MARINE BIODIVERSITY
OF THE
FEDERATED STATES OF MICRONESIA

Report prepared
by Mr. Ahser Edward for the
FSM National Biodiversity Strategy and Action Plan Project

February 2002

The FSM National Biodiversity Strategy and Action Plan Project is funded by the Global Environmental Facility, implemented by the United Nations Development Programme and nationally executed by the FSM Department of Economic Affairs

TABLE OF CONTENTS

FSM Marine Biological Diversity

Executive Summary

The islands of the Federated States of Micronesia are made up of coral reefs that are species rich. These reefs are highly beneficial to the people of the FSM for they provide food and other products that are vital for the survival of a human individual.

With the growing population of the FSM, the demand on the exploitation of the resources is heightened causing increased degradation of marine biodiversity. This biodiversity is still high within the FSM reefs but face many anthropogenic threats. Brief descriptions of the FSM islands and their locations as well as their marine habitats are given to indicate the vast diversity of the islands.

Descriptions of both pelagic and inshore fisheries are also given to show how much the waters in FSM are being exploited. One of the major weaknesses in managing the fisheries resources in FSM is the lack of catch data. Comparing pelagic and inshore data collection, the pelagic sector is far advanced and better in collecting catch data and this may be attributed to well skilled and educated personnel.

Based on the recent literature search, information on biodiversity is not as readily available and perhaps limited. Much of what information available is derived from work carried out from assessing sites for infrastructure development. Listings for major marine groups are not well documented and additional studies are necessary to properly assess all the species that exist in different ecosystems or habitats.

In terms of freshwater species, recorded from Yap in small ponds and pools, Nelson recorded 41 green algae, 13 blue-green algae, 2 red algae, 3 mosses and 10 angiosperms. Five different fish families were reported to occur in one single river in Pohnpei. Five fish individuals were recently identified as gobies, 3 of which are endemic to Pohnpei island. Other freshwater invertebrates include 3 families of Decapoda crustaceans, 2 families of snails and 5 species of shrimps from Pohnpei. Yap harbors 14 species of freshwater and brackish gastropods.

A total of 143 species of marine algae was reported from Yap which is similar to the numbers for Pohnpei as recently reported. As for corals, the numbers vary from state to state, for example, 207 species of corals were reported from Yap. The numbers for the other states are not evident but the listings are given in the Coastal Resource Inventory documentation. Fish species are abundant and highly diverse. The numbers reported for Yap and Kosrae are 393 and 410 species respectively. These numbers may be much lower than the actual count.

Turtle count for Yap state is 4 species and this number may apply to the other states of the Federated states of Micronesia. The highest number of sea cucumbers as yet recorded is from Pohnpei. There are 15 different species for Pohnpei with 11 from Yap. Yap state harbors the highest number of sea grasses on its coral reefs with a count of 7 species followed by Chuuk with

4 and Pohnpei and Kosrae with 3 species. Other invertebrate species are not well documented and are under reported in the Coastal Resource Inventory documentations.

The technical reports examine for this study seemed to focus on certain habitats and not others and the lists that result from such work do not give a holistic representation of the area or island. Reports on specific information such as endemic species, invasive species, extinct species and threatened species are very limited.

It should be noted that any statements of opinion and recommendations of this report are primarily those of the author and do not necessarily reflect the position of the NBSAP Project or the FSM Government.

Introduction

Although coral reefs cover an area of less than 0.2 percent of the world's ocean beds, they are the most species-diverse areas of all explored marine habitats, approaching tropical rainforests in their species richness**.** The coral reefs are mostly located in the tropics which extend from 30 North Latitude to 30 South Latitude. The islands of FSM are situated within the tropics and contain coral reefs that are still pristine and unexploited.

Coral reefs are very important to the people of FSM. Fish and invertebrates are extracted from the coral reefs to serve as the main source of protein in the diets. Coral reefs also provide other products that are essential for human survival.

The islands in the Federated States of Micronesia are well known for their relatively undeveloped shorelines, beautiful blue lagoons and coral reefs teeming with a high diversity of marine life. However, these islands are confronted with a variety of pressures that threaten to compromise sustainable use of natural resources. Expanding populations with booming economic development have magnified the rate of natural resources exploitation and environmental degradation.

At coastline, many people cut down mangroves to erect houses without taking precautionary measures to conserve these important coastal barriers to erosion and sedimentation.

Destructive fishing methods are being used on the reefs, including bleach and dynamite fishing, net fishing and other destructive methods that do not allow for future recovery. Coastal area dredging for coral rubble and barrier reef sand-mining are becoming more intense and the government authorities are faced with a big problem to deal with the situation.

