RMI (Simons and Graham, 1994). All but four islands in the RMI (Jabot, Lib, Nadrikdrik, Namdrik) were found to have been affected

by varying doses of radiation. This study found that radiological conditions presented no threat to the current or future generations, although conditions on the four islands merited special precautions and remedial actions (Bikini, Enewetok, Rongelap and Rongerik). Elevated levels of thyroid cancer were also noted and further study recommended for this disease. A Nationwide Thyroid Disease Study was later conducted of Marshallese born before the end of nuclear testing. The findings of this research indicate that a high level of thyroid cancer and benign nodules were found in the test subjects. An earlier hypothesis put forth that effects of radiation may have been more widespread in the Marshall Islands than previously suspected, perhaps extending beyond the four nuclear affected islands, was not supported by the data (Simons, 2005) as there was no correlation between thyroid disease and distance from the test sites excepting the four main islands.

Many Marshallese and others continue to dispute the findings of the studies, long-term ramifications and the level of responsibility that the U.S. should continue to assume for remaining affects of the nuclear tests (Government of the RMI, 2000). Aside from the medical effects of the direct exposure to the blasts and fallout, serious social, political and psychological impacts continue due to the displacement, migration, and real and perceived health risks of the affected residents of the outer islands.

Despite extensive surveys conducted at Bikini and Enewetok before and after the testing, the full and long-term ecological impacts of nuclear testing are not fully documented, particularly since the time after the closure of the Enewetok laboratory, and debate continues over some of the previous research results. The terrestrial ecosystems of the northern islands still have significant amounts of radioactive isotopes despite extensive and costly clean up efforts. Island residents believe that radiation has been responsible for a number of biological changes in plants and animals, particularly some commercially valuable species such as the arrowroot. The clean-up efforts themselves involved large-scale removal of vegetation, top soil and infrastructure construction. It is not clear whether any long-term impacts to the marine ecosystems from radiation exist. Radiological studies have cleared fish from the lagoons for human consumption. Blast craters still exist, but the extent of the impact remains largely unexplored (National Biodiversity Survey 2000).

A current controversy that could have wide ranging effects is the condition of the concrete dome put in place over the blast site on Runit Island, Enewetok and responsibility for its maintenance. This massive dome (30 feet deep and 250 feet wide) covers a bomb crater that was filled with tons of plutonium-contaminated soil from the island's cleanup. Runit island was judged to be off limits for 250,000 year due to its high degree of radioactivity. The consequences of not maintaining the dome or the possible impacts of sea level rise that might flood the dome are unknown. No agency is responsible for monitoring the dome and the RMI government has requested that an US agency be assigned this responsibility (Zackios 2005).

Resettlement of the nuclear-affected islands brings up conservation and management issues as well. Left largely without human interference for over 50 years, Bikini, Enewetok and Rongelap have habitats and natural communities that are in some ways among the most pristine in the world (overlooking the question of remaining radioactivity). Enewetok has a population of 715, Bikini is largely unsettled except for the staff of a small dive operation

and Rongelap is only beginning resettlement and also has a small tourist industry. The latter two islands communities recognize the value of pristine marine ecosystems for tourism and are taking steps to utilize this asset (Bikini Atoll Website 2005; Rongelap Atoll Website 2005). As the people of these islands return, or seek ways to utilize the islands for activities such as tourism and aquaculture, residents will be faced with resource management issues of how to conserve and manage their resources within the context of each island's special needs.

The final story of the nuclear tests and their significance to the Marshallese and the rest of the world has still not been fully played out. Those working in natural resources management or research in the RMI should be prepared to understand the historical context and current issues related to nuclear testing and their linkage to resource management.

Kwajalein and Military Uses

Kwajalein is one of the largest atolls (2850 sq km lagoon area) in the world. It is comprised of 100 islands totaling 17 sq km (6.3 sq miles) of land area making it the largest land mass in the RMI. Kwajalein was the first RMI island captured by the U.S. during WWII and has remained under military control since. The Kwajalein Lagoon is routinely used as the target site for Inter-Continental Ballistic Missile (ICBM) tests launched from Vandenburg Airforce Base in California and monitored by facilities on Kwajalein, but serves other military functions as well. The installations are managed by Kwajalein Range Services (KRS-a partnership of Bechtel National, Incorporated, Lockheed Martin, and Chugach) under contract to USAKA (United States Army Kwajalein Atoll). Raytheon previously managed the facilities. USAKA is responsible for the environmental quality of the islands occupied by them and the impacts of activities including environmental, social and cultural aspects. USAKA relies on a number of US agencies for environmental management. Joint quarterly meetings are held with corresponding RMI branches of government. Marshallese on Kwajalein mostly live on the famously crowded island of Ebeye, which has a land surface area of 0.14 sq miles.

The use of Kwajalein and the conditions under which it is leased are controversial in the international and national arenas for many reasons. Kwajalein land owners believe environmental impacts associated with military activities are occurring and are disputing the leases and payments for 11 of the islets occupied by U.S. Military infrastructure (Kwajalein Landowners Association, 2005). There are also national issues associated with the socioeconomic condition of the densely populated island of Ebeye, home to 10,000 Marshallese and one of the most impoverished in the Pacific (ADP 2003).

These are complex issues which deserved careful consideration by anyone interested in the natural resources of Kwajalein. The resources may be among the best preserved in some aspects including intact *Pisonia* forests and populations of fish such as the humpheaded wrasse now rare in other areas. Species of concern found at Kwajalein include: dolphins, whales, giant clams (tridacnids), sea turtles, coconut crabs and 54 bird species.

An overview of information on environmental management by USAKA can be viewed at: <https://www.denix.osd.mil/denix/Public/News/Earthday97/Awards/Kwajalein/kwaj.htm> l#ENVIRONMENTAL%20CHALLENGES while a contrasting view from the Kwajalein Land Owners can be accessed at: www.kwajalein.org.

RESOURCE MANAGEMENT ISSUES

Isolation and Diversity of Atolls

The geographic spread of the atolls creates an issue for resource management. While the legislative framework for resource management is strong, the difficulty of patrolling and enforcing the laws across the EEZ, and also even across a single large atoll are compounded by the distances and lack of adequate transport infrastructure. This has resulted in much fishing and harvesting activity which occurs “under the radar” including the live reef food fish trade, which are known to have used destructive practices such as poisons. Transportation has improved within recent years to the degree that long-term scientific research and monitoring can take place in the RMI, albeit with difficulty. Only a few researchers and managers currently live in the RMI and their ability to attend to all research and management needs is stretched thin, particularly considering the difficulty in obtaining funding for a geographic area that lacks the international profile among scientific communities as compared to areas such as Palau.

Loss of Traditional Resource Management Knowledge

Increasing affluence, urbanization and reliance on imported foods along with the migration of many chiefly families to the urban centers has resulted in loss of traditional resource and conservation management knowledge and enforcement. Much of the work done on resource management in recent years has focused on reviving traditional concepts of conservation and resource management such as “mo”- generally atoll-specific rules about the harvesting of resources. Opportunities include building on this concept, and at the same time introducing modern management concepts and improved information about resources to the communities.

Incentive/ Disincentive systems

One of the major challenges for appropriate management of resources is the complex system of incentives/ disincentives that are in play, leading to over-exploitation of resources.

A case study representing this situation was described in the CBNA (Baker and Chutaro, 2005).

“The complex situation leading to over-exploitation of biodiversity resources can be seen currently on Mili Atoll. Mili, as with many atolls, became engaged in the Copra trade over 100 years ago. The effort and land required for Copra production involved the loss of much of the traditional subsistence agriculture, such as Taro. The introduction of imported foods, particularly rice and flour was seen as a convenient, affordable and stable source of starch that required little time or effort to prepare.

With the decline in prices of Copra over the last few years, and despite heavy government subsidies, the private sector has stopped transporting Copra, claiming that there is no longer any profit margin in the industry. In addition, government supply vessels who provided supplies to the islands and collected the raw copra have reduced their services. Despite claims

from the Ministry of Transport & Communication that vessels are visiting each atoll at least quarterly, the last visit to Mili by a government supply vessel was reported to us as October 2003[about an 8 month gap].

Mili does not have a small-scale commercial fish-base, as do many other atolls, which provides alternative income to copra, and is somewhat regulated. Many of the fish on Mili atoll are ciguatoxic.

Currently a locally-based fishing and transport company is visiting Mili on a regular basis, and requesting that the local population harvest reef fish, sea cucumber, lobster, giant clam and reef shark fin for trade or sale with the boat. The people of Mili claim that with the loss of the copra trade, they have little option but to engage in this activity, or go hungry.

The lack of access to services from the mainland, along with the dependence on imported foods and the drop in copra prices has led to the community of Mili being vulnerable to exploitation of its marine resources in an unregulated and potentially very destructive manner.”

Mili is not a unique case- many other atolls and communities in the Marshall Islands face similar conditions and hardships that leave them vulnerable to unsustainable exploitation of their resources. A lack of awareness leads to situations such as allowing foreign live reef fish trade within their atolls” (Baker and Chutaro 2005). Growing populations and declining resources are expected to result in worst scenarios in the near future.

The opportunities to respond to this situation are to gather improved socio-economic information, identifying ways to reduce the perverse incentives leading to this situation (such as improving inter-island transport) and to establish alternative income-generating activities on the outer islands.

Establishment of Protected Areas

One key strategy that is being developed in the RMI is to establish marine protected areas (MPAs). This is in-line with the traditional “mo” conservation techniques, which were often defined as areas of reef that could not be fished at certain times of the year, or for certain species, or using certain fishing techniques. Various initiatives to establish MPAs are underway (described in more detail in the governance section of this report). Recent work done by this contributor (Baker), assessing the progress made in the implementation of the Jaluit Atoll Conservation Area, found that community education and awareness programs had been inadequate and also the degree of consultation was inadequate to achieve consensus on a workable conservation plan. Anecdotally, similar issues are being identified in other areas where there is an attempt to establish MPAs. In general, this reflects a lack of capacity and skill in change management. An opportunity is to build capacity in participatory planning techniques and in designing and delivering community education and awareness programs. A further opportunity exists in sharing “lessons learned” between the different groups attempting to establish MPAs.

Fisheries

Fisheries emerges as a major management challenge because of the crucial role fish play in the Marshallese diet and the role of fish as the major export commodity, in contrast to the immense challenges presented towards managing the resource. Major issues to do with coastal fisheries management are lack of information on catch sustainability and general lack of capacity in terms of trained individuals to work in fisheries management. Catch data is being collected, however it is inadequate to provide information on the fish stocks. A change in methodology, and increased involvement of the fishermen in the data collection could yield far more useful information on stocks. See section on Fisheries Habitats and Fishing.

Other

Many occurrences of potential interest go unreported or unsubstantiated in the RMI due to lack of trained personnel on the outer islands and lack of any channels of communications for outer islanders to report when something of interest is observed. For example, one author of this report (Haws) visited Namdrik in August 2004. During the visit, dried carcasses of seabirds were observed hanging in trees. When questioned, residents reported that large flocks of at least two species of bird numbering in the thousands had arrived at the island flying in from the west several months before, roosted in the trees, then died in large numbers. The precise species were not identified, but the larger species appeared to be a booby species, while the other principal species was smaller and dark in color. As far as is known, this is the first report of seabird die-offs in the RMI.

KNOWLEDGE AND INFORMATION BASE FOR MANAGEMENT

Sources of information and research efforts

The table below describes the key datasets for coastal ecosystem management available in the RMI. Most of this information is in the early stages of development. For example, reef surveys carried out in the last few years represent the first major studies of this kind and form baseline data. Resources and funding to continue these on a periodic basis need to be established to monitor changes in the reef ecosystem over time.

In addition to these datasets, there is a Coastal Geology Survey of Majuro carried out by SOPAC and US Army Corps of Engineers survey of biological resources on Majuro, Kwajalein and Arno.

Table 7: Available databases and sources of information (Note: this table was initially produced in the appendices to the CBNA (Baker and Chutaro 2005) and has been updated for this report.

Holding Organization	Information/ Datasets	Description	Most recent date	Format	Status/ Availability/ Accessibility
CMI	Marine Dive Survey Results - Bikini Atoll - Mili Atoll - Rongelap Atoll - Ljiekiep Atoll - Namu Atoll - Majuro Atoll	Survey using a modified AIMS method. Fish, benthic community, invertebrate data are collected.	2002 2003 2003 2001 2004 2004	Printed Report	Available from CMI upon request
	Manta Tow Survey - Arno Atoll	Snapshot of biodiversity: substrate composition, photo database and presence of algae.	2004	Printed Report (including photos)	In progress pending further surveys on Arno. Available mid-June.
RMI EPA	GIS	Coordinates describing the Jaluit Atoll Conservation Area, locations of sewage outfalls and seawalls, vegetation change on Majuro, aerial photos and satellite images of some atolls. Further information is being gathered on 4 atolls under the EPA Coastal Management Program Area.	2004	GIS Database	The RMI EPA reports that there are partial datasets including satellite and aerial photos and GIS files.
OEPPC	National Biodiversity Report "Living Atolls Amidst a Living Sea"	Comprehensive overview and listing of known species of flora, fauna and other living organisms in the RMI, including Marshallese names and uses.	1999	Printed Book	Available from OEPPC or from stores on Majuro for \$35 per copy. Was distributed to the Ministry of Education and other stakeholders at publication.

Holding Organization	Information/Datasets	Description	Most recent date	Format	Status/ Availability/ Accessibility
MIMRA	Oceanic Catch Data- Transshipment Records & Observer Records	Data includes tonnes of fish transferred, size of fish and type of fish (tuna species). Also records of by-catch and discarded catch recorded by observers, and reports of incidents involving marine mammals (dolphins, whales) and turtles.	Ongoing	Electronic	Data reported to SPC and FFA for regional tuna stock assessment and for input into development of tuna management plan.
	Coastal Fisheries Data	Data includes total weight from each outer island fishery and cost to MIMRA to purchase, across 5 fish categories according to consumer preference.	Ongoing	Paper and electronic	Data was held in spreadsheets but there was no backup and data was lost in a computer crash. Currently paper records are being reentered into spreadsheet. At present, electronic data available only to 1998.
	Aquaculture Export Data	Species and number of specimens exported	Ongoing	Paper and electronic	
	OFCF Stock Assessment of Arno	Stock assessment of clams and rabbitfish.	2004		At time of writing, data being compiled.

Institutional and individual capacity for research and management

Professional Capacity

Professional capacity is the main capacity issue in the RMI in terms of research and resource management. There are only two degree-qualified scientists amongst Marshallese nationals working in resource management. The issues surrounding this lack of capacity have been explored in more detail in the CBNA (Baker and Chutaro, 2005).

Key areas of need for educated professionals in the RMI include:

- Environmental Science/ Marine Science;
- Water Quality Monitoring;
- Resource Management;
- Resource Economics;
- Environmental Education;
- Human Resource Management;
- Information Management;
- Geographic Information Systems; and
- Management and Planning.

Areas of training need identified in the CBNA include:

Technical Skills

- SCUBA diving and marine survey techniques
- Taxonomic knowledge of corals
- GIS data management
- Aquaculture training
- Aquaculture integration with MPAs
- Development of community-based fisheries
- Manage data and information on coastal fisheries

Outreach and education

- Design and development of community outreach programs
- Development of school environmental curriculum

Organizational skills

- Management of employees/ Human resources development
- Policy development
- Strategic planning, monitoring and evaluation
- Project management/ budget and work plan preparation

Physical Infrastructure

Physical infrastructure is reasonably good on Majuro. The RMI EPA has the following resources for coastal zone management:

- a small 15 foot boat for carrying out coastal measurements and inspections; several sets of dive gear;
- low-tech GIS database workstations and a GPS basestation;
- access to vehicles; and
- access to compressors at CMI or at local dive operations.

MIMRA and CMI possess similar facilities with the exception of the GIS equipment. CMI has two laboratory facilities located at the main campus and at the Land Grant office in Laura, Majuro that includes a pearl oyster hatchery and agriculture research capabilities. Outside Majuro the access to boats and dive compressors becomes far more difficult. Most researchers have so far transported all equipment and goods from Majuro. The Jaluit Conservation Project is establishing a small office and dive facility that conceivably could be used by researchers. The Jaluit High School is also the site of an Asian Development Bank Vocational Training Center with modern training facilities including computers. The settlements at Rongelap, Bikini and Enewetok could also serve as research facilities. Several commercial dive operators have vessels and dive equipment that could be used for research. There are hatcheries with working and living facilities on Mili and Arno. USAKA at Kwajalein could also serve as facility for researchers.

Communication between most islands except Majuro and Ebeye is limited to CB radio. Telephone systems are currently being installed on Jaluit and Wotje, the regional outer island centers.

In general, research and training could be conducted at almost all islands although requirements for bringing required gear and resources would vary greatly. Workers might also be required to exercise a great deal of patience with the irregularity of transportation and be willing to live under local living conditions. Another positive aspect is the general willingness of outer island residents to assist with research and the well known Marshallese hospitality.

Funding Issues

Access to outer islands, particularly to carry out research and to collect information requires significant expenditure. The adequacy of funds to work on the outer islands varies greatly, but the RMIEPA has a greatly increased budget, however the allocation and disbursement of funds needs to be improved to allow easier acquisition of satellite images and equipment, and to facilitate the necessary travel. MIMRA and CMI departments are also increasing research and management funding. Ignore comment above, Funding for coral reef surveys and stock assessments has been done on a project-by-project basis, largely driven by Dr. Silvia Pinca at CMI Marine Science Unit. Aquaculture research and extension, and some coastal management efforts, have been funded through joint fundraising of CMI Marine Science Unit and UH-Hilo. CMI Land Grant also has access to USDA funding similar to any other Land Grant institution and it is involved in Aquaculture Research, Extension and Training. The Land Grant Program is also conducting some specific environmental research, extension and training with and without RMIEPA collaboration. It is important for RMIEPA and for CMI Land Grant to expand this collaboration more to tackle the ever changing environment.

A general phenomena for fundraising is that for sources other than the RMI government sources, fund raising depends on proposal writing which is generally contingent of the efforts of one or a few individuals with a general lack of institutionalization. When a key individual disappears from the scene for any reason, their efforts have generally not been taken up again; hence the historic lack of continuity for research and management efforts.

Information Gaps

- There is no information on coastal habitats and usage over the vast majority of the RMI. The collection of this information is being collected starting with the most densely populated first.
- No data on oil spills
- No data on coastal erosion
- Minimal data on health of reef ecosystems on some islands (see table above)
- Minimal data on human habitation and development
- Minimal data on coastal and marine water quality

Information Management and Accessibility

Information is generally poorly managed and shared and this has been identified as a major need for capacity-building in the CBNA (Baker and Chutaro, 2005).

A web-based information repository, the Biodiversity Clearing-House Mechanism, was established in 2004 under the Biodiversity Convention Add-On project. This provides an important mechanism for the management of biodiversity and environment-related information in the RMI, and should be fully supported as the key central information repository. The address of this website is HYPERLINK “<http://www.rmibio.org>” www.rmibio.org.

One issue of accessibility is that much of the past research, even seminal works, are not accessible in the RMI. For example, most documents related to the work conducted at the Enewetok Marine Biological Laboratory are not available on Majuro.

Roles of local or regional educational and research institutions

The College of the Marshall Islands (CMI) is very much involved in resource management issues. They currently provide Associate Degree level education in general sciences, marine science, aquaculture and coastal zone management. They have recently developed a course for vocational training of Marine Conservation Officer/ Technician, focusing on practical skills in the management of CLMEs (Coastal, Littoral and Marine Ecosystems), such as SCUBA diving, aquaculture, and even boat driving, repair and maintenance. Most of the reef surveys conducted in recent years have been led by CMI. In addition, the academic staff at CMI are active in working groups on resource management and provide a pool of expertise that is generally not available in the resource management agencies.

The CMI Land Grant program is charged with research and development on aquaculture and agriculture. In addition, they are mandated to carry out water quality monitoring, soil conservation and management of coastal erosion issues. However, they would need additional staff and other resources to be more effective in all these areas.

The University of the South Pacific (USP) has small campus on Majuro and offers degree level qualifications in GIS on-island. The main campus in Fiji offers various courses related to natural resource management. USP utilizes distance learning and has good facilities for this, which could be an asset to researchers and managers.

Various attempts are being made to establish internship programs with natural resource management agencies, in order to combine professional work experience in their home

country with academic study in overseas institutions. MIMRA interns have been funded through a variety of sources including CMI and the University of Hawaii-Hilo (UHH).

The University of Hawaii Hilo has been involved in the development of an aquaculture industry in the RMI through providing technical assistance, supporting policy development, business development and carrying out vocational training. The Coastal Resources Centre at the University of Rhode Island has also provided support to various activities in natural resource management, while the Fisheries Industry Technology Center at the University of Alaska-Kodiak has collaborated on fisheries management, aquaculture economics and marketing of natural products. Much of this work has been funded by USDA and the Center for Tropical and Subtropical Aquaculture. CMI also has relationships with the University of Guam and Taiwanese universities although few joint activities are conducted in the natural sciences. The National Sea Grant Program and the University of Hawaii Sea Grant Program have contributed significant funding and worked collaboratively with RMI government agencies and industry for nearly 20 years. CMI collaborates closely with the Marine and Environmental Research Institute of Pohnpei on aquaculture and related initiatives.

There is currently no education in schools about natural environment and management issues. A group led by Lihla Noori at the RMI EPA is currently carrying out a project to develop a curriculum, which will then be tested and rolled out into schools. The level of commitment from the Ministry of Education to this project is currently unknown, in the face of serious issues with the capacity of teachers in the education system and the resulting levels of literacy and numeracy from children emerging from the education system. The MOE has supported efforts at the two regional High Schools (Wotje and Jaluit) in secondary aquaculture and marine science education and is currently supporting a new project on Namdrik using giant clam culture to teach marine science.

Governance related to natural resource management

General overview

The Marshall Islands has had a varied history of colonialism and contact with foreign nations over several hundred years. However, the main impacts on natural resource management began with the “purchase” of the Marshall Islands by Germany, from Spain in 1885. During the German colonial period, coconut oil was replacing whale oil in the world market and German administration and traders oversaw the conversion of traditional agricultural practices to the ubiquitous coconut plantations. Along with this major change in resource usage came a substantial impact on the traditional social and political structures, including a weakening of traditional governance of resources which was entrenched in chiefly powers. German control lasted until 1914, in the early days of World War I when Japan moved in and took control. At the end of WWI, this control was made official under the League of Nations (NBR 2000).

The Japanese administration was to have a significant impact on governance of resources. Many laws for the Marshall Islands were established, and these remain the basis for constitutional land rights today. Of significance is the definition of land ownership which was an attempt to institutionalize the property rights as they existed at the time. This

definition remains to this day, but has failed to capture the dynamic nature of chiefly positions and land ownership, which included accountability mechanisms for Iroij (chiefs) such as challenges from Iroij on neighboring atolls, and from Alaps (junior chiefs, land custodians) if the chiefly obligations of caring for their communities were not adequately met. Thus an important element of the traditional governance system has been lost in the process of institutionalization, and the current land ownership is unchallenged and entrenched. The Japanese colonial period is characterized by intensive infrastructure development, the introduction of Japanese education systems and the role of Marshallese as laborers.

At the end of WWII, the Marshall Islands became a Trust Territory under the newly formed United Nations, administered by the United States. This again was a period of intense upheaval for the people of the Marshall Islands with deep impacts on the national sense of identity which have a lasting effect on natural resource management. From 1946 to 1958 the US nuclear weapons tests were carried out, impacting the populations of the atolls Bikini, Rongelap, Enewetok and Utrik. Peoples of the first three atolls were entirely relocated to other atolls, thus breaking their deep physical and spiritual connection with their land and natural environment. Marshallese draw most of their initial identities from those atolls where they and their clans hold traditional land rights (Hezel 2001). In addition, compensation for the nuclear-affected populations came in the form of money and food aid (canned and packaged foods). This further removed these peoples from a direct, traditionally subsistence relationship with their environment, and raised the levels of consumption across the entire society.

In 1978 the Marshall Islands passed their constitution, which came into effect in May, 1979. In 1986 the Compact of Free Association was agreed with the United States and the UN Trusteeship officially ended in 1990. The Republic of the Marshall Islands now has parallel systems of governance with an elected parliament of 33 members, as well as the traditional system of Iroij, institutionalized in the constitution and in the existence of a Council of Iroij which has the right to consider parliamentary issues. Although the formal power held by Iroij is weaker than in the past, they still command enormous respect from their peoples. Any resource management must incorporate the influence of the traditional governance and property rights system, as this has the strongest effect on the behavior of the Marshallese people.

Customary laws and arrangements

(See Appendix A taken from the CBNA (Baker and Chutaro, 2005) for maps demonstrating geographic jurisdiction of traditional resource owners and various government agencies).

Ownership of Land, Marine and Coastal Resources in the Marshall Islands

Land ownership is defined by RMI legislation, however, there is some ambiguity around the ownership of areas that may be considered CLMEs, namely coral reef systems.

Ownership of Land

All land in the Marshall Islands is privately owned, through a traditional system of custodianship. Land is owned by a chief, or Iroij, and also by the Alap. The Dri-Jerbal, or the worker class, have land-rights based on their matrilineage. The land is divided into parcels of land which usually cut across the atoll from ocean-side to lagoon side. This parcel of land is called a “weto”.

Ownership of Marine Resources

The Public Lands and Resources Act defines ownership over areas by the government of the Republic of the Marshall Islands. It takes the basic definition of public lands as those owned or maintained by the Japanese government during the Japanese administration. Specifically, all marine areas below the high watermark belong to the government with the exceptions:

- fish weirs and traps and the right to erect these as recognized by customary law;
- fishing rights on, and in water over reefs where the general depth of water is less than 4 feet at low tide, as recognized by customary law;
- the traditional and customary right of the individual landowner, clan or municipality to control the use of and materials in marine areas below the high water mark (subject to the inherent rights of ownership of the government); and
- any legal interest in or title to such marine areas.

However, the ownership definitions are not well known or understood and many people believe that legally, the local governments own the resources below the mean high water mark. In practice, the use and ownership of the resources in coastal and CLME zones lies with the local communities, and there is opportunity for conflict between traditional landowners and local governments, who are usually elected.

Much of the marine area falls into the definition of CLMEs, usually coral reefs and sea-grass beds. Jurisdiction, power and responsibility of traditional landowners with respect to these areas is ambiguous. Different atolls have different traditions as to where land and marine ownership is claimed- some claim ownership from the *weto* on land to the ocean as far as the eye can see, and to the centre of the lagoon. Others claim ownership of marine resources and reefs that may be on the opposite side of the atoll from the land-based *weto*.

Although powers and responsibilities associated with ownership are not formally defined in law, or tested in the court system, traditional resource owners hold considerable power over the use of the resources, *de facto*. Local communities may be more likely to take direction over the use of the resources from traditional landowners, than they are from laws and regulations that are difficult to enforce.

How Protected Areas are Established and Managed in the Marshall Islands

Traditional conservation practices in the past were designed to protect and manage natural resources, especially marine resources, in order to have reliable food supplies for the communities. One of these is “*mo*”, meaning taboo, usually consisting of a complex set of rules about what may be harvested, when it could be harvested and rituals to be carried out before entering a “*mo*” area or undertaking activities in that area. The erosion of traditional resource management has negative implications for biodiversity in the Marshall Islands. Today, many of the traditional chiefs no longer live on the atolls they represent, and few atoll communities have a living memory of traditional taboo or “*mo*”. The loss of knowledge, absence of the chiefs and a lack of enforcement of traditional practices has led to unchecked harvesting of marine resources. One example of this is harvesting of turtles; in the past turtles were hunted only to be used for ceremonial occasions. Today, turtle and turtle eggs are hunted without the traditional permission of the chiefs.

In terms of establishment of protected areas in modern times, there are currently several different approaches. The Jaluit Atoll Conservation Area was developed under the auspices of the South Pacific Biodiversity Conservation Program- aimed at establishing Conservation Areas in the Pacific. A management plan has been developed for Jaluit Atoll, integrating modern-style marine sanctuaries, protected mangrove areas, traditional “mo” as well as development of alternative income generating activities in eco-tourism and traditional handicrafts. The plan was developed using experienced international consultants and an intensive process of community engagement. There are many lessons to be learnt from this process, which has wide recognition internationally, and has been successful in gaining access to various forms of funding to assist in the planning and establishment of the Jaluit Atoll Conservation Area.

M²EIC is a working group led by MIMRA and having representatives of MIVA, RMI EPA, Ministry of Internal Affairs and CMI as its members. The group responds to requests from atoll Local Governments to assist in the establishment of Marine Protected Areas and associated fisheries management. To date, this group has worked closely with Local Government and private landowners on Mejatto, Likiep and Arno.

Mili and Rongelap are independently pursuing the establishment of conservation areas in their atolls. In the case of Mili, a private landowner is using their own land, in cooperation with the local council, to establish a protected area. In Rongelap, the local council is investigating establishing the area of Ailinginae as a protected area.

(The above information is sourced from the CBNA (Baker and Chutaro, 2005) and the report on Needs Assessment for the Implementation of the Ramsar Convention (Phillips and Baker 2005)).

State and national government agencies, their roles and responsibilities
Table 8: Government Agencies (this table was originally produced for the Ramsar Needs Assessment (Phillips and Baker, 2005) and has been modified to be relevant to CLMEs.

Institution	Summary of the institutional mandate	Relationship to CLMEs	Ministry responsible for implementation
<p>Environment Protection Authority (RMIEPA) Est. 1984</p>	<p>Established with broad powers and responsibilities for environmental protection and management.</p>	<p>The General Manager of the RMIEPA is also the Project Manager for the Jaluit Atoll Conservation Area. The RMIEPA is responsible for implementing many of the laws and regulations which have a direct impact on the management and protection of CLMEs.</p> <p>The RMIEPA's key roles that impact on CLMEs are:</p> <ul style="list-style-type: none"> - Promulgation of regulations over a wide range of environmental concerns; - Development of environmental impact assessment process and coastal management plans; and - Community education and awareness. - Focal point for Ramsar Montreal and Stockholm conventions. 	<p>RMIEPA is a Statutory Authority under the Office of the President</p>

Institution	Summary of the institutional mandate	Relationship to CLMEs	Ministry responsible for implementation
<p><i>Marshall Islands Marine Resources Authority (MIMRA)</i> Est. 1997</p>	<p>MIMRA is tasked with:</p> <ul style="list-style-type: none"> - Development of Community-based fisheries management - Development of income generating opportunities in Coastal Fisheries - Policy Development - Negotiation of fishing agreements and licensing of fishing vessels 	<p>MIMRA has ultimate authority over all marine resources below the low mean water mark, including marine-type CLMEs. In addition, MIMRA is responsible for working with local communities to develop management plans for sustainable use (or ‘wise use’) of resources.</p>	<p>MIMRA is a statutory authority under the Minister of Resources and Development</p>
<p><i>Office of Environmental Policy and Planning Coordination (OEPPC)</i></p>	<p>To provide policy advice to President and Cabinet on International Environmental Conventions, including Biodiversity To act as the official focal point for SPREP, GEF projects, and Barbados Plan of Action</p>	<p>Focal point for Biodiversity Convention, International Waters Program, UNFCCC, UNCCD and SPREP.</p>	<p>OEPPC is a statutory office under the Office of the President of the Republic of the Marshall Islands</p>

Institution	Summary of the institutional mandate	Relationship to CLMEs	Ministry responsible for implementation
<p><i>College of the Marshall Islands (CMI)</i></p>	<p>In environment-related areas, the college provides a broad-based science education to students, as well as education in Marshallese language, history and culture. The college also plays a role in community awareness and outreach, carrying out scientific studies and providing expertise and assistance to Local Governments or inter-agency groups (such as MEIC). A new program is being developed for vocational training in marine conservation and aquaculture.</p>	<p>The science course at CMI has an emphasis on marine and coastal systems (CLMEs). The resource assessments that have been carried out to date have been led by CMI staff and visiting scientists. CMI has started a Marine Park Officer vocational training program which could provide training for rangers in CLMEs conservation and management.</p>	<p>Ministry of Education</p>
<p><i>Ministry of Resources and Development (R&D) Est. 1979</i></p>	<p>Quarantine department is part of the Ministry of Resources and Development- established to prevent the introduction and further spread of injurious plants and animals. Implementation of Endangered species act. Is the national agency for development of Agriculture.</p>	<p>If the Ministry of R&D accept responsibility for implementation of the Endangered Species Act, they will play a critical role in this aspect of CLME conservation. Another area where they have impact is in the careful use of fertilisers and pesticides in agricultural activities, that could have a detrimental effect on CLME areas.</p>	<p>Ministry of Resources and Development</p>
<p><i>Local Governments Est. 1979</i></p>	<p>Provide services to the residents of local government areas. Implement and enforce local ordinances. Carry out planning for their local government areas.</p>	<p>Local ordinances can be an instrument for implementing CLME conservation, as is planned for Jaluit Atoll.</p>	<p>Ministry of Internal Affairs</p>

Institution	Summary of the institutional mandate	Relationship to CLMEs	Ministry responsible for implementation
<i>Office of the Attorney-General (AG)</i>	To enforce the laws through prosecution.	The attorney general prosecutes infractions of national laws (and local laws when requested to) including those concerning conservation of CLMEs.	Ministry of Justice
<i>Jaluit Atoll Local Government (JALGov)</i>	Local government has the power to make any ordinances as long as they are not inconsistent with any Act or with any other legislative instrument that has the force of law in the Marshall Islands (such as regulations formed by MIMRA or EPA, for example). Local government also has the power to appoint peace officers to enforce the ordinances.	Local government is the first point of contact for management of resources on an atoll or island. Jaluit Atoll Local Government are crucial to the implementation of the Jaluit Atoll Conservation Area, as one of the key tools for management is the translation of management techniques, such as restricted fishing practices, into local government ordinances and enforcement by local government peace officers.	

Table 9: Working Groups and Informal Institutional Arrangements (This table was originally produced for the Ramsar Needs Assessment (Phillips and Baker, 2005) and has been modified to be relevant to CLMEs.

Group/Informal Institutional Arrangement	Mandate	Relationship to CLMEs	Year activated	Ministry responsible for implementation
<i>Biodiversity Steering Committee</i>	To develop policy and plans to guide national activities carried out under the Biodiversity Convention.	Policies and plans developed by this group will include management of CLMEs areas.	2004	OEPPC
<i>Biodiversity Planning Group</i>	To develop work plans and actively participate in the management of projects, including monitoring the work of consultants.	Plans and management carried out by this group will include CLMEs.	2003	OEPPC
<i>International Waters Programme Project Steering Committee</i>	To develop policy and plans to guide national activities carried out under the International Waters Project	Some activities of this group may impact CLMEs.	2002	OEPPC
<i>M²EIC Working Group</i>	To develop policy and plans to guide the development of community based fisheries in the RMI.	The management and sustainability of coastal and in-shore fisheries relates particularly to the 'wise use' of CLMEs.	2002	MIMRA

Group/Informal Institutional Arrangement	Mandate	Relationship to CLMEs	Year activated	Ministry responsible for implementation
<i>Biodiversity Clearing House Mechanism (CHM)</i>	To collect and collate all relevant biodiversity-related information. The main mechanism for doing this is a website that will be the repository for all biodiversity-related information regarding the Marshall Islands.	The CHM will be the mechanism to manage CLME-related biodiversity information on a national level. The website address is: www.biormi.org	2004	OEPPC
<i>Jaluit Atoll Conservation Area Coordinating Committee (CACC)</i>	This institution is the administrative body for the resource owners on Jaluit Atoll and makes decisions about adoption of management practices and enforcement on Jaluit Atoll.	This organisation is the committee responsible for oversight of the Ramsar-listed Jaluit site.	2002	RMIEPA

Non-Governmental Organizations (NGOs)

Table 10: Non-Governmental Organizations active in the RMI. (This table was originally produced for the Ramsar Needs Assessment (Phillips and Baker, 2005) and has been modified to be relevant to CLMEs).

Institution	Institutional mandate	Relationship to CLMEs	Year active	Contact person
<p>Mili Atoll Nature Conservancy (MANC)</p>	<p>An NGO established to manage a protected area designated by a private landowner on Mili Atoll (note, the circumstances of this land ownership are different from the usual in that the land was purchased at one point of time and has therefore been alienated from the traditional system of land tenure). The organisation intends to establish a research station facility for visiting scientists to promote the study of atoll systems and coral reefs.</p>	<p>Much of the protected area on Mili Atoll falls under the definition of CLMEs. The research facility will encourage research of a relatively pristine environment to further our understanding of atoll and coral systems.</p>		<p>Contact person: Ben Chutaro bako@ntamar.net</p>
<p>Marshall Islands Conservation Society (MICS)</p>	<p>This is a new NGO that is being developed in order to raise awareness, build capacity and restore cultural practices for environmental and biodiversity conservation.</p>	<p>A key element of capacity lacking to date in the Marshall Islands is the existence of an environmental NGO whose role is to raise awareness and build capacity in conservation matters</p>	<p>2004</p>	<p>Contact person: Steve Why stevwhy@hawaii.rr.com</p>
<p>National Conservation Communities of the Marshall Islands (NCCMI)/ National Resource Assessment Surveys (NRASRMI)</p>	<p>These two NGOs were formally incorporated but currently lie dormant. It is expected that most of the people that were active in these will be involved in the MICS.</p>			

US programs roles and responsibilities

Table 11: Roles and Responsibilities of U.S. Programs

Institution	Institutional mandate	Relationship of institution to CLMEs
U.S. EPA	The U.S. EPA works to protect human and environmental health. Cooperates internationally (primarily with Mexico and Canada) to protect joint resources and address common issues.	USEPA has provided a small amount of support to the RMIEPA and CMI Land Grant water quality program.
USDA: Rural Development Land Grant	Includes multiple divisions covering the US Affiliated Pacific Islands including Land Grant, Rural Development and Natural Resources Conservation Service. In the RMI USDA agencies are mandated with agriculture, aquaculture, nutrition, conservation and educational outreach but has limited roles in these. Rural Development provides assistance to infrastructure and community projects. USDA also provides assistance to schools and communities through provision of food.	Has access to funding and can provide grants to organizations and institutions. Degree of activity and initiative is highly variable. Strong links to Hawaii offices of the same divisions. Rural Development has been particularly effective in providing assistance with housing aid and community projects. Support business development.
Department of Interior-Office of Insular Affairs	Mandated to assist in the conservation and management of natural and cultural resources. OIA currently prioritizes private sector development. The U.S. Deputy Assistant Secretary of the Interior chairs JEMFAC (see below).	Provides technical assistance funding and leads various development, conservation and research initiatives. OIA recently has promoting investment RMI businesses and trade, much of which is dependent on natural resources.

Institution	Institutional mandate	Relationship of institution to CLMEs
<p>Joint Economic Management and Financial Accountability Committee (JEMFAC)</p>	<p>Probably the key entity in terms of relations with the RMI, JEMFAC was created in the Compact, as amended for the purpose of approving Compact annual sector grant allocations proposed by the RMI; to review audits and reports required under the Compact, as amended; evaluate the progress made by the RMI in meeting the objectives identified in its medium term budget and investment framework; and to identify problems encountered, and recommend ways to increase the effectiveness of assistance made available under the amended Compact. JEMFAC has representative from the US and RMI governments.</p>	<p>JEMFAC approves and oversees all aspects of the use of Compact funds. As such, it potentially has the power to determine how much of total available budget for resource issues is spent within the RMI.</p>
<p>US Fish and Wildlife</p>	<p>Mandated with protection of fauna, flora and habitats. Oversees import of regulated products such as those protected under CITES.</p>	<p>Has funded and participated in coral reef surveys. Personnel make occasional visits to the RMI for outreach purposes. Could take a role in controlling export of protected species such as giant clams.</p>
<p>NOAA</p>	<p>Mandated with research and management of oceanic, atmospheric and marine resources.</p>	<p>Limited role in the RMI except through opportunities associated with Sea Grant. May fund studies such as the recent work on turtles (McCoy 2005). Monitors climatic phenomena such as rainfall and storms.</p>

Institution	Institutional mandate	Relationship of institution to CLMEs
Sea Grant	Sea Grant works to promote stewardship of marine and coastal resources in the U.S. and selected international locales.	The University of Hawaii Sea Grant program provided funding and technical assistance for 15 years until 1999 in collaboration with DOI. Once had an extension agent in Majuro. Program ended when DOI funds were withdrawn. Continues to provide extension assistance. CMI has received funding from the National Sea Grant Program.
DoD- USAKA Environmental	Mandates with management and conservation of resources on Kwajalein potentially affected by military and associated activities.	Works collaboratively with various U.S. agencies to manage natural resources and conduct EIA's where required.
Federal Emergency Management Agency	Disaster Mitigation, Preparedness, Response & Recovery planning.	FEMA provides assistance to island affected by drought, storms and other natural disasters, primarily in the form of shelter, desalinization plants, emergency food.
State Department/ US Embassy	The U.S. Deputy Assistant Secretary is one of three US members of JEMFAC. US Embassy is tasked with representing the interest of the U.S. government and protecting the rights and safety of U.S. citizens within the RMI. Handles immigration matters for RMI and U.S. citizens. Liaises with USAKA and U.S. Federal Agencies.	The U.S. Embassy has been generally supportive of environmental efforts. Collects data and information on environmental topics. Most recently supported a U.S. Embassy Science Fellowship. Could be of assistance to visiting researchers and could facilitate work in the RMI.

International and regional bodies; their roles and responsibilities
Table 12: Roles and Responsibilities of International and Regional Bodies.

Institution	Institutional mandate	Relationship of institution to CLMEs
Secretariat of the Pacific Regional Environment Program (SPREP)	SPREP is the Pacific region's major intergovernmental organisation charged with protecting and managing the environment and natural resources. SPREP provides for coordination of regional environmental-management programs. Is the secretariat of the SPREP Convention.	As most of the natural environment in the RMI are CLMEs, most of SPREP's activities in the RMI will relate directly to CLMEs.
South Pacific Applied Geoscience Commission (SOPAC)	SOPAC is an intergovernmental, regional organisation dedicated to providing services to promote sustainable development.	A recently established SOPAC/ EU program on Reducing Vulnerability in Pacific Island States focuses on hazard mitigation, aggregates for construction and water resources and sanitation. It is largely focused on the coastal zone for the RMI and utilises GIS information technology. This program should be coordinated with any assistance provided by USGS in coastal management.
Secretariat of the Pacific Community (SPC)	SPC is a regional technical and development organisation with a mandate as a technical advisory, training and research organisation.	SPC has programs in coastal fisheries, forestry, aquaculture and reef fisheries amongst others. SPC provides information and technical assistance on sustainability, management and planning for the use of these resources.
United Nations Development Program (UNDP)	UNDP is the global development network for the United Nations.	UNDP coordinates implementation of the Biodiversity Convention in the RMI. It also coordinates livelihood programs including aquaculture initiatives.
Secretariat of the Ramsar Convention	Coordinates activities around the Ramsar Convention.	Sites which are defined as wetlands under the Ramsar convention are consistent with the definition here of CLMEs.

**Policies, regulations, agreements related to natural resource management
International Conventions and Protocols that have an impact on CLMEs - Status in the RMI**

Table 13: International Conventions and Protocols (This table was originally produced for the Ramsar Needs Assessment (Phillips and Baker, 2005) and has been modified to be relevant to CLMEs).

Treaty	Origin	Date	Status	Focal Point	Significance for CLMEs
Convention on Wetlands (Ramsar Convention)		2004	Accession	RMIEPA	Overarching Convention for the conservation of CLMEs. Jaluit Atoll Conservation Area has been listed as a Wetlands of International Importance.
Convention on Biological Diversity	Rio de Janeiro 6/5/92	10/8/92	Ratified	OEPPC	Has many of the same objectives for conservation as the Ramsar Convention. There is a bilateral agreement for cooperation with Ramsar.
United Nations Educational, Scientific and Cultural Organization Convention concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention)	Paris 11/23/72	4/24/02	Accession	Allele Museum	Has many of the same objectives for conservation as the Ramsar Convention. There is a bilateral agreement for cooperation with Ramsar.
Convention for the Protection of the Natural Resources and Environment of the South Pacific Region (SPREP Convention);	Noumea 11/25/86	5/4/87	Ratified	OEPPC	There is a bilateral agreement for cooperation with Ramsar, including a joint work program.
UN Convention to Combat Desertification (UNCCD)	Paris 6/17/94	6/2/98	Accession	OEPPC	Relates to erosion and sedimentation processes which have a significant effect on CLMEs.
UN Framework Convention on Climate Change (UNFCCC)	New York 5/9/92	6/12/92 10/8/92	Signed Ratified	OEPPC	The health of coral reef systems is thought to be negatively impacted by climate change. In addition, any rise in sea level will impact coastal areas, and inland water systems and the freshwater lenses of atolls.
Kyoto Protocol to the UNFCCC	Kyoto 12/11/97	3/17/98 8/11/03	Signed Ratified	OEPPC	
Stockholm Convention on Persistent Organic Pollutants (POPs)	Stockholm 5/22/01	1/27/03	Accession	RMIEPA	Provides for the control of pollutants that could have a significant impact on CLMEs.

Other International Environment-related Conventions – Status in the RMI

Table 14: Other International Environment-related Conventions (this table was originally produced for the Ramsar Needs Assessment (Phillips and Baker, 2005) and has been modified to be relevant to CLMEs).

Name of convention	Origin	Date	Status	Focal Point
Montreal Protocol on substances that deplete the Ozone Layer	Montreal 9/16/87	3/11/93	Accession	
Amendment to the Montreal Protocol on Ozone depletion	London 6/29/90	3/11/93	Accession	
Vienna Convention for the Protection of the Ozone Layer	Vienna 3/22/85	3/11/93	Accession	
Amendment to the Montreal Protocol on Ozone depletion	Copenhagen 11/25/92	5/24/93	Accession	RMIEPA
Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer adopted by the Ninth Meeting of the Parties	Montreal 9/17/97	1/27/03	Accession	
Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer	Beijing 12/3/99	5/19/04	Accession	
Cartegena Protocol on Biosafety to the Convention on Biological Diversity	Montreal 1/29/00	1/27/03	Accession	OEPPC
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	Basel 3/22/89	1/27/03	Accession	RMIEPA
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	Rotterdam 9/10/98	1/27/03	Accession	RMIEPA

National CLME-related Legislation

Table 15: National CLME-related Legislation (this table was originally produced for the CBNA (Baker and Chutaro, 2005), was further developed for the Ramsar Needs Assessment (Phillips and Baker, 2005) and has been modified to be relevant to CLMEs).