In some areas of the Federated States of Micronesia, the reefs may be beyond repair. Recent studies showed that when an ecosystem has been destroyed, it can never recover to its original state of health, and hence to its once rich biodiversity. Nevertheless, reefs that are still pristine must be identified and be protected somehow. Therefore, there is an urgent need to collect and

compile the available information from previous studies on FSM biodiversity to identify what has been done and to suggest what must be done in order to effectively protect that biodiversity.

In order to protect the biodiversity of the coral reefs in FSM, one of the first steps is to determine species composition. Time and effort are utmost important in protecting the FSM biodiversity and perhaps even prior to the determination of the species composition of the reef, a literature search is necessary to make known the studies that have taken place which documented existence of species in FSM.

Location of FSM

The FSM is a small developing country with a total national population of over 110,000 people living on over 607 widely dispersed islands in the Caroline archipelago. This archipelago lies in a broad east-west swath across 1.5 million square kilometers of the western pacific ocean above the equator, between 138.18-162.6 East and 1.08 -9.9 North. The FSM consists of four major islands and island groups, which form the four individual states capitals of the FSM. Listed from east to west, they are Kosrae, Pohnpei, Chuuk and Yap. Three of the state capitals (Pohnpei, Chuuk and Yap) have distant outer islands or atolls as part of the state's jurisdiction.

Types of Islands in FSM

The islands in the FSM are basically of two kinds: atolls and volcanic islands. Three basic reef formations correspond to the stages of reef development of the islands. Fringing reefs represent the earliest stage and barrier reefs and atolls represent later stages. Fringing reefs are relatively young, with narrow platforms that extend a short distance from shore and do not contain a lagoon. As the reef grows outward, or upward if the sea floor sinks or the sea level rises, the innermost corals cannot keep pace and a lagoon is formed. The reef has now become a barrier reef. The barrier reefs are older than fringing reefs. Atolls start from fringing reefs surrounding volcanic islands. As the island erodes and subsides due to its own weight pressing on the sea floor, the fringing reef keeps pace with the sea surface along its seaward margin leaving a lagoon along the slope. An atoll island results when the island has completely disappeared beneath the surface. The number of atolls increases as one travels from East to West.

Description of FSM Islands

Kosrae

Kosrae Island is a high, volcanic island located a little over 5 degrees north of the equator and is the eastern most island in the FSM. The total land area of Kosrae is approximately 112 square kilometers (42 square miles). Mangroves fringe most of its coastlines reaching widths of over 0.6 kilometers along the northwest coast. Rudimentary lagoon or embayments bisect the reef platform at three places: Lelu Harbor off the east coast, Port Lottin or Utwe Harbor off the south

coast and Okat Harbor, off the north coast. Kosrae is unique in that it doesn't have outer islands in its jurisdiction.

Pohnpei

Pohnpei consists of a high volcanic island surrounded by an outer barrier reef which is interrupted at intervals by deep passes which empty into the lagoon. In the lagoon between the barrier reef and the main island a complex of both high rocky islands and low mangrove islands are found. Fringing reefs and shallow shelves border the main island and most of the smaller lagoon islands. Mangroves border most of the shoreline along both the main island and smaller lagoon islands. In the lagoon itself, numerous patch reefs reach the surface. These patch reefs range from small isolated pinnacles, a few tens of meters across, to long ridges and intricately curved and branched reefs, several kilometers or more in length, which sometimes enclose both shallow and deep secondary lagoons. A complex variety of marine habitats include the seaward and lagoon barrier reef terraces and slopes, reef flats, deep barrier reef passes, fringing islands reefs, patch reefs, coral knolls and banks, deep lagoon basins, shallow lagoon shelves, enclosed secondary lagoons, river estuaries and mangrove swamps.

There are 9 distant outer atolls in Pohnpei state. Pingelap and Mwoakilloa to the east of Pohnpei island and Pakin, Ant, Sapwuafik, Nukuoro, Kapingamarangi, and Oroluk to the southwest. Minto reef is also located to the west of Pohnpei state and has no emergent land.

Chuuk

Chuuk is a volcanic island with a very immense lagoon whose diameter exceeds 30 miles. Within the lagoon, of the main island of Chuuk, there are 18 volcanic fringing reef islands; 17 channels dissect the perimeter reef of the Chuuk lagoon. The lagoon is the home of many Japanese warships that sank during World War II.

There are 14 outer islands (atolls) of Chuuk state, whose reef areas range from 0.4 km^2 to 4.6 km^2. The number of motus (islets) on the perimeter reefs ranging from one in Pulusuk to eighty in Satawan.