Law	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<p><i>National Environmental Protection (NEP) Act Title 35 Ch 1</i> December 19, 1984 Revisions 1987, 2002</p>	<p>Establishes the national Environment Protection Authority (RMIEPA). Responsibilities: RMIEPA has broad functions and duties including (those most relevant to CLMEs):</p> <ul style="list-style-type: none"> • Policy recommendations for management and conservation of the RMI's natural resources and environment, including animals and plants within the EEZ; • Recommendations for a system of rational management of fisheries and aquatic resources, with the assistance of MIMRA; • Requirements for environmental impact assessment; and • Provision of information and education to the public regarding the protection and improvement of the environment. <p>Powers: RMIEPA has all necessary powers to carry out its objects, duties and functions (responsibilities) including: Regulation of harvesting and marketing of threatened species of fish or other aquatic life; and the power to make regulations regarding the preservation of important historical, cultural and natural aspects of the nation's culture and heritage.</p>	<p>RMIEPA</p>	<p>The National Environmental Protection Act is important to CLMEs as it is the key piece of legislation governing environmental issues, including all terrestrial, marine and wetland areas. It is under this legislation, as well as the Coast Conservation Act, that appropriate policies for CLME management may be established at a National Level.</p>	<p>Many regulations have been promulgated under this act that relate to the management of CLMEs. These can be found in the table below.</p> <p>EPA is currently only marginally involved in fisheries management.</p> <p>Provision of information and education to the public needs to be improved.</p>

Law	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<p>Coast Conservation Act Title 35 Ch 3 September 21, 1988</p>	<p>Defines “coastal zone” as the area laying within 25 feet landward of the mean high water line and 200 feet seaward of the mean low water line.</p> <p>Responsibilities: The act requires the RMIEPA to develop, amongst other things (specifically related to CLMEs): Inventory of all coral reefs within the coastal zone; Inventory of all estuarine or wetland areas with an indication of significance as fisheries or wildlife habitat; Coastal zone management plans including consideration of living resources; Environmental impact assessment process.</p>	<p>RMIEPA</p>	<p>Most of the areas falling within the definition of CLMEs fall directly within the coastal zone as defined by the Coast Conservation Act. The implementation of this Act includes the development of coastal zone management plans and an environmental impact assessment process, both of which can be primary management tools for the conservation of important wetland areas.</p>	<p>The requirements of this Act are currently well beyond national capacity for implementation, however steps are being taken to implement the Act. The EPA has recruited an expatriate environmental expert who will work with the EPA for two years to carry out Coastal Zone Surveys, Develop Coastal Zone Management Plans and develop a user-friendly environmental impact assessment process, with a focus on sustainable capacity-building within the EPA.</p>

Law	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<p>Marine Resources Authority (MIMRA) Act Title 51, Ch 1 March 28, 1988 Revisions 1989, 1991, 1992</p>	<p>Establishes the Marshall Islands Marine Resources Authority (MIMRA)</p> <p>Responsibilities MIMRA's duties related to Biodiversity conservation include: To conserve, manage and control exploration and exploitation of all living resources in the Fishery Waters (all water within the EEZ measured from the baseline of each atoll); To issue fishing licenses; To negotiate and conclude foreign fishing agreements (with the final approval by Cabinet); To participate in the planning and execution of programs related to fisheries or fishing; and To appoint authorized enforcement officers and observers.</p> <p>Powers MIMRA has power to carry out its duties. In addition, MIMRA may: Develop local fisheries, in consultation with the Local Government Councils; Issue local fishing licenses for commercial and non-commercial fisheries; Make regulations with respect to: - the conservation, management and protection of fish and other aquatic organisms; - use of fishing gear and equipment; - terms and conditions of licenses; - pollution of fishery waters.</p>	<p>MIMRA</p>	<p>A large portion of the areas falling within the CLME definition lie seaward, or lagoonward, from the low mean water line (the area covered by this Act), for example sea-grass beds and coral reef areas. Thus this act covers the exploitation and sustainable management of all the resources in these areas. There is an overlap with the jurisdiction of the Environment Protection Act, as described above.</p>	<p>Regulations have been issued under this act, relating to the licensing of fishing activities, transshipment and export.</p>

Law	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<p><i>Fisheries Act Title 51 Ch 2</i> October 13, 1997</p>	<p>This law vests the National Government with exclusive management and control over living and non-living resources within the Fishery Waters. Bans export of live fish and any other fish or marine resource without prior written permission of MIMRA. Prohibits trade, export or commercial sale of any endangered fish species as declared by the Minister. Prohibits introduction of any fish without quarantine clearance and express permission of MIMRA Director. Provides control of activities for harvesting of turtle, sponge, trochus and black-lipped pearl oyster. Prohibits fishing with poison and explosives and certain types of fishing gear as prescribed pursuant to this Act. Provides for protection of species either by declaration or by regulations.</p>	<p>MIMRA</p>	<p>This act makes broad provisions for the regulation of fishing activities within all marine areas, including CLMEs.</p>	<p>No known regulations have been issued under this act. There is no effective enforcement of the controls on harvest of turtle, sponge, trochus or pearl oyster. Of particular concern here is the harvesting of turtle.</p>
<p><i>Management and Development of Local Fisheries Act Title 51 Ch 3</i> 13 October 1997</p>	<p>Makes provisions for the development of atoll-based fisheries, adoption of local ordinances, processes of consultation with the Director of MIMRA, development of fisheries management plans and licensing. Essentially, it requires that Local Government shall consult with MIMRA before adopting ordinances or issuing fishing licenses, and that MIMRA shall assist Local Government in development of plans and fisheries.</p>	<p>MIMRA</p>	<p>Much of the area considered in a Local Fisheries area falls under the definition of CLMEs.</p>	<p>Three local fisheries management plans are in the process of being developed under this Act; for the communities of Likiep, Mejjatto and Arno. To date, these communities have come up with actions including the establishment of atoll-wide bans, protected areas and minimum sizes etc to be implemented through local government ordinance.</p>

Law	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<p>Endangered Species Act Title 8, Ch 3. 1975 Revisions 1980</p>	<p>Provides for the protection of endangered species of plants and animals through the promulgation of regulations, and prohibition of importation of exotic species. There are exceptions for legitimate subsistence food and traditional use by indigenous people where specifically excepted by the Secretary of R&D.</p> <p>Responsibilities The Secretary of Resources and Development, as the administrator of the Act is required to issue regulations including a listing of the species of endangered and threatened plants and animals of the Republic; enforce prohibition of import of any plants or animals listed in the Convention on International Trade in Endangered Species (CITES); enforce prohibition of import of exotic plants and animals (to be listed in the regulations).</p> <p>Powers The Secretary of Resources and Development, as the administrator of the Act, has the power to: set up conservation programs aimed at conserving endangered and threatened species; enforce the provisions of the Act and regulations in the Act.</p>	<p>Secretary of the Ministry of Resources and Development (R&D)</p>	<p>This Act relates to all endangered species, including those in CLMEs.</p>	<p>This Act has not been implemented. At present there is no specific protection for endangered species except those covered by the Fisheries Act, specifically sponge, black-lipped pearl oysters, trochus and turtles. Regulations for the protection of endangered species and a list of species included have not been promulgated. Regulations to prevent the importation of exotic/invasive species have not been promulgated (with the exception of those described under the quarantine regulations and which are specific to protection of agriculture, not to protection of wild species).</p>

Law	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<p>Animal and Plant Inspection Act (Quarantine Restrictions) Title 8 Ch 1 1966 Revisions 1970, 1972, 1980</p>	<p>Provides for the promulgation of quarantine regulations as a means of preventing introduction and dissemination of injurious insects, pests, and diseases into and within the Republic.</p> <p>Responsibilities The Chief of Agriculture shall: issue plant and animal quarantines and regulations; and administer the provisions of these controls and regulations.</p> <p>Powers All plants and animals (or parts thereof), aircraft and vessels and their cargoes, entering or transported within the Republic, are subject to inspection and subsequent enforcement of the regulations.</p>	<p>Chief of Agriculture (Ministry of R&D)</p>	<p>This Act covers import and control of invasive species into the RMI, including those having a negative impact on wetland areas.</p>	<p>Regulations are implemented and enforced, however the lists of plants and animals contained in the regulations are inadequate for protection of wild species.</p>
<p>Office of Environmental Planning and Policy Coordination (OEPPC) Act Title 35 Ch 4 2003</p>	<p>Responsibilities OEPPC's duties related to Biodiversity Conservation include: Advise cabinet on international conventions and instruments; Prepare position papers and statements on all international environmental instruments the RMI is party to; Seek funding from international environmental forums; Provide technical training, advice, and assistance to agencies in preparing sector and project plans; Work with other ministries and agencies in the development of policy; Prepare annual reports on the state of the environment in the RMI; and Conduct environmental or scientific reviews or assessments for the purpose of strategy planning.</p>	<p>OEPPC</p>	<p>OEPPC, established by this Act is the focal point for the Convention on Biological Diversity, and for many other environment-related conventions. Many of the activities undertaken by this office will relate to CLMEs. In addition this office can provide coordination between agencies and provide advice to cabinet on wetland-related policies.</p>	<p>As a new office, OEPPC is developing its capacity to carry out the responsibilities described in this act.</p>

Law	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<p>Local Government Act Title 35 Ch 1 18 February, 1981 Revisions 1986, 1991, 1994, 2003</p>	<p>Act describing the establishment and governance of local governments. Powers Local government has the power to make any ordinances as long as they are not inconsistent with any Act or with any other legislative instrument that has the force of law in the Marshall Islands (such as regulations formed by MIMRA or EPA, for example).</p>	<p>Local Governments</p>	<p>Ordinances made by local governments are one mechanism for the implementation of conservation management plans covering CLMEs areas.</p>	<p>n/a</p>
<p>Public Lands and Resources Act Title 9 Ch 1 Revisions 1970, 1996, 1980</p>	<p>Defines ownership over areas by the government of the Republic of the Marshall Islands. Takes the basic definition of public lands as those owned or maintained by the Japanese government during the Japanese administration. Specifically, all marine areas below the high watermark belong to the government with the exceptions:</p>	<p>n/a</p>	<p>This Act defines formal rights of ownership over various defined areas, including wetland areas.</p>	<p>Within communities and within the institutional environment, this law is not well understood- it is widely believed that the area over which local government has jurisdiction is actually owned by the local government, or alternatively by the landowners (depending on the community and past practices). In practice, rights to areas below the high watermark are often exercised by the landowners of the adjoining lands (as described below in discussion of land ownership).</p>
<p>fish weirs and traps and the right to erect these as recognized by customary law; fishing rights on, and in water over reefs where the general depth of water is less than 4 feet at low tide, as recognized by customary law; the traditional and customary right of the individual landowner, clan or municipality to control the use of and materials in marine areas below the high water mark (subject to the inherent rights of ownership of the government); and any legal interest in or title to such marine areas.</p>				

Law	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<p>Marshall Islands Visitors Authority (MIVA) Act Title 10 Ch 14 1997</p>	<p>This Act establishes the Marshall Islands Visitors Authority (MIVA) and its functions and powers. These include:</p> <ul style="list-style-type: none"> - to develop and promote the natural, scenic, cultural, historical, and recreation attractions of the Republic of the Marshall Islands in ways that will: - create an economically sound tourism resource; - foster preservation and improvement of these assets and prevent and avoid their degradation and pollution; - identify and recommend to appropriate authorities areas, land or marine features, wildlife, and marine species, physical constructions, services, historical and sociological practices and any other feature, or aspect of Marshallese life which may be tourism features or attractions, and make appropriate rules and regulations for their management and conservation. 	<p>MIVA</p>	<p>Under this Act, MIVA has influence over natural attractions in the RMI, and has a role to play in promoting and conserving these attractions, which may include wetland areas.</p>	<p>MIVA has not specifically issued any conservation measures, but is generally active in conservation activities, for example on the M²EIC working group.</p>
<p>Planning and Zoning Act Title 10 Ch 2 1987 Amended 1994</p>	<p>An Act to provide for: (a) planning in land water use; (b) the promotion of the health, safety and general welfare of the people; (c) the creation of zones in municipal areas in order to lessen the congestion and to secure safety from fire and other hazards; (d) the regulation and control of the construction of buildings and the prevention of overcrowding of land; and (e) matters connected therewith or incidental thereto.</p>	<p>None identified</p>	<p>If implemented, the plans developed under this act would impact on wetland areas.</p>	<p>No aspect of this act has been implemented. No Chief Planner has been appointed. When implemented, plans developed under this act should be consistent with Coastal Zone Management Plans developed under the Coast Conservation Act, and also with environmental guidelines established in the various regulations promulgated under the NEP Act.</p>

Note: there are other pieces of legislation that relate to environmental issues, but they are not directly related to the management of CLME areas and so have not been included in this table.

National CLME-related Subsidiary Legislation (Regulations)

Table 16: National CLME-related subsidiary Legislation (this table was originally produced for the Ramsar Needs Assessment (Phillips and Baker, 2005) and has been modified to be relevant to CLMEs).

<i>Law</i>	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<p><i>Earthmoving Regulations 1989 Amendments 1994</i></p>	<p>Regulations are subsidiary to the NEP Act. These regulations essentially provide for an environmental impact assessment process for any earthmoving activity, and implementation of appropriate measures to mitigate and prevent erosion and sedimentation-related impacts. The regulations provide for the control of earthmoving activities within the Republic of the Marshall Islands. It requires that these activities are conducted in such a way as to prevent accelerated erosion, accelerated sedimentation, and disturbance of potential cultural resources. To accomplish this, all persons engaging in earthmoving activities shall design, implement and maintain erosion control, sedimentation control, and cultural preservation measures which effectively prevent accelerated erosion, accelerated sedimentation, and adverse impact on cultural resources. Permits are required for earthmoving activities.</p>	<p>RMIEPA</p>	<p>Regulates activities that would have an impact on wetland areas in terms of erosion and sedimentation.</p>	<p>The RMIEPA is very active in monitoring earthmoving activities and issuing permits in the urban centers of Majuro and Ebeye, but do not have the resources to monitor activities on the outer islands. Due to a lack of capacity in assessing the likelihood of environmental degradation, rarely are developers required to prepare plans describing how they will control erosion and sedimentation. An expatriate expert has been placed in the RMIEPA for the next 2 years in order to build capacity in this area and develop appropriate processes.</p>

Law	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<p><i>Environmental Impact Assessment Regulations 1994</i></p>	<p>Subsidiary to NEP Act and Coast Conservation Act. The purpose of these regulations is to implement Part IV of the National Environmental Protection Act 1984 (“NEPA”) and Section 11 of the Coast Conservation Act 1988 (“CCA”) by establishing standard procedures for the preparation and evaluation of an environmental impact assessment (“EIA”) for proposed public and private development activities that may affect the quality of the environment of the Republic. These Regulations establish uniform standards under two Acts so that environmental scrutiny of proposed development activities may be streamlined and simplified.</p>	<p>RMIEPA</p>	<p>Requires development activities to undergo assessment of the potential impact on the environment, including CLMEs.</p>	<p>Not implemented due to lack of capacity- currently building capacity in the EPA to effectively implement these regulations.</p>
<p><i>Marine Water Quality Regulations 1992</i></p>	<p>Subsidiary to NEP Act. The purpose of these regulations is to identify the uses for which the marine waters of the Republic of the Marshall Islands shall be maintained and protected, to specify the water quality standards required to maintain the designated uses, and to prescribe regulations necessary for implementing, achieving and maintaining the specified marine water quality.</p>	<p>RMIEPA</p>	<p>The marine water quality is obviously a key health indicator of coastal wetland areas. In designating marine zones, consideration should be given particularly to CLMEs conservation and protection.</p>	<p>Until recently, the RMIEPA lacked the capacity to test marine water quality. Efforts over the last year or so have improved the testing of marine water and the water department of the RMIEPA is developing test methods. These regulations and the marine zones they describe are out of date and require updating if they are to be effectively implemented. The RMIEPA plans to do this in conjunction with the development of coastal zone management plans.</p>

Law	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<i>Solid Waste Regulations 1989</i>	<p>Subsidiary to NEP Act</p> <p>The purpose of these regulations is to establish minimum standards governing the design, construction, installation, operation, and maintenance of solid waste storage, collection and disposal systems. Such standards are intended to:</p> <ul style="list-style-type: none"> a) Prevent pollution of the drinking and recreational waters of the Republic of the Marshall Islands. b) Prevent air and land pollution. c) Prevent the spread of disease and the creation of nuisances. d) Protect the public health and safety. e) Conserve natural resources. f) Preserve and enhance the beauty and quality of the environment. 	RMIEPA	<p>Pollution of CLMEs and coastal waters is highly likely from spillage and leachate from solid waste disposal facilities, which are usually built on reef flats, surrounded by sea-wall or permeable 'gabions' - largely due to the lack of available land for landfill.</p>	<p>The regulations are out-of-date and contain requirements which are technically and economically unfeasible for the RMI. In the last year or so there has been great improvement in the monitoring and enforcement of these regulations, to the degree that is currently feasible.</p>
<i>Toilet Facilities and Sewage Disposal Regulations 1990</i>	<p>Subsidiary to National Health, Safety and Welfare Act</p> <p>The purpose of these regulations is to establish minimum standards for toilet facilities and sewage disposal to minimize environmental pollution, health hazards, and public nuisance from such facilities.</p>	Ministry of Health (de facto RMIEPA at present)	<p>CLMEs, including fragile coral ecosystems are susceptible to increased nutrient such as those from sewage.</p>	<p>These regulations are difficult to enforce for many reasons. Many people in the Marshall Islands do not have access to appropriate sanitary facilities and therefore human and animal waste often finds its way directly to the marine waters.</p>

Law	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<i>Plant and Animal Quarantine Regulations 2000</i>	Subsidiary to the Animal and Plant Inspection Act (1980) The purpose of these regulations is to protect the agricultural activities and general well-being of the people of the RMI. The regulations provide procedures and conditions to ensure the safe movement of plants and animals and plant and animal products into and out of the RMI, and to fulfill international obligations to prevent the movement of pests in international trade.	Ministry of R&D	These regulations are designed primarily to protect agricultural activities in the RMI, and do not address invasive species that may impact wild species in CLMEs areas.	It is unclear whether invasive species that impact natural biodiversity should be addressed in these regulations, or in the regulations that should be promulgated under the Endangered Species Act.
<i>Regulations Governing Marine Resources Under the Marine Resource Act, 1997</i>	Subsidiary to the Marine Resource Act (1997). These regulations describe licensing and enforcement arrangements for fishery operators in the RMI.	MIMRA	These regulations could potentially provide the framework for management of coastal fisheries; including CLMEs areas.	It is thought that these regulations were actually promulgated, however, the only copy the agency was able to provide is incomplete and appears to be a draft. While the regulations allow for measures controlling live reef fish and other forms of fishing, there are no specific guidelines or limitations on species or catch size attached to the licensing process. It is unclear whether the live reef fish aspects refer only to ornamentals, or also to food fishes.

Draft Regulations not yet enacted

Table 17: Draft regulations not yet enacted (this table was originally produced for the Ramsar Needs Assessment (Phillips and Baker, 2005) and has been modified to be relevant to CLMEs).

<i>Regulations</i>	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<p><i>Regulations for the Sustainable Development of the Coastal Zone</i> Draft 1994</p>	<p>Subsidiary to the Coast Conservation Act The purpose of these regulations is to implement the Act by establishing standards, criteria, and permitting procedures for development activity within the coastal zone of the Republic, having regard for the long term stability, productivity and environmental quality of the coastal zone so as to assure the sustainable development and preservation of the Republic's coastal resources.</p>	<p>RMIEPA</p>	<p>These regulations will control development in the coastal zone including CLMEs.</p>	<p>These regulations have not yet passed into law. It is expected they will be revised and promulgated after the Coastal Zone Management Plans have been developed.</p>
<p>In part, these regulations set forth criteria to determine which development activities within the coastal zone require a Coastal Zone Development Activity Permit. These criteria are established by regulation prior to the coming into operation of the Act's Coastal Zone Management Plan (hereafter the "Plan"). Upon the coming into operation of the Plan, these regulations may be amended to conform to the Plan and to give effect to the Plan's provisions, as necessary.</p>				

Regulations	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<p>Marshall Islands Pollutant Discharge Elimination System (MIPDES) Draft 1995</p>	<p>Subsidiary to the NEP Act and the Marine Water Quality Regulations (1992) The purpose of these regulations is to establish criteria to limit point source discharges of pollution into the marine and fresh waters of the Republic of the Marshall Islands (“the Republic”), and to establish a permitting system whereby any new point source of pollution discharged into the marine and fresh waters of the Republic is strictly controlled in order to protect human health, safety and the welfare of the environment.</p>	<p>RMIEPA</p>	<p>Regulations will control point-source discharges into CLMEs areas.</p>	<p>Until the RMIEPA has capacity to effectively implement the Marine Water Quality regulations, and has collected some baseline data, there is no need to promulgate these regulations</p>

A note about local government ordinances:

Various local governments have issued ordinances which impact on CLMEs, including control of fishing and collection of plants and animals. These are not covered in the scope of this work.

Coordination and collaboration between government, NGO, other entities and community stakeholders

The following table outlining working groups and planning committees describes the major established mechanisms for coordination and collaboration between stakeholders. In general, there is a high awareness of the need to involve stakeholders in participatory planning and as a result, these mechanisms have been established. In practice, there is a low level of skill in participatory planning techniques and facilitation skills.

Working Groups and Informal Institutional Arrangements

Table 18: Working Groups and Informal Institutional Arrangements (this table was originally produced for the Ramsar Needs Assessment (Phillips and Baker, 2005) and has been modified to be relevant to CLMEs).

Institutions	Summary of what the institution is designed to do	How does this institution impact on CLMEs	Year institution come into force	Ministry responsible for its implementation
<i>Biodiversity Steering Committee</i>	To develop policy and plans to guide national activities carried out under the Biodiversity Convention.	Policies and plans developed by this group will include management of CLMEs areas.	2004	OEPPC
<i>Biodiversity Planning Group</i>	To develop work plans and actively participate in the management of projects, including monitoring the work of consultants.	Plans and management carried out by this group will include CLMEs areas.	2003	OEPPC
<i>International Waters Programme Project Steering Committee</i>	To develop policy and plans to guide national activities carried out under the International Waters Project	Some activities of this group may impact CLMEs areas.	2002	OEPPC
<i>M²EIC Working Group</i>	To develop policy and plans to guide the development of community based fisheries in the RMI.	The management and sustainability of coastal and in-shore fisheries relates particularly to the ‘wise use’ of CLMEs.	2002	MIMRA

Institutions	Summary of what the institution is designed to do	How does this institution impact on CLMEs	Year institution come into force	Ministry responsible for its implementation
<i>Biodiversity Clearing House Mechanism (CHM)</i>	To collect and collate all relevant biodiversity-related information. The main mechanism for doing this is a website that will be the repository for all biodiversity-related information regarding the Marshall Islands.	The CHM will be the mechanism to manage CLMEs-related biodiversity information on a national level. The website address is: www.biormi.org	2004	OEPPC
<i>Jaluit Atoll Conservation Area Coordinating Committee (CACC)</i>	This institution is the administrative body for the resource owners on Jaluit Atoll and makes decisions about adoption of management practices and enforcement on Jaluit Atoll.	This organisation is the committee responsible for oversight of the Ramsar-listed Jaluit site.	2002	RMIEPA
<i>Mariculture Working Group</i>	An informal group comprised of interested stakeholders interested in mariculture comprised of CMI, MIMRA, UH-Hilo, Land Grant, and private sector companies.	While primarily concerned about production and technical issues, the mariculture working group members work on environmental issues related to mariculture development.	2000	Generally convened by MIMRA or CMI

Trans-boundary ecosystems considerations

Climate change is an issue of regional significance since climate change and sea level rise will affect all small island nations. Atolls are particularly vulnerable. While the RMI agencies and other Pacific Island nations are concerned, there is relatively little that can be done directly as it is the developing nations that are responsible for climate change. However, the RMI can begin to take steps to prepare for storms and high tides that will no doubt ensue and result in more damage than normally occurs. Disaster preparedness is not well covered in the RMI at the moment. One major step that all Pacific Island Nations can take is to protect fringing reefs, mangroves and other natural coastal features that protect islands from storms and high tides.

Pelagic fisheries are the principal regional issue of concern where regional action is taken. The RMI is active in the Western Fisheries Management Council and the newly established Tuna Commission based in Pohnpei. An issue of concern are indications that all major tuna species are either maximally or over-exploited. Collaboration in regional efforts to conduct stock assessments and fisheries monitoring will be important if these efforts are to succeed.

A related opportunity that is beginning to emerge are Australian efforts to provide assistance to the RMI and FSM to patrol their EEZ to prevent unauthorized fishing. Future coordination in this area is an opportunity to address poaching.

Financing for resource management

It is difficult to obtain information regarding funding for resource management activities as agencies do not generally allocate budgets to specific activities. Under requirements of the Compact of Free Association with the United States, several agencies are required to allocate budgets to specific program areas. In general, it appears that financing is available for resource management (i.e. this is not the major constraint). The limitations are in national capacity to develop proposals for external funding, and in capacity for programmatic management to utilize the funding effectively. RMI researchers and managers are also eligible to apply for competitive grants from US agencies, foundations and international organizations. Some individuals and institutions have been successful in fund raising, but the short-term and unstable nature of competitive grants limits the ability to conduct long-term research and management initiatives.

Major issues and gaps in jurisdiction, roles, policies and regulations

Overarching Conservation Management Plan

In 1994, a National Environment Management Strategy was produced under South Pacific Regional Environmental Program (SPREP) sponsorship (RMIEPA 1992). In 2000 a Biodiversity Strategy and Action Plan was developed with funding under the Biodiversity Convention (National Biodiversity Strategy and Action Plan Team 2000). This was an important step in identifying key strategies for effective conservation in the RMI, such as the revival of traditional environmental management knowledge. In addition, "Vision 2018" developed by Second National Economic and Social Summit (NESS2) held on Majuro from 26 March to 1 April 2001, provides a national framework for development

and includes some strategies for environmental management and conservation.

However, there is now an opportunity to develop a more action-oriented comprehensive national conservation management plan that clearly describes goals, targets and strategies for conservation and best management practices for natural resources. There is a need to define and agree of the roles and jurisdictions of different agencies, mechanisms for information sharing and effective cooperation, and sharing of lessons learned. In the development of this plan, it is important that the planning process is given due attention. Lessons learned from the preparation of policies and plans in the past are that without adequate engagement and full ownership of stakeholders, the plans will become a mere document and “sit on the shelf and gather dust”.

Summary of Key Gaps in National Legislation

Overall, the RMI has a broad-ranging national legislative framework for Coastal Zone conservation and management. Gaps in this legislation are, in summary listed below. These were previously reported in the Needs Assessment for Implementation of Ramsar Convention in the RMI (Phillips, Baker, 2005) except for the mention of aquaculture policy.

- Implementation of the Coast Conservation Act: there is an opportunity to implement the requirements of this, put measures in place to achieve the recommendations and to build capacity.
- Implementation of the Environment Protection Act: there is an opportunity for the RMIEPA to place increased focus on living resources, as mandated by the Act, including participation in fisheries management and consideration of what role RMIEPA can play in conserving biodiversity. A position was created for this purpose, and has been filled, but the existing capacity could greatly benefit from additional resources.
- Implementation of the Endangered Species Act is required through promulgation of regulations banning importation of invasive species, declaring a list of endangered species in the Marshalls (which could be largely taken from the National Biodiversity Report), promulgating regulations to protect these species and enforcing the regulations.
- Full implementation of the Fisheries Act would benefit from more effective monitoring and information, and issuance of guidelines regarding catch size and species.
- Final development and adoption of guidelines or regulation for aquaculture development and relevant aspects of environmental management. A policy analysis and recommendations were drafted in 2004 by a multi-institutional team.
- *Enforcement* of all Acts and subsidiary regulations is limited and would benefit from additional resources.

Awareness of Policy and Legislation

Awareness of the legal and *de facto* arrangements for ownership of and access rights to, and jurisdiction over coastal areas is low in both government agencies and in the communities of resource users.

Table 19: Existing strategies, plans and related tools (e.g. zoning, MPAs) for resource management and the status of each (may include mention of past plans if significant and/or if lessons can be learned from these).

<i>Document</i>	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<p><i>RMI EPA Strategic Plan (2004-2007)</i></p>	<p>The EPA Strategic Plan redefined the role and focus of the EPA. Due to the nature of the RMI's geography being largely coastal in nature, all of the programs outlined in the plan are relevant to CLMEs. The EPA's activities are broken down into the following Strategic Program Areas:</p> <ul style="list-style-type: none"> - Environmental Health and Water Quality; - Land and Coastal Management; - Biodiversity Conservation; and - Waste and Pollution. <p>In addition, three Strategic Program Areas for Capacity Building and Organizational Management are:</p> <ul style="list-style-type: none"> - Education and Awareness; - Information Management; and - Planning and Human Resource Management. 	<p>RMIEPA</p>	<p>The detailed plan should be read as an appendix to this report. The plan outlines strategies and activities to develop coastal zone management plans and to develop and implement a practical and effective EIA process for the RMI. In addition, strategies for water quality monitoring and waste management have a significant impact on CLMEs. The Biodiversity Program at the EPA is also relevant, although the responsibilities of the EPA in this area are less clearly defined.</p>	<p>This contributor recently carried out a review of progress against the Strategic Plan. The progress against the plan can be found in the Annual Report for 2004.</p>

Document	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<p><i>Jaluit Atoll Conservation Management Plan (RMI EPA) (Draft-2002)</i></p>	<p>An atoll-wide management plan with a focus on establishing marine protected areas (mostly on reef) and some terrestrial and intertidal protected areas, such as the mangroves at Jaluit Jaluit. The Plan attempts to integrate traditional resource management practices with modern conservation concepts. There are two levels of marine protected areas: sanctuary (no-take zones) and restricted areas.</p>	<p>RMIEPA</p>	<p>All of the areas addressed in the plan, across Jaluit Atoll, are CLMEs. The plan addresses significant ecosystems such as the mangrove area, which formed the basis for the listing of Jaluit Atoll as a Ramsar Site of International Importance.</p>	<p>This is the first site-based management plan of its kind in the RMI and the process of development and implementation has significant lessons for other management planning activities. A detailed assessment of the implementation was carried out by this contributor in November 2004. At that time the plan had not yet been passed into local laws. It has since been reported to this contributor that local ordinances have been passed to support the plan. However, based on the assessment carried out last year, there are still significant issues with implementation that include low-level of awareness of community and governance issues.</p>

Document	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<i>National Environment Management Strategy (NEMS)(1994)</i>	The NEMS was developed under the auspices of the South Pacific Regional Environment Program and to the knowledge of this contributor, no significant activities arising from the NEMS were ever implemented.		No significance.	Virtually no implementation. This contributor could find little information about the process of developing this plan. It seems that little importance was given to its implementation by the national government.
<i>Vision 2018</i>	An overarching strategic plan for development of the RMI, addressing all aspects of development including environmental aspects.	Government of the RMI	Provides some framework for environmental policy and strategy.	There are variable levels of awareness of Vision 2018 throughout government agencies, and correspondingly variable levels of integration of the priorities and strategies into lower-level policies and strategies.
<i>National Biodiversity Strategy and Action Plan (NBSAP) (2000)</i>	The NBSAP was the first major national attempt to address Biodiversity issues (not withstanding the NEMS). The resulting document identified key priorities for Biodiversity conservation in line with the framework provided by the Convention on Biological Diversity.	OEPPC	Prioritizes in-situ conservation, protected area management and traditional biodiversity-related knowledge as key biodiversity.	This plan outlines broad priorities for Biodiversity conservation, and does not describe specific actions in detail. There is a need to develop a national strategic plan for biodiversity conservation which describes specific actions, targets and responsibilities.

Document	Summary	Responsibility	Significance for CLMEs	Degree of Implementation/ Gaps
<i>Fisheries Management Plans for Mejatto, Likiep and Arno (MIMRA) (2004)</i>	Fisheries management plans which outline the framework for community-based management, public awareness and regulatory tools.	MIMRA	Addresses coastal fisheries as a key element of CLMEs and other coastal issues- for example the Mejatto plan incorporates community undertakings for beach clean-ups.	Degree of implementation is unknown to this contributor.
<i>Draft Policy for the Management of the Live Reef Fish Trade of Ornamental Fishes Within the RMI (MIMRA) (2004)</i>	Policy outlining management measures for the economically valuable live reef fish ornamental trade.	MIMRA	Addresses capture of live ornamental reef fish as a key element of CLMEs.	Policy in Draft form as of December 2004. Current status unknown by this contributor.

Socioeconomic aspects and gaps for coastal/marine resource use

A myriad of socio-cultural changes are impacting resource use and management, which traditionally was a fundamental part of the subsistence lifestyle of the Marshallese people. Urbanization and migration to the centers of Majuro and Ebeye result in a dislocation of people from their native atoll, with a resulting loss of environmental awareness and experiential knowledge.

Certain sectors of the Marshallese society have become affluent through rent payments for Kwajalein Atoll, and compensation payments for the four nuclear-affected atolls and through businesses. This in turn has increased the consumption of consumer goods and has raised the expectations of income and ability to purchase consumer goods more broadly across the society, in turn resulting in an increasing need to earn cash through the commercial exploitation of resources, particularly fisheries, that were previously subsistence only.

The development of a democratic system of governance has reduced the chiefly powers of the Iroij, which was once the primary mechanism for resource management as the Iroij would enforce the traditional “mo”, or taboo, around harvest and use of resources. In addition, most Iroij, due in part to increased affluence, now reside in the urban centers or overseas, resulting in a physical disconnect from their natural resources. This effect is in addition to the loss of knowledge of traditional conservation practices and a loss of specific knowledge of “mo” sites. It is thought that “mo” sites were often the location of nurseries, spawning sites and other areas important for regeneration and sustainability of resources.

Population pressure is increasing in the RMI as the birth rate continues to be high. Traditionally the human populations of atolls were strictly controlled to remain within the carrying capacity of the local ecosystem. It is thought that the population is now far greater than the local carrying capacity can support.

Coastal Fisheries

Coastal fishery development is of particular importance for outer islands development, in the face of the rapid decline in copra trade. Small-scale commercial coastal fisheries, with transport bases, have been established on Arno, Ailinglaplap, Jaluit, Aur, Namu, Likiep and Maloelap atolls, with heavy support from Japanese aid, primarily to supply fresh food to the local urban centers of Majuro and Ebeye. The coastal fishery has become vitally important for providing income to outer-island populations. Gaps exist in monitoring, managing, research and enforcement for the coastal fisheries.

Land-based Agriculture

The agriculture sector in the RMI provides cash income and an important food source. It provides materials for fuels, building homes, building canoes, handicraft production and traditional medicines. For the last century, the agriculture sector and in particular the copra trade was the main cash income for most Marshall Islanders. Although the world prices of copra have dropped dramatically, copra is still important to the outer islands as it is subsidized by the government and effectively redistributes income to the outer islanders. The greatest untapped potential is for copra oil as an alternative fuel source to imported fuel oil. Copra oil has been shown to be a stable and clean fuel for use in diesel

engines. Replacing the Marshall's consumption of diesel with locally produced copra oil could reduce the Marshalls' dependence on imported fuels and help maintain a developed agricultural industry here. Noni or Nin has the potential to become a cash-crop for export, given the increasing awareness of its therapeutic benefit around the world.

Tourism

In many Pacific Island economies, tourism has become the main foreign exchange earner and many consider it having the least impact on the environment. The tourism market segments in the Marshall Islands are primarily focused on scuba diving and sport fishing. Both are entirely dependent on the pristine conditions of the natural marine environment and a healthy biodiversity. Any degradation of this environment will spell doom to this promising, but young and vulnerable industry.

Handicrafts

Handicraft trade in the Marshall Islands has grown into a cottage industry supporting many families in the outer islands and its potential for income-generation is still unrealized. Handicraft materials are sourced extensively from the surrounding natural environment, both from land and sea. Handicrafts in some ways are an extension of traditional life. Much of the materials used to build homes, canoes, tools and the like are sourced from nature. Shells are an important element in many Marshallese handicrafts, and there are some indications that populations may be decreasing (see Section). Most of the above paragraphs were previously reported in the CBNA (Baker and Chutaro, 2005).

Infrastructure development

As the population continues to grow, and migration continues from the outer islands to the urban centers, infrastructure development continues. This includes the construction of airports and roads on the outer islands, requiring mining of aggregate from the coastal zone. Many examples of coastal zone development have had an unchallenged impact on the CLMEs. Although attempts have been made in the past to apply controls to infrastructure development in the form of Environmental Impact Assessment, the RMI has lacked the institutional and human resource capacity to effect this. Currently an expatriate expert is placed at the RMI EPA with the specific task of improving Coastal Zone Management, implementing an EIA process and building capacity for this process to be continued.

Needs for research and management related to economic uses

Complex conditions are in place at the outer island community level, leading to the over-exploitation of Biodiversity resources. A priority is to further understand these conditions and develop incentive measures to reduce the vulnerability of these populations to exploitation and to encourage conservation and sustainable use, along with the creation of sustainable income-generating activities and improved food security. Again, this will require a more detailed understanding of the socio-economic conditions and behaviors, especially on outer islands.

There is a need for socio-economic assessment of the impact and value of utilization of resources in different ways- for example a comparison of the feasibility, impacts and benefits of tourism against various fishing practices.

Acknowledgements

The authors would like to thank the following for their contributions of information, insights, and general support: Ben Chutaro of BCI; Bill Phillips of Mainstream Environmental Consulting; Caleb McLennan and John Bungitak of the RMI Environment Protection Authority; Deborah Barker and Yumi Crisotomos of the RMI Office of Environmental Policy and Planning Coordination; Danny Wase, Glenn Joseph, Florence Edwards and Terry Keju of the Marshall Islands Marine Resources Authority; Silvia Pinca, Don Hess, Janet Hess, Dean Jacobsen and Matang Ueanimatang of the College of the Marshall Islands; Karl Fellenius; Keith Symington-WWF Vietnam Marine Program Coordinator; Biram Stege and Mark Canney of the Ministry of Education; Ramsey and Colette Reimers and Phil Marshall of Robert Reimers Enterprises; Mike Trevor; Simon Ellis of the Marine Environmental Research Institute of Pohnpei; Bobby Muller; Tony Debrum; Lisa King; Abelardo Rojas, University of Hawaii Hilo; Jack Niedenthal; Mike McCoy of Gillett, Preston and McCoy Inc.; and Alan Fowler of the Department of the Interior.

Special thanks is due to the U.S. Embassy of the Republic of the Marshall Islands and the U.S. Ambassador, Greta Morris, and the former Deputy Chief of Mission Thomas Praster, for their support of this work through their sponsorship of an Embassy Science Fellowship for one of the authors (Haws). The National Sea Grant Program and the University of Hawaii Sea Grant College Program are also acknowledged for supporting the Fellowship, particularly Drs. Gordon Grau and Mary Donohue.

All views expressed are those of the authors' alone.

APPENDICES

Maps

The figures below are an aerial view of the downtown area of Delap, on Majuro Atoll demonstrate changes in the coastal morphology over a period from 1983 to 2004.



Figure A: Delap, Majuro Atoll 1983 Aerial Photograph



Figure B: Delap, Majuro Atoll 2004 IKONOS Satellite Image

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**Natural Resources Management Needs for
Coastal and Littoral Marine Ecosystems of**

**COMMONWEALTH OF THE
NORTHERN MARIANA ISLANDS**

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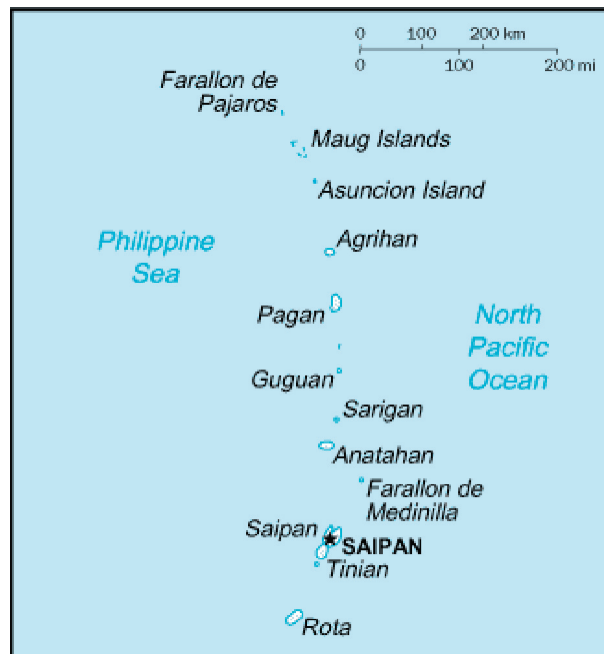
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INTRODUCTION AND BACKGROUND

Regional and National Context

The 14 islands comprising the Commonwealth of the Northern Mariana Islands (CNMI) extend approximately 400 m from Rota (14° latitude) northward to Farallon De Pajaros (or Uracas) at 20° latitude. These islands are geologically divided into two distinct types. The older southern islands are characterized as raised limestone platforms, while the northern islands are still volcanically active. The five southern limestone islands (Rota, Aguigan, Saipan, Tinian and Farallon de Medinilla) have fringing and/or a barrier reef system while the volcanic northern islands (Anatahan, Sarigan, Guguan, Alamagan, Pagan, Agrigan, Asuncion, Maug, and Farallon de Pajaros) have relatively little coral reef development. Anatahan and all islands northward are considered “recent” by Eldredge (1983). Total land mass of the CNMI is approximately 176.5 miles² (Northern Islands Mayor’s Office 1996). See Map of CNMI in Figure 1.

Figure 1. Map of the Commonwealth of the Northern Mariana Islands.



The CNMI has a very uniformly warm and humid weather throughout the year. Typically, afternoon temperatures range around 30°C while nighttime temperatures fall to 20°C. Humidity values fluctuate diurnally (70-90%) as well as seasonally (USDA-SCS 1989).

Two seasons occur in the Marianas Islands, a dry season which generally lasts from December to June and a wet season which is the remainder of the year. As expected, approximately 200 centimeters of rainfall can be recorded during the wet season, which comprises 66% of the total annual rainfall. Monthly rainfall averages 9.7 centimeters during the dry season and 27.2 centimeters during the wet season.

Over 99% of the CNMI's current population lives on three of the five southern islands; Saipan, Tinian, and Rota. Saipan supports approximately 91% of the total CNMI population (Table 1). The nine northern islands have supported various groups of ethnic groups and population levels throughout time. In recent years, four northern islands have been inhabited by small populations. These include Anatahan, Alamagan, Pagan and Agrihan. Anatahan – the site of major volcanic eruptions from 2003 to 1005 – is presently off-limits in the interests of public safety. Pagan was the site of a severe eruption in 1981 and declared off-limits, however the island has again become inhabited by a few people. Alamagan and Agrihan have sporadic low numbers of people living there. The other remaining islands are not considered appropriate for long term habitation.

Table 1: Summary of the physical attributes of the islands in the CNMI. Data obtained from Northern Islands Mayor's Office (1996) and CNMI 2000 Census.

ISLAND	LOCATION (lat/long)	AREA (Miles²)	POPULATION (2000 Census)	HIGHEST ELEVATION (feet > SL)	DISTANCE from SAIPAN (Miles)
Farallon de Pajaros or Uracas²	20° 33' N 144° 54' E	1.0	- 0 -	1,047	374
Maug²	20° 02' N 144° 14' E	0.8	- 0 -	746	334
Asuncion²	19° 39' N 145° 23' E	2.8	- 0 -	2,923	313
Agrihan	38° 44' N 145° 45' E	11.4	6 ¹	3,166	244
Pagan	18° 07' N 145° 45' E	18.6	- 0 - ¹	1,870	195
Alamagan	17° 35' N 145° 50' E	4.4	6 ¹	2,441	164
Guguan²	17° 20' N 145° 51' E	1.5	- 0 -	988	147
Sarigan	16° 43' N 145° 46' E	1.9	- 0 -	1,801	101
Anatahan	16° 22' N 145° 38' E	12.5	6 ¹	2,585	78
Farallon de Medinilla³	16° 00' N 146° 04' E	0.4	- 0 -	266	58

ISLAND	LOCATION (lat/long)	AREA (Miles²)	POPULATION (2000 Census)	HIGHEST ELEVATION (feet > SL)	DISTANCE from SAIPAN (Miles)
Saipan	15° 05' N 145° 50' E	46.5	69,221	1,554	- 0 -
Tinian	14° 58' N 145° 37' E	39.2	3,540	583	6
Aguiguan	14° 53' N 144° 35' E	2.7	- 0 -	584	16
Rota	14° 08' N 144° 12' E	32.8	3,283	1,625	69

NOTES: 1 - *The 2000 census does not identify on which of the northern islands the six persons were living. However, local knowledge suggests that they were on either Alamagan, Anatahan or Agrigan. Currently, Anatahan is presently declared off-limits indeterminately by the CNMI Government due to recent violent volcanic activity. Pagan has been recently “resettled” in an un-official capacity.*

2 - *Four northern islands are protected under the CNMI Constitution. Article XIV: Natural Resources, provides that the islands of Maug, Farallon de Pajaros, Asuncion, Guguan and other islands specified by law shall be maintained as uninhabited places and used only for the preservation and protection of natural resources, including but not limited to bird, wildlife and plant species.*

3 - *This small uninhabited island has a long term lease with the US military and is utilized as a bombing range by military aircraft.*

To gain a better understanding of the current anthropogenic affects of the northern islands, a very brief outline of the historically significant industries are provided for each period the Marianas was dominated by foreign governments.

Farallon de Pajaros *(taken directly from Russell 2003)*

Prehistoric: None documented.

Spanish: Bird hunting for feathers by Kasatani Otokichi under lease agreement with German Government (? through 1904)

German: Bird hunting (for feather export) by Pagan Company under lease agreement with German Government (1909-1911).

Japanese: None documented.

Postwar: None documented.

Maug *(taken directly from Russell 2003)*

Prehistoric: Subsistence fishing and horticulture.

Spanish: Subsistence fishing and horticulture until forced removal of islands’ residents in the late 1690s; Whaling primarily by American and British whalers (1820s-1860s); Bird hunting for feathers by Kasatani Otokichi under lease

German: agreement with German Government (? through 1904).
Bird hunting (for feather export) by Pagan Company under lease agreement with German Government (1909-1911).

Japanese: None documented.

Postwar: None documented.

Asuncion (*taken directly from Russell 2003*)

Prehistoric: None documented.

Spanish: Whaling primarily by American and British whalers (1820s-1860s). Includes shore visits for resource exploitation; Bird hunting by Kasatani Otokichi under lease agreement with German Government (? through 1904).

German: Bird hunting (for feather export) by Kasatani Otokichi under lease agreement with German Government (? through 1904); Bird hunting (for feather export) by Pagan Company under lease agreement with German Government (1909-1911).

Japanese: None documented.

Postwar: None documented.

Agrigan (*taken directly from Russell 2003*)

Prehistoric: Subsistence fishing and horticulture; Basalt stone export to Saipan, Tinian, Rota, and Guam; Timber export for canoe construction.

Spanish: Subsistence fishing and horticulture until forced removal of island's residents in the late 1690s; Re-provisioning port of call for whale ships (aborted attempt circa 1815); Whaling primarily by American and British whalers (1820s-1860s). Includes shore visits for resource exploitation; Leased to George G. Johnson by Spanish government in 1860s. No commercial activity, however.

German: Copra production under land lease to Pagan Company (1899-1914); Bird hunting (for feather export) by Pagan Company under lease agreement with German Government (1909-1911).

Japanese: Copra production; Commercial fishing; Subsistence fishing and farming by Chamorro and Carolinian residents.

Postwar: Copra production by the Northern Islands Development Company (1951-1960s); Subsistence fishing and farming; Betel nut export; Commercial fishing by Saipan-based boats.

Pagan (*taken directly from Russell 2003*)

Prehistoric: Subsistence fishing and horticulture.

Spanish: Subsistence fishing and horticulture (until forced removal of island's residents to Saipan and Guam in the late 1690s); Whaling primarily by American and British whalers (1830s-1860s). Includes shore visits for resource procurement; Copra plantation 1865-1869 (*La Sociedad Agricola de la Concepcion* established by George Johnson under lease agreement

with Spanish government on Guam); Copra production 1888s by itinerant Carolinian workers. Copra bought by a Captain Williams, master of the ship *Esmeralda*.

- German: Copra production under land lease to Pagan Company (1899-1914).
Japanese: Copra production; Rope making; Commercial fishing.
Postwar: Copra production by the Northern Islands Development Company (1951-1960s); Subsistence fishing and farming by island's resident population until island was declared off-limits following a volcanic eruption in 1981; Betel nut exports; Feral cattle and swine hunting; Commercial fishing by Saipan-based boats.

Alamagan (*taken directly from Russell 2003*)

- Prehistoric: Subsistence fishing and horticulture.
Spanish: Subsistence fishing and horticulture (until forced removal of island's residents to Saipan and Guam in the late 1690s); Whaling primarily by American and British whalers (1830s-1860s). Includes shore visits for resource procurement.
German: Copra production under land lease to Pagan Company (1899-1914).
Japanese: Commercial fishing; Copra production.
Postwar: Copra production by the Northern Islands Development Company (1948-1960s); Subsistence fishing and farming by island's transient resident community; Betel nut exports; Commercial fishing by Saipan-based boats.

Guguan (*taken directly from Russell 2003*)

- Prehistoric: Subsistence fishing and horticulture.
Spanish: Subsistence fishing and horticulture (until forced removal of the island's residents to Saipan and Guam in the late 1690s); Whaling primarily by American and British whalers (1830s-1860s).
German: Bird hunting (for feather export) by Pagan Company under lease agreement with German Government (1909-1911).
Japanese: None documented. Possibly commercial fishing.
Postwar: Commercial fishing by Saipan-based boats.

Sarigan (*taken directly from Russell 2003*)

- Prehistoric: Subsistence fishing and horticulture.
Spanish: Subsistence fishing and horticulture (until forced resettlement to Saipan and Guam in the late 1690s); Whaling primarily by American and British whalers (1830s-1860s). Includes shore visits for resource procurement.
German: Subsistence fishing and horticulture by residents of penal colony operated on the island by the German administration (1901-1906); Bird hunting (for feather export) by Pagan Company under lease agreement with German Government (1909-1911); Copra production (?).

Japanese: Copra production; Commercial fishing.

Postwar: Commercial fishing by Saipan-based boats; Periodic harvesting of betel nuts.

Anatahan (*taken directly from Russell 2003*)

Prehistoric: Subsistence fishing and horticulture; Basalt exported to Saipan, Tinian, Rota and Guam

Spanish: Subsistence fishing and horticulture (until forced resettlement to Saipan and Guam in late 1690s); Whaling primarily by American and British whalers (1830s-1860s). Includes shore visits for resource procurement.

German: Copra production under land lease to Pagan Company (1899-1914)

Japanese: Commercial agriculture, principally copra (1920s-1943); Commercial fishing (principally bonito).

Postwar: Copra produced by the Northern Islands Development Company (1951-1960s?); Subsistence farming and fishing by the island's transient resident community; Betel nut exports; Goat exports; Commercial fishing by Saipan-based boats.

Figure 2. Anatahan eruption, May 2003. Source: NOAA.



HABITAT, USES, TRENDS AND THREATS

Terrestrial Habitat Types

The flora known to date from the Marianas archipelago is not extensive. One estimate puts the total number of native and naturalized species at no more than 500 (Mueller-Dombois and Fosberg 1998). A brief description of island vegetation and/or habitat is presented below.

Southern Islands

Vegetative communities of Saipan, Tinian and Rota were originally mapped by Falanruw, *et. al.* (1989) through the use of 1976 black and white aerial photographs. The vegetation mapping classification system previously developed for use in the Caroline Islands was adapted for the three southern Mariana islands. This particular classification system identified a total of 113 different vegetation codes and was oriented more toward a botanist's perspective.

From a zoological perspective, Falanruw's, *et. al.* (1989) classification system is difficult to use when attempting to characterize wildlife habitat. Additionally, the vegetation map data is based on a snap shot taken in 1976 and is presently somewhat dated. Possibly for this reason, Engbring, *et. al.* (1986) developed a simpler and easier habitat classification system that was based on previous vegetation surveys conducted in the CNMI by USFWS botanists. Engbring, *et. al.* (1986) identified ten non-aquatic habitat types: 1) *native forest*; 2) *secondary forest*; 3) *tangantangan (Leucaena) forest*; 4) *agriforest*; 5) *open field*; 6) *marsh*; 7) *strand*; 8) *urban*; 9) *cultivated*; and 10) *bare ground*.

Both Falanruw, *et. al.* (1989) and Engbring, *et. al.* (1986) are utilized in natural resource assessments. Which classification scheme is used depends upon the goals of the particular document. A general description of the vegetation and/or habitat found on each of the CNMI Islands follow.

Farallon de Medinilla - text taken directly from Mueller-Dombois and Fosberg (1998)

"Fritz (1902) is the only person who published botanical observations from Farallon de Medinilla. Recently, Dr. Derral Herbst (pers. comm.) has documented 13 vascular plant specimens from this tiny scrap of elevated coral, but he says his list is incomplete. The only other information available to the writer (FRF) was from a few aerial color photographs taken by geologists of the U.S. Geological Survey in 1952, a photomosaic map. The island has been frequently used as a bombing target, from which the vegetation has probably suffered, although in the photographs it appears to be not very different from what Fritz described.

Fritz states that the plateau is covered by brush about 4 meters in height and a savanna with small grasses and Liliaceae. The plants he mentions by Chamorro names are *talisai (Terminalia)*, *gulos (Cynometra)*, *lada (Morinda citrifolia)*, *ahgao (Premna)*, and *nonak (Hernandia)* and *nunu (Ficus)*. Fritz noted papaya trees but no coconuts. He planted coconuts, *Casuarina*, beans, and other plants, but there is no record of whether any of them survived. No coconuts are apparent in the photographs. Part of the island still seems to be covered with sparse grass or is almost bare".

Saipan

History has played a paramount role in shaping Saipan's vegetation and habitat to what is presently seen today. Mueller-Dombois and Fosberg (1998) describe it best when they discuss Saipan's vegetation as being a product of "human occupation of at least 3500 years, including occupation by the aboriginal Chamorros, domination and alteration by four successive foreign cultures, and a major campaign during WWII. Almost the whole island has been profoundly disturbed. As a result, the vegetation patterns are neither simple nor stable."

Engbring et. al. (1986) found the island's habitat consisting primarily of "mixed second growth forests, grassy savannas, and dense thickets of introduced *Leucaena leucocephala* (tangantangan)." Tangantangan was intentionally introduced immediately after World War II by the U.S. military as an erosion preventative measure and is presently considered an invasive species by the Invasive Species Specialist Group of the World Conservation Union.

Engbring, et. al. (1986) estimated that Saipan has approximately 4% native forest habitat, 32% secondary vegetation, 28% tangantangan, 8% agroforest, 14% open field, 2% marsh, 3% strand, 7% urban, <1% cultivated and 2% bare ground.

Tinian

Engbring et. al. (1986) found the vegetation on Tinian Island to have "been greatly altered by ungulates and by human activities and a great portion of the island consists of extensive stands of *Leucaena*. The small amount of native forest remaining is restricted primarily to limestone escarpments." Distribution and quality of existing habitat is caused in part from cattle grazing activities that cover nearly half the island (Engbring, et. al. 1982). Historical farming activities by the Japanese initially affected much of the island's habitat. It has been estimated that the Japanese had at one time 25,000 acres in farmland, primarily in sugar cane (US Navy Department 1948).

Engbring, et. al. (1986) estimated that Tinian has approximately 4.9% native forest habitat, 19.2% secondary vegetation, 38.3% tangantangan, 0% agriforest, 30.9% open field, <1% marsh, 3.5% strand, 0.8% urban, 1.9% cultivated and 0.3% bare ground.

Aguiguan - text taken directly from Mueller-Dombois and Fosberg (1998)

"This small (3 X 6 km) island is just south of Tinian.... and of similar geological structure. It is a limestone platform with several flat terraces. Little if anything has been written on its vegetation, and the writer (FRF)⁶ did not study it, except briefly from the air in 1950.

As with Tinian, the Japanese cleared the level places for sugarcane plantations and planted windbreaks of *Casuarina* on the uppermost terrace. The plantations were still more or less dominated by the persisting cane and by elephant grass (*Pennisetum purpureum*). Most of the cane has since (the 1950's) died. The other parts are wooded, but the undergrowth, at least, has been affected by the large number of feral goats that inhabit the island. The composition of the forest is apparently similar to that on rough limestone and the cliffs of Tinian. A bamboo and the flamboyant tree *Delonix regia*, as well as *Leucaena leucocephala*, are conspicuous introduced plants. Another introduction, *Jatropha gossypifolia*, as on

Tinian, is locally common, probably because it is unpalatable to the goats.

Much of this information was gathered from unpublished photographs kindly furnished by George Peterson, which he took in 1954, and others by Clifton J. Davis, which he took in 1954 and 1955. Yoshio Kondo collected specimens and contributed verbal information after several visits he made in connection with experiments with carnivorous snails for control of the giant African snail, *Achatina fulica*.”

Engbring, *et. al.* (1986) estimated that Aguiguan has approximately 47% native forest habitat, 3.5% secondary vegetation, 0% tangantangan, 0% agroforest, 42.9% open field, 0% marsh, 2.5% strand, 0% urban, 0% cultivated and 3.8% bare ground.

Rota

Engbring, *et. al.* (1986) provides the following general description of Rota’s habitat. “The Japanese cultivated sugar cane on level areas of Rota. A small gauge railroad system traversed the cane fields of the eastern plateau, and remnants of the sugar mill can still be seen in Songsong. Despite this once fairly extensive agricultural system, much of Rota’s precipitous terrain is unsuitable for agriculture, and more native vegetation remains on Rota than on Saipan or Tinian. Also, Rota was spared an invasion by U.S. troops during World War II.

Nearly all of the slopes leading up to the highest mesa support well-developed native forest. Extensive areas on the eastern plateau and coastal shelves which were formally farmed have regenerated with native species, though this second-growth forest is scrubby with numerous openings and is now being developed for grazing. Where not grazed these openings are heavily overgrown with grasses, vines, and shrubs. The upper plateau and some of the slopes leading up to the plateau have several extensive openings, remnants of agricultural development, phosphate mining, and other human activities.”

Engbring, *et. al.* (1986) estimated that Rota has approximately 60.2% native forest habitat, 8.6% secondary vegetation, 0.3% tangantangan, 0.2% agroforest, 27.8% open field, 0% marsh, 1.2% strand, 1.1% urban, 0% cultivated and 0.4% bare ground.

Northern Islands

Farallon de Pajaros - text taken directly from Mueller-Dombois and Fosberg (1998)

“New field data from Ohba (1994) on the vegetation of this active volcano, which forms the most northern of the Mariana Islands, now adds to the brief, earlier account by Fritz (1902) and observations by Falanruw in 1989. One species of sedge, *Fimbristylis boninensis* (syn. *F. urakasiana*), which was described initially as an endemic, turned out to be the Bonin Island sedge. Excellent aerial color photographs, taken in 1952 by members of the Guam party of the U.S. Geological Survey and in 1953 by the U.S. Navy, suggested that the greater part of the island was covered by fresh volcanic material, lava and ash, which apparently supported very little vegetation of vascular plants. Two lighter-colored rocks of older material, protruding from this younger material, showed a thin, grassy vegetation, thought to be a mainly sparse sedges. No woody plants could be discerned.

Ohba (1994) supports this assessment and has recognized four plant community types, two sedge communities (*Fimbristylis cymosa* and *Mariscus javanicus*) and two succulent, apparently coastal, rock communities (*Portulaca lutea* and *Sesuvium portulacastrum*).

Ohba also lists such grasses as *Lepturus repens* and *Digitaria ciliaris* and the sedge *Fimbristylis boninensis* as associates of his *Mariscus javanicus* community. *Fimbristylis boninensis* is also listed as an associate of the *F. cymosa* community, which includes the creeper *Ipomoea pes-casprae* as a pioneer species on new volcanic material. Surprisingly, no record is given of the grass *Miscanthus floridulus*, which was suspected earlier by FRF to form a community type.

These facts also accord with the observations of Fritz, who speaks of a volcano with no vegetation except for sparse plant growth on fragments of older substrate. His party planted coconuts (*Casuarina*, and other plants at that time (near the turn of the century). These are not evident on the photographs taken 50 years later, and apparently none have survived, since Ohba mentions no trees.”

Maug - text taken directly from Mueller-Dombois and Fosberg (1998)

“Maug is a cluster of three small islands, parts of the rim of a partially submerged volcano, arranged in a ring around a “lagoon,” which was the old crater. The eastern island, the largest, reaches an elevation of 215 meters. These islands are very steep and rocky. The slopes are for the most part covered by a coarse grass, probably *Miscanthus*. Notes on vegetation and records of plant occurrences appear in a paper on the natural history of Maug by University of Guam parties that visited Maug in 1972 and 1975 (Eldredge et al. 1977). Some plant collections were made by these groups. Earlier Fritz (1902) wrote a brief account, republished by Prowazek (1913). FRF made notes from Banner’s photographs taken in 1945. In addition to the *Miscanthus* grass, low scrub patches with *Scaevola* and *Wollastonia* occur on all the islands.

The eastern island, according to Fritz (1902), has some trees, including coconuts, *Terminalia*, *Pandanus*, *Boehmeria*, *Hernandia*, and, according to Safford (1905), fago (*Ochrosia*). Prowazek (1913), however, interpreted fago as pago and cites it as *Pariti tiliacea* (*Hibiscus tiliaceus*). The presence of *Ochrosia* (now renamed *Neisosperma*) is more probable. Fritz reported a coconut grove situated on a ridge on the west coast. The U.S. Hydrographic Office (1952) reported that the higher slopes of East Island are covered with trees. Recent air photographs show patches of forest below the grassy slopes along the shore and running up ravines.

The natural history survey described a poor vegetation but listed 60 species of vascular plants (Eldredge et al. 1977). Ohba (1994) recognized four types of forest communities: *Hibiscus tiliaceus*, *Pandanus tectorius*, *Terminalia catappa*, and *Pisonia grandis* types. The latter two occur in gullies, especially on the leeward sides, while *Hibiscus* is found in moister situations, and *Pandanus* on slopes and cliffs. Ohba recorded at least eight other communities, including two grass communities (*Miscanthus* and *Zoysia matrella*), a sedge community (*Fimbristylis cymosa*), two scrub communities (*Scaevola taccada* and *Pipturus argenteus-Colubrina asiatica*), and several other low-growing vegetation types (two creeper communities, *Vigna marina-Ipomoea pes-caprae* and *Capparis cordifolia*), and a liliaceous community of *Crinum asiaticum*.”

Asuncion - text taken directly from Mueller-Dombois and Fosberg (1998)

“This island is a steep volcanic cone that last erupted in 1906 and still shows occasional

signs of activity. Until 1989 there was a dearth of information on this island. Its earlier vegetational history consists of information from Prowazek's account (1913), the U.S. Hydrographic Office (1952), and the Banner photographs. La Perouse visited the island in 1786, Beechey in 1827, and we may quote from Beechey's narrative (1831):

Time must have made an agreeable alteration in the appearance of this island since it was visited by La Perouse. Instead of a cone covered with lava and volcanic glass, and presenting the forbidding aspect he describes, we traced vegetation nearly to the summit, and observed woods of palm-trees skirting its base; particularly in the southwest side.

It is interesting that Beechey records *Carica papaya*, which apparently achieved a wide distribution even in such a remote island early after its introduction during Spanish times. According to Safford (1905), the indigenous people (at least of Guam), did not care much for its fruit. M. Falanruw made five visits to this and the other volcanoes, resulting in floristic lists (Fosberg, Falanruw, and Sachet 1975, 1977, 1980).

A detailed treatment of the vegetation of Asuncion is available (Falanruw 1989), based on abundant field and air photo data. Figure 5.4 shows the distribution of the major vegetation types, and Ohba (1994) provides further details. This island has been intermittently inhabited since the mid-seventeenth century, when Sanvitores, the first European visitor, found it inhabited. Consequently, its lowest south and southwest slopes and relatively flat land are in coconut groves, and old garden plots can be found around a few abandoned dwellings. Otherwise, disturbance has principally been from landslides, which are frequent on loose ash slopes.

A rather scrubby, mixed broadleaf forest, dominated by *Terminalia* spp. (*T. catappa*, mainly, and including *T. rostrata* and *T. samoensis*), is the most extensive forest type. This forest occupies the southern slopes above the coconut groves, extending about halfway up to the summit, and on the lower slopes around the whole west side. It is interspersed with a low scrub, especially in ravines. The area above clifftops support a scrub and forest matrix, and in openings area mats of the fine, mat-forming grass *Zoysia matrella* and *Chrysopogon aciculatus*. Patches of coastal thicket and a scrubby forest of several broadleaf tree species spread from the ravines. The same woody plants as are frequent in the *Terminalia* forest are found in the ravines and coastal thicket, including *Pandanus*, *Premna*, *neisosperma*, *Trema*, *Ficus*, *Pipturus*, *Erythrina*, and *Hibiscus tiliaceus*. This scrub forest continues up the ravines, extending above the principal wooded areas.

Above the scrub forest is a complex of fernland, with dense stands of *Davallia solida*, *Nephrolepis hirsutula*, and *Phymatosorus scolopendria*. These form a thick mass of rhizomes intermixed with patches of *Miscanthus*, bare landsides, and ridges of bare rock. There is a large, inverted triangle of a bare 1906 lave flow at the upper elevation. The mixed matrix of thin, low scrub, grass, and fernland extends irregularly to the summit crater. This fern, grass, and low scrub complex reaches down the north and northeast slopes to the coastal bluffs. The east slope is mostly bare landslides.”

Agrihan - text taken directly from Mueller-Dombois and Fosberg (1998)

“This island is a larger and recently active (1917) volcano cone 965 m high. The island is oval in outline, 10 km from N to S and 5.5 km from E to W, and composed largely of beds of loose ash, with some interbedded basaltic flows. Its flora is reasonably well known through the collections of Kanehira, Hosokawa, and Fosberg, and now through the study of Ohba (1994). Since the visit of Fritz in 1901, there has been volcanic activity, possibly of a major character, as he records the altitude of the central peak as only 750 m. His brief characterization of the vegetation (1902), however, is in accord with the account given below, which is summarized from Fosberg’s personal observations and from notes by Kanehira (1934) and Hosokawa (1934).

The vegetation, though locally varied, is separable into two main complexes. The steep ash slopes, which cover the greater part of the island, are clothed with dense sword grass (*Miscanthus*) and cut by ravines, which are wooded well up towards the top of the mountain. The *Miscanthus* grass is dense, well over head high and difficult to traverse. The crater, at the summit, had not been examined botanically. The coastal benches and bluffs are covered by a mixture of thickets and woods of *Casuarina*, *Ficus*, *Hibiscus tiliaceus*, and various other native trees where the terrain is too steep or rough for the planting of coconuts. Coconut plantations occur where there are small bits of reasonably level land.

The general characteristics of the vegetation of this island suggest a relatively dry climate, even if allowances are made for the effects of the extremely rapid drainage through the coarse volcanic ash. Vascular epiphytes appear to be absent. The increasing abundance of ferns, which occurs towards the upper parts of the wooded ravines, shows that the humidity, at least, is greater there. This may well be due to the cloud cap that often covers the upper part of the mountain. Surface water seems to be entirely absent except during rainy weather, when there is some runoff in the ravine bottoms.

Ohba’s (1994) new data show that there are no *Pisonia-Terminalia* forests. Instead, Agrihan’s forest type, not described for the preceding three islands [Asuncion, Maug, and Uracas], is the *Aglaia-Elaeocarpus* forest. The two key species are *Aglaia mariannensis* (Meliaceae, a Mariana endemic) and *Elaeocarpus joga* (a Micronesia endemic). This mesic broadleaf forest contains a mixture of other species, commonly including *Psychotria mariana*, the pandan vine *Freycinetia reineckii*, the tree fern *Cyathea aramaganensis*, and the herbaceous fern *Pteris boninensis*. Ohba considers this to be the upland climax forest (from 250 to 500 m elevation) of the larger Northern Mariana islands (Agrihan, Pagan, Sarigan, and Anatahan).”

Pagan - text taken directly from Mueller-Dombois and Fosberg (1998)

“Pagan is the largest of the Northern Mariana Islands, with an area of 48 km². The island has the form of a panhandle and is composed of two high, volcanic centers connected by a wide, low isthmus. The more northern of these, Mt. Pagan, 570 meters in elevation, was active not long before 1950, and minor activity, such as warm springs and emissions of steam and hot gases, could still be observed in 1950. The topography then was very diverse, much of it steep and rough. The surface was made up of relatively fresh lava flows and beds of ash and coarser pyroclastic material. Slightly elevated reef limestone of limited extent was found on the eastern and northern coasts.

Plant collections have been made on Pagan by Marche, Kanehira, Hosokawa, Anderson, Bonham, Fosberg, Moore, and Raulerson. A catalogue of the vascular flora has been prepared on the basis of these by Fosberg (1958). A small fossil flora has also been found and was reported by Fosberg and Corwin (1958). The geology was thoroughly studied in 1954 by Corwin et al. (1957). Notes on the vegetation were made in connection with the geological study by Bonham. Fosberg was able to make records and photographs during a short stop in 1950. After Fosberg's (1958) report, a destructive eruption took place (1980).

The vegetation of Pagan in 1950 gave a general impression of semi-aridity; indeed, large areas would be classed physiognomically as deserts. This is probably not so much a reflection of climatic dryness as of the extreme porous substrates and of the pioneer nature of the vegetation occupying the surfaces of recent volcanic ejecta. In the very few low, wet areas, such as to the west and south-west of the Freshwater Lake, or Inner Lake, there were luxurious thickets of broad-leaved trees; in places bordering the lake, the conditions were somewhat marshy. Luxuriant patches of woods also occurred in hanging valleys on the west side of the south end of the island. A mixed-scrub forest of low stature formed thickets and patches up to several hectares in extent on the plains north and south of Mt. Pagan, in places extending up the lower slopes of the volcano. Scrub forest also occurred on steep slopes on the west shore of the isthmus and in the numerous ravines throughout the island. It varies in height from 3 to 8 meters and in density from open parkland to dense, tangled thicket. The understory was sparse, but in denser areas, the low, tangled branches of the trees seriously obstructed movement. The effects of the 1980 eruptions on this vegetation are not yet on record, but Ohba (1994) reports that the extensive 1980 lava field and ash deposits are still devoid of almost any vegetation.

The loose volcanic ash that covered large areas, especially on the western side, was vegetated largely by an almost pure stand of *Miscanthus floridulus*. This formed a coarse, harsh, brakelike grassland 1 to 3 meters in height and very dense in places. On the steepest slopes and above 250 meters in elevation, this grass tended to be shorter, and the clumps more widely spaced. Above 450 m it was sparse to absent.

Lava flows may be virtually bare, as on the northeast side of Mt. Pagan. But they can support scattered clumps of *Miscanthus* and trees of *Casuarina*, as on the eastern and southeastern sides of Mt. Pagan and the central upland of the southern part of the island. As on many of the flows and lava cliffs, they can even be covered by almost pure forests of *Casuarina*. *Casuarina* and the fern *Nephrolepis hirsutula* are among the earliest invaders on new lava. These two species were found well established on a fresh, black 'a' flow in the depression at the western base of Mt. Pagan in 1950. This flow has been dated by Tanaka-date (1940) as having occurred in 1925. In 1950 it showed no sign of visible weathering.

On plains of ash soil, the vegetation is generally a grassland with scattered trees or clumps of trees. The trees may be *Pandanus tectorius*, *Casuarina equisetifolia*, or any of a number of broad-leaved species. Many of these areas were under cultivation before WW II but were weedy in 1950; they had rows of *Casuarina* and other trees planted by the Japanese as windbreaks. *Jatropha gossypifolia*, a fleshy-stemmed shrub introduced by the Japanese in the late 1930's, had spread, and it dominated large areas in the central part of the island.

Clumps of trees of various kinds marked the sites of houses. On the gently sloping north-western part of the island was a large coconut plantation. Smaller ones were located in many parts of the island, both on plains and on talus cones. Coconut trees were also common in ravine mouths and on steep slopes near the sea. The large plantations were of relatively recent dates, but there was no way of knowing the ages of the smaller clumps of coconuts that were mixed with other vegetation in various parts of the island. Some may very well have dated from pre-European times.

A small, slightly raised coral reef on the east coast was the only known locality on the island for *Pemphis acidula*, *Capparis cordifolia*, and several other plants of rough limestone habitats. However, *Pemphis-Capparis* scrub may also occur on similar reefs on the north end of the island.

The vegetation on steep slopes, rough ground, and relatively fresh lava was little disturbed by human activities. The sword grass has been burned over large areas, but such burning does not seem to be much of a deterrent to *Miscanthus*. In favorable places the grass, after being burned in 1954, grew to waist height within six weeks. Such burning, however, tends to eliminate associated species and keeps *Casuarina* from gaining a foothold. As noted above, the area of more gentle ash slopes, plains, and talus cones has been very much altered by humans. The cultivated areas were abandoned after WWII and allowed to grow into weed fields. Some of these were gradually reoccupied up to the time of the 1980 eruption. The coconut plantations had changed little before the eruption, except they had become choked with weeds and young coconut seedlings.

The above account was mostly written before the 1980 eruption. Since that time, there have been few species additions. Large tracts of vegetation were completely eliminated in 1980 by lava and ash blanket deposits.

Ohba (1994) essentially confirms the picture of devastation with no revegetation since the 1980 eruption, noting *Casuarina* forest as the most predominant vegetation in the northern part of Mt. Pagan. Ohba adds that the relatively old central volcanoes, with more weathered surfaces, support *Pandanus tectorius* stands and, above 150 m elevation, an impoverished *Elaeocarpus joga* forest, which has been degraded by goats. The more severe degradation state is said to be *Miscanthus* grass cover. On the southern volcano there are remnants of native forest where the endemic tree genus *Guamia* was originally found. This species, *G. mariannae*, is now considered extinct on Pagan due to goat grazing.”

Alamagan - text taken directly from Mueller-Dombois and Fosberg (1998)

“This island is a dormant volcano in many respects similar to Agrihan, but smaller (44 km²) and lower (744 m high). Plant collections and notes on the vegetation have been made to about the same extent and by the same people as those on Agrihan. Topographically, in addition to steep, dissected ash slopes, this island has gently sloping lava flows extending to the base on the northern and south-western sides. The southern end is a high bluff with very large, recent landslides and great talus slopes at its base, all almost devoid of vegetation. There are two craters. As on Agrihan, surface water is absent except during rainy weather.

The dominant vegetational feature, as on the other Northern Marianas, is the *Miscanthus* sword grass on the ash slopes. These slopes are incised well towards the top by deep

ravines, which are densely wooded with mixed, species rich, broad-leaved forest made up of many species. The upper middle slopes have a sparse scattering of woody vegetation, which Kanehira (1934) described as a continuous stand of tree ferns. This tree fern species is *Cyathea aramaganensis*, which Ohba (1994) recorded also from Pagan. This tree fern species has branches at the base of the trunk, which can be larger than 1 m in diameter. The uppermost slopes are thickly covered by *Miscanthus* sword grass. In the crater, according to Kanehira, there are bushes and grasses, the latter occupying spots at the foot of the vertical walls.

In the lowlands steep, eroded areas, bluffs, broad ravines, and talus, if wooded, are covered by thickets with tangled undergrowth. The outstanding landform here, however is the gently sloping surface of the lava flows. These lava flows, where reasonably smooth, are planted to coconuts. In places, however, they are exceedingly rough and covered by a type of forest resembling that on the rough limestone in the southern Marianas. These forests are made up of *Ficus prolixa*, *F. tinctoria*, *Pipturus*, *Pouteria*, *Hibiscus tiliaceus*, *Elaeocarpus joga*, *Melanolepis*, *Premna*, *Morinda citrifolia*, *Guamia*, *Psychotria mariana*, *Trema orientalis* var. *argentea*, *Aidia cochinchinensis* (Rubiaceae), and other trees, including *Aglaia mariannensis*. The undergrowth is generally very sparse, the two most important components being the ferns *Phymatosorus scolopendria* and *Asplenium nidus*. Towards the seaward edge, just as in the forests on limestone in the southern Marianas, the stature of this vegetation is much lower, and shrub species are more numerous than tree species. *Pandanus* is commonest on bluffs over the sea, and *Casuarina* was seen only in such situations.

Judging by a greater abundance of epiphytes, the more luxuriant vegetation, and the presence of great numbers of tree ferns, Alamagan is distinctly wetter than Agrihan in situations of comparable substrates.”

Guguan - text taken directly from Mueller-Dombois and Fosberg (1998)

“Guguan is one of the most uninhabited of all tropical islands. It is among the smaller and lower (301 m) uninhabited islands, in size comparable to Uracas. Fritz (1902) provided an earlier published account of the vegetation. There has been some volcanic activity since, judging from the apparently fresh lava that covers large areas, especially on the northern part. According to Fritz, the northern part was of recent volcanic ash and was covered by grass and the parasitic *Cassytha*. There were many *Pandanus* trees in the ravines. In the southern part is a valley where Fritz planted coconuts, *Casuarina*, beans, and gourds.

On recent aerial photographs the interior is covered chiefly by barren, black lava, with some grass visible near the edges. M. Falanruw visited Guguan more recently and collected many species and reports the presence of locally dense vegetation. The flora of Guguan is listed in Fosberg et al. (1975). Ohba (1994) reports that recent ash deposits are covered with *Ipomoea pes-caprae* var. *brasiliensis*, *Fimbristylis cymosa*, and other typical members of the strand vegetation and that scrub patches of *Pipturus argenteus* and *Colubrina asiatica* occur within the strand vegetation matrix. The moister ravines are filled with *Pisonia grandis* forest, and the upper, drier ravines and ridges are stocked with *Terminalia catappa* forest. The island is free of goats and other ungulates.”

Sarigan - text taken directly from Mueller-Dombois and Fosberg (1998)

“This is a dormant volcano, also conical in shape and about 550 m in elevation. From the few brief reports and photographs available, the steeper slopes seem to be covered by *Miscanthus*, as is usual for these young islands. The lower slopes have coconut plantations, except where too steep, as on the southwest side, or where there are lava flows, as on the north side. Such flows are forested, and there are a few scattered coconut trees. Forest or thicket also runs up the ravines. There are a number of species of woody plants, but *Hibiscus tiliaceus* is especially prominent, forming tangled thickets laced with morning glory (*Ipomoea pes-caprae*) and other vines (such as *Stictocardia tiliifolia*). Near the summit is some scrubby growth, including *Cyathea* tree ferns. Plants collected there by M. Evans are reported by Fosberg et al. (1975).

Ohba (1994) found native *Pisonia grandis* forest on upland ridges, and a plateau at 400 m was covered with the short grass *Chrysopogon aciculatus*. He also found abandoned fields at midelevation covered with miscanthus, and the whole island suffered severely from the impact of goats.”

Anatahan - text taken directly from Mueller-Dombois and Fosberg (1998)

“Anatahan is among the larger islands, about 7 km from east to west and 3 km from north to south. It is also an extinct or dormant volcano, with a broad, shallow crater, to the east and west of which the high remnants of the rim form peaks. The steep slopes are cut by deep ravines, giving the sides a folded aspect. In these ravines there is said to be some surface runoff during rains.

The lower slopes are thickly wooded, as is the south side of the high, western peak. There are many coconut plantations in the valleys and on lower slopes close to sea level. The ridges on the steeper slopes are covered by *Miscanthus* grassland, with the ravines between them wooded. It is not certain whether the broad plain on the bottom of the crater is grassy or covered by thickets. It is probably swampy or marshy. *Pandanus* is common in the thickets and woods near the shore and on the slopes above. Near abandoned dwellings are citrus trees and banana plants. There are said to be breadfruit trees in the valleys. A popular account (Maruyama 1954) on the life of the Japanese castaways, who occupied the island from 1944 to 1951, gives a vivid impression of the island and its vegetation, though little scientifically acceptable information on the vegetation is included. M. Falanruw (pers. comm.) Visited the island in 1975 and reported a rather rich vegetation. Specimens collected by her are reported by Fosberg et al. (1975).

Ohba (1975) reports that the native forest has mostly degenerated to *Miscanthus* grassland from goat grazing, and further to *Chrysopogon aciculatus* short grass cover in particularly heavily impacted areas. The ravines contain thickets of *Hibiscus tiliaceus*, and fog-frequented cliffs have remnants of *Elaeocarpus joga* forests with tree ferns of *Cyathea aramaganensis*.”

Surface Water Resources

Inland Lakes or Ponds

Only two of the five southern islands have lakes; Saipan and Tinian. The two islands each have one freshwater lake that supports an adjacent wetland complex that is utilized by federally endangered species. These systems are not connected to groundwater systems and are considered important natural resources with the government actively implementing protectionist measures.

Saipan Island:

Lake Susupe is the largest inland water body in the CNMI and the only natural perennial lake on Saipan. This isolated water body and its associated wetland habitat has no surface water or hydraulic connection to the nearby marine waters of Saipan Lagoon. The lake is located approximately 3,500 feet inland from the Philippine Sea in an area of southwestern Saipan known as Chalan Kanoa (Wong and Hill 2000).

Although not known as a potable water source and considered by some as contaminated, the lake was an industrial water source used in the operations of the Japanese sugar mill facility located at Chalan Kanoa. This slightly brackish-water lake was also used for “*washing, flushing, fire fighting and other uses not requiring potable water*” (Davis 1958).

The lake is located in a low marshy area approximately 2 square miles in size that lies along the coastal plain zone. Lake size during “*normal*” water levels is estimated at 45 acres which is about 1 to 2 feet above mean sea level. The watershed of the lake is estimated at 4.72 square miles with headwaters (intermittent) originating from two areas; Mount Tagpochau to the north and the Fina Sisu ridge to the east. Along the western boundary of the drainage area lie Susupe and Chalan Kanoa Villages (Wong and Hill 2000).

Surface runoff into Lake Susupe is believed to be minor except during extended heavy rains when the low lying neighboring villages of Susupe and Chalan Kanoa are often flooded. During dry years surface runoff into the lake is likely not measurable (Wong and Hill 2000).

The USGS (Wong and Hill 2000) investigation into lake bathymetry found the deepest point to be -4.26 feet mean sea level (MSL) with a average altitude of the lake bed at -2.60 feet MSL. Of the two previous attempts at mapping lake bathymetry, the USGS (2000) study more closely matched lake depths obtained by the USCOE (1981) than the van der Brug (1985) study who recorded a maximum depth of -5.5 feet MSL.

As expected from a shallow open water lake system, Lake Susupe waters were found to be well-mixed and showed no evidence of thermal stratification. Water temperature (range = 28.0 to 32.0 °C), specific conductance (range = 2,300 to 4,630 mS/cm), pH (range = 7.19 to 8.40) and dissolved oxygen values (range 5.8 to 8.8 mg/L) remained relatively uniform across spatial and depth gradients. With respect to drinking water standards, lake waters were found to be high in dissolved solids (range = 1,260 to 2,760 mg/L) with the dominant major ions being comprised of sodium and chloride. Additionally, the water is “*hard*” with alkalinity measurements ranging between 108 and 183 mg/L as CaCO₃. Ranges in water chemistry variables are expected to be seasonal as water input during the rainy season (e.g.,

where the volume of lake increases) will dilute the existing chemical parameters (Wong and Hill 2000).

Lake bottom substrate is described by Wong and Hill (2000) as a “*muddy layer of organic-rich sediment*” and is further described as “..... *fine-grained sediment is about 3 to 7 ft thick, unconsolidated, with a reddish-brown color, an odor of hydrogen sulfide, and a gelatinous consistency*”.

A conceptual water balance model was developed for Lake Susupe based on current limited information obtained by the USGS during their 1990 study (Wong and Hill 2000). The model is comprised of three parts and are described below:

1. Lake Susupe fills to capacity during the rainy season; as much as twice the dry season volume. Water input was identified as rain falling directly into the lake and surrounding associated wetlands with minor contributions from surface runoff.
2. Following rainfall input, water is lost from the lake system through evaporation and small amounts of ground-water flow.
3. During the dry season Lake Susupe continues to lose water through the evaporation process while a small volume of ground water flows into the lake system.

Due to the apparent minimal ground-water flow into, and out of Lake Susupe, coupled with rainfall input almost equaling the evaporation rate for the lake system, it was surmised that lake volume is controlled primarily by atmospheric processes of rainfall and evaporation (Wong and Hill 2000).

In summary, the Lake Susupe wetland complex is one of the more unique and special wildlife habitats in the CNMI. It is considered by some (Best and Davidson 1981; Stinson 1993) to be the only area in the CNMI to have an extensive waterbird community comprised of both native and migratory species. It is utilized by two wetland associated wildlife species that are Federally and locally protected; the Endangered nightingale reed-warbler (*Acrocephalus luscinia*) and the Endangered Mariana common moorhen (*Gallinula chloropus guami*). This wetland complex was also utilized by the recently de-listed Marianas mallard (*Anas platyrhynchos oustaleti*), a questionable species now considered extinct by the USFWS.

Tinian Island:

Lake Hagoi, the second lake in the southern islands, is sited on raised limestone terrace in northern Tinian (Stinson 1996). Whereas Lake Susupe on Saipan has been the subject of several multi-faceted research investigations, Lake Hagoi on Tinian has received little attention except for its value relative to wildlife habitat. Lake Hagoi is included in the large parcel of land that was leased back to the U.S. Navy after World War II (Stinson 1996).

Engbring, et.al. (1986) estimated the “*lake size*” at 15 hectares, but did not offer details as to what were its physical limits as the lake occasionally goes dry during droughts (Stinson 1993). A later study conducted by the USFWS (1996) while investigating the biology of the Marina common moorhen, characterized the lake wetland complex as a 3.09-acre (1.25 ha)

open water pond that is surrounded by a diverse “interior” wetland vegetative community (*Scirpus litoralis*, *Acrostichum aureum*, *Paspalum disticum* and *Phragmites karka*) totaling 12.12 acres (4.9 ha) in size. This core wetland is encircled by a distinctive homogenous band of *Phragmites karka* that totals approximately 23 ha (57 ac). Near the outer perimeter of the wetland complex, patches of *Hibiscus tiliaceus* and bamboo (*Bambusa vulgaris*) has also been recorded (Stinson 1996). Approximately 80% of the entire wetland complex is dominated by *Phragmites karka*.

Water depths in Lake Hagoi ranged from a high of 34 inches in the southern section to a high of 39.5 inches in the northern section. As the lake dried during their study period (July 1994 to August 1995), the lowest water levels were 0.0 inches in both sections (USFWS 1996).

Lake Hagoi is utilized by one wetland associated endangered wildlife species, the Mariana common moorhen. Stinson (1996) reports that this lake “occasionally supports the highest concentrations of Mariana Common Moorhens reported at any site.”

Of the nine Northern Islands, only Pagan contains any surface water resources. There are two lakes located in north Pagan near the active volcano; Lake Sinalung and Lake Lagona. Presently, emergent vegetation along the lakes are rare due to the chronic impact of grazing by feral ungulates during the 1960’s and 1970’s and then the dramatic 1981 volcanic eruption which deposited a large volume of cinders along the lake shores (Stinson 1993). It should be noted that the following physical description of the two Pagan lakes by Corwin, et.al. (1957) were obtained before the 1981 eruption event.

Pagan Island:

The 43-acre Inner Lake, also known as Sinalung Lake, lies in the northwestern part of the island along the inner basin. This lake is approximately 1,840 feet long in a NNE-SSW direction and 1,720 feet wide in an E-W direction.

Average depth of the water is 50 feet with a maximum depth of 75 feet. Total volume of the lake has been estimated at 2,150 acre-feet. The lake bottom is nearly flat with the sediment being characterized as “fine-grained mud or muck”. The lake’s water surface is approximately 4 feet above mean sea level and it has no tidal fluctuations.

Water quality is such that it is unsuitable for most uses; the average chloride content is 2,500 ppm while total dissolved solids measured 4,500 ppm. Salinity levels are highest in the vicinity of the warm springs along the southeast shore. The water is considered unsuitable for most uses (Corwin, et.al. 1957).

The second lake, Lagona Lake, lies just south west of Inner Lake and is separated from the ocean by a coastal sand bar approximately 30 feet above sea level. This 39.5-acre lake is approximately 2,460 feet long in a N-S direction and 1,020 feet wide in an E-W direction.

Average depth of the water is 40 feet with a maximum depth of 65 feet. Total volume of the lake has been estimated at 1,580 acre-feet. The lake bottom is mostly “fine-grained mud and are covered by organic debris which is distributed by wave action during typhoons.” Due primarily to its location, tidal influences are small with an average amplitude of 3.5%

of the ocean. The lake's water surface averages approximately 0.5-foot above mean sea level.

Water quality is such that it is unsuitable for most uses; the average chloride content is 7,000 ppm while total dissolved solids measured 16,000 ppm. The water is considered unsuitable for most uses (Corwin, et.al. 1957).

Stream systems

Stream systems on the southern islands of Rota, Tinian and Saipan are fairly well known with existing USGS topographical maps for each island. In contrast, stream systems for Aguiguan and Farallon De Medinilla are unknown and believed to be non-existent.

Based on the definition of perennial streams requiring year-round flow into adjacent near shore coastal waters, no perennial streams are known from the southern islands (Davis 1958; Engbring, *et.al.* 1986; van der Brug 1985; Carruth 2003). However, there are sections of certain streams that may be classified as perennial, especially in the Talakhaya watershed area on Rota (USGS 1994) and the Talofofu watershed area on Saipan (van der Brug 1985). It is believed by some that Rota may have had perennial streams historically. However since much of the water from the Talakhaya water shed system is presently utilized as municipal water, the total potential volume of water has been substantially decreased, therefore possibly interrupting stream discharge at the mouth.

As such, some CNMI streams only discharge into adjacent near shore marine waters only after heavy rainfall events. The rainfall threshold that would generate a stream discharge has not been determined for any of the stream systems and will likely vary depending upon size of watershed, underlying soil types and the saturation level of the soils.

Knowledge of the stream systems occurring on the Northern Islands are virtually unknown, except by those few individuals who have spent time there. The possibility of finding perennial streams are likely to be very rare. Corwin, et.al. (1957) writes about the occurrence of streams on Pagan, one of the better known of the northern islands, "*Because of generally high permeability and infiltration rates for volcanic materials, runoff is very small. No streams were observed even during moderately heavy rains.*" It is assumed that the comment on Pagan streams may also apply to the remaining northern islands.

Near Shore Marine Resources

Coral reefs

During a general investigation into the coral reef areas of the American flag Pacific islands, Hunter (1995) found the 14 islands comprising the CNMI to have 45 km² of reef areas between 0 - 3 nm from shore and 534 km² of reef areas between 3 - 200 nm. The largest reef habitat in the CNMI, approximately 311.7 km², was found surrounding Farallon de Medinilla, a designated U.S. Military bombing range. However, these figures present an inflated amount of the actual reef area that is covered by living coral. "Reef habitat", as defined by Hunter is "*...substratum adjacent to coastlines (or on shoals) from depths of 0-100 m that is primarily composed of hard-bottom.*" Therefore, coverage by living corals on reef areas was not addressed as a variable in calculating the total reef area of the CNMI. For the purposes of this general discussion, coral reefs are considered as shallow reef areas

generally less than 100 feet in depth with any substantial (not defined) amount of living coral.