Yap

The Yap Island Proper, another volcanic island, is made up of a complex of four major islands and ten smaller ones arranged in an elongated fashion to form a triangular figure. The entire group of islands is surrounded by a fringing reef system. The length of the island measured on its north/south orientation at its extreme borders is about 31 kilometers (19 miles) while the east/west boundaries have a width of 12 kilometers (7.5 miles). The total land area of the entire island is 95 square kilometers (36.8 miles).

The Yap Proper has an extensive fringing reef system encircling it. The outer reef flat margins are dissected by eight deep channels of various sizes. Nearhore region of the island is fringed with mangrove forests comprising of 1,171 hectares which is about 12% of the total land area.

Yap island proper has an interesting and unique reef feature as part of its fringing reef, the lagoon holes are located on both the windward and leeward reefs.

There are 15 outer atolls in the state of Yap. All these atolls have many small islets located on the perimeter reefs, ranging from Ulithi with 32 to Gaferut, Pigelot, Satawal and West Fayu with only one islet each. Their lagoon depths range from several meters to several hundred meters.

Coastal Communities

The coral community is divided into several habitats. A brief discussion of coral reef types was presented earlier to give a clear distinction of the different coral reef habitats.

High islands contain the greatest number of reef habitats. They are the only islands that contain fresh and brackish water habitats. For this reason, a short discussion on the freshwater habitat will be included in this section. Atolls, on the other hand, do not have well-developed mangrove communities.

Coral reef communities may vary among the three coral island types but generally they all possess the following communities in the order from land towards the ocean: Sandy beaches, rocky shores, estuaries, mangroves, sea grass beds, fringing reef flats, lagoons, barrier reef flats and reef slopes. Generally, these communities are what constitute the intertidal zone. Other zones of the marine ecosystems beyond the intertidal zone include the neritic zone, the oceanic zone and the abyssal plain. These zones are briefly discussed below.

Freshwater habitat

The freshwater habitats are the rivers and streams which are extensive in the high islands of Pohnpei and Kosrae and the freshwater lakes which are known to exist on the island of Yap proper. Based on the recent studies by Nelson et. al., (1997), Buden et. al., (2001 a, b), species of decapod crustaceans and amphidromous gobies are found in high numbers in the headwater streams as well as the rivers in Pohnpei. There may be existence of other types of organisms but their records have not been seen in the literature.

Sandy beaches

This habitat may be absent from the high volcanic islands that have mangrove forest bordering them. Sandy beaches may fringe the lagoonal islands of the volcanic island and may be very common in the oceanic atolls on the lagoon side of the islands. Small crabs and copepods inhabit this area of the intertidal zone.

Rocky shores

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 molluscs 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.

Estuaries

This area of the reef is characterized by mixture of salt and fresh water with very low visibility. Common fish species in this area include the mullets. The seagrass *Enhalus acoroides* is common. Micro-atoll Porites corals are often seen in this area, 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.

Mangrove

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.

Sea grass beds

This is an important habitat and is found beyond the mangrove forest. It's roots help stabilize the sediment and their leaves provide shelter and food to many organisms as well as an additional 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 grasses as food. Crustaceans and molluscs 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 in this part of the reef ecosystem. Several species of sea cucumbers and urchins also are common inhabitants of the sea grass beds. Many species of sea cucumbers use the sandy bottoms of the sea grass beds to filter food materials for their survival and therefore inhabit this productive area. When the weather and the water conditions are appropriate, jellyfishes are found in abundance.

Fringing reef flats

The reef flat is the intertidal and 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 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 a 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.

Lagoon

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.

Barrier reef flat

This area of the reef contains vineer 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*.

Reef slope

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.

Neritic zone

This area is a relatively shallow ocean that extends to the edge of continental shelf. Primary productivity here depends on planktonic algae growing as deep as the light can penetrate.

Oceanic zone

This zone is located over the ocean basins with its primary productivity dependent upon the depth to which the light can penetrate. The producers are planktonic algae that support secondary and higher consumers (eg. fish) in the nekton. It is known that the net productivity of the open ocean is little better than that of the desert.

Abyssal zone

This zone is the bottom of the ocean basins. This area is very dark and it is the region where few populations of bottom-dwelling organisms make up the benthos. These are consumers and decomposers who depend on the organic matter drifting down from the upper portions of the sea.

State of the FSM Coral reef biodiversity

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). Reef biodiversity is highest in the Indo-Western Pacific, which is also thought to have the world's highest overall marine biodiversity. Over half of the world's coral reefs are located within this region of which FSM is part.

It is estimated that the FSM has 300 species of corals, over 1,000 species of fish and 1,200 species of mollusks. This information is yet to be confirmed by further review of the literature or otherwise it may not been documented. Other major marine groups do not have their numbers well documented and therefore further studies are necessary to collect such data.

Threats to coral reef biodiversity

The sources of degradation of coral reefs are varied and numerous. Unfortunately, most of the coral reefs that receive 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-Nino Southern Oscillation) events, and freshwater runoff (Maragos, 1997, Wilkinson, 1998).

In order to determine the human influences on the coral reef biodiversity, both pelagic and inshore fisheries should be examined.

Pelagic Fisheries

Micronesian Fisheries Authority (MFA) is mandated under Title 24 of the FSM code to manage the use of FSM' tuna resource. To concur with the expectations of the National Government in terms of the benefits derived from the tuna resource, MFA has adopted three main objectives: First, to ensure that the EEZ resources are used sustainably. Second, to ensure that the uses of the resources obtain the maximum sustainable economic benefits, and lastly to promote economic security for the nation through the uses of these resources. Under the same title (Title 24 of the FSM code), Marine Resources Act of 2002 has been enacted to ensure the sustainable development, conservation and use of the marine resources in the exclusive economic zone by promoting development of, and investment in fishing and related activities in the context of effective stewardship.

The Exclusive Economic Zone (EEZ) of the Federated States of Micronesia is one of the largest EEZs under national jurisdiction in the Central and Western Pacific Ocean and covers an area approximately 900,000 square miles. The fishery in the FSM EEZ is not so diverse as the inshore fishery and includes fishing activities ranging from artisanal fisheries to industrial scale longline, pole and line and purse seine fishing. The industrial fisheries species of main target include skipjack tuna (*Katsuwonis pelamis*), yellowfin tuna (*Thunnus albacares*), and bigeye tuna (*Thunnus obesus*).

The tuna resource is a shared resource among the fishing nations in the region. In order to ensure the sustainable use of the tuna resource, FSM participates in regional management initiatives to fulfill its obligations under certain regional and international agreements. For this purpose, FSM is a signatory party to several international agreements or conventions few of which includes: The United Nations Convention on the Law of the Sea, The Forum Fisheries Agency Convention, the 1995 United Nations Fish Stocks Agreement and the most recent Convention for the Conservation and Management of the Highly Migratory Fish Stocks in the CWPO. FSM is also a member of the sub-regional group commonly known as the Parties to the Nauru Agreement (PNA) which comprises the 8 countries with the largest and most productive EEZ's.

The Federated States of Micronesia national government entered into bilateral and multilateral arrangements with distant water fishing nations to fish in the FSM EEZ. Of the nations fishing in the EEZ waters of the FSM, only the United States is engaged in a multilateral arrangement in

terms of purse seining fishing. The Parties to the US multilateral arrangement include all 16 countries of the Forum Fisheries Agency (FFA). All the other fishing nations are engaged in bilateral or other types of arrangements and they include Japan, South Korea, Taiwan, Peoples Republic of China, Vanuatu, Solomon Islands, Panama, and Kiribati. The FSM has its own fleet of domestic longliners and purse seiners fishing in the Western and Central Pacific.

The FSM government generates part of its revenue from charging fishing fees on both the gear type and flag country. In 1999, FSM government collected over $13 million in access fees for all the gear types with purse seining accounting for the largest share. During the same year, the number of fishing vessels fishing in this region added up to 489 with 302 longliners, 149 purse seiners and 38 pole and line. Japan accounted for most of the longliners while Taiwan dominated the purse seine fleet; Japan remained the only country still employing the pole and line fishing operations, but they are dwindling in number.

Monitoring of the fishing in the EEZ

The Micronesian Fisheries Authority employs a well-trained and capable staff that comprised the research section headed by a fisheries biologist with extensive experience in tuna fisheries. This section monitors and collects catch data from all the fishing vessels registered to fish in the FSM EEZ. As part of the fishing arrangement with all the registered vessels fishing in the FSM waters, each vessel is required to relinquish reports on the catch and all the activities that are being undertaken during a fishing trip. MFA is engaged in a highly regarded on-board user-funded observer program that places a local individual on the fishing vessel to monitor fishing activities. At the office, a fisheries biologist studies the collected catch data from the reports of each fishing vessel and analyzes it. Under the Ocean Fisheries Program, the Secretariat of the South Pacific Commission (SPC) provides technical expertise, advises and supports the fisheries management program. Forum Fisheries Agency (FFA), on the other hand, assists MFA on economic issues with a minor role in management issues.