Using the simple coral reef classification scheme described in Veron (2000), representatives of both fringing and barrier reefs can be found in the CNMI. These reef systems are in various states of development depending upon a multitude of physical and geological variables. As expected, the geologically older southern islands of Rota, Tinian, Saipan, Aguigan and Farallon de Medinilla have relatively greater coral development when compared to the younger volcanic islands that lie north of Farallon de Medinilla. There are several instances where volcanic eruptions have negatively affected the adjacent near shore coral reefs in the Northern Islands (e.g. Pagan Island in 1981 and Anatahan Island in 2004).

Saipan has the most developed barrier reef system in the CNMI. The Saipan Lagoon stretches the length of Saipan on its lee (west) side and is approximately 30.7 km² (Duenas and Associates, Inc. 1997) in size. Tinian has a small barrier reef system (Eldredge and Randall 1980) that partially protects Tinian Harbor at the village of San Jose. The remaining reef systems found in the CNMI are fringing reefs with the more well developed reefs on Tinian and Rota Islands.

To date, there has been 256 species of corals comprising 56 genera and 41 octocorals of 20 genera identified from CNMI waters (Turgeon et. al. 2002). As previously alluded, the southern islands has a greater range of coral reef habitats and species diversity when compared with the geologically younger Northern Islands.

Near shore invertebrate communities

Southern Islands:

The marine invertebrate communities of the southern islands are relatively well known when compared with their northern island counterparts. However, this knowledge is generally limited to Saipan, Tinian and Rota waters. Of those three islands, Saipan has the best known invertebrate communities as it is the most populous island. As expected, resource management issues tend to receive a higher level of effort on those islands with higher human populations.

A recent comprehensive overview of the Mariana marine invertebrate fauna and flora can be found in Paulay (2003). This work consists of a series of collected papers entitled “*Marine biodiversity of Guam and the Marianas*” and was published by the University of Guam through it’s *Micronesica* journal. Though focusing on Guam marine biota, much of the biological information also includes the islands of the CNMI, specifically the five southern limestone islands. Topics include benthic marine macroalgae and seagrasses, sponges, corals, polychaetes, Bivalvia, Gastropoda, Crustacea, and Echinodermata.

Marine studies covering various marine invertebrate species on Saipan have been conducted by the local Division of Fish and Wildlife (DFW) office, or in concert with their staff. Usually those species studied have some commercial value and therefore, subject to over harvesting. This includes sea cucumbers (Chandran 1988; Duenas and Associates, Inc. 1997) and trochus gastropods (Adams, et.al. 1994; Trianni 2002). Gourley (1997) provides a general literature review of the near shore natural resources of the CNMI. Though found

in substantially deeper waters, Wilder (1977) investigated abundance of the deepwater shrimps *Heterocarpus laevigatus* and *H. ensifer* off the coast of Guam. These shrimp species were commercially fished for a short period of time on Saipan with a description of this fishery provided by Ostazeski (1997). Additionally, there are numerous scientific papers published on marine invertebrates that can be found in the scientific journal published by the University of Guam, *Micronesica*, as well as other journals.

Northern Islands:

Knowledge of the marine invertebrate communities of the Northern Islands is at the most basic level; a taxonomic checklist. Though the DFW has antidotal data scattered in various annual reports, the most intensive Northern Islands biological survey was conducted during 1992. This expedition, sponsored by the Chiba Natural History Museum and Institute (Japan) and the CNMI Division of Fish and Wildlife, surveyed every northern island except Farallon de Medinilla due to its use as a bombing range by the US Military. A summary of the expedition's research related to the major taxonomic marine invertebrates is discussed below.

Historical and current survey data on the molluscan fauna was summarized in Kurozumi and Asakura (1994). The species list includes 4 chitons, 456 gastropods and 68 bivalves as well as various unidentified molluscs, for a total of 555 "species".

Decapod crustaceans were investigated by Asakura, et. al. (1994), Takeda, et.al. (1994), and Hayashi, et.al. (1994). Twenty-eight species of Anomura crustaceans were recorded. The list includes; Callianassidae (1 species), Coenobitidae (6 species), Diogenidae (9 species), Paguridae (3 species), Galatheidae (1 species), Porcellanidae (7 species), and Hippidae (1 species) (Asakura, et. al. 1994). Takeda, et.al. (1994) recorded 62 species of Brachyura crustaceans from the Northern Islands. Representatives of the following families were collected: Dromiidae, Dynomenidae, Majiidae, Parthenopidae, Atelecyclidae, Portunidae, Xanthidae, Menippidae, Pilumnidae, Trapeziidae, Ocypodidae, Grapsidae, and Gecarcinidae. Hayashi, et.al. (1994) identified 26 species of 6 families of macruran Decapod crustaceans while two Gonodactylid species of Stomatopoda crustaceans were recorded by Hamano (1994).

Irimura, et.al. (1994) listed 15 species (12 families in four classes; excluding Holothurians) of echinoderms that occurred in the Northern Islands. Of this listing, eight species were discovered to be new records for the Marianas Islands.

Near shore reef fish communities

With respect to the near shore reef fish fauna found in the Marianas (including Guam), the recent work of Myers and Donaldson (2003) identified 1,106 species of inshore and epipelagic fish. Of this number, 1,019 may be considered shorefishes. Typical of other coral reef Indo-Pacific coastal areas, the top 20 most abundance families comprises 73% of the total number of species. Fifty-eight per cent of the inshore ichthyofauna is comprised of widespread Indo-Pacific species. Circumtropical species make up 3.6% while close regional associations exist with eastern fauna (18.3%) and western and southern faunas (17.6%). Ten species have their distribution limited to the Micronesian region while ten species are known to be endemic to the Marianas.

A recent Federal court decision determined that the US Government has ultimate jurisdiction over the waters surrounding the CNMI; from the low water mark out to 200 nm. However, for the sake of managing the resources, an agreement was reached between the two governments whereby the Division of Fish and Wildlife was designated the management authority for those near-shore resources within 3 nm from shoreline. Management of those fishery resources found in Federal waters, from 3 nm to 200 nm, lies with the Western Pacific Fishery Regional Management Council (WPRFMC), of which the CNMI is a member. Annual reports on the status of the CNMI's pelagic and bottomfish fisheries are published by the WPRFMC and was used as the primary information source for characterizing the pelagic and bottomfish fisheries.

The basis for the following fishery descriptions is the Commercial Purchase Data Base. This data collection system indirectly records actual fish landings on Saipan by recording all local sales to commercial seafood establishments. For the most part, bottomfish and pelagic fishing vessels are based out of Saipan where they also land their catch. Though there are a couple of fishing ventures that travel to the northern islands, fishing effort is concentrated around the southern islands.

Bottomfish fishery

The following overview of the CNMI bottomfish fishery includes both shallow-water and deep-water species. Fishery descriptions were taken directly from the 2002 Bottomfish Annual Report (WPRFMC 2004a). For an indication of the magnitude of the bottomfish fishery, Table 2 shows historical combined bottomfish landings for shallow-water and deep-water species by year and the number of boats that participated in the fishery.

“The Commonwealth of the Northern Mariana Islands’ (CNMI) bottomfish fishery occurs primarily around the islands and banks from Rota Island to Zealandia Bank north of Sarigan. However, the data are limited to the catches landed on Saipan, which is by far the largest market.... The fishery is characterized in this report by data collected through the Commercial Purchase Database, which indirectly records actual landings by recording all local sales to commercial establishments. This data collection system is dependent upon voluntary participation by first-level purchasers of local fresh fish to accurately record all fish purchases by species categories on specially designed invoices. Division of Fish and Wildlife (DFW) staff routinely collected and distributed invoice books to 34 participating local fish purchasers in 2002; which include the majority of the fishmarkets, stores, restaurants, hotels, government agencies, and roadside vendors (fish-mobiles). This is a marked reduction from 42 participants last year, because many vendors are no longer open.

Although this data collection system has been in operation since the mid-1970s, only data collected since 1983 are considered accurate enough to be comparable for most aspects of the fishery. The identification and categorization of fishes on the sales invoices has improved markedly in the last 10 years. Unfortunately, two inherent problems remain in the database. First, a number of the bottomfish MUS” (note: Management Unit Species) “are not listed on the sales receipts. This was partially corrected by the addition of new taxa (but not all BMUS species)” (note: Bottomfish Management Unit Species) “to the receipts

(black jack, giant trevally, amberjack, ehu, blueline snapper, kalikali, and sickle pomfret were added to sales invoices in 2001). However, not all vendors are using the new receipts. Moreover, for those BMUS species not specifically listed on the receipts there remains some confusion regarding where they should be added to the receipts. Second, the market is changing, with more fishermen pooling their catches and sales often representing more than a single on-day trip by a single fisherman.

The CNMI's bottomfishery still consists primarily of small-scale local boats engaged in commercial and subsistence fishing, although a few (generally <5) larger vessels (35-60 ft) usually participate in the fishery. The bottomfishery can be broken down into two sectors: deep-water (>500 ft) and shallow-water (100-500 ft) fisheries. The deep-water fishery is primarily commercial, targeting snappers and groupers. The snappers targeted include members of *Etelis* and *Pristipomoides*, whereas the eight-band grouper (*Epinephelus octofasciatus*) is the only targeted grouper. The shallow-water fishery, which targets the redgill emperor (*Lethrinus rubrioperculatus*), is mostly commercial but also includes subsistence fishermen. These fishermen are taking not only bottomfishes, but many reef fishes (especially snappers and groupers) as well. Hand lines, home-fabricated hand reels and electric reels are the common gear used for small-scale fishing operations, whereas electric reels and hydraulics are the common gear used for the larger operations in this fishery. Historically, some trips have lasted for more than a day, but currently, effort is defined and calculated on a daily trip basis. Fishing trips are often restricted to daylight hours, with vessels presumed to return before or soon after sunset, unless fishing in the northern islands. In terms of participation, the bottomfish fleet consists primarily of vessels less than 24 ft long that are usually limited to a 30-nm radius from Saipan. The larger commercial vessels that are able to fish extended trips and which focus their effort from Esmeralda Bank to Zealandia Bank are presumed to have landed the majority of the deep-water bottomfish reported through the purchase receipt forms. In 2002, the most consistent high liner of previous years did not fish and a second high liner only fished the first 5 months of 2002.

Bottomfishing requires more technical skill than pelagic trolling, including knowledge of the location of specific bathymetric features. Presently, bottomfishing can still be described as "hit or miss" for most of the smaller size (14-25 ft) vessels. Without fathometers or nautical charts, the majority of fishermen utilizing smaller vessels often rely on land features for guidance to a fishing area. This type of fishing is inefficient and usually results in a lower catch-per-unit effort (CPUE) in comparison with pelagic trolling. These fishermen tend to make multi-purpose trips - trolling on their way to reefs where they fish for shallow-water bottomfish and reef fish. Larger sized (25-ft and larger) vessels typically utilize Global Positioning System (GPS), fathometers, and electric reels, resulting in a more efficient operation. In addition, reef fishers are now commanding a consistently higher price than in previous years. This appears to be reflected in an increased number of fishermen using small vessels focusing on reef and/or pelagic species over bottomfishes.

The participation of fishermen in the bottomfishery tends to be very short term. During the past 6 years, 64% of the mafute' fishermen and 62% of the onaga fishermen only sold fishes for a single year, and none sold fishes in all 6 years. Among the high liners selling

more than 500 lbs/yr, 67% of both mafute' and onaga fishermen only made large sales in a single year, and none made sales >500 lbs/yr in more than 3 of the 6 years. Whereas tenacity of mafute' fishermen in the bottom fishery drops with each year (64% participation for 1 yr, 20% for 2 yrs, 10% for 3 yrs, 6% for 4 yrs, and 1% for 5 yrs), the tenacity of onaga fishermen is higher for 3 yrs of participation than for 2 yrs (62% participated for 1 yr, 10% for 2 yrs, 20% for 3 yrs, 6% for 4 yrs, and 2% for 5 yrs). This likely reflects the greater skill and investment required to participate in the deep-water bottomfishery. In addition, these tend to be larger ventures that are more buffered from the vagaries of an individual's choices and are usually dependent on a skilled captain/fisherman. Overall, the long-term commitment to hard work, maintenance and repairs, and staff retention appear to be difficult, if not impossible for CNMI bottomfishermen to sustain more than a few years." (WPRFMC 2004a).

Table 2: CNMI bottomfish landings (in pounds) by year for combined shallow-water and deep-water bottomfish landings. Data obtained from WPRFMC (2004a).

YEAR	BOTTOMFISH LANDINGS (in pounds)	NUMBER of BOATS	YEAR	BOTTOMFISH LANDINGS (in pounds)	NUMBER of BOATS
1983	28,529	90	1993	18,461	20
1984	42,664	102	1994	25,470	32
1985	40,975	55	1995	36,102	34
1986	29,912	54	1996	66,362	70
1987	49,715	43	1997	64,090	69
1988	47,313	29	1998	59,040	50
1989	24,438	29	1999	56,201	51
1990	13,628	29	2000	45,619	66
1991	7,116	20	2001	71,660	75
1992	10,598	37	2002	47,110	53

Pelagic fishery

Overview of the CNMI pelagic fishery was obtained directly from the 2002 Pelagics Annual Report (WPRFMC 2004b). For an indication of the magnitude of the pelagic fishery, Table 3 shows historical pelagic landings by year and the number of boats that participated in the fishery.

“The Northern Mariana Islands pelagic fishery occurs primarily from the island of Farallon de Medinilla south to the island of Rota. The fishery is characterized using data in the Commercial Purchase Data Base.....

Table 3: CNMI pelagic landings (in pounds) by year and number of fishermen (boats) landing any pelagic species. Data obtained from WPRFMC (2004b).

YEAR	PELAGIC LANDINGS (in pounds)	NUMBER of BOATS	YEAR	PELAGIC LANDINGS (in pounds)	NUMBER of BOATS
1983	245,986	92	1993	181,395	54
1984	341,137	97	1994	147,086	66
1985	234,223	75	1995	200,676	89
1986	307,460	96	1996	281,205	114
1987	205,069	60	1997	218,882	107
1988	334,523	77	1998	240,711	89
1989	286,784	77	1999	176,997	106
1990	181,078	77	2000	186,850	108
1991	188,644	74	2001	178,893	112
1992	199,157	105	2002	253,273	86

Trolling is the primary fishing method utilized in the pelagic fishery. The pelagic fishing fleet, other than charter boats, consists primarily of vessels less than 24 ft in length which usually have a limited 20-mile travel radius from Saipan. In 2002 about 55 vessels were identified as involved in full-time commercial fishing and 41 vessels were classified as part-time. No fishing and/or recreational usage included 312 vessels.

Twenty-six vessels were registered with the Boating Safety Office as charter vessels for 2002. Charter vessels generally retain their catches, selling half or more to local markets. While the general magnitude of charter boat sales is unknown, it is questionable whether the local market can absorb these catches without impacting commercial fishermen. No logbook system is currently in effect.

The primary target and most marketable species for the pelagic fleet are skipjack tuna. Yellowfin and mahimahi are also marketable species but are seasonal. During their seasonal runs, these fish are usually found close to shore and provide easy targets of the local fishermen. In addition to the economic advantages of being near shore and their relative ease of capture, these species are widely accepted by all ethnic groups. This has kept market demand fairly high due to the continuing immigrant population growth on Saipan (over half of the population on Saipan is nonnative).”

Special Aquatic Habitats

Mangrove swamps

Mangrove swamps are extremely rare in the CNMI as this unique habitat type occurs only on Saipan. The two general areas (Raulerson 1987) where this habitat occurs is located

along the mid-coastal plain on the leeward (west) side of the island. Only one species of mangrove *Bruguiera gymnorhiza* is found and according to Raulerson (1987) this species is at its northern-most geographical limit in Micronesia on Saipan.

The two areas where mangroves are located include the Lower Base wetland complex and American Memorial Park in Garapan. The mangrove component of the Lower Base wetland complex (designated as site E-1 by ERC Environmental and Energy Services (ERCE), 1990) is approximately 3 acres in size (ERCE 1990). American Memorial Park (site P-13 in ERCE 1990) had several areas where mangroves were found; a mixed-species inland wetland complex approximately 23 acres and a thin strip of mangroves growing along the lagoon shoreline.

Wetlands

For this discussion, wetlands are considered special aquatic inland habitats as defined by the U.S. Army Corps of Engineers Clean Water Act section 404 regulatory program. Wetlands are defined by the Clean Water Act as:

“Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.” (33CFR 328.3).

“Jurisdictional” inland wetlands occur only on the southern islands of Rota, Tinian and Saipan. With respect to the Northern Islands, only Pagan has inland wetlands. Over 85% of the total wetland acreage is located on Saipan, with approximately 60% of that being comprised of the Lake Susupe wetland complex (discussed previously).

Most wetlands found in the CNMI are classified as depressionnal palustrine emergent systems that are dominated by monospecific stands of karrisu (*Phragmites karka*). Karrisu is an obligate wetland plant species belonging to the reed family. For Saipan, there are approximately 239 hectares of palustrine wetlands and 16 hectares of lacustrine wetlands; almost 2% of the total area of Saipan.

The largest wetland complex in Tinian is the previously discussed Lake Hagoi wetland complex; a palustrine wetland. Additionally, there is a one-hectare lacustrine wetland with 16 hectares of contiguous palustrine wetland and 22 small lacustrine and palustrine wetlands. In total, Tinian has 49 hectares of freshwater wetlands.

Rota has the more unique wetlands found in the CNMI. These slope wetlands are sustained by groundwater seepage where the water table is perched on volcanic rock that meets the surface and provides baseflow to the streams.

The two inland lakes on Pagan were previously discussed.

Sea grasses

Tsuda, et.al. (1977) listed three species of seagrasses that were known from the CNMI; *Enhalus acoroides*, *Halophila minor*, and *Halodule uninervis*. A fourth species of sea grass, *Halophila ovalis*, was recently discovered during a sea turtle assessment study on Saipan

(Kolinski et.al., 2001). Only two islands in the CNMI are known to have seagrasses; Saipan and Rota. By far, Saipan contains the most extensive seagrass meadows found in the CNMI and can claim possibly as much as 99% of the total seagrass coverage. Most of the seagrass habitat found in Saipan waters is limited to the leeward (west) side of the island within the Saipan Lagoon barrier reef system. All four seagrass species occur in Saipan Lagoon with *Halodule* comprising vast meadows of both homogenous stands and with mixed *Halophila*. *Enhalus* beds appear to lie closer to shorelines and are concentrated more in the central and northern lagoon. Though presently being investigated by the CNMI Government, there is very little quantitative information currently available on seagrass habitats in Saipan Lagoon.

Rota's seagrass habitat is likely to be ecologically insignificant and is comprised of scattered small patches on *Enhalus*. The larger seagrass bed was located in Rota West Harbor and consisted of approximately 12 distinct patches totaling 812.94 ft². This seagrass bed is no longer present in its original state due to a harbor improvement project that was implemented soon after the Division of Fish and Wildlife transplanted most of the sea grass in two nearby sites; Anjota Island area and Mafuiron Rock (Sablan, et.al. 1983). Sablan (1983) reports another *Enhalus* seagrass bed located at As Malate, approximately 4.9 miles from Rota East Harbor. Total area of 14 distinct patches of these sea grasses were estimated at 415.2 ft² during a brief survey in 1983 (Sablan, et.al. 1983). Presently, the transplanted seagrasses at the Anjota Island site appear to be in good condition, though lateral bed growth has been minimal since 1983 (pers. comm. - J. Gourley). The Mafuiron Rock transplantation site has not been as successful with well over 50% of the original transplanted area bare as observed during a 2002 site visit. A more recent site visit in 2005 discovered that these beds have almost disappeared (pers. comm. - J. Gourley).

SPECIES OF CONCERN

Federally listed Endangered/Threatened Species

The Endangered Species Act (ESA) was initially passed by the US Congress in 1973 with a stated purpose of conserving “*the ecosystems upon which endangered and threatened species depend*” and to conserve and recover listed species. To this end, the Federal Government, through the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, identifies those species of concern that meet the criteria for being classified as either Endangered or Threatened. In general, species are classified depending upon stability of the population and magnitude of threats facing the species.

With respect to the CNMI, as of the date of this report the USFWS has listed 15 Endangered and/or Threatened species; two mammals, six birds, four reptiles and three plants (Table 4). This list does not include the experimental Guam rail (*Rallus owstoni*) population on Rota. The Guam rail is an island endemic on Guam and classified as Endangered. For comparison purposes, Table 4 also includes those species identified by the CNMI Government as requiring protection and their status. It should be noted that only the sea turtle species under U.S. Fish and Wildlife Service (USFWS) jurisdiction, instead of NMFS, are listed.

Table 4: Federal and Locally Protected Species in the CNMI.

Information obtained from CNMI Commonwealth Register (Vol. 22, No. 4; April 20, 2000) and <http://pacificislands.fws.gov/>, supplemented by personal knowledge.

PROTECTED SPECIES	U.S. FEDERAL GOVERNMENT	CNMI GOVERNMENT
MAMMALS		
Mariana fruit bat (<i>Pteropus m. mariannus</i>)	Threatened	Threatened/Endangered
Sheath-tailed bat (<i>Emballonura semicaudata</i>)	Candidate for listing	Threatened/Endangered
AVIFAUNA		
Mariana common moorhen (<i>Gallinula chloropus guami</i>)	Endangered	Threatened/Endangered
Mariana (= Guam) swiftlet (<i>Aerodramus bartschi</i>) ¹	Endangered	Threatened/Endangered
Micronesian megapode (<i>Megapodius l. laperouse</i>)	Endangered	Threatened/Endangered
Nightingale reed-warbler (<i>Acrocephalus l. luscini</i>)	Endangered	Threatened/Endangered
Mariana crow (<i>Corvus kubaryi</i>)	Endangered	Threatened/Endangered
Rota bridled white-eye (<i>Zosterops rotensis</i>)	Endangered	Threatened/Endangered
Tinian monarch (<i>Monarcha takatsukasae</i>)	De-listed	Threatened/Endangered
REPTILES		
Green sea turtle (<i>Chelonia mydas</i>)	Threatened	Threatened/Endangered
Hawksbill sea turtle (<i>Eretmochelys imbricata</i>)	Endangered	Threatened/Endangered
Leatherback sea turtle (<i>Dermochelys imbricate</i>)	Endangered	<i>not recognized</i>
Loggerhead sea turtle (<i>Caretta caretta</i>)	Threatened	<i>not recognized</i>
Micronesian gecko (<i>Perochirus ateles</i>)	<i>not recognized</i>	Threatened/Endangered
PLANTS		
Tronkon guafi (<i>Serianthes nelsonii</i>)	Endangered	Threatened/Endangered
<i>Nesogenes rotensis</i>	Endangered	<i>not recognized</i>
<i>Osmoxylon mariannense</i>	Endangered	<i>not recognized</i>
Cat's tail (<i>Lycopodium phlegmaria</i> var. <i>longifolium</i>)	<i>not recognized</i>	Threatened/Endangered

NOTES: The currently accepted AOU scientific and common name is used.

Table 5 identifies by island those Federal Endangered and Threatened species for the CNMI. NMFS listed marine wildlife species were not included due to the general lack of interaction between the species and humans. Due to the scarcity of recent data, the distributional data provided in the table is subject to revision as additional information is obtained.

Table 5: Distribution of Federally Protected Terrestrial Vertebrate Wildlife Species and Plant Species of the CNMI.

ENDANGERED and THREATENED SPECIES	ROTA	AGUIJAN	TINIAN	SAIPAN	NORTHERN ISLANDS (including FDM)
AVIFAUNA					
Rota bridled white-eye (<i>Zosterops rotensis</i>)	single- island Endemic ^f	N/A ^f	N/A ^f	N/A ^f	N/A ^f
Mariana crow (<i>Corvus kubaryi</i>)	Present ^a	Not Present ^a	Not Present ^a	Not Present ^a	Not Present ^a all islands
Mariana swiftlet (<i>Aerodramus bartschi</i>) ¹	Extirpated ^a	Present ^a	Extirpated ^a	Present ^a	Not Present ^a all islands
Mariana common moorhen (<i>Gallinula chloropus guami</i>)	Present ^c	Not Present ^a	Present ^a	Present ^a	Pagan - Extirpated ^a
Nightingale reed warbler (<i>Acrocephalus l. luscini</i>)	Not Present ^a	Present ^a	Extirpated ^b	Present ^a	Alamagan-Present ^a Pagan - Extirpated ^a
Micronesian megapode (<i>Megapodius l. laperouse</i>)	Extirpated ^a	Present ^a	Present ^d	Present ^a	Present ^a all islands
MAMMALS					
Mariana fruit bat (<i>Pteropus m. mariannus</i>)	Present ^h	Present ^h	Present ^h	Present ^h	Present ^h all islands
PLANTS					
Tronkon guafi (<i>Serianthes nelsonii</i>)	Present ^l	Not Present ^l	Not Present ^l	Not Present ^l	Not Present ^l all islands
<i>Nesogenes rotensis</i>	Present ^m	Not Present ^m	Not Present ^m	Not Present ^m	Not Present ^m all islands
<i>Osmoxylon mariannense</i>	Present ^m	Not Present ^m	Not Present ^m	Not Present ^m	Not Present ^m all islands

Distributional data based on ^a Reichel and Glass (1991), ^b Steadman (1999), ^c Takano (2003),

^d O'Daniel and Krueger (1999), ^e USFWS (1998), ^f Proposed Rule: FR: Vol.66(192), 3 October 2001,

^g Wiles and Worthington (2002), ^h Final Rule: FR:70 (4) January 6, 2005, ^l USFWS (1993), ^m USFWS (2000).

NOTES: The currently accepted AOU scientific and common name is used.

Species accounts for the more obvious terrestrial federally listed wildlife for the CNMI follows.

Marianas fruit bat

The Marianas fruit bat occurs throughout the Mariana Islands, however only the Guam population was Federally listed as Endangered on 27 August 1984 {49 FR 33881-33885}. The CNMI population was considered a separate population and was not recognized by the USFWS as requiring protection at the time of listing. With updated information, the USFWS has recently listed the Marianas fruit bat as Threatened throughout its range, which includes the islands of the CNMI (FR: 70 (4) January 6, 2005). No critical habitat was designated for this species in the CNMI. The Marianas fruit bat was originally afforded Endangered/Threatened status by the CNMI Government and published in the Commonwealth Register on January 15, 1991.

The Marianas fruit bat is typically found in association with native limestone forest. Tree species primarily used for roosting includes mature fig trees (*Ficus* spp.) and chopak (*Mammea odorata*). Other trees which have been used are: ironwood, *Macaranga thompsonii*, zebrawood (*Guettarda speciosa*) and fagot (*Neisosperma oppositifolia*).

Twenty-two species of plants have been documented as food sources in the Mariana Islands; foods consist of fruits (17 species), flowers (seven species) and leaves (one species). Primarily frugivorous, food sources include the following plants: breadfruit (*Artocarpus* spp.), papaya, cycad (*Cycas circinalis*), kafu (*Pandanus tectorius*), pacific almond (*Terminalia catappa*), kapok (*Ceiba pentandra*), coconut palm, gaogao, and da'ok (*Calophyllum inophyllum*) (USFWS 1990).

Although Saipan has few or no resident bat colonies, the neighboring island of Aguigan has a small resident population (USFWS 1990). Wiles and Glass (1990) noted that Marianas fruit bats irregularly flew between the islands of the southern Marianas.

Micronesian megapode

The Marianas Islands Micronesian megapode subspecies was listed as an Endangered species by the USFWS on June 2, 1970 {35 FR 8491-8498}. To date, no critical habitat has been designated for this species. The CNMI Government also classified this subspecies as Endangered/Threatened and included it on the local CNMI list that was published in the Commonwealth Register on January 15, 1991.

Figure 3. Micronesian Megapode. Source: CNMI Division of Fish and Wildlife.



The Micronesian megapode is found in the Marianas and Palau Islands and is comprised of two sub-species; *Megapodius l. laperouse* which occurs in the Marianas Islands and *Megapodius l. senex* which occur in the Palau Islands. Some authors consider *senex* a full species due to its geographical isolation, smaller size and differences in breeding habits (Elliott 1994).

Within the Marianas archipelago, the megapode is known to occur on Saipan and on eight or nine of the ten islands north of Saipan (Reichel and Glass 1991, USFWS 1998b). Recently, CNMI-DFW and USFWS biologists reported sightings of this bird on Farallon de Medinilla, an active U.S. military bombing target located north of Saipan (Lusk and Kessler 1996). Megapodes are common on Aguiguan but presently considered extirpated on Guam and Rota. The existence of megapodes on Tinian has been uncertain over the last 20 years (Engbring, et al. 1986, Glass and Aldan 1988, Wiles, et al. 1987). Even with three confirmed sightings of megapodes on Tinian in 1995, their population status is still unclear (USFWS 1996).

The megapode is a pigeon-sized dark brown to blackish land bird that forages on the ground but also roosts on tree branches. The most distinct characteristic of this bird is its nest, which is built on the ground in the form of a large mound (with tunnels or burrows). The nest may be made of leaves, soft soil, organic litter, and cinder (Dekker 1990, Stinson 1992). The heat from this mound incubates the eggs laid in the center of the mound (Pratt, et al. 1987). The incubation period is unknown for the Micronesian megapode. The bird is not known to actively maintain its nest for thermoregulation.

There are several hypotheses on the evolution and distribution of the megapodes on the various islands of the Pacific Ocean. Megapodes have limited flying skills although

Pratt and Bruner (1978) reported that the Palau subspecies could fly distances of several kilometers among the small islands. However, its presence on widely separated islands in the Pacific point to possible intentional introduction by man (Dekker 1990). In many of the islands, as discussed by Lister (1911), megapode eggs were used as a steady source of food. At least for this reason, it is possible that the megapode was introduced to the various islands in the Pacific. Baker (1951) contends, however that there is no evidence to support this hypothesis. Lister (1911) also reported that megapodes on Saipan were domesticated in the past.

The CNMI-DFW studied megapode biology and ecology on the northern island of Guguan. These reports indicate that this bird remains in pairs, and each pair establishes, maintains, and advertises its territory. The territory is also defended at least during a portion of the year (Glass and Aldan 1988). Since the chicks are independent and capable of flying from the moment they are hatched, no parental care is provided (Pratt, *et al.* 1987, USFWS 1998b). Information on the size of the territory established and maintained by each pair is sketchy. However, based on the observation reported by Lister (1911), it can be inferred that the territory size is rather small and depends largely on available nesting and foraging habitats. Glass and Aldan (1988) derived a preliminary estimate of a minimum territory size on Saipan of around one hectare (2.47 acres).

Megapodes on Saipan are largely restricted to limestone forest areas, generally near cliff bases (USFWS 1998b). This conclusion is based on observations of megapodes at Marpi near Suicide Cliff and Banadero Trail areas (CNMI-DFW unpublished reports; Engbring, *et al.* 1986). The CNMI-DFW also reported this species to use tangantangan forests which lie adjacent to tentative forest habitat at times (Glass and Aldan 1988). Birds on the northern islands occur in all habitats including open un-vegetated areas and grasslands, as well as forests, but seem to prefer forest (USFWS 1998b).

This omnivorous bird was once believed to be present on all the Mariana Islands but was extirpated on Guam and Rota because of egg depredation and hunting of adults. The population on Saipan has always been low, and it was once thought that the bird became extirpated on Saipan; but in 1978, it was rediscovered in the Marpi area (Pratt and Bruner 1978). It is not clear whether this bird was previously extirpated on Saipan or whether the small population is the result of reintroduction or re-colonization (Engbring, *et al.* 1986). Engbring, *et al.* (1986) estimated the 1982 Saipan population of this species to be 40 birds, all in the Suicide Cliff area. The only megapode detected during the 1997 repeat of the Engbring, *et al.* (1986) surveys were detected in the Marpi area, when one bird was observed and two other megapodes were heard (A. Marshall, USFWS, pers. comm, 1997). The most recent Marpi megapode siting was noted in the Biological Assessment prepared for the Saipan Integrated Solid Waste Management System; a pair of megapodes (at minimum) were observed in the cliff area immediately east of the Marpi depression (MES 1999). The CNMI DFW reported the first sighting of one bird from the Naftan area in 1986. According to the May 1987 monthly report, a CNMI-DFW inspection of a Mr. Dave Pangelinan's farm in the Naftan area in 1987 proved to be negative although Mr. Pangelinan maintained that a "*small population*" of megapodes existed on his farm and that the megapodes would harass his domestic chickens. The CNMI-DFW has other sighting

records of megapodes from Obyan and Naftan areas, but in each instance only one bird was seen or heard. The only recent megapode observation in this area was made by S. Mosher (USGS-BRD) while working with the nightingale reed-warbler.

The CNMI-DFW estimated the megapode population to be about 1,500 in the entire Mariana Islands (Stinson 1992). Craig (1992) reported this species to be rare on Saipan with small (less than 20 birds) numbers present in the Marpi area. This estimate placed the population size at 0.02 birds per hectare. Megapode populations on Saipan are believed to have declined mainly because of poaching, habitat loss and predation.

Nightingale reed-warbler

The nightingale reed-warbler is classified as Endangered and was listed by the USFWS on June 2, 1970 {35 FR 8495}. The CNMI Government also recognized this species as Endangered/Threatened and included it in the local list which was published in the Commonwealth Register on January 15, 1991. Although six islands within the Marianas archipelago have historically contained reed-warbler populations, Guam's population became extirpated during the late 1960's while Pagan's population disappeared sometime before 1981. The Aguiguan Island population was thought to be extirpated during the mid-1980's, however two males were observed in 1992 with subsequent observations during 1993 and 1995 (USFWS 1998a). Saipan Island contains the largest population of reed-warblers in its known distribution. No critical habitat has been designated for this species.

The nightingale reed-warbler is a small, pale brownish-yellow bird with a long bill. Three subspecies are recognized in the Mariana Islands: *yamashinae* from Pagan, *luscinia* from Guam, Saipan and Alamagan, and *nijoi* from Aguiguan (USFWS 1998a). An unpublished USFWS report by Steadman (1995) suggested numerous, human-related prehistoric extinctions of Pacific island birds which alludes to the presence of reed-warblers on other inhabited islands of the Marianas archipelago, such as Tinian (as cited in USFWS 1998a). The population on Guam has been extirpated since the 1960's partly because of the brown tree snake but also because of wetland loss, major fires, and pesticide use (Engbring, *et al.* 1986; Reichel, *et al.* 1992). The subspecies on Pagan was extirpated between the 1960's and 1981 (Glass 1987, Reichel, *et al.* 1992). Volcanic activity, development, and grazing by feral animals and the resultant impact on habitat are probably the main reasons for the absence of reed-warblers on Pagan (Reichel, *et al.* 1992) The Aguiguan population was thought to be extirpated in the 1980's, however two singing males were observed in 1992 (Craig and Chandran 1992). The present population on Aguiguan is estimated at less than ten birds. The lack of undergrowth vegetation on Aguiguan as well as small island size and extreme habitat changes in the past several decades are considered to be important factors for the near absence of this bird on that island (Engbring, *et al.* 1986, Reichel, *et al.* 1992).

Saipan contains the largest population of nightingale reed-warblers in the Marianas archipelago. A survey completed in 1982 (Engbring, *et al.* 1986) estimated the Saipan population of this species at 4,867 individuals. This remains the only reliable and comprehensive survey for the island, but may have become outdated by changes brought about by the increase in island population and associated development. During May 1997, the 1982 (Engbring, *et al.* 1986) Saipan forest bird surveys were repeated by the

USFWS in cooperation with USGS-BRD and the CNMI-DFW (USFWS 1997). Based on the preliminary analyses of the 1997 survey data, the Saipan population is estimated at 4,225 individuals, however the report is still in draft form. Therefore, the 1997 population estimate (USFWS 1997) will not be used for assessing impacts to the species.

Considering the absence or rarity of this species on the other southern Marianas Islands, it is important that habitat management practices be adopted on Saipan to preserve and enhance existing habitats for this bird to the greatest possible extent. The population on Saipan may serve as the gene bank for this species in the Marianas, although the population on Alamagan may also be important.

The reed-warbler population on Saipan appears to be widely distributed in various habitats. This species is believed to be primarily a wetland bird that on Saipan has expanded its niche to include a variety of upland habitat types. The subspecies on Guam and Pagan were apparently exclusively restricted to wetlands (Reichel, *et al.* 1992). The birds found on Saipan, however have been identified in tangantangan forests, wetlands, vegetation around wetlands, disturbed areas and secondary forests. Tangantangan forest, in recent years, appears to have become a valuable habitat to this species.

This insectivorous bird feeds on insects and their larvae; in addition, its diet includes geckos, lizards, spiders and snails (Craig, unpublished data, Marshall 1949, Seale 1901). Nestlings are fed a variety of food items, including small caterpillars, large spiders, grasshoppers, skinks, geckos, ants, moths and praying mantis (Mosher 1997). Understory vegetation is believed to provide important habitat for this bird (Engbring, *et al.* 1986; Reichel *et al.* 1992). Tangantangan forests provide more edge and open-space habitats with abundant undergrowth vegetation and may thus be preferred by the reed-warbler (Chandran 1995). Pratt, *et al.* (1987) reported that this species is especially abundant in tangantangan forests. Craig (1992) studied the territories of these birds in Marpi and reported that habitat choice was variable and that there was no predominance of tangantangan or elephant grass in the territories of this species at Marpi. The USGS-BRD is conducting research on habitat use of reed-warblers in uplands that will be available for use in the future for management practices to enhance habitat for reed-warblers. Engbring, *et al.* (1986) recorded the highest density of this species (112 birds per square kilometer) in the Fandang (Obyan and Naftan areas) region of Saipan. They could not correlate the high density with tangantangan because a similar habitat at Marpi had a very low density.

The biology and behavioral ecology of the nightingale reed-warbler have been little studied, and until recently, sparse information was available on their life history, nesting and breeding habitats, and habitat and territory use patterns (Craig 1992; Reichel, *et al.* 1992). However, an 18-month study on the ecology of this species was initiated in January 1997 by the USGS-BRD in cooperation with the CNMI-DFW and the USFWS. Results of this study are contained in a series of quarterly reports and one annual report (Mosher 1997). The final report will act as thesis for the graduate student who conducted the research, but has yet to be completed. The reed-warbler is known to be monogamous, unlike some of its mainland relatives (Craig 1992). This species is also very territorial and males, at least, may remain in their territory for several years though females may move more frequently

(Craig 1992; Mosher 1997). Males are extremely vocal and frequently break into song to defend their territory, particularly during breeding season (Craig 1992). Preliminary evidence indicates that breeding occurs year round and that predation and typhoons can have a major influence on the timing of breeding activity (Mosher 1997).

Mariana moorhen

The Mariana common moorhen is classified as an Endangered Species and was listed by the USFWS on August 27, 1984 {49 FR 33885}. The *guami* subspecies is limited to the Marianas Archipelago and found presently on Guam, Saipan, Rota and Tinian. Data indicates that historical populations also occurred on Pagan (USFWS 1991). The Saipan population is estimated at a “conservative” 100 birds (Stinson, *et. al.* 1991). Critical habitat has not been established for this species.

The moorhen relies on wetland habitat for both food, cover and breeding. The CNMI-DFW (1993) describes optimal Moorhen habitat as:

“either permanently or seasonally flooded wetlands that have low salinity, an absence of tilapia, and ideally a shallow seasonally flooded area that produces exposed mud or meadow as flood waters recede.” Further habitat descriptions include: *“No Moorhens were encountered within thick reed stands, but were seen at any open water adjacent to reeds...”*

Mariana (=Guam) swiftlet

At taxonomically unstable family, the Apodidae is divided into two subfamilies (Cypseloidinae and Apodinae), with a further subdivision of the Apodinae into three tribes; Collocaliini, Chaeturini and Apodini. The Mariana swiftlet is classified in the Collocaliini subfamily which contains four genera (*Hydrochous*, *Collocalia*, *Aerodramus* and *Schoutedenapus*) and 28 species worldwide. Historically, the locally found swiftlet species was known as the Island swiftlet (*Aerodramus vanikorensis*) and Guam swiftlet (*Collocalia bartschi*) (AOU 1995). Chantler (1999) has adopted the scientific name *Aerodramus bartschi*. Presently, nomenclature appears to have stabilized with The American Ornithologist’s Union (AOU 2002) now recognizing this species as the Mariana swiftlet (*Aerodramus bartschi*). Although swiftlets are widespread throughout southeastern Asia and Micronesia (Baker 1951), the current consensus is that only one species occurs in the Marianas archipelago.

The Mariana swiftlet was classified as an Endangered Species and listed by the U.S. Fish and Wildlife Service on August 27, 1984 {49 FR 33885}. No critical habitat has been designated for this species. The CNMI Government also classified this species as Endangered/Threatened and included it on the local CNMI list that was published in the Commonwealth Register on January 15, 1991. Even with the restricted range, Chantler (1999) does not consider this species globally threatened.

Within the Marianas, swiftlet populations are limited to the southern islands of Guam, Saipan, Agiguan, and Tinian. According to the recovery plan (USFWS 1991), this species has not been reported north of Saipan. Though historically abundant on Rota at least until the 1940’s the islands population declined to a point where they disappeared by the 1970’s. In the following decade, Pratt *et. al.* (1987) believed the Rota swiftlet population to be extirpated.

The Mariana swiftlet was introduced to Oahu Island (Hawaii) in 1962 and has been documented breeding in Halawa and Moanalua Valleys. Population levels are small, with only 12 breeding pairs identified during 1989 (Chantler 1999). Never-the-less, this species is considered established in Hawaii (AOU 1995).

The Recovery Plan (USFWS 1991) reports eleven bird colonies as occurring on Guam, Aguigan and Saipan. The Guam population estimate of 400 individuals was obtained from a single cave (Mahlac Cave) during the 1986 -1987 census. Census data from 1983 -1985 estimated the Aguigan and Saipan populations at 970 in five colonies and 3,160 in five colonies, respectively. Another swiftlet population estimate was obtained for Saipan by Engbring, et. al. (1986) utilizing an island wide survey conducted during 1982. Based on that study, the Saipan swiftlet population was estimated at approximately 9,120 or 84/km². The large discrepancy between the two population estimates for Saipan can not be precisely explained.

Since the development of the Recovery Plan (USFWS 1991), there are currently ten known swiftlet caves on Saipan: Da'ok; Celis; Ladder; Hospital; Doc's; Takpochao, Navy Hill; Tin Can; Japanese Tunnel; and Hourglass. Results of the April and October (2000) surveys found the mean total number of swiftlets at 3,886.5. Based on average counts from the 2000 surveys, approximately 71% of the island's swiftlet populations were found in: Navy Hill Cave, Doc's Cave and Tin Can Cave. After examining long term count data on the four main caves, the "numbers of birds have remained relatively stable in each one, with perhaps a slight overall increase in recent years" (CNMI -DFW 2000).

A consensus of five active swiftlet caves (Black Noddy, Cliff, Pillar, Guano, and Landing Caves) was conducted on Aguiguan during March/April 2000 and a total count of 408 birds were recorded. Guano Cave contained the largest population of 337 swiftlets. Though based on admitted data limitations, the DFW surmised that "*swiftlet numbers on Aguiguan may have remained relatively stable over the past 15 years*" (DFW 2000).

This species has an unusual capability to echo locate which allows it to utilize caves for roosting and nesting. Typical swiftlet caves are described as "2 m high or higher and chambers with dark zones where the birds nest." (USFWS 1991). Although primarily crepuscular feeders (Pratt, et. al. 1987), swiftlets "*may forage over a wide variety of terrain and vegetation, they seem to favor ridge crests and open grassy areas where they capture small insects while flying*" (USFWS 1991). Engbring, et. al. (1986) also found Mariana swiftlets utilizing a diversity of habitats, however small openings in the vegetation are preferred.

Based on the Recovery Plan (USFWS 1991), it appears that the species is most threatened by human activities that disturb nesting caves; such as guano mining and vandalism. Six recovery objectives were identified in the Recovery Plan: (1) preserve and manage known swiftlet caves; (2) survey for, secure, and manage additional colonies of swiftlets and potentially usable caves; (3) determine reasons for decline; (4) promote population re-expansion into suitable historical habitat; (5) develop suitable criteria for complete delisting; and (6) monitor population. The most important limiting factor appears to be associated with disturbance to active swiftlet caves.

CNMI listed Endangered/Threatened Species

The CNMI Government passed a law on January 15, 1991 which identified locally Endangered/Threatened species. This list includes two mammals, seven birds, three reptiles and two plant species (Table 3). The CNMI law did not differentiate between Threatened and Endangered categories and are thus jointly classified. The CNMI Threatened/Endangered species list contains three species not officially recognized as either Endangered or Threatened by the Federal Government: sheath-tailed bat (*Emballonura semicaudata*), Micronesian gecko (*Perochirus ateles*) and the Cat's tail (*Lycopodium phlegmaria* var. *longifolium*). The CNMI Endangered/Threatened species list was updated in the Commonwealth Register on 20 April 2000, however no changes in the species list were made.

Invasive Species

Though the actual count is unknown, the number of non-indigenous wildlife and plant species in the CNMI are numerous. However not all exotics become invasive species. For the purposes of this report, an invasive species will be defined as “a species that is 1) non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112).” As can be seen, there is much latitude in determining what defines an invasive species when the criteria includes futuristic and conditional terms such as “is likely”. Identifying invasive species in the CNMI will be based partially on best judgment, historical documentation and current situations and will certainly be open to criticism.. Unfortunately, only time will tell whether certain species now considered as “harmless” exotics in the CNMI will actually evolve into invasive species.