The Department of Justice is responsible for enforcing the law that mandates the surveillance program of the FSM EEZ but must require the coordination of all the concerned agencies. The area of the FSM exclusive economic zone covers an area of 900,000 square miles of open seas and is patrolled by three boats. This level of support may not be sufficient to provide for this important and costly role.

Inshore Fisheries

Micronesians have long been known for their close association with the ocean. This is evidenced by the congregation of villages and communities along the coastline. People of Micronesia depend on the ocean to supplement their diets with protein. Their daily schedule often is divided between tending small farms, (planting yams, bananas and other stable crops) carving canoes, building and residential houses, and fishing in the ocean for fish and shellfish. The chore of fishing was never only a man’s job but women could take part too, as is the case in Kosrae and in parts of the main islands and the outer atolls of the FSM.

In Kosrae women are still actively involved in net fishing to catch small fish on the reef flat. While in Pohnpei, the women are more involved in using a hook while standing in the seagrass bed at high tide and catching emperors by tossing a baited hook several feet. Women in Pohnpei are still engaged 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 somewhat unsustainable harvest process called gleaning where rocks on the reefs are turned over and whatever is suitable for eating is picked. Now everyone can access the oceans to extract what they may gather as beneficial. Whether you are a citizen, a non-citizen, man, woman or children you have open access to the waters.

In the distant past, only fishermen were traditionally permitted to fish with their then fishing gears. These gears were primitive and highly inefficient. One can guess that back then fish and all the marine animals were in abundance. Even with the primitive gears, an unskilled fisherman could still bring home sufficient catch to feed the family and to share with the neighbors.

Recently, fishermen become very skilled and are now using many types of fishing gears which are highly efficient. These gears include nets whose monofilament lines are very strong and almost invisible to the eyes of fishes, strong lines for night bottom fishing, a wide variety of lures and better gears for night spear-fishing. All of the above to a certain degree contribute to the rapid depletion of the marine resources.

Fishermen themselves are complaining, especially those dependent on the inshore fisheries for subsistence income. It is becoming a serious concern that inshore fisheries are declining and regulatory measures must be installed to manage this resource. Marine education and environmental awareness programs must be carried out to help educate the people for better management.

In all the states of the Federated States of Micronesia, Marine Resources departments have been installed to deal with all the marine affairs. Unfortunately, these departments are shorthanded and cannot carry out these tasks as demanded by the department. Management of the resources require data collection to include size of catch, number of fish sold to the markets, number of boats actively fishing, number of fishermen actively fishing and poundage exported and so on. However, the government agencies often hire and employ individuals who may not have the educational and training to undertake such duties.

In an effort to protect, preserve and manage the marine resources, a move to establish Marine Protected Areas (MPA) is effect. These areas are set up as “no take” areas where no one is allowed to fish or extract marine products. Pohnpei and Kosrae are 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 the trend now is toward establishing MPAs.

Available information on Aquatic biodiversity of FSM

Information on biodiversity is depauperate and extensive field surveys are required to obtain additional data. The little information available is largely from very informal studies with general

focus on reviews and inventories of species diversity. Much of this information is provided by technical reports produced from infrastructure development assessment surveys.

Freshwater

Few literature exist that report on the freshwater fauna of FSM. These studies are of Yap, (Nelson, 1989; Nelson, 1997) and Pohnpei (Maciolek et al., 1987; Buden, 2001 a&b).

Freshwater plants

The only study that attempts to reveal the freshwater plants is that of Lobban (1989) who collected from unstable habitats of small ponds and small streams found in Yap, Micronesia. This report recorded 41 green algae, 13 blue-green 2 red algae, 3 mosses and 10 angiosperms. No other records of freshwater plants are known in Micronesia besides the records made from Yap.

Fish

Maciolek et. al., (1987) reported 5 different families of fish in the Nanpil River, some of these may have been gobies, which 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.

Freshwater invertebrates

Maciolek (1987) reported 3 families of Decapod crustaceans, 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.

Marine

Algae

A total of 143 species of algae were reported from Yap not including the algae from the outer islands of Yap (Tsuda, 1978). They include 10 Cyanophyta, 58 Chlorophyta, 17 Phaeophyta and 58 Rhodaphyta. Other studies were conducted but gave much lower counts than Tsuda, for example Amesbury, 1978.

A most recent report by Hodgson et. al., (2000), reveals that the marine flora of Pohnpei now comprises of 52 Chlorophyta species, 22 Phaeophyta species; and for Ant Atoll alone, the species count stands at 60 Chlorophyta and 11 Paeophyta.