Most regulatory programs addressing exotic introductions or invasive species issues are managed by the Federal Government. The CNMI Government has not passed legislation addressing invasive species. One of the earliest attempts (1977) to address the problem was Executive Order 11987, which directed Federal agencies and encouraged states, to restrict exotic species introductions into natural ecosystems. In 1990, congress passed the Non-indigenous Aquatic Nuisance Prevention and Control Act (NANPCA) or the “Zebra Mussel Act”. Six years later, NANPCA was re-authorized and amended by the National Invasive Species Act of 1996. This act directed federal agencies to address introductions and infestations of exotic species. More recently, the US Coast Guard promulgated voluntary guidelines for ballast water management in order to decrease the spread of alien marine species introductions within US waters.

Most of the invasive species found in the CNMI are primarily associated with terrestrial environments and include both plant and animal species. The most invasive species on Saipan and Tinian would likely be the tangantangan tree (*Lucaena leucocephalus*). Tangantangan was introduced after Saipan was taken by the U.S. military during World War II as an erosion preventative measure. This was necessary due to the destruction of large areas of vegetated habitat, much of it sugar cane fields, during military actions. A shrubby legume, this species is fast growing and provides good ground cover. Because Saipan was intensely seeded, a substantial amount of this type habitat presently exists. (Engbring, et. al. 1986). Due to the large amount of homogenous tangantangan stands, Engbring, et. al. (1986) classified it as a distinct habitat type.

Tangantangan is classified as an invasive by the Invasive Species Specialist Group of the World Conservation Union and has been nominated as among the 100 of the “World’s Worst” invaders by the Invasive Species Specialist Group (ISSG) (Global Invasive Species Database 2006). This species is also identified by the South Pacific Regional Environmental Programme as a “dominate invader” (Meyer 2000).

Other non-native plant species considered invasive include: ivy gourd (*Coccinia grandis*); *Operculina ventricosa*; lantana (*Lantana camara*); balsam pear (*Momordica charantia*); Chain-of-love (*Antigonon leptopus*); love-in-a-mist (*Passiflora foetida*); *Chromolaena odorata*; and mile-a-minute-vine (*Mikaina micrantha*). Of these species, the ivy gourd and *Operculina* appear to becoming out of control in certain areas of Saipan and have completely covered over forest canopies. In an effort to control the spread of ivy gourd, the DLNR has implemented a biological control program involving the release of two species of weevils that attack the ivy gourd. One species (*Acythopeus burkhartorum*) forms galls while the other (*Acythopeus coccinia*) is a leaf-miner. The first introduction was conducted during May 2003 on Saipan. Success of the project will likely not be fully realized for several more years.

Non-native vertebrates that could be considered invasive species include: the cane toad (*Bufo marinus*); rats (*Rattus* spp.); musk shrew (*Suncus murinus*); Eurasian tree sparrow (*Passer montanus*) and feral populations of goats, cattle and pigs. Lastly, the Brown Tree Snake (*Boiga irregularis*) would likely be considered a good candidate for the list despite the CNMI’s population not being at a level where the species has caused economic or wildlife associated problems.

Brown Tree Snake

The Brown Tree Snake has had a profound effect on Guam’s economy in the form of unexpected power outages and trouble shooting costs incurred by the island’s utility company. Indirect impacts from power outages to Guam businesses can be substantial. Additionally, this species has substantially altered the island’s avian community (Savidge, 1987) and is believed to be responsible for the extirpation of 10 of the 13 native forest bird species. With a similar climate, vegetation and wildlife resources as Guam, the CNMI would expect the same disastrous results should the BTS obtain a foothold in the CNMI.

With respect to the CNMI, a total of 108 snake sightings have been reported since 1982; with 68% (N=74) confirmed as possible brown tree snake sightings (Table 6). Of the total number of snake sightings, Saipan has the most; 95 sightings and 11 brown tree snake captures. Tinian has the second highest sighting record with 9 sightings and no captures and Rota has the least; 4 sightings and 2 Brown Tree Snake captures (CNMI - Brown Tree Snake Interdiction Program 2004).

It should be noted that since the release of the last annual BTS program report, there has been one additional credible BTS sighting at the Saipan Airport on 20 March 2005 (pers. Comm., Nate Hawley, DFW Herpetologist).

Table 6: Summary of Brown Tree Snake Sightings/Capture in the CNMI since 1982. Data taken from CNMI - Brown Treesnake Interdiction Program (2004).

ISLAND	NUMBER OF SIGHTINGS	NUMBER OF CAPTURES	LOCATION OF CAPTURES	NUMBER OF CAPTURES	DATE OF CAPTURES
SAIPAN	95	11	Seaport/Airport	8	<i>not reported</i>
			Capital Hill	1	13 March 1998
			As Teo	1	14 March 1992
			Chalan Kanoa	1	15 December 1991
TINIAN	9	- 0 -	<i>n/a</i>	<i>n/a</i>	<i>n/a</i>
ROTA	4	2	Seaport	2	<i>not reported</i>

Since the inception of the BTS Interdiction program during the early 1990's, two other snake species have been captured on the island of Saipan: a Gopher Snake -*Pituophis sp.* (captured during 1983) and a Striped Bronzeback Snake (*Dendrelaphis caudolineatus*) that was captured on 7 May 1990 (CNMI - Brown Treesnake Interdiction Program 2004). It is not known whether these two species would become invasive if they became established in the CNMI.

With respect to certain uninhabited northern islands (and Aguigan), uncontrolled population growth of feral ungulates (goats, cattle and pigs) have created havoc with the native vegetation ecosystem. Grazing has affected the species composition of the native habitat as new plant growth is eaten before maturing. This indirectly affects those native wildlife species that depend on certain levels of habitat quality (or species composition) to sustain their population. The CNMI Government, in conjunction with the US Fish and Wildlife Service, has implemented a feral animal eradication program for select islands. This is a long term project that is already starting to see results in habitat improvements on one island.

ABIOTIC ASPECTS

This section addresses coastal erosion, water quality and anthropogenic phenomena and other associated issues. Though not specifically identified in the topics list, volcanism is a very real and serious issue in the CNMI that should be addressed. The CNMI has several active volcanoes in the northern part of the island archipelago and has become a major deciding factor when it comes to re-colonizing the northern islands or affecting the island's habitat and wildlife. This issue also should be fully explored during the planning stages should any of the volcanic islands be identified as a target for research.

Coastal Erosion

Coastal erosion issues vary among the CNMI islands and the magnitude of the problem is dependent primarily upon the level of development, compliance with existing regulatory programs and/or the presence of an unchecked feral ungulate populations. As expected, the former issues are associated more with Saipan and the latter with the northern islands.

Southern Islands

Coastal erosion issues are of the greatest concern on the most populated and developed island of Saipan. Though not widespread, there are localized concerns where heavy rainfall events will erode the many coral roads found on Saipan (e.g., LauLau Bay road and Obyan Beach road). Depending upon the site location and magnitude of the rainfall event, occasional discharges of sediment laden runoff will be discharged to the near shore marine waters. Despite these known problems, the Division of Environmental Quality administers the Earthmoving and Erosion Control (E&EC) regulatory program that addresses this problem.

As most of the shorelines of the CNMI islands are rock, coastal beach erosion issues would be primarily limited to the sandy beaches found along the Saipan Lagoon. The first example is the beach fronting American Memorial Park in Garapan. The beach along the “point” is being eroded away while the adjacent Hyatt Hotel beach, immediately south, is showing accretion. Barring the fact that beaches are dynamic processes to begin with, the cause for this erosion has not been definitively identified. A second beach area being eroded is the short stretch of beach immediately north of Sugar Dock in Susupe. It has been suggested that the Sugar Dock pier structure acts as a groin and as such, provides a barrier to the normal longshore transport of sand materials. The beach south of Sugar Dock appears to be stable with some indication of accretion (general observations) over the past 20years. Other smaller examples exist along the Beach Road Pathway (Garapan to San Jose) however, these erosion prone areas are more related to single typhoon events.

One of the most controversial coastal erosional issues was the eroding away of the eastern end of Managaha island and resulting accretion of its’ western shore during the mid-to late 1990’s. Managaha Island is a very small islet located inside the barrier reef system near the mouth of the Saipan Lagoon entrance channel. The cause of this action was the removal of a World War II shipwreck from the eastern end of the island by the CNMI Government. The shipwreck was functioning as a groin and once removed, the Managaha sandy beach shorelines became dynamic and re-shifted.

Figure 4. Managaha Island.



Tinian and Rota have a few erosion prone problem areas, but these islands also have a E&EC program in place. If the problem areas are not presently being addressed, at least they have been identified as such.

Some have expressed concerns over the affects of bombing on the island of Farallon de Medinilla. There is a general suspicion that the military bombing activities are destroying the vegetation that has resulted in unchecked erosion along the cliff lines and the discharge of sediment laden runoff into near shore waters. The seriousness of this issue is not known and requires further investigation.

Northern Islands

Several of the northern islands (Sarigan, Pagan, Agrihan and Anatahan) have had historical introductions of goats, pigs and cattle that have since become feral (Kessler 1997). Unchecked population growth has resulted in substantial grazing activities that indirectly has caused degradation of forest habitat, especially undergrowth and new growth. It is believed that the lack of ground cover caused by over grazing has exacerbated the erosion problem in certain areas.

A joint DFW/USFWS feral animal eradication project, completed in 1998, basically eliminated the feral animals on Sarigan Island. The final phase of this program involved shooting feral goats and pigs in a 60-day period which began in January 1998. Nine hundred and four goats and sixty-eight pigs were eliminated during this period of time.

During 1991, a feral animal eradication project was carried out on Aguigan Island (a southern island) that resulted in the removal of 189 goats. Unfortunately, it was estimated that about 40 goats were left (Rice 1991). A reconnaissance survey was conducted four years later by DFW and the following conclusion was reached (FY95 CNMI Wildlife Report):

“Now, four years later, the vegetation appears to be making a recovery in some parts of the island. Seedlings about three feet high were numerous in certain forested areas. This is in stark contrast to the previous report; no seedlings and a defined browse line that went to a level approximately five feet above the ground.”

Unfortunately, the feral goat population is gradually making a comeback on Aguigan Island but not to a point whereby the vegetation has been severely affected. This problem will have to be revisited until all the feral animals can be removed.

Another feral animal eradication plan was conducted on Anatahan with similar success.

Marine Water Quality

Marine waters surrounding the CNMI are generally considered good to excellent in quality, except when in close proximity to wastewater or storm water outfalls. Marine waters are classified as either Class AA or Class A with coastal waters being defined by the CNMI Water Quality Standards regulations as: “*all waters of a depth less than twenty (20) fathoms, or waters up to a distance of 1,000 feet off-shore from the mean high water mark, whichever is the greater distance form the shoreline.*” These regulations were updated in 2004.

The CNMI Water Quality Standards describes and defines Class AA marine waters in Part 5.1(a) as:

“It is the objective of this class that these waters remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-related source of actions. To the extent practicable, the wilderness character of such areas shall be protected. Mixing zones for dredging and the discharge of dredged or fill material may be permitted as allowed under Part 9.6 of these standards. Mixing zones for any other discharge shall not be permitted. The uses to be protected in this class of waters are the support and propagation of shellfish and other marine life, conservation of coral reefs and wilderness areas, oceanographic research, and aesthetic enjoyment and compatible recreation with risk of water ingestion by either children or adults.

The classification of any such water area as Class AA shall not preclude other uses of such waters compatible with these objectives and in conformance with the criteria applicable to them.”

Class A marine waters are described and defined in Part 5.1(b) as:

“It is the objective of this class of waters that their use for recreational purposes and esthetic enjoyment be protected.

Any other use shall be allowed as long as it is compatible with the protection and propagation of fish, shellfish, and wildlife, and with compatible recreation with risk of water ingestion by either children or adults. Such waters shall be kept clean of solid waste, oil and grease, and shall not act as receiving waters for any effluent which has not received the best degree of treatment of control practicable under existing technology and economic conditions and compatible with standards established for this class. A zone of mixing is approvable in such waters.”

Southern Islands

Rota

All marine waters are designated Class AA {Part 6.1 (a)} except those coastal waters known as East Harbor and West Harbor, which are designated as Class A {Part 6.1(b)}.

Agiguan

All marine waters are designated Class AA {Part 6.2 (a)}.

Tinian

All marine waters are designated Class AA {Part 6.2 (a)} except those coastal waters known as San Jose Harbor, which are designated as Class A {Part 6.2(b)}.

Saipan

All marine waters are designated Class AA {Part 6.3 (a)} except for two discrete areas of waters that are classified as Class A {Part 6.3(b)}. These two areas include: (1) “waters up

to 3,000 feet from the mean high water mark on the shoreline from the entrance to Smiling Cove Marina to Saddok As Agatan, inclusive of the waters within Smiling Cove Marina and its entrance channel and (2) waters surrounding the Agingan Wastewater Treatment Plant, within a 1,000 foot radius of the outfall.”

Farallon de Medinilla

All coastal and oceanic waters are designated Class A {Part 6.4 (b)}.

Northern Islands

All marine waters surrounding each of the nine Northern Islands are designated Class AA {Part 6.4 (a)}.

Freshwater Water Quality

Based on a standard of potability, water quality of the limited CNMI fresh water lakes and ponds are likely to be considered poor (see discussion in Section II A (1)). Water quality of intermittent streams are expected to be variable depending upon surrounding activities. However, as rainfall increases the volume of stream flow, water quality will progressively worsen.

Fresh surface waters are classified as either Class 1 or Class 2 with fresh water being defined by the CNMI Water Quality Standards regulations as “*all waters with dissolved inorganic ions of less than 500 ppm.*” These regulations were updated in 2004.

The CNMI Water Quality Standards describes and defines Class 1 fresh surface waters in Part 5.2(a) as:

“It is the objective of this class that these waters remain in their natural state as nearly as possible with an absolute minimum of pollution from any human-caused source. To the extent possible, the wilderness character of such areas shall be protected. Wastewater discharges and zone of mixing into these waters are prohibited.

The uses to be protected in this class of water are for domestic water supplies, food processing, the support and propagation of aquatic life, groundwater recharge, compatible recreation and aesthetic enjoyment including water contact recreation with risk of water ingestion by either children or adults.”

Class 2 waters are described and defined in Part 5.2(b) as:

“It is the objective of this class of waters that their use for recreational purposes, propagation of fish and other aquatic life, and agricultural and industrial water supply not be limited in any way. The uses to be protected in this class of waters are all uses compatible with the protection and propagation of fish and other aquatic life, groundwater recharge, and with recreation in and on these waters. Compatible recreation shall include limited body contact activities. Such waters shall not act as receiving waters for any discharge which has not received the best degree of treatment or

control practical under technology and economic conditions and compatible with the standards established for this class. A zone of mixing is permissible in these waters.”

As there are no fresh water surfaces designated as Class 2 waters, all fresh surface waters in the CNMI are classified as Class 1 waters.

Volcanism

The Mariana Islands developed west of the Mariana Trench along the edge of the Philippine Plate and consists of both active and dormant volcanoes. The northern islands are high volcanic islands while the southern islands (Tinian, Rota and Guam) are uplifted basement blocks. To the east, the Pacific plate is subducting beneath the arc along the Mariana trench. Two important submarine features, the Mariana Trough and the West Mariana Ridge, lie to the east of the island arc system and are considered part of the Philippine Sea plate.

The Mariana block, containing the island arc system, is moving apart from the Philippine Sea plate at a spreading rate (relative to the Philippine Sea plate) about 15 mm/yr in the northern islands to about 45 mm/yr near Guam. At the same time, the convergence (subduction) rate for the Mariana forearc (relative to the Pacific plate) is approximately 35-45 mm/yr at 19° N to 55-70 mm/yr at 13.5° N (Kato, et.al. 2003).

Thirty-six earthquakes greater than 6.5 on the Richter Scale have occurred in the vicinity of the Marianas Trench over an 88 year period; from 1902 to 1990 (Moore, et al. 1992). Historically, this area is not known for very large earthquakes. Researchers have estimated on the basis of plate convergence rates and plate ages that a Moment Magnitude of 7.4 is the maximum likely magnitude for the Mariana subduction zone (Earthquake Spectra 1993). However, the 8 August 1993 Guam earthquake (Moment Magnitude of 7.7 or Richter Magnitude of 8.1) demonstrated that the Mariana subduction zone is capable of larger earthquakes than previously thought.

Threats from volcanic eruptions is probably the single largest uncontrollable impediment to settling the Northern Islands. The island targeted for re-population, Pagan Island, has the most active volcano (Mount Pagan) in the Mariana Island Arc (Trusdell report dated 7 June 2001).

Southern Islands

The five southern islands (Farallon De Medinilla, Saipan, Tinian, Aguiguan, and Rota) are all relatively older (geologically speaking) and more stable than the Northern Islands. Therefore volcanic eruptions are not expected as there are no active volcanos.

Northern Islands

In contrast to the older and more geologically stable southern islands, the northern islands are rife with volcanic activity. The volcanic activity for each of the northern islands is summarized below.

Farallon de Pajaros - taken directly from Smithsonian's *SEAN Bulletin* (V. 6, No. 9) and *Global Volcanism Network* (V. 15, No. 10 to V. 17, No. 6)

Summary:

Type: composite with caldera

Activity: active

Last Eruption: 1989

Rock Type: ?

Eruptive Volume: ?

Latitude: 20.53 N

Longitude: 144.90 E

Geologic Background:

The small 2-km-wide island of Farallon de Pajaros (Uracas), the northernmost and most active volcano of the Marianas Islands, has been referred to as the “*lighthouse of the western Pacific*.” The symmetrical, sparsely vegetated summit is the central cone within a caldera, remnants of which are seen on the SE side. Flank fissures have fed lava flows during historical time that form platforms along the coast. Both summit and flank vents have been active during historical time. Eruptions have also been observed from submarine vents, and Makhahnas seamount lies about 10 km to the SE.

Historic Activity:

Farallon de Pajaros has erupted frequently in the 20th century. However, because it is at the northern end of the chain about 400 km from Saipan, the volcano is observed only intermittently, and low-level eruptive activity might be missed. Frequent Strombolian activity and accompanying lava flows were observed in 1952-53 from the Uracas crater.

Recent Activity:

Strong seismic and acoustic signals apparently generated by submarine volcanism were recorded on Sept. 21-22, Dec. 22-24, and Dec 26-27, 1989. Probably originated from a site about 30 km south of Farallon de Pajaros

Maug - taken directly from *Global Volcanism Network* (V. 17, No. 6)

Summary:

Type: composite

Activity: dormant

Last Eruption: ~100,000 yrs BP

Rock Type: ?

Eruptive Volume: ?

Latitude: 20.02 N

Longitude: 145.22 E

Geologic Background:

The Maug Islands consist of three remnants of a large stratovolcano enclosing a 2.5-km-wide caldera containing a submerged central cone that rises to within 20 m of the surface. Maug is mapped as Quaternary; widespread corals and reefs support long period of general

quiescence but do not rule out recent mild volcanic activity.

Historic Activity:

Maug has not erupted during historic time.

Recent Activity:

No activity evident on May 13, 1992.

Asuncion - taken directly from *Global Volcanism Network (V. 17, No. 6)*

Summary:

Type: composite

Activity: dormant

Last Eruption: 1906

Rock Type:?

Eruptive Volume:?

Latitude: 19.66 N

Longitude: 145.40 E

Geologic Background:

A single large asymmetrical volcano, steeper on the NE, forms 2.6 x 3.4 km wide Asuncion Island. The steep NE flank terminates in high sea cliffs. The southern and western flanks are mantled by ash deposits that may have originated in historical time.

Historic Activity:

An explosive eruption in 1906 also produced lava flows, but other historical eruption reports are of uncertain validity.

Recent Activity:

Vigorous steaming was occurring from several locations in the summit crater during observations on May 18, 1992.

Agrikan - taken directly from *Global Volcanism Network (V. 15, No. 7 to V. 17, No. 6)*

Summary:

Type: composite with caldera

Activity: dormant

Last Eruption: 1917

Rock Type: basalt - andesite

Eruptive Volume:?

Latitude: 18.88 N

Longitude: 145.67 E

Geologic Background:

The highest of the Marianas arc volcanoes, Agrigan contains a 500-m-deep, flat-floored caldera. The elliptical island is 8 km long; its 965-m-high summit is the top of a massive 4,000-m-high submarine volcano, the second largest in the Marianas Islands. Deep radial valleys dissect the flanks of the thickly vegetated stratovolcano. The elongated caldera is 1 x 2 km wide and is breached to the NW, from where a prominent lava flow extends to the coast and forms a lava delta. The caldera floor is surfaced by fresh-looking lava flows and also contains two cones that may have formed during the volcano's only historical eruption in 1917. The island's youngest lava flows traveled NNW through a breach in the caldera wall, forming a delta near the ocean. A 300-m-diameter cone on the floor of the 4 square kilometer central caldera may have formed during the 1917 eruption. A rift zone trending N10°E passes through the caldera and includes young cones on the N and S coasts. Extensive pyroclastic deposits cover older lava flow sequences dominated by basalts, but also including basaltic andesites and andesites.

Historic Activity:

During the last eruption, in April 1917, blocks up to 1 cubic meter fell on the south coast, 5 km away, and as much as 3 m of ash and lapilli were deposited on a coast village during 2 days of activity, prompting its evacuation. A 300-m-diameter cone on the floor of the 4 square km central caldera may have formed during the 1917 eruption. Fumarolic activity was occurring from one of the cones on the caldera floor 1976.

Recent Activity:

August 1, 1990 overflight showed increased fumarolic activity. Ground survey in Sept.-Oct. showed no sign of increased activity. Re-measurement of ground control stations showed no significant changes in May 1992.

Alamagan - taken from *Global Volcanism Network*

Summary:

Type: composite

Activity: dormant

Last Eruption: 1887

Rock Type:?

Eruptive Volume:?

Latitude: 17.60 N

Longitude: 145.83 E

Geologic Background:

Alamagan is the emergent summit of a large stratovolcano with a roughly 350-m-deep summit crater east of the center of the island. The exposed cone is largely Holocene in age. A 1.6 x 1 km graben cuts the southwest flank. A voluminous basaltic-andesite lava flow has extended the northern coast of the island, and a lava platform also occurs on the south flank. Pyroclastic-flow deposits erupted about 1000 years ago have been dated.

Historic Activity:

Most of the recent eruptions have been violently explosive; thick pyroclastic-flow deposits cover most of the island. A small eruption was reported in 1864, and another was thought to have taken place in 1887 or a few years earlier, but these historical reports are considered to be invalid.

Recent Activity:

Fumarolic activity

Guguan - taken from *Global Volcanism Network (V. 17, No. 6)*

Summary:

Type: composite

Activity: dormant

Last Eruption: 1883

Rock Type: ?

Eruptive Volume: ?

Latitude: 17.32 N

Longitude: 145.85 E

Geologic Background:

The small island of Guguan, only 2.8 km wide, is composed of an eroded volcano on the south, a caldera with a post-caldera cone, and a northern volcano. The latter has three coalescing cones and a breached summit crater that fed lava flows to the west and NW. The 287-m high point of the island is the south rim of the caldera.

Historic Activity:

The only known historical eruption of Guguan took place between 1882 and 1884 and produced the northern volcano and lava flows that reached the coast. Reports of a 1901 eruption have been discredited.

Recent Activity:

No gas emission.

Sarigan - taken from *Global Volcanism Network (V. 17, No. 6)*

Summary:

Type: composite cone

Activity: dormant

Last Eruption: ~100,000 yrs BP

Rock Type: ?

Eruptive Volume: ?

Latitude: 16.71 N

Longitude: 145.85 E

Geologic Background:

Sarigan volcano forms a 3-km-long, roughly triangular island. A low truncated cone with a 750-m-wide summit crater contains a small ash cone. The youngest eruptions produced two lava domes from vents above the south crater rim and farther to the south. Lava flows from each dome reached the coast and extended out to sea, forming irregular shorelines. The northern flow overtopped the crater rim on the north and NW sides. The sparse vegetation on the flows indicates they are of Holocene age.

Historic Activity:

No historic eruptions.

Recent Activity:

No gas emission.

Figure 5. Sarigan Island. Source: NOAA.



Anatahan - taken from *Global Volcanism Network (V. 15, No. 3 to V. 18, No. 8)*

Summary:

Type: composite with caldera

Activity: dormant

Last Eruption: ~100,000 yrs BP

Rock Type: ?

Eruptive Volume: ?

Latitude: 16.35 N

Longitude: 145.67 E

Geologic Background:

Anatahan is located about 120 km north of Saipan. Prehistoric volcanic activity at Anatahan has built an island about 9.5 km long and 4 km wide, consisting of two large cones linked at their summits by an elongate, roughly E-W trending depression (compound caldera of both collapse and explosive origin). The elongated, 9-km-long island of Anatahan consists of two coalescing volcanoes with a 2.5 x 5 km, E-W-trending summit depression formed by overlapping summit craters. The floor of the steep-walled crater of the younger eastern cone is only 68 m above sea level. The sparseness of vegetation on the most recent lava flows on Anatahan indicate that they are of Holocene age.

Historic Activity:

No historic eruption are known (prior to 2004), but solfataric activity occurs in the summit area. Boiling hot springs on the eastern crater floor and solfataras at the base of the nearby crater wall.

Recent Activity:

Series of earthquakes March 30-April 27, 1990, magnitude 3 to 5. Large shallow lake in east part of main caldera disappeared, but had reappeared by October. Ground surveys showed no significant deformation since Sept. 1990.

An earthquake swarm beneath Anatahan on May 29, 1993 resulted in the islands of Anatahan, Farallon de Medinilla, and Sarigan being declared off-limits until further notice. Seismicity continued into mid August and then declined. The island was evacuated in 1990 following a shallow earthquake swarm and has remained uninhabited.

The most recent major eruption occurred on 5 April 2005 with an ash plume extending at its highest level ever - approaching 50,000 feet (CNMI EMO Volcanic Eruption Advisory #1a: April 6, 2005).

MAJOR RESOURCE MANAGEMENT ISSUES

This section will attempt to identify those management issues that are in need of further management efforts. Some of these issues have been identified as problems requiring addressing, however for one reason or another, they have not been resolved. This list should not be considered inclusive.

Among the major resource management issues are:

1. Management of near shore reef-fish fisheries;
2. Water quality problems at site specific locations in Saipan Lagoon;
3. Water quality problems at Managaha Island;
4. Unknown plume direction and dilution of the Sadog Tasi wastewater outfall in the Saipan Lagoon;
5. Unsafe harbor facilities (i.e., entrance channel) at Rota West Harbor; and
6. Determine whether the anchoring of the AMSEA Vessels or Pre-positioned ships, are actually causing a significant problem to the reef resources and if so, attempt to resolve the issue.

Terrestrial Resource Management Issues

7. Control of invasive plant species. Develop an eradication program for the more problematic plant species (e.g., ivy gourd (*Coccoloba grandis*) and *Operculina ventricosa*)
8. Continued implementation and support for the existing BTS Interdiction Program. Development of new technology to catch BTS in a food rich environment
9. Investigate whether the recently documented exotic, the orange-cheeked waxbill (*Estrilda melpoda*) on Saipan, could become a competitor to native wildlife species.

STATUS OF KNOWLEDGE AND INFORMATION FOR MANAGEMENT

GIS Information Base

The Coastal Resources Management Office has one of the more active environmental GIS programs in the CNMI. Though no master list of available GIS information has been developed, the GIS supervisor is very knowledgeable and approachable for information requests.

Aerial Photographs

Black and white island-wide aerial photographs taken during 1976 and 1987 are available for Saipan, Tinian and Rota at 1:10,000 scale. Color aerial photographs at 1:10,000 scale were obtained of the Saipan Lagoon coastline during 1996 and 1999.

There are limited color aerial photographs of several of the northern islands (e.g., Pagan, Alamagan, Sarigan, and Anatahan) taken during 1994, however cloud formations in some photographs have diminished their usefulness.

The best source of recent archival CNMI aerial photographs is at the Coastal Resources Management Office in San Jose, Saipan. The best source of historical World War II related aerial photographs of the CNMI is at the Bishop Museum in Honolulu. The Northern Marianas College Library archival section also has historical photographs, but the extent of their aerial photograph collection is unknown.

Saipan Lagoon Resource Monitoring Program

The following marine resource program description was obtained directly from DEQ (2004). This report also contains the results of the long term monitoring program.

“The CNMI Inter-Agency Marine Monitoring Team (MMT) was initially established in 1997 to help CNMI understand the current conditions of their coral reefs and coral reef resources. It has developed and expanded over the past 7 years to improve data collection techniques, data accuracy, staff training, and spatial coverage. It is the goal of the CNMI Marine Monitoring Team to carry out long-term monitoring to continually assess our reefs as CNMI grows. DEQ plays a major role in the MMT through its Marine Biologist, Non-Point Source Pollution program, and laboratory Program. Two biocriteria monitoring programs presently exist; the Saipan lagoon and Nearshore Coral Reef programs. Both of these are very different for EPA funded bio-criteria monitoring programs in the U.S. mainland, due to the nature of tropical marine systems.

Coral reef benthic communities were evaluated by calculating a ratio of crustose coralline algae (CCA) to all other algae. Justification comes from studies which show CCA as the preferred substrate for coral settlement, and other turf and macroalgae to increase sediment trapping and inhibit coral survival (Rogers, 1990, Richmond, 1997, Fabricius and De'ath, 2001). A second measure of health of coral reef health was provided by coral community surveys, completed independently of benthos data collection. Three measurements of the coral community were averaged to quantify the overall integrity of each reef. These are community evenness, species richness, and average colony diameter (Meesters et al., 2001, Clarke and Warwick, 2001). An average is suggested because these measures can be affected by the geological and physical setting of a site, and all three addressed simultaneously serve to evaluate a reef regardless of its environmental setting. Methodology used to acquire coral reef data can be obtained at (<http://www.deq.gov.mp/MMT/Reef.htm>), Houk, 1999, and Houk, 2000).

Water quality assessment efforts have increased over the past 2 years. The coastline of Saipan (75.52 km) consists of 38% (28.57 km) sandy beach, of which 88% is monitored by either or both water quality assessment programs..... The coastline of Managaha is all sandy beach and monitoring efforts cover the entire island. Tinian Island has only 12% sandy shores, of which 71% are monitored. Rota has a 30% beach coastline, of which 35% is monitored. The present results show that 40.24 km of impaired coastline exists around CNMI, 28.05 km on Saipan, 0.19 km on Managaha, 4.5km of Tinian, and 8.5 km on Rota. An explanation of these results has been discussed above, and is mainly due to stringent orthophosphate and dissolved oxygen water quality standards that do not represent ambient condition. Regardless, these numerical data will serve as a baseline for future assessment of CNMI waterbodies.”

Marine Water Quality Monitoring Program

The following water quality program description was obtained directly from DEQ (2004). This report also contains the results of the long term monitoring program.

“The Division of Environmental Quality Surveillance Laboratory was established by the Commonwealth of the Northern Mariana Islands to provide monitoring data required under the Safe Drinking Water Act (P.L. 93-523) and other environmental programs. The data generated by the laboratory are used to evaluate the quality of drinking water and recreational waters in the Commonwealth. Therefore, a quality assurance plan is essential in the generation of these data and is an important part of the day-to-day activities of the laboratory. The DEQ Environmental Surveillance Laboratory Quality Assurance Manual includes Standard Operating Procedures (SOPs) for sampling, testing, reporting, and providing quality assurance for traditional water quality parameters.

The laboratory has a quality assurance plan with two primary functions: 1) It assures that proper quality control practices are implemented in day-to-day laboratory task, and 2) It assures that the reported data are valid, and are of a known precision and accuracy. The elements of a basic quality control program are well defined by federal statute. Although the success of the program depends upon the training, professional pride and awareness of each individual technician, final responsibility for the reliability of reported analytical results rest with the Environmental Surveillance Laboratory Supervisor.

The Environmental Surveillance Laboratory is responsible for measuring the quality of water that is used by the public for drinking, recreational and/or other purposes. It is the objective of DEQ's Environmental Surveillance Laboratory to assure that the data reported are valid, and of known precision and accuracy.

On a weekly basis, DEQ monitors 39 fixed stations along Saipan's most used West coast beaches for microbiological and chemical parameters. Six beaches on the Northeast coast and six beaches on the Southeast coast are monitored only on a quarterly basis because the quality of the water is consistently good and a smaller population uses these less developed areas. Eleven sites around Managaha Island, a small (1.5 km coastline) island located within the Saipan lagoon, are also monitored on a monthly basis.

Each month, Tinian and Rota monitor eleven and twelve beach areas respectively.... These sites are frequently used by the community so they are now being monitored for microbiological and chemical parameters on a monthly basis.

The microbiological and chemical parameters that the Division of Environmental Surveillance Laboratory currently monitors includes: Salinity (ppt), Dissolved Oxygen (% D.O.), Temperature (C), pH, Turbidity (NTU), Orthophosphate (PO4), Nitrates (NO3), and *Enterococci* bacteria (cfu/100ml). These parameters are monitored on a weekly basis for Saipan West Beaches, and 6 week on/off intervals for all other locations.”

Table 7 lists the marine water quality monitoring sites presently being surveyed by the DEQ for Saipan and Managaha Islands, while Table 8 lists the Tinian and Rota monitoring sites.

Table 7: Saipan and Managaha Island Microbiological and Chemical Monitoring Sites. (obtained from DEQ 2004).

Wing Beach	Community School	Bird Island Beach
PauPau Beach	Sugar Dock	Jeffrey's Beach
Nikko Hotel	CK Dist #2 Drainage	Grand Hotel
San Roque School	CK Dist #4 Lally Beach	Old Man By the Sea
Plumeria Hotel	Chalan Piao Beach	Marine Beach
Aqua Resort Hotel	Hopwood School	Tank Beach
Tanapag Meeting Hall	San Antonio Beach	Forbidden Island
Central Repair Shop	PIC Beach	North Laulau Beach
Sea Plane Ramp	San Antonio Lift Station	South Laulau Beach
DPW Channel Bridge	Grotto Cave	Obyan Beach
N. Puerto Rico Dump	Chalan LauLau Beach	Ladder Beach

S. Puerto Rico Dump	San Jose Beach	Unai Dangkulo Beach
Smiling Cove Marina	Hyatt Hotel	Managaha Beaches
American Memorial Park Drainage	Dai-Ichi Hotel	Diamond Hotel
Outer Cove Marina	Garapan Drainage #1	Garapan Fishing Dock
Micro Beach	Samoan Housing	Garapan Beach
Hafa-Adai Hotel	Civic Center Beach	Garapan Drainage #3
Garapan Drainage #2		

Table 8: Tinian and Rota Island Microbiological and Chemical Monitoring Sites. (obtained from DEQ 2004).

Tinian

Unai Masalok Beach
 Unai Dangkolo Beach
 Unai Babui
 Unai Chulu
 Leprosarium Beach I
 Leprosarium Beach II
 Tachogna Beach
 Taga Beach
 Harbor
 Kammer Beach

Rota

Coral Garden Beach
 Kokomo Beach Club
 Swimming Hole
 Mobile Station Storm Drainage
 East Harbor Dock
 Tweksberry Beach
 West Harbor Marina
 District #2 Storm Drainage
 District #1 Storm Drainage
 Veterans Memorial Beach
 Teteto Beach
 Guata Beach

Commercial Fisheries Data Collection Program

As previously described in the bottomfish and pelagic fisheries descriptions, the Division of Fish and Wildlife has a long term fisheries data collection program known as the Commercial Purchase Data System. Basic fisheries data is collected from first-time purchasers (retailers or wholesalers) of locally caught seafood products and recorded on specially designed “invoice”. Data parameters collected include; species of fish or species group, total pounds, price per pound, fishermen name and date. Though this data collection program is voluntary in nature, the Division of Fish and Wildlife is working on passing legislation to make fisheries data collection mandatory in order to obtain better quality data.

GOVERNANCE

CNMI Government Regulatory Programs

Management responsibilities over various aspects of the CNMI’s aquatic and terrestrial resources are agency oriented and are shared between the Coastal Resources Management Office (CRMO), the Division of Fish and Wildlife (DFW), and the Division of Environmental Quality (DEQ). Minimizing physical anthropogenic impacts to the coastal resources are primarily addressed by the CRM through its permitting program, while DEQ is primarily responsible for monitoring the quality of ground water, fresh water, and marine waters. The DFW focuses its conservation efforts on maintaining biological community diversity and fishery stocks at levels sufficient to sustain existing fishery efforts and regulating the importation of live wildlife species (i.e., potential farm animals). As can be expected with this scenario, several permits have overlapping responsibilities which requires the applicant to obtain multiple permits (including some Federal permits) for the same activity.

Coastal Resources Management (CRM)

The enabling legislation which formulates the mandate of the Coastal Resources Management Office (CRMO) is Public Law 3-47 (Coastal Resources Management Act) which was passed by the Legislature in 1983.

The CRM regulatory program has two types of permits: a Major Siting Permit and a Minor Siting Permit. As the name implies, Major Siting Permits are usually required for those larger development projects that may affect coastal resources. “Major Siting” is defined in Section 5 of the regulations and is restated below:

W. “Major Siting” means any proposed project which has the potential to directly and significantly impact coastal resources, as provided for in Section 11 A of these regulations. The phrase includes, but is not limited to the following:

- (I) Energy related facilities, wastewater treatment facilities pipelines, transportation facilities, surface water control project, harbor structures;*
- (ii) Sanitary land fills, disposal of dredged materials, mining activities, quarries, basalt extraction, incinerator projects;*
- (iii) Dredging and filling in marine or fresh waters, point source discharge of water or air pollutants, shoreline modification, ocean dumping, artificial reef construction;*

- (iv) Proposed projects with potential for significant adverse effects on submerged lands, groundwater recharge areas, cultural areas, historic or archeological sites and properties, designated conservation and pristine areas, or uninhabited islands, sparsely populated islands, mangroves, reefs, wetlands, beaches and lakes, areas of scientific interest, recreational areas, limestone, volcanic and cocos forest, and endangered or threatened species or marine mammal habitats;*
- (v) Major recreational developments and major urban or government developments;*
- (vi) Construction and major repair of highways and infrastructure development;*
- (vii) Aquaculture or mariculture facilities, and silva culture or timbering operations; and*
- (viii) Any project with the potential of affecting coastal resources which requires a federal license, permit or other authorization from any regulatory agency of the U.S. Government.*
- (ix) Any project, or proposed project, that may cause underground injection of hazardous wastes, of fluids used for extraction of minerals, oil and energy, and of certain other fluids with potential to contaminate ground water. Any such project, or proposed project, shall be primarily governed by the CNMI Underground Injection Control Regulations and supplemented by these Regulations.*

A Major Siting permit will require the development of an Environmental Impact Assessment, the holding of a Public Hearing, and a thorough review by representatives of the CRM Regulatory Agencies. The latter involves the following: Secretary, Department of Commerce; Secretary, Department of Lands and Natural Resources; Executive Director, Commonwealth Utilities Corporation; Historical Preservation Officer; Director, Division of Environmental Quality; and Secretary, Department of Public Works.

After the application is submitted, the CRM has 30 days in which to certify the application complete or request additional information. After the application is certified complete, the CRM Regulatory Agencies then have sixty days in order to make a decision to either issue or deny the permit.

Division of Environmental Quality

The DEQ is a line agency under the Governor and was mandated by the Commonwealth Environmental Protection Act to:

“develop and administer programs, including where appropriate, a system of standards, permits, or prohibitions, to prevent or regulate activities concerning the discharge of pollutants to the air, land, water, wetlands and submerged lands.”

In order to protect the islands' ground water resources, DEQ regulatory programs include the permitting of individual waste water disposal systems (IWDS), well drilling and well operations, and above- and below-ground fuel storage tanks. Their non-point source pollution program requires Earth Moving and Erosion Control Permits for all mechanized

earth moving activities. The DEQ also administers the state certification program for Federal water related permits - the Section 401 Water Quality Certification (Section 401 WQC). Finally, the CNMI air quality regulations require permits for the larger power generators, even though they may be used for back-up purposes only.

DEQ regulatory programs include:

(1) CNMI Water Quality Standards Regulations (updated 2004)

The U.S. Environmental Protection Agency (USEPA) delegated authority to the DEQ to administer the Section 401 WQC program of the Clean Water Act (CWA) when the CNMI Water Quality Standards Regulations were promulgated in early 1990's. This regulatory program authorizes the CNMI to basically approve, condition, or deny various Federal water-related permits that are issued in the CNMI. These include: the USCOE-CWA Section 404 permit, the USCOE-R&HA Section 10 permit, and the USEPA-CWA Section 402 NPDES permit.

The above Federal permits are not valid without the required CNMI state certification (e.g., Section 401 WQC), and vice-versa.

(2) Earthmoving and Erosion Control Regulations

Any type of mechanized earthmoving activities will require an Earthmoving and Erosion Control Permit. Earthmoving design plans for the facility will require prior "clearance" from the Historic Preservation Office (HPO), as well as the Division of Fish and Wildlife (DFW). The HPO will evaluate the significance of the proposed project site and the magnitude of earthmoving activities relative to impacts on historical and/or cultural artifacts that could be disturbed or destroyed. On the other hand, the DFW will assess whether the project site contains any habitat of special concern or any endangered species. As a general rule, the DEQ will not begin to process an Earthmoving and Erosion Control application until the HPO and DFW clearances are submitted.

(3) Individual Wastewater Disposal System (IWDS) Rules and Regulations [adopted on 27 November 2002 in Commonwealth Register, Vol.24 (11)]

Originally promulgated in 1992, these regulations were substantially amended, and subsequently repealed and reenacted in 2002. In addition to regulating the design of wastewater and disposal systems (e.g., septic tanks and leaching fields or other treatment systems), the inclusion of "*confined animal facilities*" (e.g., pigs, goats, cattle and chickens) was added to their regulatory authority.

A DEQ-Land Disposal Permit must be obtained if more than 55 gallons of wastewater per day will be disposed onto the ground. Depending upon the determination of the DEQ, volume of discharge, project site location (over an aquifer or within 150 feet of the mean high water mark along the shoreline), soil percolation rates, and possibly salinity, the Land Disposal Permit may not be a viable option of wastewater disposal.

(4) Under-ground (UST) and Above-ground Storage Tank (AST) regulations [initially adopted in 1992 - Commonwealth Register, Vol.14 (09); and Revised Interim Criteria for Aboveground Storage Tanks]

The regulations are slightly different for UST and AST. The UST application and renewal fees are more expensive and have a greater regulatory burden as these tanks are generally used by auto service stations or fuel distribution centers. Additionally, the UST requires a second permit, a DEQ-UST Permit to Operate, prior to actually being able to use the tank. As a general rule, the AST is a better choice for the aquaculturist.

The AST will require a DEQ-AST Permit to Install. In order to protect the groundwater resources, the AST regulations have established specific setback requirements from public water supply wells.

(5) Well Drilling and Well Operations Regulations [initially adopted in 1992 – Commonwealth Register Vol.14(9); amended 1994 – Commonwealth Register Vol. 16(2)]

Drilling and operating wells require two different permits. The DEQ-Exploratory Well Drilling Permit is required to initially site the well and authorize the drilling component. During the facility planning phase be sure that the proposed well site complies with the established setback requirements from water supply wells (both private and public).

Once the well has been drilled, the applicant must then apply for a DEQ-Well Operations Permit. The DEQ-Well Operations Permit expires every year on 30 September and therefore, must be renewed annually.

(6) Air Pollution Control Regulations [initially adopted in 1987 - Commonwealth Register, Vol.9(1)] (Currently being revised)

A DEQ-Permit to Construct and Operate must be obtained for any power generator with a power source that has a BTU gross rate greater than 500,000 BTU per hour. This regulatory requirement is applicable for any on-site power generator systems: emergency or full-time.

Division of Fish and Wildlife

The enabling legislation that created the Division of Fish and Wildlife (DFW) was passed in 1981 as Public Law 2 - 51. The stated purpose of DFW is to “provide for the conservation of fish, game, and endangered species, and for other purposes.”

The DFW has regulatory programs overseeing the importation/exportation of live animals and management authority over fisheries and wildlife issues. They are also the primary responsible agency for the development of Marine Protected Areas.

U.S. Federal Government Regulatory Programs

The U.S. Federal Government appears to base its resource management strategy more with Congressional laws that require multiple agency cooperation. The US Congress has passed several environmental laws that focus on major environmental issues. These laws

include the Clean Water Act (CWA), the Rivers and Harbors Act of 1899 (R&HA), and the Endangered Species Act (ESA). The more difficult and complex of the three Acts are the Clean Water Act and Endangered Species Act.

Following a brief overview of the relevant components of each Act is a summary of the regulatory program for each Federal agency that is involved in administering the intent of the Acts.

Rivers and Harbors Act of 1899:

Section 10 of the Rivers and Harbors Act of 1899 (R&HA) regulates the placement of structures in “*navigable waters*.” Potential aquaculture activities regulated by this program in the CNMI include placing structures within the territorial sea (seaward three nautical miles from the mean high water line). Examples include: dock or pier pilings, breakwaters, bulkheads, pipelines, anchoring or mooring buoys, and floating platforms. In contrast to the CWA’s definition of “*waters of the US*” which is very broad, “*navigable waters*” as defined by the R&HA is limited to those waters within the territorial sea. When comparing the two terms, “*navigable waters*” could be considered a subset of “*waters of the US*”. Because the CNMI has no intertidal river systems, in virtually all cases within the CNMI, “*navigable waters*” are limited to coastal lagoon waters and oceanic waters out to three nautical miles (e.g., territorial seas).

In most instances, the U.S. Army Corps of Engineers will have jurisdictional authority for CNMI in-water activities requiring R&HA permits. Their role in administering the Act is included in the following discussion under the Clean Water Act.

Clean Water Act of 1977, as amended:

The Federal Water Pollution Control Act of 1948, later completely revised and renamed the Clean Water Act (CWA) in 1977, was passed by the U.S. Congress in order to “*restore and maintain the chemical, physical, and biological integrity of the Nation’s waters*.” The CWA regulates virtually all physical alterations and discharges into “*waters of the US*.” Within the CNMI, this term includes; all territorial seas (three nautical miles seaward from the mean high water mark) and lagoons surrounding each island; Lakes Susupe (Saipan) and Hagoi (Tinian) and their surrounding karriso (*Phragmites karka*) wetlands; intermittent streams that have a physical connection to the ocean or lagoon (for example, Saddok Dogas, Saddok Tasi and Saddok Talofofa on Saipan); and other wetlands (for example, the Lower Base wetland complex on Saipan). Several of the more relevant sections of the CWA are explained below.