Corals

During the study of the Yap Coastal Resource Inventory, (1989) which cover a vast area of the reef from the mangrove to the reef flats to the limited part of the reef slopes, twenty-one families of corals representing 63 genera and 207 species were reported.

A rather poor listing of coral for Pohnpei is given in Pohnpei Coastal Resource Inventory, (1986). For Chuuk, the coral listing is far from complete because the records are made from the specific site surveys which were restricted to the lagoon area and do not give a holistic representation of the reefs in Chuuk. The highest number of known recorded corals to Kosrae is 156 species based on the Kosrae Coastal Resource Inventory, (1987).

Fish

Fish species were abundant in Micronesia and the area of high diversity was the reef slope with 20 fish families. In the lagoon, a total of 80 species were observed which could be many times less than what could be counted from the reef slope, Yap Coastal Resource Inventory, (1989). The total number of fish species known to date for Yap is 393 as reported by Myers, (1999). Over 54 species of fish were recorded at the site in the lagoon and the nearshore waters in the proximity of the site of the Colonia dock.

The Kosrae Coastal Resource Inventory, (1989) reported 292 species of fish, whereas Myers, 1999, reported 410 species of fish from Kosrae known to date. The fish list for Pohnpei is given in PCRI, (1986). Chuuk lacks a Coastal Resource Inventory report and it's recorded fish species lists are given in other reports as Amesbury et. al., (1977) and Clayshulte et. al., (1978).

Reptiles

Four species of turtles occur in Yap, two of which are widely recognized by fishermen. The green turtle (*Chelonia mydas*) is the most abundant species with moderating nesting colonies in outer island of Yap. The second most common is the hawksbill turtle (*Eretmochelys imbricata).* Other less common, are the olive ridley turtle (*Lepidochelys olivacea)* and the leatherback turtle (*Dermochelys coriacea*), YCRI, (1989). All these species of turtles are reported in the literature throughout Micronesia.

Sea Cucumber

A record of 11 species of sea cucumbers is known for Yap, according to the YCRI report. Fifteen different species are reported to be found in Pohnpei PCRI, (1986). The numbers are lower for Chuuk as reported in Clayshulte et. al., (1978) and Amesbury et. al., (1977) and for Kosrae as reported in the Kosrae Coastal Resource Inventory, (1989).

Sea Grass

Tsuda et al., (1977), reported seven species of sea grasses from Yap and this is later confirmed by Tsuda and Kamura, (1990). These species include: *Cymodocea serrulata, C. rotundata, Enhalus acoroides, Thallasia emprichii, Halophila minor, H. ovalis* and *Syringodium isoetifolium.*

Tsuda, (1977) reported two species of seagrass found in Pohnpei. McDermid and Edward, 1999 reported a third species of sea grass *Cymodosia rotundata* from Nah Pali, Pohnpei. It is suspected that there may be more than three species found in Pohnpei and further investigation is required to report the remaining unreported species. Sea grass list for Chuuk and Kosrae are 4 and 3 species respectively.

Other invertebrates

Other important major marine groups are not well documented but are under reported in all the Coastal Resource Inventories of the three states of Yap, Pohnpei and Kosrae. U.S. Army Corp of Engineers didn't carry out similar work in Chuuk and therefore Chuuk state didn't have a Coastal Resource Inventory report. Reports as Amesbury, (1977) and Clayshulte, (1978) did record occurrence of other marine species such as crustaceans, molluscs, and sea cucumbers. These records were not representative of the entire island of Chuuk because they were only focussed on specific habitats of the lagoon and did not include habitats of the barrier reef and the reef slope.

Introduced Marine species in Micronesia

One of the best-documented introductions is that of the marine top snail *Trochus niloticus.* Between 1927 and 1931, *Trochus niloticus* was introduced from Palau to Chuuk and between 1929 and 1939 it was introduced to Pohnpei. In 1959, it was further introduced to Kosrae, (Smith, 1988). Recently, the top shell has been introduced to most of the outer islands, especially outer islands in Yap and in Pohnpei. It should be noted that this species occurs naturally in Yap. So far, this is the only marine species that has been introduced throughout most of the islands in FSM mainly due to its economic importance. In 1999, the green snail, *Turbo mormoratus*, was introduced to Kosrae from Okinawa (pers. obs.). One freshwater species of fish Tilapia, *Oreochromis mossambicus*, is also known to be introduced to Yap. Gawel, (1988) survey report reported a list of marine species that are introduced to the Federated States of Micronesia.