Section 402 National Pollution Discharge Elimination System or NPDES: Section 402 NPDES, specifically regulates the discharge of pollutants into “*waters of the US*.” There are two related issues; those activities that involve direct discharges into near shore waters (or other “*waters of the US*”) and therefore require individual permits, and those project (or construction) sites that may have storm water discharge issues with near shore waters. The later situation is covered under a Construction General Permit.

Section 404 specifically regulates the discharge of fill material into “*waters of the US*”. This includes most earthmoving activities within the territorial sea (three nautical miles

seaward from the mean high water mark), in/along intermittent streams that have a physical connection to the ocean/lagoon, and jurisdictional wetlands. Compensatory mitigation is usually required for unavoidable impacts to regulated resources.

The USCOE administers the R&HA Section 10 regulatory program (regulates placement of structures in “*navigable waters*”) and has been for over 100 years. The Clean Water Act Section 404 regulatory program (regulates the discharge of fill material into “*waters of the US*”) is also directly administered by the USCOE, however the USEPA has environmental guidance and oversight.

Although the two above regulatory programs were created from different Acts, the USCOE has only one comprehensive application and processes both permits simultaneously as if they were one.

Administrative reviews and assessments of pending USCOE applications are conducted by the NMFS and USFWS Hawaii offices, as well as certain CNMI resource agencies. These reviews focus on project impacts to endangered species (known as ESA Section 7 consultation) and to the aquatic ecosystem in general. Another administrative review is conducted by the local CNMI Historical Preservation Officer and their Federal counterpart, the Advisory Council on Historical Preservation. Their review is required under Section 106 of the National Historic Preservation Act and focuses on project impacts to historic properties. Basically, all these agencies act in an advisory role to the USCOE and recommends mitigating permit conditions to be included into the permit, if issued.

It should be noted that at least two other local permits will be required in order to authorize the same activity applied for with the USCOE application: a CRM-Major Siting Permit and a DEQ-Section 401 WQC. The DEQ-Section 401WQC must be issued to validate the Federal USCOE-Section 10/404 permit and vice versa.

Of all the regulatory permits that one may encounter in the CNMI, the CWA Section 404 permit can be the most complex (depending upon what activities are being permitted) and possibly expensive. First of all, the proposed project must be able to meet the various goals outlined in the CWA Section 404(b)(1) Guidelines. This includes but is not limited to, whether there are any practicable alternatives (the water dependency test) available for the proposed project that will not affect jurisdictional wetlands or “*waters of the US*”. If this test is passed, then the USCOE will likely require compensatory mitigation in the form of creating new habitat (e.g., wetland) to offset project related impacts to the regulated natural resource (e.g., wetland). At this point, compliance costs could exceed project viability. Pre-planning strategy should involve avoidance of this permit foremost, and secondarily, minimization of project impacts on those regulated resources being affected.

Although the CNMI is under the administrative authority of the USCOE Honolulu District, the point of contact for all CNMI R&HA Section 10 and CWA 404 regulatory issues is the USCOE Guam Regulatory Office.

With respect to the CWA Section 402 NPDES regulatory program, the U.S. Congress delegated administrative responsibility to the USEPA. The USEPA works closely with the local DEQ in the processing of this permit.

An individual Section 402 NPDES permit will be required for any discharge of effluent (pollutants) into near shore marine waters or “*waters of the US.*” Applications must be submitted to the USEPA Region 9 (San Francisco, CA) office for processing. Effluent monitoring will likely be required as part of the permit, if issued.

With respect to construction site storm water issues which are also covered by the Section 402 NPDES program, the USEPA has issued a NPDES Construction General Permit for storm water discharges at construction sites that are greater than one acre in size. The purpose of the NPDES Construction General Permit is to decrease the regulatory burden by eliminating the need to obtain an individual Section 402 NPDES permit for earthmoving activities at construction sites. If the area of the aquaculture facility exceeds the minimum one acre, then it is necessary to comply with the regulations. A permit will not actually be issued by the USEPA, but the USEPA will need to be provided with a Notice-Of-Intent (NOI) for the pending construction work.

Although initially established by the USEPA to be a simple process, there are several steps that must be completed prior to sending the NOI to the USEPA. First, a Storm Water Pollution Prevention Plan (SWPPP) must be prepared that will require a written approval letter from the DEQ. At the time the SWPPP is submitted to DEQ for review, an application fee must also be paid to the DEQ. The NOI is then completed and sent to the USEPA (by the applicant) with the accompanying DEQ approval documentation for the SWPPP.

Endangered Species Act of 1973, as amended:

The Endangered Species Act (ESA) was initially passed by the US Congress in 1973 and has been re-authorized and amended several times. The purpose of the Act is to conserve “*the ecosystems upon which endangered and threatened species depend*” and to conserve and recover listed species. Those wildlife species which have been determined to have dangerously low population levels or are in imminent threat of extinction and thus requiring Federal protection are classified as Endangered or Threatened. Endangered is defined in Section 3(6) of the Act as

“...any species [including subspecies or qualifying distinct population segment] which is in danger of extinction throughout all or a significant portion of its range.”

A threatened species is defined in section 3(19) of the Act and is defined as

“.... any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.”

Enforcement of the ESA is shared between the U.S. Fish and Wildlife Service (Department of Interior) and the National Marine Fisheries Service (Department of Commerce). Jurisdiction of the USFWS extends to terrestrial and freshwater wildlife species while the NMFS’s primary responsibility is with the marine wildlife species.

Under Section 9 of the ESA, it becomes unlawful to “take” an endangered or threatened (e.g., listed) species. The term “take” is defined by the ESA as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct.” The term “harm” has been further defined to include “significant habitat modification or degradation.”

If impacts to Endangered Species can not be avoided, the two procedures available to resolve Endangered Species issues are the ESA Section 7 consultation or ESA Section 10 Incidental Take Permit. These are discussed briefly below:

Section 7 of the ESA requires that any Federal action agency coordinate or consult with the USFWS or NMFS to ensure that the project does not jeopardize the continued existence of a listed species or destroy or adversely modify designated critical habitat. With respect to development projects, the requirement of any Federal permit (for example, a USCOE-Section 10 or 404 Permit or USEPA-Section 402 NPDES Permit) will constitute a Federal action (or “Federal nexus”) and therefore require Section 7 consultation for the entire project, not just the specific action requiring a permit. The Section 7 consultation process is between the Federal action agency and either the USFWS or NMFS; the applicant has little to no direct involvement. If endangered species or its habitat, or designated critical habitat, occurs on the project site, the consultation process can get more involved and require more time as the USFWS or NMFS must issue a Biological Opinion prior to the USCOE or USEPA issuing their permit. Critical habitat has been designated for only one Endangered species in the CNMI. In October 2004, the USFWS designated approximately 28% (actually 6,033 acres) of the entire island of Rota as critical habitat for the Marina crow (*Corvus kubaryi* (FR: Vol.69, No.208).

The Section 10 Incidental Take Permit is a regulatory mechanism whereby permit applicants can resolve endangered species issues if their project does not have a Federal nexus. If the proposed development project will not require any Federal permits and has no other Federal connection, then this route may be appropriate should listed species or their habitat occur on the proposed site and a “take” is anticipated. Though they have no regulatory authority, the local DFW will also likely be involved.

Existing Resource Management Measures

Zoning

The initial Zoning Act was passed by the Legislature in 1993 and covered the island of Saipan. However, public outcry after implementation of the new regulations caused the Legislature to later repeal the Act. The issue lay dormant for 10 years until the current administration began investigating the possibility of re-activating the Zoning Act. It was discovered that the Act had not been properly repealed years ago and thus, was still in force. To meet the zoning challenges required for improving the Garapan commercial area, a new Zoning Board was installed the beginning of 2005. The Zoning Board is moving cautiously and is focusing its initial efforts on the Garapan commercial district rather than an all encompassing island wide zoning program. The newly formed Board has yet to develop regulations.

Conservation Areas

Conservation areas have been designated in the CNMI Constitution, through legislative action and by the Division of Fish and Wildlife. Management schemes for the CNMI's conservation areas range from no-take to limited-take, with several Marine Protected Areas being established for specific species, such as sea cucumbers or trochus. The terrestrial and marine conservation areas in the CNMI are as follows:

Maug Island Conservation Area

Designated as a no-take wildlife conservation area by Article 14 of the CNMI Constitution with the stipulation that the island shall remain uninhabited.

Farallon de Pajaros or Uracas Island Conservation Area

Designated as a no-take wildlife conservation area by Article 14 of the CNMI Constitution with the stipulation that the island shall remain uninhabited.

Asuncion Island Conservation Area

Designated as a no-take wildlife conservation area by Article 14 of the CNMI Constitution with the stipulation that the island shall remain uninhabited.

Guguan Island Conservation Area

Designated as a no-take wildlife conservation area by Article 14 of the CNMI Constitution with the stipulation that the island shall remain uninhabited.

Bird Island Marine Sanctuary (Saipan)

Designated in 2001 as a no-take marine conservation area by Public Law 12-46.

Forbidden Island Marine Sanctuary (Saipan)

Designated in 2001 as a no-take marine conservation area by Public Law 12-46.

Laulau Bay Sea Cucumber Reserve (Saipan)

This limited-take species reserve was established by the DFW through regulations promulgated under the authority of Public Law 2-51.

Lighthouse Reef Trochus Reserve (Saipan)

This limited-take species reserve was established by the DFW through regulations promulgated under the authority of Public Law 2-51.

Tank Beach Trochus Reserve (Saipan)

This no-take species reserve was established by the DFW through regulations promulgated under the authority of Public Law 2-51.

Bird Island Wildlife Conservation Area (Saipan)

Designated as a no-take wildlife conservation area by Public Law 12-83.

Kagman Wildlife Conservation Area (Saipan)

Designated as a no-take wildlife conservation area by Public Law 12-83.

Saipan Upland Mitigation Bank (Saipan)

Designated as a wildlife conservation area by Public Law 12-83. In addition, a MOU with the U.S. Fish and Wildlife Service establishes this conservation area as a mitigation bank to compensate for develop associated impacts to the endangered nightingale reed-warbler.

Managaha Marine Conservation Area (Saipan)

Designated as a no-take marine conservation area by the CNMI Constitution and Public Law 12-12.

Sasanhaya Fish Reserve (Rota)

Designated as a no-take marine conservation area by Rota Public Law 10-8.

Sabanna Heights Conservation Area (Rota)

Designated as a no-take wildlife conservation area by Rota Public Law 9-1.

Wedding Cake Conservation Area (Rota)

Designated as a no-take wildlife conservation area by Rota Public Law 9-2.

I'Chenchon Park Bird Sanctuary (Rota)

Designated as a no-take wildlife conservation area by Rota Public Law 9-3.

NGO Environmental Groups

Environmental oriented NGO's are a relative new comer to the CNMI. None of the larger more organized and well funded NGO's that are commonly found in the US mainland have offices in the CNMI. However, they occasionally get involved in issues that include the CNMI, such as critical habitat lawsuits for endangered species (e.g., Marianas crow).

Currently the following environmental NGO's are present in the CNMI. Activity levels of the various organizations vary from not presently active to fairly active.

Mariana Islands Nature Alliance:

This is the most recent NGO formed in the CNMI. Their Board of Directors was only recently identified during April/May 2005. The contact person is Ms. Erica Cochrane at mina@minapacific.org.

Team Responsible for Environmental Enhancement of Saipan (TREES):

Established in 2003, the contact person is Mr. Ivan Groom (Treasurer) nico@saipan.com

CNMI Organization for Conservation Outreach (CoCo):

This CNMI Government outreach program conducted its first public meeting on 25 January 2005. The three environmental problems the group has agreed to focus on includes; littering and illegal dumping, sewage overflow/outfall problems and invasive species. Contact person is Ms. Qamar Schuyler qamar.schuyler@crm.gov.mp.

Isla Conservation Association:

Contact person is Ms. Tina Sablan tinasablan@yahoo.com

United Northern Mariana Islanders Association:

Contact person is Ms. Cinta Kaipat cintamkaipat@chamorro.com

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**Natural Resources Management Needs for
Coastal and Littoral Marine Ecosystems of**

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INTRODUCTION AND BACKGROUND

Regional and National Context

Guam (13° 28' N, 144° 45' E) is the largest, southernmost island in the Mariana Island Archipelago located in the western Pacific (Figure 2). Due to the high ratio of coastline to land area, the coastal environment is particularly important (Randall and Holloman 1974). An assessment of past and present conditions should be established in order to properly manage these coastal systems. Coastal regions worldwide have seen an increase in population and development over the last half century. The overpopulation and development increase is magnified in the tropics due to the desirable climate. Development of the coast may be directly proportional to negative effects on coral reef health. According to the 2000 census, Guam's population was 154,805, a 16% increase over 1990 (Bureau of Statistics and Plans website, January 24, 2005).

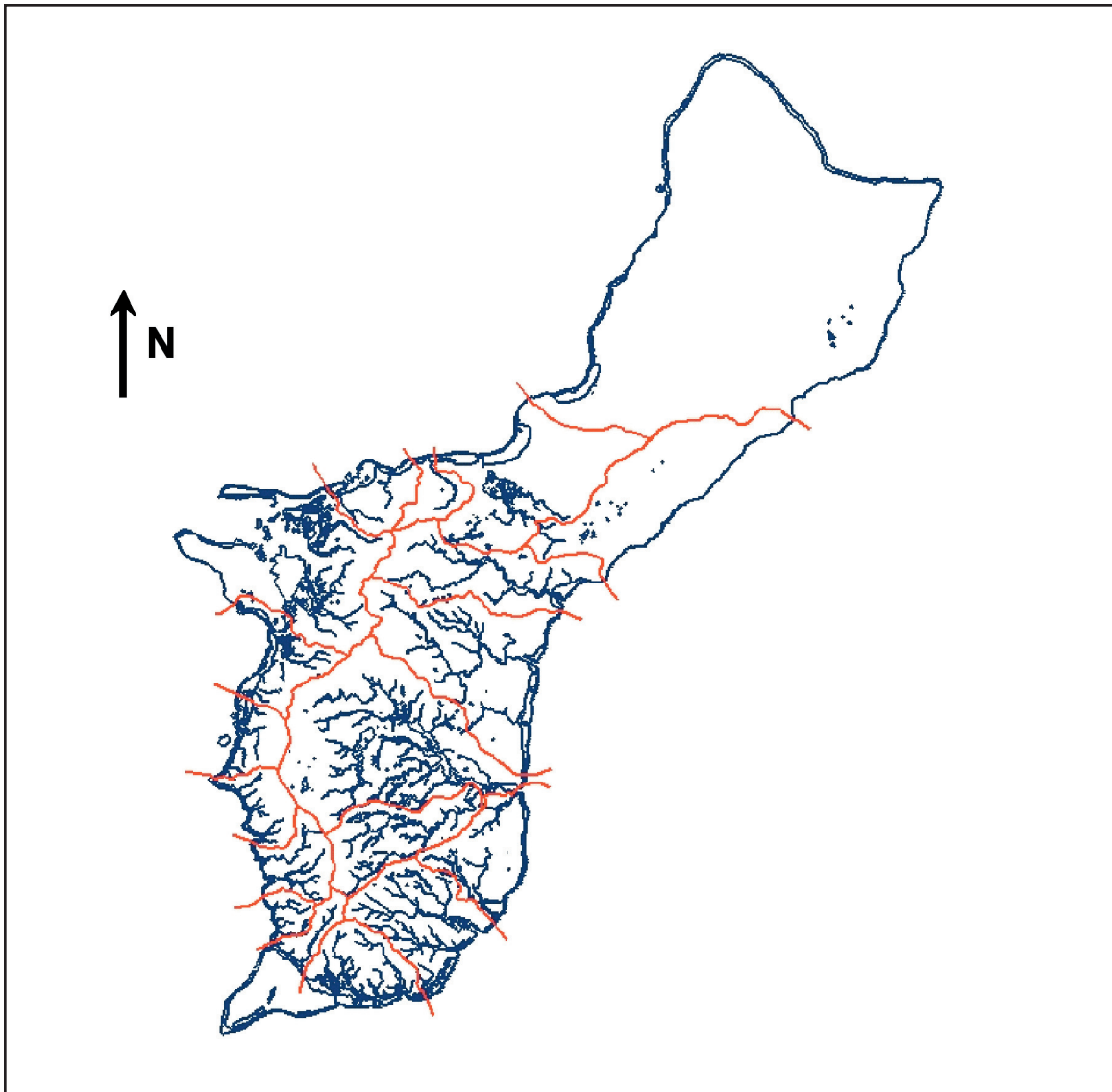
General climate characteristics are humid (>60% relative humidity) and warm, usually ranging from 24 °C in the evening to 33 °C during the day. Northeast trade winds persist during the fall and winter months. Severe weather such as tropical storms and typhoons occur annually. Typhoons occur most between August to November and March to May. Seasons are seen as wet during the months of July through November and dry during the months of January through May (Randall and Holloman 1974). However, other large climatic events, such as El Niño, can have an effect on the seasons making them less distinguishable. Tides and currents bring in warm water, providing necessities for the high species diversity on the reefs in Guam. Tides are semi-diurnal, with two highs and two lows per day. The north equatorial current, caused by northeast trade winds, usually results in a 1-2 knot current flowing west (Randall and Holloman 1974).

On a larger scale, Guam is composed of 19 watershed systems (Figure 3). Average annual rainfall is very high in this region ranging from 90 to 150 inches (Randall and Holloman 1974 and monthly rainfall data from 2003-2004 National Weather Service, Guam). Geologically, the northern region of the island is uplifted limestone whereas the mountainous central and southern regions are volcanic. The dissimilarity in geological structure translate into distinctly different habitats. Because of the obvious distinction between the two regions, this report will discuss them separately under each subheading, rather than as a whole.

Figure 1. Map of Guam



Figure 2. Watershed boundaries are in orange and wetlands are shown in blue. Figure courtesy of Bureau of Statistics and Plans.



HABITATS, USES, TRENDS AND THREATS

Terrestrial Habitat Types

The uninhabited, undeveloped parts of the northern half of the island are mostly covered with a mixture of limestone forest and secondary forest. Plant life in these forests chiefly consists of groves of tangantangan (*Leucaena leucocephala*), screwpine (*Pandanus dubius*), wild breadfruit (*Artocarpus* sp.) and coconut palms (*Cocos nucifera*). Species listed in Table 1 (Randall and Holloman 1974; Sanchez 1970) may also be found. Native fauna that are present in lesser numbers include the Mariana fruit bat, *Pteropus mariannus mariannus*, and the Mariana crow, *Coryus kubaryi*. Feral pigs are of the larger mammals found in the north. Some of the northern most limestone forest habitats accommodate the only population of the endangered Mariana fruit bat found on Guam.

Table 1. Plant Species of Guam's Limestone Forests

Latin name	Local name	English name
<i>Artocarpus</i> sp.	Dugdug	Wild breadfruit
<i>Carica papaya</i>	Papaya	Papaya
<i>Cycas circinalis</i>	Fadang	Cycad
<i>Ficus</i> sp.	Nunu, taotaomoana	Banyan
<i>Glochodium marianum</i>	Abas duendes	Mini Guava
<i>Hibiscus tiliaceus</i>	Pago	Sea Hibiscus
<i>Intsia bijuga</i>	Ifet	Ipil
<i>Mangifera indica</i>	Mango	Mango
<i>Muntingia calabura</i>	Mansanita	Panama Cherry
<i>Pandanus dubius</i>	Pahong	Screwpine
<i>Pandanus tectorius</i>	Kafu	Pandanus
<i>Polypodium scolopendria</i>		Palm fern
<i>Premna obtusifolia</i>	Ahgao	
<i>Thelypteris interrupta</i>		Willedow's maiden
<i>Triphasia trifolia</i>	Limonchina	

In the central and southern regions, the steep sloping hills and peaks are covered mainly by grassy savanna and the ravines are filled with secondary forest with thick underbrush such as vines. Savanna areas are covered mostly by the sword grass, *Miscanthus floridulus*. Ravine forests are mainly, but not exclusively comprised of species located in Table 2 (Sanchez 1970). Many of these species are used for food or medicinal purposes. Dominant animals inhabiting these forests are the feral pig and the Philippine deer populations usually hunted for food by humans.

Table 2. List of plant species found in Guam's ravine forests

Latin name	Local name	English name
<i>Acacia confusa</i>	Sosugi	Acacia
<i>Acacia</i> sp.	Acacia	Acacia
<i>Aidia cochinchinensis</i>	Sumak	
<i>Albizia lebeck</i>	Trongkon-kalaskaks	
<i>Annona muricata</i>	Laguana	Sour Sop
<i>Areca</i> sp.	betelnut	Betel palm
<i>Bidens pilosa (alba)</i>		Guam daisy
<i>Calophyllum inophyllum</i>	Da ' Ok	
<i>Carica papaya</i>	Papaya	Papaya
<i>Casuarina equisetifolia</i>	Gago	Ironwood
<i>Delonix regia</i>	Atbut	Flame tree
<i>Glochodium marianum</i>	Abas duendes	Mini Guava
<i>Hibiscus tiliaceus</i>	Pago	Sea Hibiscus
<i>Ludwigia octoralis</i>		Mexican seedbox
<i>Luffa cylindrica</i>		
<i>Mangifera indica</i>	Mango	Mango
<i>Morinda citrifolia</i>	Lada	Noni-Custard Apple
<i>Muntingia calabura</i>	Mansanita	Panama Cherry
<i>Pandanus dubius</i>	Pahong	Screwpine
<i>Mangifera indica</i>	Mango	Mango
<i>Pandanus tectorius</i>	Kafu	Pandanus
<i>Piper guahamense</i>	Pupulu	
<i>Pithecellobium dulce</i>	Kamachile	
<i>Polypodium scolopendria</i>		palm fern
<i>Premna obtusifolia</i>	Ahgao	False elder
<i>Pterocarpus indicus</i>	Narra	
<i>Scaveola sericea</i>	Nanaso	Half flower
<i>Syndrella nodiflora</i>		
<i>Terminalia catappa</i>	Talisai	
<i>Thelypteris interrupta</i>	fern	willedow's maiden
<i>Triphasia trifolia</i>	limonchina	

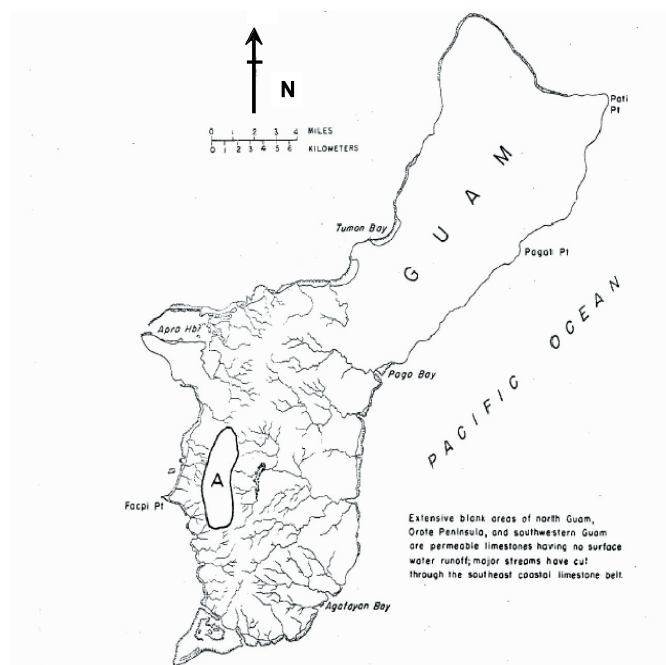
Surface Water Resources

Rainwater on the north half of the island flows through the porous limestone and over the underlying volcanic rock to become groundwater. Water may evaporate into the atmosphere,

enter the streams or move through the soil/rock to groundwater reservoirs and then to springs and seeps that all eventually discharge into the sea (Randall and Holloman 1974). Uplifted limestone is very porous so freshwater readily moves through and eventually seeps into the ocean. There are a few sinkholes where limestone opens over the underlying volcanic rock. These exposed freshwater lens features represent a unique type of freshwater habitat that is typically not very diverse. These sinkholes are usually host to specialized cavernicolous shrimp and fish species. There are no other standing water sources on the northern half of the island, because of the porous nature of the limestone. However, some of the sinkholes extend to the saltwater table and therefore have an integration of multiple species types (Brent Tibbatts, Department of Aquatic and Wildlife Resources-DAWR, Freshwater Biologist, pers. comm.). Mixing of the freshwater lens and the underlying saltwater can be observed in cracks and caves in the limestone cliffs along the coast.

Most surface water features are located on the southern half of the island (Figures 2 and 3) with approximately one hundred named rivers (Best and Davidson 1981). Average stream flow to the ocean is 250 millions of gallons per day (mgd) (Randall and Holloman 1974). There are multiple watersheds feeding into the coastal lowlands, including adjacent reefs. There are many freshwater springs where water pools on volcanic rock. Some rivers travel over differing terrain, sometimes resulting in waterfalls. Usually there are associated pools located above and below the falls. Leptospirosis is a common human disease caused by bacteria found in these streams due to the inflow of animal waste upstream. This disease is of concern because tourists and locals visit these locations for hiking and swimming recreation.

Figure 3. Drainage pattern of Guam. A, is rough summit land. Figure taken from Randall and Holloman 1974.

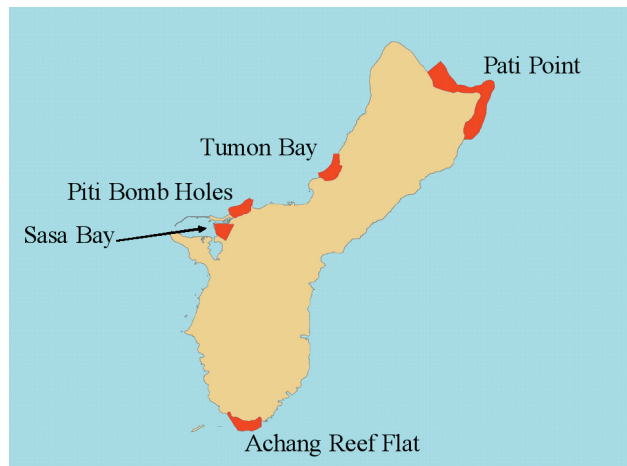


Fena Lake, the largest reservoir in Guam, encompasses approximately 200 acres in the south-central region of the island (Figure 3). It was completed in 1951 to provide a dependable water supply for the U.S. Navy on Guam. By 1955, pondweed (*Potamogeton crispus*) and bladderwort (*Utricularia* sp.) had become established near the banks and especially in the shallow waters at the back end of the reservoir in depths of 15 ft. or less (Brock and Yamaguchi, 1955). In order to control these plants, 2 species of tilapia (*Oreochromis mossambicus* in 1956, *Tilapia zillii* most likely in 1957) were introduced into the reservoir (Brock and Takata 1956; Nelson and Eldredge, 1991). Between 1962 and 1968 other species, including tucunare (*Cichla ocellaris*), small mouth bass (*Micropterus dolomieu*), large mouth bass (*Micropterus salmoides*), and channel catfish (*Ictalurus punctatus*) were introduced to control the stunting of the tilapia and/or to increase angling opportunities. Mosquito fish (*Gambusia affinis*; some time before 1955) and guppies (*Poecilia reticulata*; in 1956) were also introduced to the reservoir for the control of mosquitoes (Brock and Yamaguchi 1955; Brock and Takata 1956). Surveys to monitor the status of the introduced species ended in 1969, and since that time, no stock assessments have been conducted in Fena Reservoir. Additionally, other species, such as unwanted aquarium pets, have been deposited in the lake over the years (Guam-online.com website).

Near-shore Marine Resources

Guam's beaches are composed of either white sand consisting of calcareous organic remains or brown/black sand consisting of detrital volcanic minerals (Randall and Holloman 1974). The rest of the coastline is limestone cliffs or shelves. Near shore habitats include sand flats, seagrass beds in the lagoons and a few small mudflats. Seagrass beds are host to a number of fish and invertebrate species. The largest occur in Guam's lagoons including lagoons in several of the Marine Protected Area's (MPA's, Figure 4). Guam has three species of seagrasses: *Enhalus acoroides* and *Halophila minor* in the Family Hydrocharitaceae, and *Halodule uninervis* in the Family Potamogetonaceae. The largest of Guam's seagrasses, *Enhalus acoroides*, grows up to 1.5 meters in height and usually forms circular patches. It inhabits the sandy-silt areas near the mouths of rivers in the southern half of Guam. *Halodule uninervis*, up to 15 cm high, is abundant in Cocos Lagoon; a few patches can also be found on the shallow sandy reef flats near shore in the southern bays. The third seagrass, *Halophila minor*, is the only seagrass that is not grass-like but consists of small, stalked, elongated, veined leaves (up to 1.5 cm high) arising from horizontal runners. This species can be found in shallow sandy reef flats and deeper lagoon environments (Guampedia.com website). Sandflats in the lagoons are typically host to small fish, a number of sea cucumbers and other small invertebrates. Mudflats are typically associated with mangrove areas and are sometimes submerged. They host few species, mostly detrital organisms, due to the lack of oxygen in the lower mud layers.

Figure 4. Location of Marine Preserves in Guam. Figure courtesy of Dave Burdick, NOAA, Coral Reef Initiative.



Coral reefs

Guam’s reef types include fringing, patch, submerged, and barrier reefs (Randall and Eldredge 1976). Overall, they are probably the most important habitat type in Guam. The general structure of coral reefs essentially remains the same over time (Figures 5a & 5b), although biologically they are constantly changing.

Figure 5a. 1953 (left) and 2003 (right) topographic maps showing no change in reef structure of Cocos Island, a barrier reef and island off the southern tip of Guam. Maps courtesy of USGS.

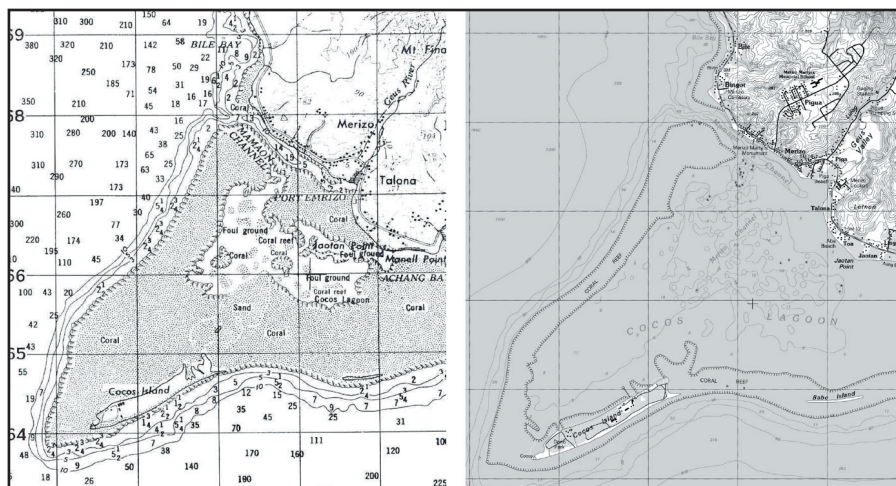
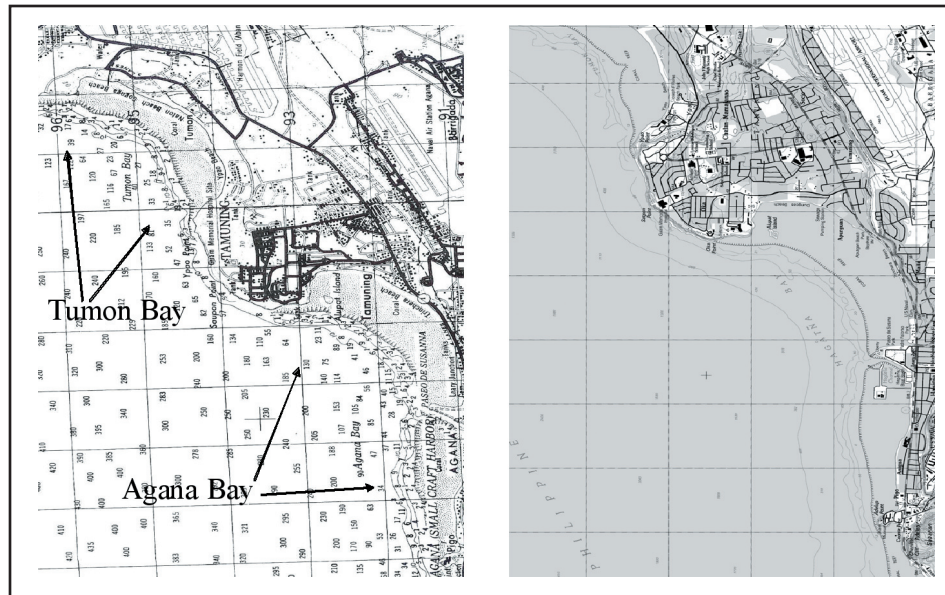


Figure 5b. 1953 (left) and 2003 (right) maps showing little change of reef structure at two tourist-frequented lagoons. Maps courtesy of USGS.



Coral reefs surrounding Guam are of great social and economic importance. Tourism is the basis of Guam's economy, therefore so are the beautiful beaches and reefs. Despite several setbacks during 2003, Guam still hosted almost 1 million visitors (GVB, 2004).

The indigenous people have relied on subsistence fishing as a part of their culture for thousands of years. The reefs provide food for the people as well as protection from annual storms. Over 5,000 marine species inhabit Guam's reefs (Paulay 2003), making Guam a very diverse locale. There are two turtles that nest in Guam; the endangered hawksbill turtle, *Eretmochelys imbricata* and the threatened green sea turtle, *Chelonia mydas*. Many of Guam's public agencies are setting up long-term monitoring programs in order to obtain data relevant to promoting proper management and conservation of coastal resources. They usually educate the public and, in some cases, encourage public involvement in conservation schemes.

Five MPA's (Figure 4) were established in 1997 but not enforced until 2001. They extend landward from 10 m above the high tide mark to the 600 ft. contour line offshore. A marked increase has been seen in size and abundance of organisms living within these areas just in the four years the MPA's have been enforced (Jay Gutierrez, DAWR, pers. comm., data publication still in press).

Biotic threats to reefs

Acanthaster planci (Crown of Thorn Starfish-COT) predation in Guam drastically reduced coral richness and diversity in the late 1960's (Tsuda 1970, Bonito 2002). Species composition shifted from *Acropora* and *Montipora* dominance (preferred food of *A. planci*) to a *Porites*- and *Leptastrea*- dominated community. It is believed that reefs can recover quicker from a natural disturbances of this sort because *Acanthaster* does not destroy the structural integrity of reef framework (Colgan 1987).

Diseases are not believed to be a major threat to Guam's coral reefs although some are observed such as the disease found on massive *Porites* called "pigmentation response", which is a pink iridescent color, and the "white syndrome" found in Acroporid corals. These diseases still have very simple names because they have not been well studied. Competition of introduced species may not be as devastating on reefs as it is in freshwater systems but still may offer some level of harm to other reef fauna, at least as far as resources are concerned.

Specialized Aquatic Habitats

Brackish Water Habitats

Guam's wetlands are extremely important filters for downstream environments including the surrounding coral reefs and are critical habitat for coastal migratory birds and the few native bird species left. Wetlands, which are found on the southern half of the island, are generally important for flood control, absorbing excess water, and for supplying water to adjacent areas during dry periods. According to Wiles and Ritter (1993), there are four types of wetlands in Guam: freshwater swamps, natural freshwater marshes, man-made freshwater wetlands, and estuarine wetlands. Freshwater swamps are located near rivers or other pooling water and have woody vegetation. Natural freshwater marshes are usually characterized by grasses, sedges and ferns and are more swamp-like areas. Man-made freshwater wetlands, like the above-mentioned Fena Lake, were originally formed as reservoirs for humans, cattle or crops. Estuarine wetlands generally are situated near or are part of mangrove stands. Figure 2 shows wetlands of the island in blue. Many of these wetlands are critical habitat for migratory bird species that fly through Guam. Historically, many of the wetlands were lost due to filling of large areas by the military, though it is undeterminable how much was actually affected (Wiles and Ritter 1993).

Coastal Forests (Mangroves)

Mangroves in Guam are less abundant and sparsely dispersed when compared with other islands in Micronesia. They are, however, the largest stands in the Mariana Islands. There are a few patches located around the island but they are not significant habitat for an abundant source of species diversity. In most mangroves, the prop roots are juvenile nursing areas for many fish and invertebrate species (Lobban and Scheffer 1997). In Guam, Amesbury et al. (1977) found this not to be the case. There are, however, a few species dwelling in these forests including mudskippers, detrital organisms, and several species of mollusks and crabs. As one type of wetland, mangroves are very important for decomposition, flood control and collecting sediment runoff.

SPECIES OF CONCERN

Endemic and native species

Guam has relatively few endemic or native species as compared to what might be found in a similar sized continental areas. Many of these species are endangered or threatened.

Table 3: Endemic or native birds of Guam

English name	Scientific name	Status
Guam Flycatcher	<i>Myiagra freycineti</i>	endemic species
Guam Rail	<i>Rallus owstoni</i>	endemic species
Rufus Fantail	<i>Rhipidura rufifrons uraniae</i>	endemic subspecies
Brindled White-eye	<i>Zosterops c. conspicillatus</i>	endemic subspecies
Micronesian Kingfisher	<i>Halcyon c. cinnamomina</i>	endemic subspecies
Marianas Crow	<i>Corvus kubaryi</i>	throughout the Marianas
Vanikoro Cave Swiftlet	<i>Aerodramus vanikorensis bartschi</i>	widespread in East Pacific
White-throated Ground-Dove	<i>Gallicolumba x. xanthonura</i>	tramp species
Cardinal Honey-eater	<i>Myzomela cardinalis saffordi</i>	tramp species
Marianas fruit-Dove	<i>Ptilinopus roseicapilla</i>	tramp species

There are 6 native species of skinks and 3 native species of geckos. There are no native species of mammals except for one extinct (*Pteropus tokudae*) and one extant species of bat (*P. mariannus mariannus*).

Threatened and Endangered Species

There are several species on the federal endangered list in Guam other than the two above-mentioned sea turtles including the Mariana crow, *C. kubaryi*, the Guam Micronesian kingfisher, *Halcyon cinnamomina cinnamomina*, the Guam rail, *Gallirallus owstoni*, both of which exist only in captivity in Guam, the Mariana common moorhen, *Gallinula chloropus guami*, the Mariana gray swiftlet, *Aerodramus vanikorensis bartschi*, and the Mariana fruit bat or flying fox, *P. mariannus mariannus*. Some of these may exist or forage in coastal areas. Several animals are already extinct such as the little Mariana fruit bat, *Pteropus tokudae*, the broadbill, *Myiagra freycineti*, and the Mariana mallard, *Anas oustaleti*.

Recovery plans have been developed for the extant species. There have been wild breeding populations of the Guam rail established on Rota. The kingfisher continues to decline towards extinction, even in captivity. The moorhen and swiftlet are still present in Guam in small numbers in the wild. The Mariana crow has around 11 individuals in the wild in

Guam, 10 of those were recently released from captive breeding. The successful protection of their nests from the brown tree snake has led to an increase in surviving eggs per clutch (Table 4, courtesy of DAWR Wildlife Division).

Introduction of the brown tree snake, *Boiga irregularis*, which preys on the eggs, chicks and adults of birds, and the loss of critical, i.e. coastal, habitat are considered important contributing factors relating to species losses. The population of feral cats in Guam's jungles is also a growing concern. In 2003, feral cats killed all of the Guam rails released from the captive breeding program at Andersen Air Force Base (Paul Wenninger, DAWR, Wildlife Biologist, pers. comm.).

Brown Tree Snake

The brown tree snake, *Boiga irregularis*, has had tremendous economic and environmental impacts on Guam. The snake, accidentally introduced after WWII, has decimated the bird species of Guam. Losses of several species were apparent by the 1960's. Since introduction, the snake has been linked to the extinction or local disappearance of nine of the eleven native bird species. Five of these were endemic. The snake is also thought to be responsible for declines or disappearance of 9 lizard species, possibly linked to the extinction of one species of bat (Little Marianas fruitbat, *Pteropus tokudae*) and declines in the two bat other species (Fritts and Leasman-Tanner 2001).

Periodically, there are snake-caused power outage somewhere on the island. While most of these affect a limited area, some are widespread or island-wide blackouts. Everything from school lighting, computers used by retail outlets, traffic signals, to refrigeration of perishable goods are subject to these power interruptions. The costs due to direct damages and lost productivity are conservatively estimated at \$1-4 million dollars each year. Snake related stories result in unflattering publicity for the island and undermines the tourism industry indirectly. In addition to these issues, many federal and local government agencies invest scarce resources to control the snakes. These efforts slow shipping/transportation processes and increase costs. The snakes cause an increase in healthcare costs, due to the number of snakebites per year (1 per 1,000 visits to hospital) and an increase in disease as the native lizards and birds affect by snakes no longer keep insect populations restrained. Out-of-control populations of insects can also have negative effect on the agricultural industry. Snakes consume commercial poultry resulting a greater need to import eggs and poultry.

The brown tree snake is among the most critical threats to island biodiversity throughout the Pacific and Hawaiian Islands. Islands receiving airlines, airfreight and ships from Guam include Commonwealth of the Northern Marianas, Hawaii, the Federated States of Micronesia (Pohnpei, Kosrae, Yap, and Chuuk), Palau, Okinawa, and American Samoa. While control measures are taken at island airports, the introduction of one pregnant female snake is potentially sufficient to touch off an ecological disaster similar to that of Guam. As transportation improves in the region, additional precautions and funding will be necessary. Additionally, this case exemplifies the susceptibility of islands to invasive species and controls are warranted for other invasives which are not covered by the Brown Tree Snake programs.

Table 4: List of Threatened or Endangered Species in Guam (species that are extirpated or extinct are not listed)

GROUP	PROTECTED SPECIES	FEDERAL STATUS	# of individuals	Government of Guam Status
Mammals	Mariana fruit bat (<i>Pteropus m. mariannus</i>)	Threatened	200-450 in wild	Endangered
	Mariana common moorhen (<i>Gallinula chloropus guami</i>)	Endangered	100-200 in wild	Endangered
Birds	Guam rail (<i>Gallirallus owstoni</i>)	Endangered	about 180 in captivity	Endangered
	Micronesian kingfisher (<i>Halcyon c. cinnamomina</i>)	Endangered	60 in captivity	Endangered
	Guam swiftlet (<i>Aerodramus nikorensis</i>)	Endangered	<400 in wild	Endangered
	Micronesian starling (<i>Aplonis opaca guami</i>)	Not recognized	<250 in wild	Endangered
	Mariana crow (<i>Corvus kubaryi</i>)	Endangered	Approx. 10 in wild	Endangered

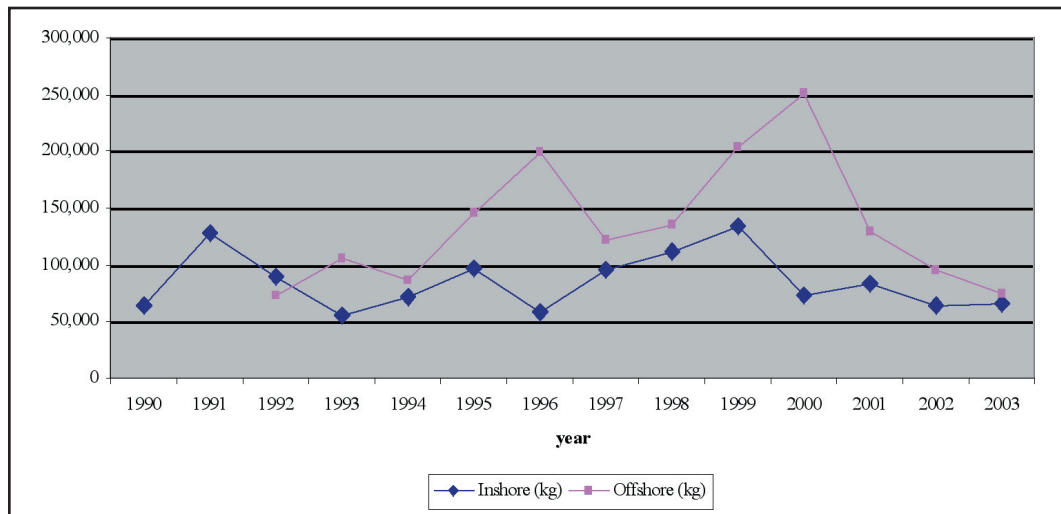
GROUP	PROTECTED SPECIES	FEDERAL STATUS	# of individuals	Government of Guam Status
Reptiles	Green sea turtle (<i>Chelonia mydas</i>)	Threatened	Unknown but still present in wild	Threatened
	Hawksbill sea turtle (<i>Eretmochelys imbricata</i>)	Endangered	Unknown but still present in wild	Endangered
	Leatherback Sea Turtle (<i>Dermochelys coriacea</i>)	Endangered	Very rare	Endangered
	Oceanic Gecko (<i>Gehyra oceanica</i>)	Not recognized	Rare	Endangered
	Micronesian Gecko (<i>Perochirus ateles</i>)	Not recognized	Found on Cocos Is.	Endangered
	Pacific Slender-toed Gecko (<i>Nactus pelagicus</i>)	Not recognized	Uncommon in southern Guam, rare otherwise	Endangered
	Snake-eyed Skink (<i>Cryptoblepharus poecilopleurus</i>)	Not recognized	Common on Cocos Is.	Endangered
	Tide-pool Skink (<i>Emoia atrocostata</i>)	Not recognized	Rare on Cocos Is.	Endangered
	Azure-tailed Skink (<i>Emoia cyanura</i>)	Not recognized	Rare on Cocos Is., possibly extirpated on Cocos, holding the only population in the Mariana Islands	Endangered
	Slevin's Skink (<i>Emoia slevini</i>)	Not recognized	Rare on Cocos Is.	Endangered
	Moth Skink (<i>Lipinia noctua</i>)	Not recognized	Rare on Guam, holding the only population in the Mariana Islands	Endangered

GROUP	PROTECTED SPECIES	FEDERAL STATUS	# of individuals	Government of Guam Status
Plants	Tree-Fern (<i>Cyathea lunulata</i>)	Not recognized	Several hundred	Endangered
	Ufa-halomtano (<i>Heritiera longipetiolata</i>)	Not recognized	750-1,000	Endangered
	Hayun-lago (<i>Serianthes nelsonii</i>)	Endangered	1 adult/several seedlings	Endangered
	No common name (<i>Tabernaemontana rotensis</i>)	Candidate for listing	25-30	Not recognized

Economically important species

Guam's fisheries are very important to the economy. Tuna fishing boats from foreign countries, i.e., Taiwan, Japan, Korea, etc.) call at Guam's port year around. Whereas the tuna industry is important for bringing in external monetary sources to support Guam's economy, the introduction of large, more capable fishing vessels within the last five decades has brought on stronger support of the local fishers. Figure 6 (data courtesy of DAWR) shows the number of kilograms of reef-associated fish caught annually over thirteen years, with annual take always exceeding 50,000 kg.