Endemism

Patterns of marine endemism are generally not well known. Most marine species appear to have much larger ranges than terrestrial species because of their life cycles. Many species, including sedentary organisms such as clams and coral, produce free-floating planktonic larvae. Their young may drift for as little as a few hours or up to 6 months or more, depending on the species, before changing into their adult forms. This free-floating stage permits these species to disperse well beyond spawning areas. However, endemism does occur within marine communities; it appears to be proportionately higher in areas surrounding isolated oceanic islands and thermal vents. Although broad distributions may mean that marine species are less vulnerable to extinction than their terrestrial kin, not all marine species may be as wide-ranging as is currently believed. A recent effort to map the distribution of coral reef fish revealed that of the 950 species whose ranges were mapped (about 23 percent of the total), one third were limited to areas of less than 2,220 square kilometers.

No studies known from the search that have actually focused on determining the species endemism in FSM and even throughout the rest of Micronesia. Because of the much higher living ranges of the marine species, it is quite difficult to determine the species endemism as pointed out earlier.

Reports of fish species endemism in the Federated States of Micronesia include Buden et. al. (2001), Myers, (1999) and Parenti and Maciolek, (1993). Listed below are the endemic species, the habitats and the area where these species are found:

Species	Habitat
Yap	
Pleurosicya carolinensis	Lagoon reef flats in sea grasses
Pohnpei	
Stolenphous multibranchus	Coastal waters
Lentipes sp.	Deep water
Sicyopterus eudentatus	Freshwater
Acanthurus chronixis	Outer reef slope
Perioglossus verticalis	Estuaries
Kosrae	
Dinematichthys randalii	Reef terraces
Stenogobius sp.	Freshwater streams
Stiphodon sp.	Freshwater streams

Threatened, Endangered and Extinct

The diminishing numbers of fish and invertebrates reported for example, in Pohnpei, species of *Bulbometapon muricatum,* humpheaded parrotfish can only be caught for home consumption but not for sale. Another species of wrass, *Cheilinus undulates* may also be threatened. Fishermen in Pohnpei have been saying that the fish is no longer seen in the same numbers as before.

Because of the high exploitation of several species of giant clams throughout the Federated States Micronesia, they may be threatened as well. One species, *Tridacna gigas* has been extirpated in the FSM. Fossils of *T. gigas* are now seen in piles of dredged spoil but the animal is no longer seen alive on the reefs; efforts to reseed the reefs with these animals are ongoing. Other species, such as the *Hypoppus hypoppus* are also being depleted and like the *T. gigas,* they are being cultured to be used for restocking on the reef flats.

The green sea turtle, *Chelonia mydas* and the hawksbill turtle, *Eretmochelys imbricata,* are placed on the U.S. list of being threatened and endangered respectively. However, these species are traditionally harvested in Yap outer islands and to a certain extend in Yap proper and uncontrollably harvested through out the Federated States of Micronesia.

Invasive species

Information on invasive species in Micronesia has been difficult to locate. Although not documented, it has been reported in Pohnpei by fishermen that a catfish species called *Plutosus lineatus* exhibits invasive behaviors. Reported by Myers, (1999) as a native species of Pohnpei, but fishermen are contradicting the report and claim that the fish never previously occurred in Pohnpei waters.

Conclusion

Information in the existing libraries in the FSM have on hand in terms of marine biological diversity is very minimal. However, a more thorough search is required to reveal the actual documentation of marine biodiversity in FSM.

Recommendations:

1. Some biodiversity noted studies that have been done in FSM were never published but unpublished reports of the results may have been deposited at Marine Resources offices or other government offices and never reach the libraries. A move to bring this documentation to a centralized location is crucial.

2. Some publications are old and written in languages other than English. To be more useful, they should be translated to English language.

3. Existing laws on protection of the marine environment must be reviewed, revised, with new ones formulated and legislated to address current marine issues. Laws on protection of the marine environment must be enforced to ensure longevity of the marine ecosystems.

4. More improved management measures must be instituted to help protect the FSM's biodiversity. To better manage the marine inshore fishing and other activities, all the Marine Resources offices must expand their programs to include collection of catch data and monitoring of the coral reefs.

5. There is an urgent need to conduct scientific studies that would address topics on marine ecosystem inventories to include specific information such as endemic species, invasive species, endangered species, threatened species and extinct species. It may also be important to conduct studies that would include complete listings of major marine groups.

Literature Cited

Amesbury, S. S., R. N. Clayshulte, T.A. Determan, S.E. Hedlund, and J.R. Eads, 1978. Environmental Monitoring Study of Airport Runway Expansion site Moen, Truk, eastern Caroline Islands. Part A: Baseline Study. University of Guam Marine Laboratory, Technical Rept. No. 51, 87 p.