Figure 6. Yearly catch (kg) of reef-associated inshore and offshore fish around Guam (data courtesy of DAWR).



Trochus sp., (Chamorro=aliling, English=top shell) was introduced within the last 50 years but is considered by some to be an economically important species. After removal and consumption of the animal, the lustrous shell is used to make buttons and other accessories, which are exported or sold locally.

The aquarium trade is growing in popularity worldwide. Guam's warm waters are home to many decorative marine fish including species from many of the more popular families including Chaetodontidae, Acanthuridae, Pomacanthidae, Pomacentridae Labridae, Scariidae, Zanclidae; and less sought after fish such as Serranids, Blenniidae, Gobiidae, Microdesmidae, Ostaciidae, Tetradontidae, Diodontidae.

Guam also has an aquaculture industry based on marine shrimp and tilapia. Agriculture is a mixture of tropical vegetables, fruits, nuts and ornamental plants. All of these are dependent on soil conservation measures, maintenance of water sources as most agriculture depends on irrigation and can be affected by invasive species.

Coral reefs and their inhabitants that are visually pleasing, but are not demand within the aquarium trade, are still economically important for tourism. Many visitors come to vacation in Guam and activities may include use of the reefs for snorkeling and diving. Dive tour operators charge between \$85.00 and \$110.00 per person for a 2-tank tourist day trip. This cost is in addition to the already high travel and accommodation prices (see Table 5 below, data courtesy of Guam Visitors Bureau).

Table 5: Tourism data for 2000.

Nationality	Length of Stay	Expenditure per day	Average Age Male*	Average Age Female*	Percent Female	Percent Male	Single	Married
Japanese	3.7	\$128.11	33	30	55	45	41	59
Korean	3.6	\$440.56	32	29	47	53	17	83
Hong Kong	4.5	\$450.44	33	31	55	45	39	61
Taiwan	3.5	\$335.71	32	30	52	48	47	53
US/Hawaii	13.3	\$387.37	41	38	30	70	45	55
*Weighted average based on info for age groups (18-29), assumes the age group 60+ comprises ages 60-69, and excludes UNKNOWN ages.								
AVERAGE SPENDING BY NATIONALITY								
Nationality	Air Fare	Hotel	Food	Snorkeling	Other			
Japanese	\$331.00	\$203.00	\$176.00		\$432.00			
Korean	\$474.00	\$293.00	\$144.00		\$84.00			
Hong Kong	\$361.00	\$242.00	\$228.00		\$545.00			
Taiwan	\$250.00	\$155.00	\$209.00		\$32.00			
US/Hawaii	\$1,816.00	\$747.00	\$495.00		\$364.00			
MOTIVATION TO VISIT GUAM								
Nationality	SCUBA	Watersports (Non tour package)	Seas, Beach, Climate					
Japanese	5	16	40					
Korean	2	6	18					
Hong Kong	15	30	51					
Taiwan	13	21	40					
US/Hawaii	8	2	11					
OPTIONAL TOUR PARTICIPATION RATES (percent)								
Tour	Japan	Korea	Hong Kong	Taiwan	US/Hawaii			
Dolphin Watching	13	5	17	48	5			
Underwater Observation	11	0	20	19	8			
SCUBA	10	17	24	30	16			
Fishing	4	1	7	8	4			
Parasailing	11	6	17	17	5			
Jet Ski	10	53	28	20	5			

Culturally important species

Species that are culturally important in Guam are listed in Table 6. Traditional fishing methods have been passed down through generations. Atulai, the small bigeye scad, has an annual run as does the mañahak or rabbitfish. The seasonal arrival of specific and highly prized juvenile fish, is an important and much anticipated event. Reef gleaning is also an important practice with target species including; sea cucumbers, octopus, and trochus. Due to overfishing and other factors, all of these fisheries are in the decline.

Table 6: List of Guam's culturally important species

Latin name	Chamorro name	English name
Acanthuridae (family)	hugupau	surgeonfishes (many kinds)
<i>Acanthurus guttatus</i>	hamoktan	white-spotted surgeonfish
<i>Acanthurus lineatus</i>	hiyok	striped tang
<i>Acanthurus triostegus</i>	kichu	convict tang
<i>Bolbometapon muricatus</i>	atuhong	large bumphead parrotfish
Carangidae (family)	i' e'	immature skipjacks (< 10 cm)
Carangidae (family)	mamulan	mature skipjacks (> 90 cm)
Carangidae (family)	tarakitu	mature skipjacks (25-90 cm)
<i>Chanos chanos</i>	bangus	milkfish
<i>Cheilinus</i> spp. or Scaridae (family)	palaksi	wrasses or parrotfish < 50 cm
<i>Cheilinus undulatus</i>	tangison	giant wrasse (humphead)
<i>Coryphaena hippurus</i>	botague, ahimahi	dolphinfish
<i>Elagatis bipinnulatus</i>	achemsom	small rainbow runner
<i>Etelis coruscans</i>	onaga	onaga
<i>Hipposcarus longiceps</i>	gulafi	yellow longnose parrotfish
Holothuroidea (family)	balaté	sea cucumber
<i>Katsuwonis pelamis</i>	bonito	skipjack tuna
Kyphosidae (family)	guili	rudderfishes
Lamniformes (family)	halu'u	sharks
<i>Lethrinus elongatus</i> , <i>L. rubrioperculatus</i> , <i>L. xanthochilus</i>	lililuk	grey emperors
<i>Lethrinus nubilosus</i> , <i>L. harak</i>	mafute'	emperors
<i>Makaira mazara</i>	marlin	marlin
Mugilidae (family)	laiguan	any mullet
Mullidae (family)	ti'ao	immature goatfish (< 10 cm)
<i>Naso lituratus</i>	hangon	orangespine unicornfish
<i>Naso</i> spp.	tátaga'	mature unicornfish

Latin name	Chamorro name	English name
Scaridae (family)	laggua	parrotfishes (> 50 cm)
<i>Selar crumenophthalmus</i>	atulai	small bigeye scad
Serranidae (family)	gadao	groupers
Siganidae (family)	hiteng	rabbitfish (> 20 cm)
Siganidae (family)	mañahak	immature rabbitfish (< 5 cm)
Siganidae (family)	seyun	rabbitfish (10-20 cm)
<i>Siganus argenteus</i>	mañahak lesu	immature forktail rabbitfish
<i>Siganus spinus</i>	mañahak ha' tang	scribbled rabbitfish (< 5 cm)

Invasive Species

Another major concern for the fresh and brackish water resources is the introduction of non-native species. The most critical species, the Brown Tree Snake, is discussed above. There are many other introduced species on Guam but only some of them are considered invasive, or cause a negative impact to their surroundings. Fena Lake is a manmade reservoir that contains introduced non-native fish species (Lobban and Schefter 1997). There are ten native freshwater fish species in Guam, seven of them are gobies. They have an amphidromous life cycle; involving a marine environment at some point. There are at least eleven exotic fish species and at least seven exotic snail species that have been introduced into Guam's freshwater environments. They were introduced in a number of ways including aquaculture escapes, pet trade release, and purposeful introduction for human consumption or for biocontrol of other exotics. Humans pouring bleach into rivers, as means to collect fish/shrimp, has also been a problem (Tibbatts pers. comm.). Rivers take years to recover from such events. Table 7 includes a list of aquatic invasive species found in Guam.

Table 7: List of invasive species in Guam

Group	Family	Species
Plants	Hydrocharitaceae	<i>Egeria densa</i>
	Pontederiaceae	<i>Eichornia crassipes</i>
	Hydrocharitaceae	<i>Hydrilla verticillata</i>
	Lemnaceae	<i>Lemna minor</i>
	Nymphaeaceae	<i>Nymphaea</i> sp.
	Araceae	<i>Pistia stratiotes</i>
	Alismataceae	<i>Sagittaria subulata</i> var. <i>kurziana</i>

Group	Family	Species
Snails	Lymnaeidae	<i>Lymnaea viridis</i>
	Physidae	Physid sp.
	Ampullariidae	<i>Pila conica</i>
	Planorbidae	planorbid sp. 1
	Planorbidae	planorbid sp. 2
	Ampullariidae	<i>Pomacea canaliculata</i>
	Viviparidae	<i>Sinotaia magnificiana</i>
Amphibians	Bufonidae	<i>Bufo marinus</i>
	Leptodactylidae	<i>Eleutherodactylus coqui</i>
	Leptodactylidae	<i>Eleutherodactylus planirostris</i>
	Microhylidae	<i>Kaloula pulchra</i>
	Hylidae	<i>Litoria fallax</i>
	Microhylidae	<i>Microhyla pulchra</i>
	Rhacophoridae	<i>Polypedates megacephalus</i>
	Ranidae	<i>Rana (Pelophylax) nigromaculata</i>
	Ranidae	<i>Rana (Pelophylax) sp.</i>
Reptilians	Chelydridae	<i>Chelydra serpentine</i> - first found in 1998
	Emydidae	<i>Chinemys reevesi</i>
	Kinosternidae	<i>Kinosternon sp.</i>
	Emydidae	<i>Ocadia sinensis</i>
	Trionychidae	<i>Pelodiscus sinensis</i>
	Emydidae	<i>Terrapene carolina triunguis</i>
	Emydidae	<i>Trachemys scripta elegans</i>

Group	Family	Species
Fish	Cichlidae	<i>Astronotus ocellatus</i>
	Cyprinidae	<i>Barbus lateristriga</i>
	Belontiidae	<i>Betta brederi</i>
	Channidae	<i>Channa striatus</i>
	Cichlidae	<i>Cichla ocellaris</i>
	Clariidae	<i>Clarias batrachus</i> - introduced in 1910
	Poeciliidae	<i>Gambusia affinis</i>
	Cichlidae	<i>Oreochromis mossambicus</i>
	Cichlidae	<i>Oreochromis niloticus</i>
	Cichlidae	<i>Oreochromis zilli</i>
	Microdesmidae	<i>Parioglossus philippines</i>
	Poeciliidae	<i>Poecilia latipinna</i>
	Poeciliidae	<i>Poecilia reticulata</i>
	Poeciliidae	<i>Xiphophorus helleri</i>
	Poeciliidae	<i>Xiphophorus maculata</i>

ABIOTIC ASPECTS

Climatic and natural disasters

There are many abiotic threats to Guam's reefs. Landslides, caused by earthquakes or rain, can result in significant sediment transport, smothering vast areas of reef. A very destructive earthquake with a magnitude of 8.2 shook Guam in 1997, but there are also many smaller earthquakes every year that are strong enough to cause damage.

Powerful winds and rains from major storms, i.e. typhoons, cause major stress on these reef systems. Wood, metal or other flying debris piles up on and around the reefs and there is a constant influx of freshwater/sediment runoff. Guam has been hit by four major typhoons in the last decade (Porter et al. 2004), all of which had devastating effects on the surrounding reefs.

On April 27, 2002 there was an earthquake with a magnitude of 7.2 shaking the island and leaving it without power, damaging buildings and breaking several water pipes (PDN website). During the same year Typhoon Chata'an (July 30, 2002) and Super Typhoon Pongsona (December 12, 2002) produced heavy rain and sustained winds of 75-130 mph and gusts up to 180 mph damaging over 7,000 homes and businesses, leaving the island without water and power and leaving many homeless. The cleanup efforts following these storm events resulted in the collection of trash and also vegetative debris originating from hillsides. The loss of vegetative cover leaves the underlying soils vulnerable to erosion and deposition on nearby reef systems.

Global climate change has recently emerged as an environmental threat worldwide. Increasingly extreme temperature changes are being recorded in all ecosystems. Coral reefs in tropical environments are extremely sensitive to these changes. Even a small temperature increase can cause corals to bleach, but mass mortalities have not been frequently recorded in Guam (Porter et al. 2004), though they have been observed in other nearby locales such as Australia and Palau. Other risks caused by global warming for Pacific Islands include water supply shortages from lack of rainfall, food supply shortages due to loss of agricultural lands, and loss of coastal lands, loss of some ecosystems and, for atolls, possible loss of existence of all land due to the rise of sea level (Lobban 1997).

Coastal Erosion

Coastal development over the last five decades in Guam has had devastating effects on adjacent reefs by causing massive amounts of silt and sediments to runoff into the ocean. This is particularly true in southern Guam where highly erodible soils and steep slopes are present. Construction or land clearing without the use of proper sedimentation controls is commonly observed in Guam. Eutrophication can overwhelm the living reef. Fertilizers used on golf courses or waste put out by sewage treatment plants cause death to corals and the influx of nutrients trigger simultaneous algal blooms. These coral-algal community shifts are being seen worldwide at least partially due to poor coastal management. Sedimentation from illegal, intentional burning of vegetation for hunting purposes, has been the cause of much destruction on coral reefs, particularly in the large savannah areas in southern Guam. Off road recreation vehicle use in popular southern badlands contribute to these problems by expanding scarred areas.

Storm surges also cause a massive amount of erosion, especially to the areas directly in near the water line. During Super Typhoon Paka (1997) an entire cemetery by Inarajan Bay was destroyed including long stretches of nearby Route 4. The cemetery near Umatac Bay has been severely impacted and may be lost during the next large storm event.

Water quality

Water quality conditions are measured by a variety of factors including temperature, salinity, metal content, nutrient influx, etc., and suitable water conditions are important for retaining healthy coastal systems. For Guam, water quality is a big issue, as it is generally seen as poor. As stated earlier, corals can bleach due to poor water quality. Other than uncontrollable factors such as temperature and salinity, regulations have been created concerning the control of anthropogenic effects such as water pollution and nutrient loading (near sewage outfalls). Guam EPA (GEPA) performs weekly tests for fecal coliform levels in the popular swimming areas (44 beaches) and has formerly closed beaches due to unhealthy levels. They have a weekly notice posted in the daily paper and on their website for residents and visitors. Table 8 shows bays and beaches that have had bacterial levels above the accepted standards just within 2005. Those highlighted occur every month and are located all around the central-southern area of the island (GEPA website). Guam EPA also tests drinking water and ground water for contamination. There have been times when drinking water from the tap was advised against in certain villages, with “boil water” notices before use or consumption. During these times, businesses (mainly restaurants) in these villages were unable to serve water or ice.

The GEPA Water Resources Management Program plays a key role in managing and protecting Guam’s principal source aquifer from pollution and overpumping. The program is responsible for implementing the Water Resources Development and Operating Regulations, Underground Injection Control (UIC) Regulations, Wellhead Protection and Water Quality Standards. The Water Resources Management Program is also responsible for permitting and inspecting production and underground injection wells on Guam. GEPA is continuously collecting data on groundwater lens characteristics and using it to determine how the groundwater resource has been affected and to what extent future development can or should occur. The data is also used to determine whether changes or modifications to the current management are necessary (GEPA website).

Table 8: Bays and beaches with unacceptable bacterial levels during 2005 (highlighted).

Village	Location
Agat:	Namo Beach, Agat Bay, Bangi Beach, Nimitz Beach
Agat:	Bangi Beach, Nimitz Beach, Southern Christian Academy Beach, Agat Bay, Namu Beach
Asan:	Adelup Park Beach (Fonte River), Asan Bay
Chalan Pago:	Pago Bay
Hagåtña:	Hagåtña Bayside Park
Inarajan:	Inarajan Pool, Inarajan Bay
Piti:	Santos Memorial Park
Tamuning:	Alupang Beach, Trinchera Beach, Padre Palomo Park Beach
Talofofo:	Talofofo Bay
Umatac / Merizo:	Toguan Bay
Umatac / Merizo:	Toguan Bay

Human Activities

As mentioned, Guam's reefs are of great economic importance. The island has seen extreme impacts caused by anthropogenic factors. Many recreational activities are responsible for physical destruction of coral reef habitat. Some of these activities include fishing, SCUBA diving, snorkeling, windsurfing, jet-skiing, kayaking, etc. The use of boats is involved in many of these activities and may also have very serious negative impacts when they are carelessly operated. Groundings, damage by anchors, and illegal vessel discharges are cause for concern and happen more often than many people think. Within the last year, the U. S. Coast Guard had six reported groundings (Petty Officer Grady, pers. comm.), but there may have been others that were not reported. Ships dumping ballast water are believed to be the responsible party for introduced marine species. They have been claimed responsible because the commercial port has higher diversity than does the rest of the island and the port is where new species are usually first identified.

Fishing is another human impact devastating the reefs. Overfishing on the reef is a major concern as the catch per unit effort has decreased by half since the 1980's and has not yet recovered (Porter et al. 2004). Scuba spear fishing has been outlawed in all of the Mariana Islands except Guam. Fish are given no chance for escape with this method of fishing, especially at night and if fishers miss their target, the spear can imbed in the reef causing physical damage. Numbers of fish can be drastically reduced over short periods of time. Dynamite fishing, an older method that has been outlawed, was very destructive and there

are many areas that have still not recovered. Bleaching is another outlawed fishing method that has caused major problems. Dynamite fishing and the use of bleach may be the most destructive techniques as they kill the entire flora and fauna surrounding the fish being targeted leaving vast dead areas of reef. Other destructive fishing methods found in Guam include the use of disposable light-test monofilament gill nets, and to a lesser extent, drag nets, both of which are grossly indiscriminate methods for targeting fish species. Reef gleaning has emerged as a relatively new practice thought to impact marine resources. This practice includes the overharvesting of a number of reef animals and the destruction of fragile corals by foot traffic during seasonal low tides.

One of the more recently publicized community issues is the illegal, intentional burning of grasslands in the south. Hunters set fire to initiate a growth of new vegetation, consequently establishing in a new place for deer to feed. As a result, rain showers carry massive amounts of sediment from burned uplands, into adjacent rivers and streams, and ultimately onto the reef systems. This practice persists despite focused educational efforts.

MAJOR RESOURCE MANAGEMENT ISSUES

Many of Guam's management issues are shared among other Pacific island nations. Common aspects include the sensitivity of island ecosystems, poor planning for development and for the use of scarce management funds. In Guam, there is a shortage of funds for proper management and, therefore, there is a shortage of conservation officers to enforce the laws. According to the Pacific Daily News (May 9, 2005), the Government of Guam deficit has ballooned to \$300 Million dollars. Natural resource management usually occupies a relatively low position among a set of competing priorities during periods of economic slowdown.

Marine Resource Management Issues

Resource management strategies have slowly materialized on Guam. Marine resources have suffered years of degradation as a result of the absence of education, management planning and clear regulations. Now, in conjunction with U.S. federal agencies, Guam government agencies have prepared better management initiatives to utilize coastal resources more appropriately.

Fisheries

DAWR oversees fisheries management with a wide range of responsibilities ranging from performing creel surveys where catch data is gathered directly from local inshore and offshore fishers to collecting and analyzing total length and abundance data from the MPA's to determine if they are making progress. Conservation officers are based out of this agency, though there are too few to properly enforce the law and some individuals still continue to poach within the preserves.

Water Quality

Guam EPA is responsible for water quality issues such as testing bacteria levels in areas that are frequented by the public, such as Tumon Bay, the tourism-based site where most of the hotels and nicer beaches are located on the island. This area is just south of the

Tanguisson power plant, adjacent to a sewer outfall. The outfall is located at a depth of 60 feet/ 18 meters and the plume rises to the surface most days. There is a usual southward current, although Tumon Bay is located inside a lagoon and dilution may be sufficient before reaching the fringing reef. Otherwise, Tumon Bay also has natural runoff and sewers coming from the bordering hotels that cause bacteria problems and nutrient influx that, in turn, cause algal blooms (sometimes noxious algae or cyanobacteria) (Palmer 2003).

Other major water quality issues include groundwater nitrogen loading (McDonald 2002) and Guam's water quality standards (WQS) listed below (DAWR website). WQS requirements are established under the federal Clean Water Act (Section 303), and its regulations (40CFR Part 131). The Act requires the Governor or water pollution control agency of each state to, from time to time (but at least once each three year period), hold public hearings for the purpose of reviewing and, as appropriate, revising its water quality standards.

The most notable recent revisions to Guam's WQS address:

Antidegradation. The existing policy, to ensure that water quality is maintained and protected, was revised to meet federal requirements.

Groundwater. Numeric water quality criteria for groundwater were included. The criteria help clarify what water quality levels are necessary to retain our sole source aquifer as an acceptable drinking water resource. They are based on maximum acceptable concentrations of specific contaminants that can adversely affect public health and which may occur in public water systems.

Numeric criteria for surface waters. Numeric criteria (e.g. microbiology, pH, nutrients, and toxic substances) were updated and newly adopted to reflect updated federal requirements.

Effluent limitations. Protections were included for threatened and endangered species, and for those organisms harvested for food. Sections were added which allow schedules of compliance for point source discharges that need time to comply with the new requirements, establish federally required low-flow requirements for permit limit calculations, and identify petroleum spill prevention requirements for those facilities having a capacity of 660 gallons or greater. The spill prevention language helps ensure protection of our aquifer from accidental contamination.

Wetlands and water quality certifications. Requirements related to these sections were clarified. Unnecessary or redundant language was removed. Application forms were eliminated from the body of these standards so that revisions to the forms can be made by agency staff as necessary, without going through a regulatory revision process.

General Reef Health

A National Parks Service, War in the Pacific Park biologist is currently collecting data related to sedimentation on national park system reefs in Guam. With proper data analysis there may be more grounds for funding to aid education aimed at mitigating the effect of reef smothering sediment loading. Park service officials are also studying small mammals and the streams on the parks lands with the aid of U. S. Geological Survey.

The U. S. Coast Guard has developed strict regulations on dumping of wastewater anywhere less than 3 nm offshore. Oil spills and improper dumping of ballast water is also illegal, though vessels continue with such operations.

DAWR, in an effort to conserve the state of the reefs, worked in conjunction with other non-government agencies (i.e., dive shops) to install a mooring system at the most popular dive sites, to prevent the use of anchors and to install large buoys for fishing offshore, to endorse those fisheries that do not require anchor utilization.

Terrestrial Management Issues

Wildlife

The USDA in conjunction with DAWR has brown tree snake project has been employed for the eradication of the invasive species that caused the extinction of several of Guam's native bird species including the Mariana Mallard, *Anas platyrhynchos oustalioti*, the Guam Flycatcher, *Myiagra freycineti*, the Rufous Fantail, *Rhipidura rufifrons uraniae*, and the Bridled White-eye, *Zosterops c. conspicillata*. Snake eradication requires the use and maintenance of cages exploiting small rodents as bait. Brown tree snakes in Guam have caused more than a thousand power outages, damaged agricultural interests by preying on poultry, killed many pets, and poisoned numerous children. These agencies are also working to bring back some of Guam's native bird species, such as the Guam Rail, with the establishment of a captive breeding program. Some birds were formerly introduced into the wild but did not survive.

The U. S. Fish and Wildlife Service has a wildlife refuge in the north located at Ritidian Point. Their major purpose is to manage critical habitat for Guam's extirpated and endangered species. The refuge is home to the only colony of Mariana fruit bats left on the island. Beaches within the refuge are important sea turtle nursing grounds. The habitat is also important as a potential resource for the reintroduction of threatened or endangered species such as those in the DAWR captive breeding program.

There have been some major errors made with the introduction of certain species for bio-control of other species, such as weevils and the moths to control the introduced plant species that had gone out-of-control. Instead, the moths and weevils became unmanageable and are now eating the native plant species, flame trees, guava, mango, etc., including decorative plants around the island. Clearly this is a strong argument for not introducing alien species even under the best-intentioned justifications.

STATUS OF KNOWLEDGE AND INFORMATION BASE FOR MANAGEMENT

Recently the governmental agencies and research institutions have been working together for better coastal resource management. All of the conservation and management agencies listed below collaborate to attain a greater knowledge of coral reef issues. Unfortunately, some issues remain unaddressed for long periods due to conflicts of interest, one such example was the implementation of the MPA's. The MPA's were established in 1997 but not enforced until 2001 due to legal conflicts. Each agency has jurisdiction over specific management issues. For example, GEPA is responsible for waste management and DAWR is responsible for fisheries management. Other federal agencies, i.e. NOAA, are supporting

the Government of Guam agencies through the temporary placement of individuals with specific technical capabilities to ensure an effective relationship between the Government of Guam and federal agencies.

The U.S. Federal Government makes available grant programs to states and territories such as the Coral Reef Initiative Grant (NOAA). This program makes management data available to the public and can be obtained by contacting the appropriate agency. For example, the DAWR Fisheries section has been conducting inshore and offshore creel surveys for more than twenty years and is continuing this data collection. The University of Guam Marine Laboratory has been monitoring different aspects, i.e. algal communities or coral cover, of various sections of reef in Guam for varying time periods. Reef Check, a long-term reef monitoring program, has been set up by NOAA for annual surveys of set areas. The United States Air Force and the United States Navy exercise control over large properties and coastal resources in northern and southern Guam respectively. In some areas, collection of scientific data for the purpose of management and conservation is restricted and/or prohibited (i.e., Fena Reservoir).

GOVERNANCE

Government of Guam

Department of Agriculture, Division of Aquatics and Wildlife Resources (DAWR)

192 Dairy Rd., Mangilao, GU 96913

(671) 735-3958

www.guamdawr.com

Contacts: Brent Tibbatts, Freshwater Biologist, Jay Gutierrez, Biologist III

Purpose: to restore, conserve, manage, and enhance the aquatic resources in and about Guam and to provide for the public use of and benefits from these resources.

Bureau of Statistics and Plans, Coastal Zone Management Program (BSP)

www.spc.int/prism/country/gu/stats/

Contact: Evangeline Lujan

Purpose: In an effort to combat coastal problems, the program cooperates with other Guam agencies that require permits for coastal activities.

Environmental Protection Agency (GEPA)

<http://guamepa.govguam.net>

Contacts: Mike Gawel, Planner IV, Mike Mann, Biologist (USEPA)

Purpose: “It is hereby declared to be the public policy of this Island of Guam that a high quality environment be maintained at all times to guarantee an enjoyable life for all people at present and in the future, and that environmental degradation of the quality of land, water, and air by any pollutants, including all physical, chemical, and biological agents, should not be allowed. “To these ends, it is the purpose of this Act to provide a united, integrated, and comprehensive island-wide program of environmental protection and to

provide a framework to fulfill that task.”

Guam Environmental Protection Agency Act (10 GCA, Chapter 45, §45102)

<http://www.guamepa.govguam.net/>

Contacts: Randel Sablan, Acting Administrator

Purpose: Guam EPA is responsible mostly for pollution management and is organized into five Divisions. The Divisions carry out various programs to protect the environment on Guam. Among these are the Administrative Services Division, the Environmental Monitoring and Analytical Services (EMAS) Division, the Environmental Planning and Review (EPR) Division, the Air & Land Programs Division and the Water Programs Division.

University of Guam Marine Laboratory (UOGML)

<http://www.uog.edu/>

Contacts: Barry Smith, Director, Dr. Peter Schupp, Associate Professor

Purpose: The UOGML works collaborates with government agencies, when needed, to aid in the collection of scientific data, usually ecological or biological, for use in proper management. The primary mission of the Marine Laboratory faculty is basic and applied research on the biology of tropical marine organisms, with emphasis on the conservation and development of marine resources of the near-shore waters of Guam and Micronesia. Graduate and undergraduate students play an important role in these research activities. Community service is promoted through the activities of a Marine Extension Agent, the research faculty, and graduate students.

Micronesian Area Resources Center (MARC)

<http://www.uog.edu/>

Purpose: The Guam and Micronesia Collections will continue to provide reference materials in a variety of formats for the benefit of researchers within and apart from the University community. The Reference Collection, the Spanish Documents Collection, and the Manuscript Collection will continue to seek out documents of historical significance for the region and organize them for use by the people of Guam, the region, and researchers worldwide.

Water and Environmental Research Institute of the Pacific (WERI)

www.weriguam.org

Contact: John Jocson, Staff Hydrologist

Purpose: WERI works in collaboration with government agencies, when needed, to aid in the collection of scientific data, usually geological or hydrological, for use in proper management. The role of the Institute is to provide water and energy resources information by conducting basic and applied research in an interdisciplinary environment, training students, and disseminating research results.

Department of Land Management

PO Box 2950, Hagatna, GU 96932

(671) 475-5255/5263

<http://www.admin.gov.gu/dlm/index.html>

Contact: J.A.Martinez, Director

Purpose: The Department of Land Management is responsible for land administration, planning, surveying and records.

US Department of the Interior

National Parks Service, War in the Pacific, NHP (WAPA)

www.nps.gov

Contact: Duane Minton, Biologist

Purpose: The Natural Resources division is actively conducting studies to document sedimentation on the island's coral reefs and documenting the effects of wildfire on tropical savannah grasslands, so the park can establish best management practices for reducing erosion. As participants in a nation-wide coral reef monitoring program, the park is dedicated to long-term monitoring of Guam's coral reefs, and is committed to completing comprehensive inventories of the park's flora and fauna.

Guam National Wildlife Refuge-U.S. Fish and Wildlife Service-Ritidian Unit

<http://www.fws.gov/pacific/pacificislands/wnwr/guamnwrindex.html> Refuge Manager

Contact: Refuge Manager

P.O. Box 8134, MOU-3

Dededo, Guam 96912

(671) 355-5096

(671) 355-5098 fax

E-mail: Gerry_Deutscher@fws.gov

Purpose: protection of threatened species and habitats such as the remaining populations of the endangered Mariana fruit bat, Mariana crow, and the *Serianthes nelsonii* tree

National Oceanic and Atmospheric Administration

National Weather Service Office

www.prh.noaa.gov/pr/guam

Contact: Frank Wells, Science and Operations Officer

Coastal Management Program

<http://www.ocrm.nos.noaa.gov/czm/czmg Guam.html>

Contacts:

John Tomczuk, Coral Management Fellow, Coastal Services Center based at BSP

Dave Burdick, Pacific Islands Assistant, Pacific Services Center based at UOGML

Val Porter, Coral Reef Monitoring Assistant, National Ocean Service based at DAWR

ACKNOWLEDGEMENTS

The author would like to thank Joel Sablan of ARC Environmental Services for offering me the opportunity to compose this summary and for overall comments. I would also like to thank Val Porter, Trina Leberer, Brent Tibbatts, Paul Wenninger, Dr. Peter Schupp, Petty Officer Carrie Lee Grady, Dave Burdick, John Tomczuk, Matt Brown, Dwayne Minton and Barry Smith for their advice and resource information.

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**Natural Resources Management Needs for
Coastal and Littoral Marine Ecosystems of**

AMERICAN SAMOA

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INTRODUCTION AND BACKGROUND

The Territory of American Samoa, commonly referred to as American Samoa, is part of the Samoa Archipelago, an island group located in the Central Pacific Ocean. American Samoa was established as a political unit as a result of a treaty between the U.S. and Germany in 1899. It is the only US Territory located south of the equator. The island group is comprised of five volcanic island and two coral atolls. The volcanic islands include Tutuila, Aunu'u, and the Manu'a group (Ofu, Olosega, and Ta'u). Tutuila is the political and economic center and, along with the small offshore island of Aunu'u, has 96% of the population. The two coral atolls are Rose Atoll (located 260 km east of Tutuila) and Swains island (located 360 km north of Tutuila). The total land area of the islands is approximately 75 sq miles (202 sq km), an area slightly larger than Washington, DC.

Most Samoa residents are of Polynesian extraction and culture still exerts a strong influence on daily life and resource management. The per capita income is about \$6600 annually with tuna cannery and government employment being the principal occupations in addition to service jobs and traditional occupations. Tourism is growing and may become a more significant economic contributor.

This report provides assessment and management information of American Samoa natural resources and does not consider the remainder of the Samoan Archipelago, although where commonalities will be noted where they exist between the two political units.

Regional context and resources

American Samoa is part of the Samoan Archipelago which also includes the Independent State of Samoa, previously called Western Samoa. Although the two island groups now exist as separate political units, close cultural and familial ties have been maintained. Residents of both areas maintain a largely traditional way of life, although American Samoa has closer economic ties to the U.S. and more commercial economic activity as exemplified by the tuna fishing and canning industries centered at Pago Pago, one of the best deep water ports in the South Pacific.

The traditional lifestyle is known as "Fa'a Samoa", which continues to play an important role in Samoan society today. Greater importance is placed on the dignity and achievements of the group rather than the individual. The communal lifestyle is structured around the extended family, called the "aiga", which is a self-sustaining group whose members cooperate by contributing products of their labor to the aiga. The chief, or "matai" is chosen by family members and is responsible for the well-being of the aiga, maintenance of family lands and the communal economy. Villages are composed of one or more aigas with common interests and local pride. About 90 percent of the land is communally owned by aiga. The existing tenure law on communal lands prohibits alienation of any real property except freehold land to any person whose blood is less than one-half Samoan. Unless the Governor approves the transfer in writing, it is unlawful for any matai or a Samoan family to alienate any family lands to any person or lease it for any term more than 55 years.

Figure 2. A village meeting in Samoa.



The closest neighboring nations are Tonga and Fiji to the south, and Tuvalu to the north. American Samoa has its principal relations with the U.S., other island nations, Australia and New Zealand.

In terms of natural resources management, the most important relationship would seem to be between American Samoa and Western Samoa because of the close proximity and shared cultural heritage between these two Pacific Island entities. Relations are however, generally sporadic. There was a recent meeting in 2005 of officials from the two Samoas in Apia, Samoa, to discuss joint efforts and collaborations in various areas involving trade and commerce, resource use and management, immigration and emigration, etc. This meeting was a follow up to a meeting of the two Samoas in May of 2002 to discuss these issues and form collaborative efforts where possible. This is an opportunity that could be further exploited for the benefit of both nations. An example of recent cooperation was a fashion and trade show which showcased different products being produced in Samoa. There is a clear need for more events such as this between the two Samoa's that promote trade and tourism. Other types of joint efforts could include exchange visits and workshops by corresponding agencies and organizations and the establishment of collaborations on projects of mutual interest.

One thing that hurt relations between the two Samoa's within the past year were the differences between the governments on immigration requirements for American Samoa Nationals and Samoan's citizens. The new Attorney General of American Samoa decided to enforce a 14-day permit for Samoan citizens visiting the Territory, which until then had not been enforced. This resulted in the Samoa Parliament establishing an immigration law that required Nationals to apply for a permit to enter Samoa and have a valid U.S. passport. Previously, Nationals could travel to Samoa using only a Certificate of Identity. This hurt the travel industry in both countries as it now takes more money and time to acquire valid travel documents. As a result, relationships between the two Samoas are at the moment

Figure 1: Map of American Samoa



strained and opportunities to establish partnerships on joint efforts will aid in rebuilding the relationship.

The current population of American Samoa is at about 60,000 and is growing rapidly (21% each year). Immigration rates are high at 20.98 per 1000. More Samoans or part-Samoans live in the U.S. (133,680, U.S. Census 2000) than American Samoa (57,881) (CIA, 2005). This is in part due to lack of economic opportunities given the limited options which are mostly resource based, as well as government policies which encourage out-migration. High economic growth rates affect direct affect natural resources management through encroachment by coastal development towards the ocean and upwards into the mountains and increased pressure on all natural resources (Okimoto, pers. comm. 2005).

NATURAL RESOURCES OF AMERICAN SAMOA

Forest and vegetation habitats

Almost all of the forest in American Samoa is classified under the broad term “lowland forest”. Montane ridge, slope, valley, lava flow forests, and various flat land areas (swamps, marshes, mangroves), ranging from 3000 to 0 ft, are all included in this term, although twenty plant community types have been identified in American Samoa. The shifting agriculture traditionally practiced by Samoans probably enhanced overall forest diversity, both in species composition and habitat structure, as did the introduction of new species.

Unlike virtually every other tropical country, a significant proportion of American Samoa is still covered in primary tropical forests and native vegetation. The islands of the Territory are too small and steep for commercial forestry to be viable. Most of the forest that has been lost is in coastal areas. The greatest loss of unique forest habitats has occurred as the few level areas of American Samoa were developed for human settlement in the last 100 years. As much as 80% of the lowland rainforest has been lost (WWF, 2005). These habitats, such as mangroves forests, stream habitat and lava flow forests of Tafuna plain are rare and under continual threat. Primary forest at higher elevation and on a steeper slope has been affected by development, although these forests are threatened by agricultural development, hurricanes and invasive species. (EPA, 2002).

Forest and vegetation types and representative species are listed in Table 1.

Table 1: American Samoa Forest habitats (source: WWF, 2005, taken from Whistler 1978, 1980)

Forest/vegetation type	Common tree/shrub species	Comments
Forest Habitats		
Lowland rain forest	<i>Diospyros samoense</i> <i>D. elliptica</i> <i>Calophyllum inophyllum</i> , <i>Dysoxylum samoense</i> <i>D. maota</i> <i>Pometia pinnata</i> <i>Planchonella samoense</i> <i>Syzygium spp.</i> <i>Myristica fatua</i>	Lowland rainforst is the most extensive forest habitat type

Forest/vegetation type	Common tree/shrub species	Comments
Montane rain forest	<i>Dysoxylum huntii</i> <i>Syzygium spp.</i> <i>Weinmannia spp.</i> <i>Canarium harveyi</i> <i>Rhus taitensis</i> <i>Astronidium spp.</i>	Montane rainforest is the second most common forest habitat type
Cloud forest	<i>Reynoldsia pleiosperma</i> <i>Weinmannia samoense</i> <i>Dysoxylum huntii</i> <i>Coprosma savaiiense</i> <i>Dicranopteris linearis</i> <i>Freycinetia storckii</i> <i>Cyathea spp.</i>	Occurs above 650 m
Scrub forest	Montane scrub <i>Pandanus scrub</i> Littoral scrub Montane forest swamp Summit scrub	Occur at various altitudes
Vegetation types		
On low land lava flows	<i>Fagraea berteriana</i> <i>Glochidion ramiflorum</i> <i>Arytera brackenridgei</i> <i>Morinda citrifolia</i> <i>Metrosideros collina</i> <i>Weinmannia samoensis</i>	
On higher lava flows	<i>Vaccinium whitmeei</i> <i>Spiraeanthemum samoense</i> <i>Coprosma strigulosa</i>	
Littoral vegetation	<i>Scaevola taccada</i> <i>Pandanus tectorius</i> <i>Barringtonia asiatica</i> <i>Calophyllum inophyllum</i> <i>Pisonea grandis</i> <i>Cocos nucifera</i>	

Major threats include clearing for human habitation, agriculture and other development. Two significant cyclones in 1990 and 1991 also affected 53% of forest and led to spread of a wildfire that destroyed large tracts of forest (Elmqvist et al. 1994). Introduced species such as *Mikania micrantha* and *Solanum torvum* threaten native plant species (WWF and IUCN 1995).

Watershed

The American Samoa archipelago is composed of five main islands: Tutuila, Aunu'u, Ta'u, Olosega, and Ofu. Tutuila is the largest island (53 mi²) with the most people (55,414 people as of 2000). Population growth and its attendant pressures on natural habitats and resources have highlighted the need for aquatic resource monitoring in American Samoa. Of special concern are coral reef habitats, reef fish assemblages, and surface water ecosystems. A watershed classification is a useful framework upon which to develop agency monitoring programs, especially stream and nearshore marine monitoring programs, as a classification scheme can provide a priori expectations concerning the condition of adjacent aquatic habitats. US Census data from 2000 were used to calculate population density in Territorial watersheds, and density was used as a surrogate for human disturbance within each watershed. From population density data, four watershed classes were defined: pristine (<100 individuals/mi²), minimal (>100 but less than 500 individuals/mi²), intermediate (>500 but less than 1000 individuals/mi²), and extensive (>1000 individuals/mi²). This watershed classification has been the first step to establishing an integrated monitoring program for Territorial waters. For instance, ASEPA developed a stream monitoring program based on this classification scheme. Preliminary results from that stream monitoring are consistent with the expected changes in stream condition across watershed class. Whether other aquatic habitats (e.g., beaches) are also consistent with this scheme is unknown at this time (DiDonato, 2004).

Streams

Tutuila, the largest island of American Samoa, is the location of the majority of American Samoa's perennial stream ecosystems. These systems are poorly understood and currently under threat by Tutuila's burgeoning human population. The American Samoa Environmental Protection Agency (ASEPA) monitors local streams using a modified probabilistic design. To select streams for monitoring, all perennial streams on Tutuila are pooled into four classes, representing levels of anthropogenic disturbance (pristine, minimal, intermediate, extensive) within island watersheds. These classes are determined from watershed population density. Serious modifications in channel structure, flow regimes, and nutrient dynamics have already occurred (DiDonato, in press), and this will likely continue as human pressures for land and household water increases (DiDonato, 2004).

Wetlands (freshwater, brackish, mangroves)

American Samoa has both saltwater and freshwater swamps and marshes, as well as cultivated and ruderal wetlands and a number of perennial streams. Much the most important wetlands are the mangrove swamps and coastal freshwater marshes. Wetlands are threatened and it is estimated that as much as 5 acres (2 ha) is lost each year (Bardi and Mann, 2004). A survey of American Samoa wetlands was conducted by Biosystems

Analysis in 1991 and much of the following information is extracted from this study unless otherwise noted.

American Samoa consists of 7 islands, which have a total land area of about 76 square miles. Tutuila alone makes up 71% of this land mass and is one of the islands, along with Aunu'u, that contain mangrove wetlands. Due to the lack of flat, developable land on Tutuila, and the population growth rate increase, this has resulted in the decrease of wetlands. Between 1961 and 1990, 4.6 percent of American Samoa's wetlands have been lost each year. Given the island's topography, development is confined within a narrow band of land between the lower slopes and the ocean. The decreasing acreage of wetlands is expected to continue because of the high demand for flat accessible land. While it is said that mangrove wetlands were bountiful at the mouths of most freshwater streams in American Samoa, the majority of these areas have been filled.

There are approximately eight locations where mangrove wetlands occur in American Samoa. Three of these are very small with a combined area of less than half a hectare (Aua, Vatia, and Alofau - 1 acre). Although five main mangrove areas still remain (Nu'uuli, Masefau, Aunu'u, Leone & Aoa), none of these cover extensive areas.

Volk (2000) succinctly summarizes the findings of the Biosystems Analysis study and other researchers with regards to wetlands as,

“Freshwater marshes usually occur along the coast in areas where stream outlets to the sea are blocked by sand barriers. These barriers cause the streams to spread out into low-lying areas, saturating the soils. The dominant plants are *Cyclosorus interruptus*, *Acrostichum aureum* and *Eleocharis dulcis* (Cole et al., 1988). Of all the types of vegetation in American Samoa, coastal freshwater marshes have been the most affected by man. These wet areas, often in close proximity to villages, are ideal for growing taro (*Colocasia esculenta*) and have been extensively cultivated for hundreds of years. Very little undisturbed coastal marsh remains today, and the only site which appears to be relatively undisturbed is the marsh inside Aunu'u Crater (Whistler, 1976). Whistler (1976) describes eight areas of coastal marsh covering a total of 96 acres (38.9 ha): Vatia marsh (2.8 ha) and Alao marsh (1.6 ha) on Tutuila; Faimulivai Marsh (13.8 ha) and Aunu'u village marsh (8.9 ha) on Aunu'u; Luma marsh (7.3 ha) and Fusi marsh (0.8 Ha) on Ta'u; a small marsh on the west coast of Olosega (2.4 ha); and Vaoto marsh (1.6 ha) on Ofu. All of the marshes except Faimulivai Marsh on Aunu'u have been extensively modified by taro cultivation. However, this has been abandoned at the Fusi and Vaoto marshes, and these are now reverting to a more natural condition.

There are many streams on Tutuila, but virtually none on the Manu'a Islands. The wetlands associated with these streams are of very limited extent, being restricted to the margins of the streams and to channels of intermittent streams. The wetland vegetation is dominated by *Brachiaria mutica*, *Coix* sp. and *Canna* sp., as well as many other weedy species found in wetland taro patches. *Barringtonia samoensis*, a medium-sized tree closely related to the dominant coastal forest tree *Barringtonia asiatica*, is commonly found along mountain streams (Whistler, 1976). The riparian (streamside) vegetation of American Samoa is briefly summarized in the American Samoa Stream Inventory (U.S. Army Corps of Engineers, 1981).

Approximately 100 species of vascular plants have been reported from the wetlands of American Samoa. Four of these are considered to be rare in the territory. The tree *Erythrina fusca*, the mangrove *Xylocarpus moluccensis* and the sedge *Cyperus odoratus* are each known from only two sites, while the herb *Limnophila fragrans* is known from only three sites. Although all four species are common elsewhere in the Pacific, they should be considered as endangered species in this American territory (Whistler, 1976)".

Most of the wetland sites on Tutuila Island have experienced some loss over a thirty-year period between 1961 and 1991. The total wetland acreage for Tutuila Island has been reduced from 488.12 acres in 1961 to 350.93 acres in 1991, a loss of 137.19 acres in just this time period alone. Almost ten years later, we predict this value has doubled in 2001. Mangrove wetlands surrounding the Nu'uuli Pala Lagoon have suffered the greatest loss—approximately 61 acres, representing a 33% decline since 1961. Tula has lost 8 acres, representing a 58% decline. The Leone Pala Lagoon has lost over half of its wetlands since 1961. The freshwater marsh in Vatia seems to have increased slightly (+ 0.45 acres). This is probably the result of the abandonment of taro cultivation which has allowed surface waters to flood a wider area.