Amesbury, S. S., R. N. Clayshulte, T.A. Determan, S.E. Hedlund, and J.R. Eads, 1978. Limited Current and Underwater Biological Survey at the proposed Fishery Complex Site on Dublon Island, Truk. University of Guam Marine laboratory, Technical Rept. No. 36 p. 49.

Buden, D. W., D. B. Lynch, J. W. Short, and T. Leberer. 2001a. Decapod Crustaceans of the Headwater Streams of Pohnpei, Eastern Caroline Islands, Federated States of Micronesia. University of Hawaii Press. Pacific Science 55:257-265.

Buden, D. W., D. B. Lynch, R. E. Watson. 2001b. The Gobiid fishes (Teleostei: Gobioidei: Sicydiinae)of the Headwater Streams of Pohnpei, Eastern Caroline Islands, Federated States of Micronesia. Micronesica 34:1-10.

Clayshulte, R. M., J. A. Marsh, R. H. Randall, J. O. Stojkovich and M. E. Molina, 1978. Limited current and biological survey at the proposed fishery complex site of Tol island, Truk. University of Guam Marine laboratory Technical Rept. No. 50.

Gawel, M. 1988. Marine species introduced to the Federated States of Micronesia. Bulletin of Marine Science, 41: 635.

Hodgson, L. M., and K. J. McDermid, 2000. Marine Plants of Pohnpei and Ant Atoll: Chlorophyta, Phaeophyta and Magnoliophyta. Micronesica 32: 289-307.

Lobban C. S., et. al., 1990. Periphyton, excluding diatoms and Desmids from Yap Caroline Islands. Micronesica 23: 27-40.

Maragos, J.E., 1997. Coral Reef Health in the Central Pacific. In: Grigg, R.W. and Birkeland, C., ED. 1997. Status of Coral Reefs in the Pacific. University of Hawaii Sea Grant College Program Publication.

Maciolek, J. A., and J. I. Ford, 1987. Macrofauna and the environment of the Nanpil-Kiepw river, Pohnpei Eastern Caroline Islands. Bulletin of Marine Science. 41(2):623-632.

McDermid, K. J. & A. Edward. 1999. Seagrass community composition and biomass at Nahpali Island, Pohnpei. Micronesica 31:255-262.

Myers, R. F. 1999. Micronesian Reef Fishes: A practical guide to the Identification of the coral reef fishes of the tropical central and western Pacific. Coral Graphics Production.

Nelson, G. S., J.E. Parham, R. B. Tibbatts, F. A. Camacho, T. Leberer and B. Smith. 1997. Distributions and Microhabitats of the Amphidromous Gobies in Streams of Micronesia. Micronesica 30:83-91.

Nelson, S. G. 1989. The inland aquatic habitats of Yap. University of Guam Marine Laboratory. Technical Report No. 92.

Parenti, L. R., and J. A. Maciolek. 1993. New sicydine gobies from Ponape and Palau, Micronesia, with comments on the systematics of the subfamily Sicidiinae (Teleostei: Gobiidae). Bulletin of Marine Science 53:945-972

Smith, D. S., 1988. Topic Reviews in Insular Resource Development and Management in the Pacific U.S.- Affiliated Islands. University of Guam Marine Laboratory, Technical Rept. No. 88.

Tsuda, R. T., 1978. Marine Biological Survey of Yap Lagoon. University of Guam Marine Laboratory, Technical Rept. No. 45.

Tsuda, R. T., Fosberg, R.T., and Sachet M.H. 1977. Distribution of Sea Grasses in Micronesia. Micronesica: Vol 13: 191-198.

Tsuda, R. T., and Kamura, S. 1990. Comparative Review on the Floristics, Phytogeography, Seasonal Aspects and Assemblages Patterns of the Seagrass Flora in Micronesia and the Ryukyu Islands. Reprinted from Galaxea, Sesoko Marine Science Center.

Wilkinson, C. R., ED. 1998. Status of the Coral Reefs of the World. Australian Institute of Marine Science.

PCRI, 1986. Pohnpei Coastal Resource Inventory. U. S. Army Engineer, Pacific Ocean Division, Ft. Shafter, Hawaii.

KCRI, 1989. Kosrae coastal Resource Inventory. Environmental Resources Section U. S. Army Engineer District, Honolulu, Hawaii.

YCRI, 1989. Yap Proper Coastal Resource Inventory. U. S. Army Corps of Engineers Pacific Ocean Division Ft. Shafter, Hawaii.