The wetlands on Aunu'u Island appear to have increased slightly from 11.76 acres in 1961 to 111.93 acres in 1991, a difference of 0.17 acres. The wetland areas associated with the Pala Lake, the taro fields, and the Aunu'u Crater appears unchanged from 1961. The school swamp seems to have increased slightly (+ 0.17 acres). This reason is not known. As for Manu'a there have been little gains or losses in the aerial extent of the wetlands in Manu'a. Slight losses appear to have occurred at Luma (1.24 acres, a 4.6% loss) and Olosega (1.39 acres, a 15.9% loss). The greatest loss has been at Fusi, on Ta'u, (3.38 acres, a 70% loss). It has been assumed that there has been no change in the wetlands at Va'oto Marsh in Ofu or at Lesi'u in Ta'u (Brighthouse, 2005).

A major threat to all wetlands is urban development. Flat land is scarce on the islands and as land tenure increasingly shifts from communally owned to individual ownership, this land commands premium prices and is subject to development pressure. Dumping of a wide variety of rubbish (organic, inorganic, toxic) and the run-off from piggeries also contaminates aquatic areas. Steps are being taken to control these impacts.

Coastal Lagoons

Much of American Samoa is surrounded by fringing coral reefs with a variety of associated coastline habitats: reef flats and moats, shallow lagoons, estuaries, mud and sand flats, eel grass and mangrove swamps. Of vital social and economic importance for fishing, boating, tourism and agriculture, these areas are disappearing and degradation is occurring.

Among the larger coastal lagoons and similar water bodies are:

Leone Bay, located on the southwest Tutuila coast, is a shallow marine bay with mudflats, two estuaries, mangrove forest and salt marsh. Originally consisting of 16.2 ha of wetland but now only 8.4 ha.

Pala Lagoon (Nu'uuli Pala), located on the south Tutuila coast, is a marine bay with fringing mangrove, two streams and several springs. Originally consisting of 74.7 ha reduced to 49.7 by 1991. An important reproductive site for fish and invertebrates.

Lake Namu, located on Swain's Island, it is an enclosed brackish lagoon 1.5 km long and 1.0 km wide. An area of salt marsh is located on the north side (Volk, 2000).

The importance and value of these habitats is known only in a general sense, such as some fish may use these areas as nursery grounds, and near shore habitats like mangroves help reduce land-based sedimentation to offshore coral reefs, etc. A more detailed understanding is lacking; however, this comment needs to be considered in a broader perspective – coral reefs make up most of the near shore environment and relatively little is known about them except that they are severely over fished.

Coastal lagoons are home to a wide variety of organisms including:

Vertebrates

Pacific Black Duck (*Anas superciliosa*)
Purple Swamphen (*Porphyrio porphyrio*)
Pacific Reef Heron (*Egretta sacra*)
Bar-tailed Godwit (*Limosa lapponica*),
Bristle-thighed Curlew (*Numenius tahitiensis*),
Banded Rail (*Rallus philippensis*)
Pacific Golden Plover (*Pluvialis fulva*)
Wandering Tattler (*Heteroscelus incanus*)
Ruddy Turnstone (*Arenaria interpres*)
Collared Kingfishers (*Halcyon chloris*)
Wattled Honeyeaters (*Foulehaio carunculata*)
Sanderling (*Calidris alba*)
White-tailed Tropicbird (*Phaethon lepturu*)
Brown Noddy (*Anous stolidus*)
Black Noddy (*A. minutus*)
White Tern (*Gygis alba*)
Sheath-tailed Bat (*Emballonura semicaudata*)
Mullet (Mugilidae)
Barracuda (*Sphyraena barracuda*)
Jack (*Caranx ignobilis*)
Hawksbill turtle (*Eretmochelys imbricata*)

Invertebrates

Scyphozoan (*Cassiopeia* sp.)
Sea Cucumbers (*Stichopus* sp. and *Actinopyga* sp.)
Snails (*Littorina* sp. and *Nerita alicata*)
Mangrove oyster (*Isogamon* sp.)
Clam (*Gafrarium tumidum*)
Mantis shrimps (*Lysiosquilla* sp.)
Fiddler crabs (*Uca* sp.)
Land crabs (*Cardisoma* sp.)
Mangrove crab (*Scylla serrata*)
Freshwater prawns (*Macrobrachium* sp.)

One particular shoreline environment in American Samoa is attracting close scientific scrutiny: the well-developed backreef moat on the south shore of Ofu Island. A 3-year investigation lead by Dr. Charles Birkeland (University of Hawaii) is underway in Ofu “lagoon” that may provide key information about the susceptibility of corals to global climate change. Water temperatures in the moat can fluctuate 6 °C daily, yet the moat is inhabited by about 100 coral species that grow well there. Birkeland’s group is looking at intrinsic (adaptation) and extrinsic factors (e.g., water motion) that moderate the impacts of increasing water temperatures. The findings may have widespread applications (Brighouse, G. 2005).

American Samoa is developing a small field station at Ofu to help facilitate and attract further marine research at this location (Craig and Green, 2005).

Coral Reefs

The total reef area of American Samoa is 296 km² and consists of fringing reefs (85%), a few offshore banks (12%), and two atolls (3%). The fringing reefs have narrow reef flats (50-500 m) and depths of 1000 m within 2-8 km of the shore. These reefs contain a diverse assemblage of 890 fish, 200+ coral, and 237+ algal species; and there are many other invertebrates. (Wilkinson, 2004).

Coral reef assessment and monitoring has been sporadic over the past 20 years. Some monitoring has been conducted under short and medium term projects. Recently, monitoring activities have been coordinated in 3 major programs: 1) the Community Based Fisheries Management Plan Program of the Fisheries Division; 2) the SW Pacific Global Coral Reef Monitoring Network; and 3) the Samoa Marine Biodiversity Protection and Management, an IUCN project. In addition, the Coral Reef Advisory Group, which is a governor appointed task force composed of five local agencies that administers American Samoa’s Coral Reef Initiative, recently developed a monitoring plan for coral reefs in the Territory. This organization is also in the process of developing a marine protected areas program which will assign 20% of the coral reefs in American Samoa as no take areas by 2010 (Coral Reef Advisory Group, 2005).

The diverse Samoan reefs provide food, infrastructure, and shoreline protection. Crown-of-thorns starfish (COTS) outbreaks, hurricanes, and mass coral bleaching episodes have caused declines in hard coral cover, but coral reefs now show good recovery. Hard corals are in good condition after the COTS outbreak in 1978, however, coral cover declined by 78% between 1917 and 2001 in the industrialized Pago Pago harbor. Climate change impacts such as warm-water coral bleaching and coral diseases pose the major threats to the structure and function of the reefs, along with over-fishing. The high population growth rate (2.1% per year) is adding pressure with threats of extensive coastal development, increasing fishing, loss of wetlands, soil erosion and coastal sedimentation, inadequate solid and hazardous waste disposal, and pollution (Wilkinson, 2004).

Figure 3. Reef gleaning.

Monitoring data from 2003-2004 showed that live coral cover was reasonably high. The average live coral cover in 2003-2004 at the permanent monitoring sites within MPAs and selected sites around Samoa was 34.5%. Live corals were dominant on the reefs of Savai'i (47.5%) and Manono (32.6%) Islands, whereas sand, rubble and rock dominated the substrate of Upolu Island. The high dead coral cover was a result of coral breakage from storms. An insignificant number of bleached corals were recorded; this was probably due to COTS or other localized causes, rather than warm water bleaching. Algal cover on Upolu was high, with *Sargassum* spp. dominating. Observations during rapid surveys show coral diseases appear to be increasing, but this needs to be assessed further.

Table 2. Summary of coral and other organisms of Samoan reefs. Coral cover appears to be healthy and little bleaching has occurred. Source: Wilkinson, 2004.

Island	Live Coral (%)	Dead Coral (%)	Algae (%)	Abiotic (%)	Other (%)	Coral Bleached (%)
Upolu	23.2	9.2	21.5	41.2	0.6	3.9
Savai'i	47.5	15.6	7.1	27.4	2.0	0.4
Manono	32.6	6.0	15.1	26.9	0.0	0.0
Mean	34.5	10.3	14.6	31.8	0.9	1.4

It is important to note that American Samoa's reefs have a high economic value. In a survey study conducted by consultants from JE Jacobs in 2004 for the Department of Commerce Coastal Zone Management Program and Coral Reef Advisory Group, it was estimated that the value of coral reefs to residents and visitors are currently worth \$5 million USD/year at minimum for coral reefs and \$0.7 million for mangroves. If non-use values are included,

the values rise to \$10 million for corals and \$1.5 million for mangroves. Fisheries products and uses accounts for the bulk of the use value, but recreational uses are also significant. The \$2 million invested in coastal management pales in comparison to the potential value of the resources to be protected (Spurgeon, et. al., 2004).

Species of concern

Like the other Pacific Islands, many of Samoa's endemic and native species are threatened or endangered.

Efforts are being made by the American Samoa Invasive Species Team (ASIST) to combat alien species in the Territory. ASIST is a recently formed organization that consists of representatives from ten conservation and agricultural agencies that include the National Park Service of American Samoa, American Samoa Community College Community and Natural Resources Division (Land Grant), Department of Marine and Wildlife Resources, American Samoa Department of Education, United State Coast Guard, American Samoa Environment Protection Agency, American Samoa Treasury/Custom, USDA Natural Resources & Conservation Service, American Samoa Department of Agriculture, and American Samoa Department of Port Administration. Tavita Togia (tavita_togia@nps.gov) of the National Park Service is the team leader of ASIST.

Samoa is home to a number of endemic species. There are 37 species of land birds, of which 84% are endemic as well as 4 introduced species. Notable among these are 6 species of fruit-eating pigeons. The Samoan wood rail and sooty rail are believed extinct (Merlin and Juvik 1983). The flying fox bat (*Pteropus samoensis*) is endangered due to hunting for local and regional consumption (Brautigam and Elmqvist, 1990). Tree snails are under threat by habitat destruction and the introduction of predatory snails (*Euglandina rosea*). At least four species of turtle are found in American Samoa, although only two species are officially listed by USFW.

Among the 100 species of vascular plants, four additional wetland species are considered rare in American Samoa although common in other Pacific areas. These are not listed by USFW: *Erythrina fusca* (tree); *Xylocarpus moluccensis* (mangrove); *Cyperus adoratus* (sedge) and *Limnophilia fragrans* (herb) (Whistler, 1976).

Table 3: Listed, proposed or candidate species under the U.S. Endangered Species Act (U.S. Fish and Wildlife Service, 2005)

Common Name	Scientific Name	Status
Birds		
Australian gray duck	<i>Anas superciliosa</i>	Threatened species
Spotless Crake	<i>Porzana tabuensis</i>	Recommended for listing-candidacy
Friendly Ground Dove	<i>Gallicolumba stairi</i>	Recommended for listing-candidacy
Many-colored Fruit Dove	<i>Ptilinopus perousii</i>	Recommended for listing-candidacy
Humpback whale	<i>Megaptera novaeangliae</i>	Recommended for listing-candidacy
Samoan Fruit Bat	<i>Pteropus samoensis</i>	Species of Concern
Sheath-tailed Bat	<i>Emballonura semicaudata</i>	Threatened species
Reptiles		
Green sea turtle	<i>Chelonia mydas</i>	Threatened
Hawksbill turtle	<i>Eretmochelys imbricata</i>	Endangered
Invertebrates		
Mt. Matafoa different snail; Sisi	<i>Diastole matafaoi</i>	Species of concern
Sisi snail	<i>Diastole schmeltziana</i>	Species of concern
Tutuila tree snail; Sisi vao	<i>Eua zebrine</i>	Recommended for listing-candidacy
Sisi snail	<i>Ostodes strigatus</i>	Recommended for listing-candidacy
Ofu tree snail; Sisi vao	<i>Samoana thurstoni</i>	Species of concern
Sisi snail	<i>Trochomorpha apia</i>	Species of concern
Plants		
No common name	<i>Acaronychia retusa</i>	Species of concern
No common name	<i>Elatostema tuilense</i>	Species of concern
No common name	<i>Habernaria monogyne</i>	Species of concern
Papaono	<i>Litsea samoensis</i>	Species of concern
No common name	<i>Manikara dissecta</i>	Species of concern

Invasive Species

Samoa is also home to a number of introduced and invasive species that may threaten habitat or native flora and fauna.

Table 4: Invasive and introduced species of American Samoa.

Common Name	Scientific Name	Status
House mouse	<i>Mus musculus</i>	Invasive species
Roof rat	<i>Rattus rattus</i>	Invasive species
Norway rat	<i>Rattus norvegicus</i>	Invasive species
Polynesian rat	<i>Rattus exulans</i>	Invasive species
Feral pigs	<i>Sus scrofa</i>	Invasive species
House gecko	<i>Hemidactylus frenatus</i>	Invasive species
Marine toad	<i>Bufo marinus</i>	Invasive species
Red-vented bulbul	<i>Pycnonotus cafer bengalensis</i>	Invasive species
Jungle myna	<i>Acridotheres fuscus</i>	Invasive species
Common myna	<i>Acridotheres tristis</i>	Invasive species
African snail	<i>Achatina fulica</i>	Invasive species
Rosy wolf snail	<i>Euglandina rosea</i>	Invasive species

MAJOR RESOURCE MANAGEMENT ISSUES

Some of main challenges for management are identified in the Coral Reef Advisory Group (CRAG) Local Action Strategy (LAS) (American Samoa Coral Reef Local Action Strategy Framework) (CRAG, 2004). Among these are overfishing, land based pollution, climate change, and overpopulation. The main challenges with regards to overfishing are enforcement and engaging communities in setting up effective MPA's. For land based pollution, the main challenge is getting better land practices to reduce sediment runoff. While there may be little that can be done locally with respect to climate change, a priority is to understand existing and potential effects and assess the resiliency of coral reefs. Raising awareness and government programs and social support for reducing the rate of human population increase may have some affect on population growth (Fenner, 2004).

Population Growth

There continued to be a net increase in population despite high rates of out-migration which only partially relieve pressures on natural resources. Population growth, in part spurred by high rates of teenage pregnancy, is directly affecting natural resources due to encroachment of development on coastal areas and up into the mountain areas. The Governor has convened a population task force to examine ways to help curb the rapidly growing population on Tutuila, which would include having religious leaders support the use of birth control methods within their parishes.

Fisheries

Reef Fisheries

The coral reef fish fauna in American Samoa is quite diverse with 890 species. This is approximately twice the number that occur on Hawaiian and Caribbean reefs, but half the number found on the more diverse reefs of Indonesia and northern Australia. The small size and steep slopes of the islands, which contain relatively few shallow water habitats, limit reef fish populations.

Figure 4. Artisanal fishing in Samoa.



Major changes in the fish communities on Tutuila and Aunu'u correlate with the changes in the coral communities and fishing activity. Some fish species populations are in good condition, but others are seriously depleted (small size and low abundance) by targeted over-fishing of groupers, parrotfishes and snappers.

Fish surveys are showing that there are few large fish on the reefs around the 5 main islands, which indicates serious over-fishing. This depressing situation was not sudden, as surveys in 1996 and 2004 show that there have been few large fish on local reefs for at least 8 years. Additionally, surveys by NOAA in 2002 show that densities of large fish on the main islands (Tutuila and Manu'a) were much lower than the remote atolls (Rose and Swains), which were much lower than the unfished Northwestern Hawaiian Islands. A six-fold decrease in fish density between the main islands and remote atolls is further evidence for over-fishing. American Samoan reefs still have an abundance of small herbivorous surgeonfish and parrotfish, which help graze the macro-algae and prevent them from overgrowing corals.

Reef fish are harvested by subsistence and artisanal (small-scale commercial) fishers on the 5 main islands. Artisanal fishers include night-time free divers who spear reef fish,

and small boat fishers who fish for deepwater bottomfish. Spear fishermen started using scuba gear around 1994, and quickly doubled their catch rates; the practice was banned by executive order in 2001 following evidence of dramatic declines in reef fish. The fish harvested are usually eaten by the families or sold at local stores; there are no exports. Bumphead parrotfish, which were never common, were last seen in 1995, and are now presumed to be locally extinct. Bottom fishing flourished briefly in the early 1980s when the fishery was subsidized, but it declined after the subsidies were removed and the few available fishing grounds were fished out. Most of the remaining bottomfish boats converted to longline fishing for albacore in 2001.

Two trends in these fisheries are that subsistence fishing has been declining steadily over the past two decades as villagers shift from a subsistence to a cash-based economy, and coral reef fish and invertebrate resources have declined significantly in abundance and size due to overfishing. Giant clams and parrotfish are over-fished, and there has been heavy fishing pressure on surgeonfish. Monitoring teams see fewer and smaller groupers, snappers and jacks; The NOAA divers confirmed the low abundance of large fishes and sharks around the main islands in February 2004 (Figure 5).

There is a critical need for long-term protection of fish (see discussion of this topic in attached article, “Over-fished coral reefs in American Samoa: no quick fix” by Craig and Green 2005), but current federal MPAs are unenforced and therefore currently ineffective. Community-based MPAs are more effective but do not provide long-term protection (they have short-term goals). (Craig and Green, 2005).

Open Water Fisheries

Fishing and processing pelagic fishes (wahoo, albacore, bigeye, skipjack and yellowfin tuna) are the most important economic activities in American Samoa. The dynamics of the fishing industry underwent a radical change in 1995 when long lining was introduced from Western Samoa. Since that time, fishing effort and catch increased until 2002 at which point both began to decline. Most species show a decrease in average size between 2000-2004 while CPUE decreased (Western Pacific Fisheries Management Council 2004). This may indicate overfishing.

Two canneries (Star Kist and Chicken of the Sea) employ 5,150 workers, about 74% of the total American Samoa workforce and it is estimated that over 80% of the economy is dependent on this activity. Recent decreases in tuna supply, concerns about U.S. tax subsidies for the processors and a recent increase in the minimum call into question the future of this industry (Faleomavaega, 2004; Toleafoa, 2005). Closure of one or both canneries would have disastrous effects on the economy which could result in more out-migration and drastically increased pressure on other natural resources.

Figure 5. Decreasing lengths of target fishes (surgeonfish, unicornfish, parrotfish, snappers, emperors, groupers, jacks and sharks) on Tutuila. Source: Green 2002, reproduced from Wilkinson 2004).

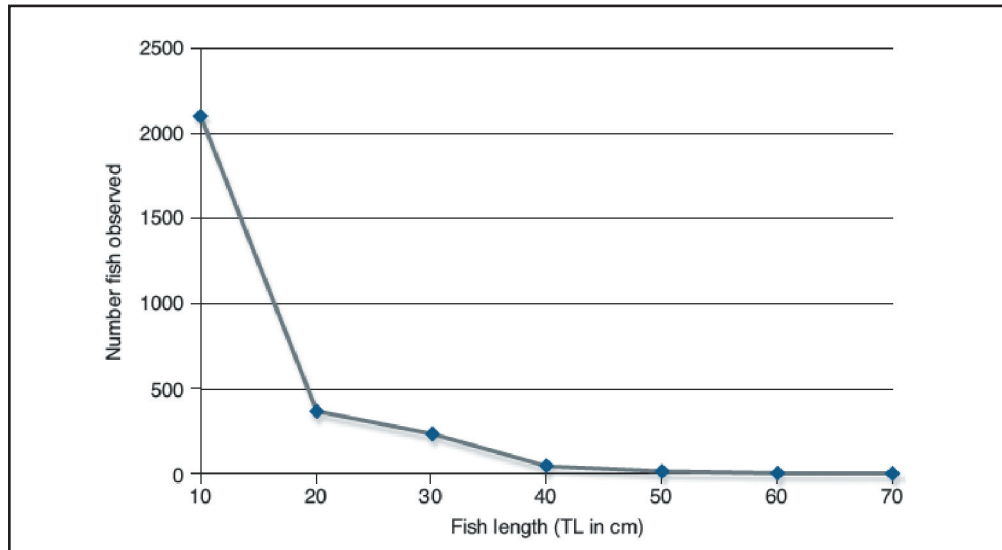
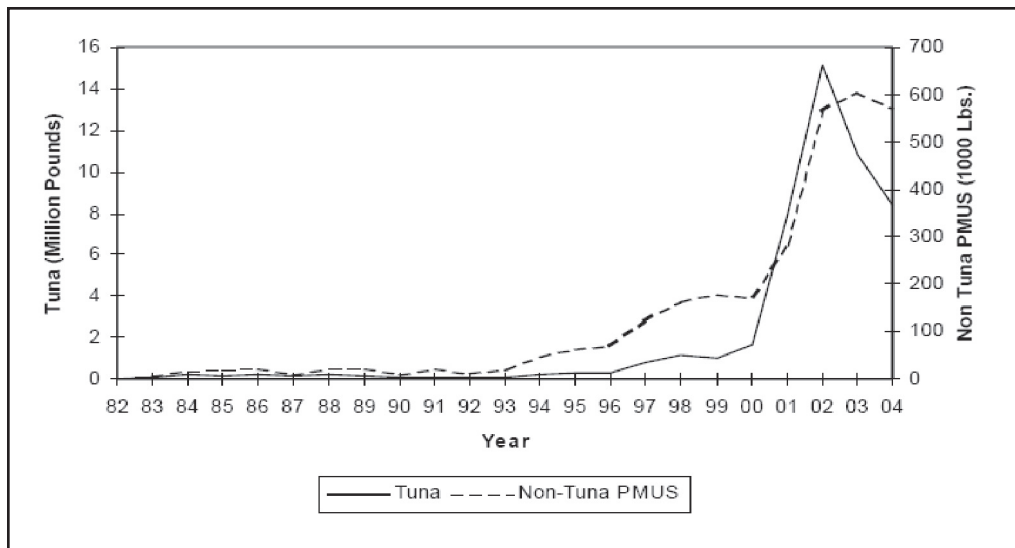


Figure 6: American Samoa annual estimated total landings of Tuna and Non-Tuna PMUS (Source: Western Pacific Fisheries Management Council, Preliminary Report, 2004, American Samoa Annex)



The 2002 State of the Environment Report for American Samoa (EPA, 2002) states that the over-fishing along with other factors has resulted in decreased catches of bottom fishes. The resources are experiencing a downward trend, indicating that it is either declining in quality and/or decreasing in quantity due to human and natural actions, which calls for major conservation and management actions.

Aquaculture

UH Sea Grant Extension plays a vital role in the American Samoa community by serving as a conduit for information and technology transfer between researchers and aqua farmers. These activities, which focus on education and outreach programs, and capacity building of personnel throughout Hawaii and the U.S. affiliated Pacific Islands, are designed to assist in the development of the aquaculture industry and produce an educated community that will make significant contributions to the local economy.

Attempts by the American Samoa government to diversify its economic base have been hampered by American Samoa's remote location, limited means of transportation into and out of the Territory, and exposure to severe weather. With a 12 percent average unemployment rate and little infrastructure to support tourism, there is a critical need for creating industries that will be sustainable and compatible with traditional Samoan culture.

In September 2002, the University of Hawaii Sea Grant College Program, with the assistance of Congressman Eni Faleomavaega and American Samoa Community College President Adele Satele-Galea'i, established a Sea Grant Extension presence in American Samoa for the purpose of promoting aquaculture development.

Two projects that Sea Grant has supported were the development of a tilapia hatchery and grow out fish farms on Tutuila in partnership with the Samoa Family Sunfish Cooperative, a group consisting of tilapia farmers, and the development of a giant clam hatchery for producing clams for the marine aquarium trade in partnership with NGO Native Resources Developer, Inc. For the past three years, Sea Grant has been working with local and regional partners such as the American Samoa Community College Community and Natural Resources Division, American Samoa Resource Conservation and Development Council, Inc., Secretariat of the Pacific Community, and Center for Tropical and Subtropical aquaculture to promote and develop the aquaculture industry in the Territory. Another NGO, Tausala Ole Moana Aqua, Inc., is working on developing a facility in Malota to raise moi, giant clams, tilapia and other ornamental invertebrate species.

A marketing study conducted by the Pacific Business Center Program in partnership with Sea Grant examined the local demand for tilapia (Chesire, 2004). The results of the study indicated that in 2003 over 30 stores sold frozen, imported tilapia at an average price of \$1.38/lb. Six restaurants also sold cooked tilapia. The annual consumption of tilapia was estimated at 170,000 pounds. Compared with marine fish which at the time sold for \$2.50-3.00/lb, tilapia was and still is a more affordable choice by Samoans. The tilapia coop is currently raising red tilapia with plans to market it live and/or fresh with the goal of capturing a share of the marine fresh fish market. This effort could assist in reducing the demand for marine fish and help to conserve this marine natural resource.

The Pacific Business Center Program (Cheshire and Valeriano, 2004) was also contracted by Sea Grant to assess the United States market for giant clams for the marine aquarium industry. In their report, the authors found that the world wide market for giant clams is approximately 140,000 clams annually with market being split almost evenly between the United States and Europe. The source of giant clams for the United States market came from producers in the Pacific, with the majority (80%) of clams being harvested from the wild. Based on the data collected, the authors believe that “there is a large unmet demand that is only constrained by supply,” which is encouraging news for local efforts to develop a viable giant clam industry in American Samoa.

ABIOTIC ASPECTS

The Coral Reef Advisory Group identified population growth as a major threat to coral reefs, especially on Tutuila where there are more than 1000 people per km². Streams carry sediments and nutrients to coastal waters and most villages have experienced major flooding, stream sedimentation, and damage to reef health. Many point sources of pollution have been identified and mitigated, and non-point sources of pollution are now the major stress in coastal areas. The sources of nutrients in local streams include faulty or improperly constructed septic tanks and concentrated animal waste from small family-owned pigsties. Industrial, commercial, and military activity in Pago Pago Harbor degraded water quality and reefs, but limited evidence suggests that harbor reef habitats may be recovering in response to reduced pollution (Wilkinson, 2004).

Watershed and Wetlands Management

Population growth and its attendant pressures on natural habitats and resources have highlighted the need for aquatic resource monitoring in American Samoa. Of special concern are coral reef habitats, reef fish assemblages, and surface water ecosystems. With respect to stream ecosystems, several studies have been commissioned to determine the current status and potential impact of population on freshwater resources (e.g. M&E Pacific 1979). Studies have concluded that freshwater resources are still in good condition, although concerns for recharge of underground aquifers suggest that groundwater resources could suffer from land use changes and pollution impacts in the near future. Furthermore, increased development may directly impact the stream ecosystems themselves; many streams, especially in the populated areas, are extensively modified. Many more will continue to change as land use and resource extraction patterns continue to support the island’s growing population.

Management of watershed is performed by the Environmental Protection Agency (EPA) through the assistance from the Watershed Advisory Group of the Ocean Resource Management Plan under the coordination of the Coastal Zone Management Program of the Department of Commerce.

Management of lagoons and wetlands are performed through the administration of the American Samoa Coastal Management Program. The ASCMP Administrative Rules mandate the establishment of a system of environmental review, along with economic and technical considerations, at the territorial level intended to ensure that the environment is given appropriate consideration in the land use decision-making process. Subsequently, provisions are described that establish a consolidated land use permitting process, known

as the Project Notification and Review System, including developmental standards, procedures for the designation, planning and management of Special Management Areas, procedures for determination of federal consistency. Multiple government institutions participate on the Project Notification and Review System ensuring ample review of all land use decisions.

The Community Based Wetlands Management Program (CBWMP) is a bottom-up resource management program in which the village actively participates in managing, conserving, and protecting its wetlands. This is a first of its kind program in which the village and the government are partners rather than adversaries in resource management. It is a learning process for DOC, and growing pains should be expected. Thus the community is empowered and therefore more likely to accept and follow the self-created plan. The opposite is the traditional top-down regulatory approach where the heavy hand of the government and the law rule.

Research on the coastal lagoons and wetlands of American Samoa are completed on an agency basis. Funding for such projects comes from federal and/or territorial grants and the research is generally focused on supporting the agency's goals (Brighouse, 2005).

The American Samoa Environmental Protection Agency (ASEPA) is responsible for tracking the condition of local aquatic resources, including stream, beach, and nearshore marine habitats. The ASEPA has recently adopted a watershed approach to monitoring and assessing these ecosystems (Pedersen 2000). Concurrent with many watershed-level programs, the ASEPA will monitor stream ecosystems to assess the overall condition of these habitats in the Territory. ASEPA also conducts weekly bacterial tests of selected beaches around Tutuila and reports the results in the form of a beach advisory in the local newspaper. In addition, ASCC Land Grant researcher Dr. Don Vargo conducts monthly sampling of 49 freshwater streams on Tutuila to determine the level of human impact on these streams through monitoring changes in various water quality parameters.

Figure 7. Pago Pago, Tutuila. Capital of American Samoa.



Water Quality

The majority of Tutuila population resides near the base of the mountains and adjacent to the sea. Villages are numerous and widespread, with houses, piggeries and plantations reaching up into the hills to take advantage of what little workable and productive land is available. Previously, villages relied on streams for household and drinking water, collected in reservoirs on the stream above the village. These reservoirs still exist, and some villagers use this water to supply piggeries, for washing or for outdoor showers.

However, a rapidly growing population has negatively impacted many village streams, and human and agricultural wastes are directly and indirectly discharged into waterways. Consequently, streams in heavily developed areas have become polluted by elevated bacterial levels and are unsafe for drinking or swimming. Many streams and their surrounding watersheds are continuously altered by unchecked development. For example, houses are built in close proximity to streams or, alternatively, stream flow is obstructed by refuse, building materials and other waste materials, which results in unnecessary destruction and flooding when flow is high. Agriculture development, such as the removal of large numbers of trees for plantations, and construction projects, further contribute to soil erosion and sedimentation of freshwater and marine environments. This is especially apparent after heavy rains and flooding. Sedimentation and coastal pollution are both known to contribute to coral reef degradation.

The majority of the population is supplied with safe, chlorinated drinking water. This pumped from a limited and deteriorating ground water source, most of which comes from the Tafuna Plains. This plain is the only large, flat area of the land on the island, but it is also the most densely populated.

Solid waste

Solid waste management has been turned over to the American Samoa Power Authority (ASPA) from the Department of Public Works, under whose administration operations and maintenance of the dump and collection were constant problems. Under ASPA's administration, the landfill has been improved. Collection stations have been set up, and several studies to improve solid waste management in the Territory have been initiated. A conceptual study for integrated waste management was completed in 1995.

Coral and sand mining

The mining of sand and coral rubble is a problem in American Samoa. One reason is cultural. Samoans use sand and coral rubble to decorate their properties. This culturally accepted practice, combined with the lack of enforcement by government agencies charged with regulating this activity, have led to a depletion of this resource and a decline/disappearance of sandy beaches in American Samoa. Although mining of sand, coral and rubble is illegal, there is little enforcement. Spurgeon et. al (2004) estimate that economic costs associated with mining are between \$470,000 to 2.3 million annually due to beach loss, need for shore line hardening, etc.

INSTITUTIONAL AND INDIVIDUAL CAPACITY FOR RESEARCH AND MANAGEMENT

Institutional capacity for research and management has been improving in the past year or so, particularly in the Department of Marine and Wildlife Resources. However, funding is highly dependent on the federal government, Organization and support from other local government agencies is sometimes less than it could be. There is considerable research done by visiting scientists, but almost no local capacity to do research. There is data gathering by local agencies. There is a proposal for a marine laboratory which would significantly increase local capacity, but funding is yet to be identified, and it is likely to take 5 years or more to secure funding and build the facility. There is no local research institution. Funding for enforcement appears to be quite inadequate. For instance, Fagatele Bay National Sanctuary has no enforcement. The Marine Patrol does not patrol and the Coast Guard has no boat. At this point, managers collect information, but some managers seem to have no tools to actually manage anything (Fenner, 2004).

These are the following resource agencies that are working together to research and manage the resources in American Samoa through collaborative efforts and individual agency projects:

National Park of American Samoa

(web site: <http://www.nps.gov/npsa/>)

- Fish survey in the National Park of American Samoa (web site: <http://www.nps.gov/npsa/NPSAfish/NSAim.htm>).
- Coral survey in the National Park of American Samoa (web site: <http://www.nps.gov/npsa/NPSAcorl/corlnamA.htm>).
- Sea-Surface Temperatures and Drifter Buoys (in partnership with NOAA).
- Factors Affecting the Distribution of Corals in Ofu Lagoon (in partnership with the University of Hawaii).
- Assessing the Impact of Climate Change on Coral Reef Systems (in partnership with the World Wildlife Fund).

Fagatele Bay National Marine Sanctuary

(web site: <http://www.fbnms.nos.noaa.gov/html/research.html>)

- Monitoring survey of marine plants, corals, coral diseases, invertebrates and fishes found in Fagatele Bay.
- Water quality monitoring in Fagatele Bay (in partnership with the American Samoa Environmental Protection Agency).
- GIS data from recent shallow-water multibeam bathymetric surveys and submersible dives (web site: <http://dusk2.geo.orst.edu/djl/samoa/>).

American Samoa Environmental Protection Agency

- Stream Monitoring: Sampling of freshwater streams on Tutuila for physical and chemical parameters.
- Beach Monitoring: Weekly measurements of seawater for physical and bacterial parameters at recreational and swimming beaches on Tutuila.
- Ocean Water Quality: Evaluation of ocean water quality from samples taken just over the reef crest on Tutuila and Manu'a.

Department of Marine and Wildlife Resources

(web site: <http://www.asg.gov.com/departments/dmwr.asg.htm>)

- Community-based Fisheries Management Program
- Monthly assessments of offshore fishery by catch method
- Survey of inshore reef fish fishery
- Fruit bat population survey

Coral Reef Advisory Group

(web site: <http://doc.asg.as/crag/>)

- Coral Reef Monitoring Program
- Marine Protected Areas Program

Land Grant, American Samoa Community College Community and Natural Resources Land Grant

(web site: http://www.ctahr.hawaii.edu/adap2/ascc_landgrant/)

- Research that addresses agricultural and environmental problems that include crop production, identification and control of arthropod pests, weeds, and diseases, forestry issues, water quality and agricultural economics.

Coastal Zone Management Program-Department of Commerce

(web site: <http://www.ocrm.nos.noaa.gov/czm/czmamericansamoa.html>)

- Responsible for managing coastal resources within three miles of the shoreline including: fisheries habitat, hazards, marine debris, and human use impacts (agriculture, earth-moving, and construction).

Although these agencies have their own individual management plans and action plans, they also work together in various working groups in planning, developing, and implementing projects to improve and protect the resources of the Territory.

Status of knowledge and information base for management

Sources of information, databases and studies for management

Some of the principal resources are:

- An assessment of the economic value of coral reefs and mangroves in American Samoa is available on the web site of the Coral Reef Advisory Group, which administers American Samoa's Coral Reef Initiative (web site: <http://doc.asg.as/CRAG/Projects.htm>).
- Information on agriculture and fishing in American Samoa are available online through the Department of Commerce's Statistical Division web site (<http://www.asdoc.info/Statistic/statshp.htm>). Found on this site are links for the American Samoa Yearbook 2003 and 2004, Agricultural Census 1999, and the Statistical Yearbook for 2001 (<http://www.spc.int/prism/country/as/stats/Agriculture%20and%20Fishing/AF.htm>).
- Geographical information system data on American Samoa can be found on the American Samoa GIS User Group's web site (<http://doc.asg.as/>).
- Database of coral species found in the National Park of American Samoa (web site: <http://www.nps.gov/npsa/NPSAcorl/corlnamA.htm>).

- Database of fishes found in the National Park of American Samoa (web site: <http://www.nps.gov/npsa/NPSAfish/NSAfish.htm>).
- Fagatele Bay National Marine Sanctuary GIS Data Archive (web site: <http://dusk2.geo.orst.edu/djl/samoa/>).

Information management

Information is often stored in paper form, or in individual computers. There is a proposal to have a database for all information on a dedicated server. Presently most information is available to those who ask the responsible agency or person (Fenner, 2004).

In addition, the Watershed Advisory Group meets sporadically to exchange information and strategies on managing watershed issues.

GIS data is now available for wetlands. Wetland GIS data originated from the Wetland program under the Coastal Zone Management Program of the Department of Commerce. However, all of it was in State Plane coordinate systems. It also contained no metadata describing method of collection or what it represented, and a lot of the available data was CADD files from DPW Lands and Survey Department. It took a lot of time organizing and cleaning up the available data and also generated a lot of additional data. The original data is still available but has become out of date or has been merged into a single file that is now more user friendly. All previous wetland data available was reprojected to UTM as used by American Samoa GIS Community. A majority of the available wetland GIS boundaries however, were digitized from USGS quads and not delineated in the field using ACOE methods. Thus, it is important to continue the Community Based Wetland Management Program in order to conduct wetland delineations with in-house GPS equipment for the villages of Alofau, Aua, Vatia, Masefau, Maleoloa, and Aoa.

Aerial photography from numerous wetland villages (Masefau, Leone, Nu'uuli, Aunu'u, and Vatia) spanning numerous years (1961, 1970, 1990, and 1994) were scanned and rectified in order to be used as backgrounds for analysis and map making. The IKONOS imagery is often unclear, cloudy, or does not make "pretty" maps. So this effort was done to create better maps as well as conduct the mangrove trend analysis that was not completed.

Data that has been created and is now available:

1. Wetland villages of American Samoa;
2. Wetlands of American Samoa (created by merging data from various sources, see metadata);
3. Leone wetland agreed line;
4. Nu'uuli wetland agreed line, ratified in March 2003;
5. Aunu'u wetland polygons and survey points from DPW/ASCMP delineation in 1999;
6. Tula DPW/ASCMP delineation points as well as polygons that represent wetlands for both delineations;
7. Masefau DPW/ASCMP delineation points. Incomplete, only a small area to the south was delineated;
8. Potential wetlands that should be delineated in the future and protected under ASAC 26.0;

9. 1961 Leone wetland line; and
10. 1961 Nu'uuli mangrove line- not completed, need to view original print with stereoscope to finalize.

All data except for (7), (8), and (10) are final with metadata

Gaps in information collection and management

American Samoa harvests some 100 species of marine fish and invertebrates, but little biological information is available for all but a few. We know little about the dynamics of our offshore marine ecosystems, except that a modest number of tuna are caught in our EEZ. A key element in calculating sustainable catches of fish is to know the age structure of fishes being harvested. In order to assess the age structures, an otolith aging lab and age-verification capabilities are needed in American Samoa.

There are also gaps in research information also includes bycatch rates of non-target fishes, turtles, seabirds in offshore waters. An international approach is needed in order to conserve migratory turtle stocks. More long and short term studies related to impacts of climate change are critically needed (Craig and Green, 2005).

Role of education and research institutions to management issues

The only educational institution of higher learning is the American Samoa Community College (ASCC). Local agencies have outreach to provide information to local schools and the community college. Also the community college provides some volunteer students for some projects. However, there is no local research institution and no local faculty that have research programs on coral reefs. (Fenner, 2004).

The US Department of Agriculture founded American Samoa Land Grant is based at ASCC. The Land Grant Program combines programs and projects related to Agriculture Extension, Resource Development, Natural Resources, Animal, Plant and Environmental Sciences. In promoting sustainable agriculture research and education, Land Grant works in partnership with local government departments and agencies, using multi-disciplinary approaches to solve the growing problems facing the territory's natural resources (Brighouse, 2005). Efforts include alternative crops, plant pathology, agricultural economics, soil conservation, water quality, identification of arthropod pests and forestry.

The College also has a marine science department and hosts the Sea Grant Program. Sea Grant is part of the Community & Natural Resources Division (Land Grant) at ASCC and plays a vital role in the community by serving as a conduit for information and technology transfer between researchers and aquaculture producers. Sea Grant's activities, which focus on education, capacity building and aquaculture extension, are designed to assist in the development of the aquaculture industry and produce an educated community that will make significant contributions in economic development and stewardship in American Samoa.

A Sea Grant presence was established in September of 2002 through a partnership between the University of Hawai'i Sea Grant College Program, the honorable Congressman Eni Hunkin Faleomavaega and Dr. Adele Satele-Galea'i, the President of the American Samoa Community College. The extension agent who is based at the college works with other regional aquaculture service organizations in the Pacific to establish economically

viable giant clam and tilapia industries in American Samoa. The agent, in addition to the aquaculture extension responsibilities, also serves as the director of the Marine Science Program at the college and instructs one course per semester.

The Marine Science Program is part of the Science Department at the college. Students wishing to pursue a career in marine biology may earn an Associate of Arts degree in Marine Science. Recognizing the critical shortage of qualified Samoans in the marine science field, the Marine Science Program devotes a substantial effort to building capacity by offering its students opportunities to obtain invaluable hands-on experience and technical training through participation in internships (e.g., NOAA Minority Serving Institutions Student Internship Program in Aquaculture and the Micronesia and American Samoa Student Internship Program), research projects, workshops and training programs offered by local and visiting resource managers and scientists. Students are also given the chance to attend summer programs at other universities (e.g., Sea Grant Marine Science Undergraduate Research Fellowship Program and Undergraduate Mentoring in Environmental Biology Program at the University of Hawaii at Manoa), as well as serve the community through an inter-institutional service-learning exchange program with a community college in Hawai'i. Other activities associated with this program include aquaculture extension services, education outreach at annual community events (e.g., National Fishing and Boating Week, Reefweeks, Ocean Fest, Ocean Symposium, and Camp Tiftifi), science fair judging and conducting teacher training and curriculum development workshops for K-12 science teachers on the marine environment. These activities are designed to prepare students for advanced studies at higher education institutions elsewhere and to produce a work force to supply the local labor market. A secondary goal of the Marine Science Program is to develop an educated community that will contribute to conservation efforts in the Territory through the demonstration of good stewardship practices.

In Fall 2005, ASCC obtained funding through the NOAA Education Partnership Program to support program development of the Marine Science Program. The NOAA funds will be used to strengthen and enhance course offerings, as well as purchase equipment and supplies to support the implementation of new and existing projects. These projects include the development of a Marine Options Certificate Program for majors and non-majors who have an interest in learning more about marine science, second year support for the inter-institutional service-learning exchange program exposes students to career opportunities in marine science and natural resources, and capacity building efforts via internships at the college and abroad (e.g., Seacamp in Florida). Finally, a portion of the funds will be used to support the professional development of local science teachers.

Policy and regulatory issues

While a variety of federal and Territorial laws and regulations relate to wetlands protection, enforcement is needed to protect these valuable resources. Many land-filling activities, especially within mangrove wetlands on Tutuila Island, result in piecemeal losses of wetlands that are either exempt from current regulation or occur without due process or permit review.

Compounding the problem associated with regulation and enforcement are cultural forces and a general shift in social attitudes by Samoans. Under the Samoan land tenure system, wetlands are perceived as land owned by the village. The perception of Western public rights is not culturally appropriate in the Samoan culture and, thus the concept of public good conflicts with village interests. Samoans see the use of land as subject to the decisions of their matai and village councils, not the federal or Territorial governments. While some residents may be familiar with resource protection they feel compelled to remain silent when higher-ranking residents make land use decisions that negatively impact wetlands but are traditionally within their decision-making authority. Samoan communal and subsistence land use practices are also eroding from increasing western influences and the shift to a cash economy. Furthermore, the general public does not have enough information about where wetlands are located, their biological and social functions, the regulatory requirements surrounding wetland areas, and the activities that damage the wetland's fragile ecosystems.

Programs have been instituted, including the Community Based Wetland Management Program, to educate the community on a village level about the importance of resource management. Legislative means have also been used through the establishment of Special Management Areas. Special Management Areas are managed as areas that possess unique and irreplaceable habitat to American Samoa. Currently, the two mangrove areas, Leone Pala Lagoon and the Nuuuli Pala Lagoon have been delineated and designated as Special Management Areas (Brighthouse, 2005).

Enforcement

With regards to the management of natural resources, the Department of Marine and Wildlife Resources is tasked with managing both terrestrial and marine biotic resources. There is also a NOAA Office of Law Enforcement which is tasked with enforcing Federal rules and regulations in the Territory regarding marine resources. The Department of Agriculture oversees the import and export of agricultural goods and provides agricultural services and support for the Samoan Community. The Department of Health is tasked with inspecting and issuing citations regarding the location of piggeries next to homes and freshwater streams (e.g., at least 50 feet from a home or stream). The Department of Public Safety enforces the litter law. Generally, enforcement has not been adequate to the task in part due to strong community and family ties that make citing offenders a sensitive issue.

There is also community-based enforcement to consider. Village communities in American Samoa have for many years managed their reef areas and enforced their village rules and regulations. As a tradition, villagers will practice their traditional fishing methods when utilizing their reef areas. Safe and effective fishing practices were often used and the results were plenty of fish and shellfish caught for family consumption. Management of the reef depends greatly on how well organized the village in regards to its matai system, women's group, and untitled men's group. Effective management in the early days were well practiced and enforced by villages. American Samoa has gone through major changes over the century, as change is inevitable. These changes include new technology and advanced methods that alter the approach and perception of the local people on how to earn more and live better.

Priority Research and Management Issues

In October 2001, the American Samoa government undertook a three year project to develop a comprehensive plan to manage its valuable ocean resources. Based on the recognition that there was very little integration among the various governmental agencies that managed ocean resources in the Territory, an Ocean Resources Management Program (ORMP, web site: <http://www.asdoc.info/CZM/Ocean.htm>) was developed through stakeholder input. The ORMP is under the direction of the American Samoa Coastal Management Program and is designed to coordinate efforts and provide linkages among the various agencies that manage ocean resources. The priority issues that were identified in the ORMP include:

- Over fishing
- Coastal Water Quality
- Oil Spills & Ocean Pollution
- Trans boundary Fisheries Stocks
- Federal & Territorial Responsibilities for American Samoa
- Evaluating the potential for ocean aquaculture
- Threats to Coral Reef Ecosystems
- Mangrove Habitat Degradation

Acknowledgements

Thanks to Darren Okimoto and Richard Volk for helpful suggestions and additional information.

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