Federated States Of Micronesia Marine Resources Profiles

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PREFACE

The South Pacific Forum Fisheries Agency (FFA) was approached by the Marine Resources Division, Department of Resources and Development, Federated States of Micronesia (FSM) national government, to provide technical assistance in the compilation of a set of marine resources profiles. The terms of reference provided to the consultant were:

1. With assistance from national fisheries staff, examine all closed and current files pertaining to fisheries resource matters in the Federated States of Micronesia;

2. Assess, collate and compile all written matter, data, etc, which provides information relating to resource abundance, distribution, exploitation, etc, in FSM;

3. Review existing legislation controlling the exploitation of living marine resources in FSM and advise on appropriate regulations for controlling the existing fisheries for those resources currently not protected;

4 Based on the information examined, produce a comprehensive set of resource profiles for the marine resources of FSM.

The report was prepared during and after a five week visit to all states in FSM during January and February, 1992. This report provides an overview of the marine resources identified as being of importance to the commercial, artisanal and subsistence fisheries sectors in FSM. The main purpose is to provide the basic information required to assess the current levels of exploitation, and to identify the research and management requirements for future developments.

The information for each marine resource is divided into four main areas: a brief description of the resource (the species present, their distribution, and the aspects of their biology and ecology relevant to exploitation and management); an overview of the fishery (its utilization, production levels and marketing); the status of the stocks; and management concerns (research issues, the current legislation and policies regarding exploitation, and recommended management options).

As the four states of FSM essentially act independently in regard to marine resources exploitation and management of the twelve-mile zone area, wherever possible information relating to each state is noted separately.

A comprehensive listing of marine resources references is also available for FSM (see Izumi, 1992). The references cited throughout the report should be consulted for more details on specific resources.

Funding for this report was provided by the Australian International Development Assistance Bureau. The assistance provided by Mr Moses Nelson and Miss Lucille Apis (FSM Marine Resources Division) was greatly appreciated. The cooperation provided by Mr Peter Sitan (MMA), Mr James Movick (NFC), Mr Jerry Fagolimul (NAC), Mr Tashiro Ludwig and Mr Flinn Curren (PMRD), Mr Mike Molina and Mr Jack Sigrah (KMRD), Mr Mark Mailo (CDMR), Mr John Iou (YMRMD) and Mr Patrick Peckalibe (YFA) and all their associated staff was excellent.

The author assumes full responsibility for the contents of this report. Opinions, where expressed, are his alone and in no way reflect the policy of FFA or any of FSM marine resources agencies at either the national or state levels.

LIST OF ABBREVIATIONS & ACRONYMS

CCM - Community College of Micronesia
CDMR - Chuuk Department of Marine Resources
CITES - Convention on the International Trade in Endangered Species
CPUE - Catch Per Unit Effort
DWFN - Distant Water Fishing Nations
EDA - Pohnpei Economic Development Authority
EEZ - Exclusive Economic Zone
FAD - Fish Aggregating Device
FFA - Forum Fisheries Agency
FSM - Federated States of Micronesia
IUCN - International Union for Conservation of Nature & Natural Resources
KMRD - Kosrae Marine Resources Division
MIC - Micronesian Island Conservation
MMA - Micronesian Maritime Authority
MMDC - Micronesian Mariculture Demonstration Center
MOP - Mother of Pearl Shell
MSY - Maximum Sustainable Yield
NAC - National Aquaculture Center
NFC - National Fisheries Corporation
NGO - Non-government Organization
NMRD - National Marine Resources Division
OFCF - Overseas Fishery Cooperation Foundation
PMRD - Pohnpei Marine Resources Division
RTTP - Regional Tuna Tagging Programme
SPC - South Pacific Commission
SSAP - Skipjack Survey and Assessment Programme
TTPI - Trust Territory of the Pacific Islands
US - United States of America
YFA - Yap Fishing Authority
YMRMD - Yap Marine Resources Management Division

TABLE OF CONTENTS

SUMMARY

The Federated States of Micronesia (FSM) is composed of the four states of Kosrae, Pohnpei, Chuuk and Yap. The estimated population in 1990 was 100,520. The total land area is only 270.6 square miles, with 2,776 square miles of lagoons, and an Exclusive Economic Zone (EEZ) of over 1.1 million square miles.

The marine resources are the country's largest natural resource, of which the tuna species represent the most important commercial resource. The national government is responsible for overseeing local and foreign fishing activities and resource management in the EEZ (12 to 200 miles from the reefs). The state governments manage their 12 mile territorial waters.

The development of domestic commercial tuna fishing operations have been identified by the national and state governments as the top priority in their economic development plans. With assistance from the national government, each state is independently developing shore facilities, acquiring longline vessels, and two of the states are involved with operating purse seine vessels through joint ventures with foreign partners. The national government is involved through joint venture agreements with the states. The Micronesian Maritime Authority is responsible for collecting and analyzing catch data in conjunction with the South Pacific Commission's tuna program.

Assessments of the deep-slope resources indicate that they are not adequate to sustain commercial fishing at other than an artisanal level. The inshore fishery resources are currently exploited primarily for subsistence purposes. Around the larger urban centers there is some small scale commercial fishing to supply the domestic markets. The level of development of the inshore fisheries sector varies considerably from state to state, as do future plans. Yap has reserved inshore marine resources for subsistence and artisanal fisheries only, and is under traditional control and management. Chuuk State is trying to encourage small scale commercial fishing of inshore areas, primarily to satisfy the domestic demand, but also with a view to generating export revenue. Virtually no quantitative stock assessment information is available for inshore marine resources in FSM. For the domestic inshore fisheries the collection of catch and market data varies considerably from state to state. With the exception of Kosrae, there are no estimates for the subsistence harvest of marine resources. Until reliable harvest information is available, management of the resources will be extremely difficult. The collection and analysis of catch information should be made a priority by all states.

The development of inshore fisheries should be undertaken with caution as these resources are easily over-exploited. To date development has been largely piecemeal, with no overall development plan. Marketing difficulties, especially with exports, has been a major problem with small scale fisheries development.

The development of aquaculture in FSM has been restricted to reseeding programs for giant clams and trochus, seaweed farming and sponge farming trials. A review of the FSM aquaculture activities in 1990 indicated that the sector will not be a significant revenue earner for the country. However, certain fin-fish species, giant clam and sponge farming may be suitable for artisanal level production.

Legislation regarding the exploitation and management of marine resources at both the national and state levels urgently requires reviewing and updating. A large portion of the legislation has been transferred from the former Trust Territory of the Pacific Islands code and needs to be modified to suit the activities occurring in each state. There also appears to be unnecessary duplication between the national and state laws.

There is very little cooperation between the various marine resource management agencies. Each state

acts independently, often repeating the same mistakes made previously by other states. Considerable benefits could be obtained by a greater exchange of information. For example, the management of trochus harvesting has varied from state to state, and there has been virtually no exchange of survey and management information. With the increased emphasis on fisheries development, a greater exchange of information between the states is essential.

A. BACKGROUND

A.1 THE COUNTRY

The Federated States of Micronesia (FSM) consists of 607 islands spread over more than a million square miles of the Western Pacific Ocean, within an east-west chain of islands known as the Caroline Islands. FSM lies between the equator and 14°N latitude and between 135°E and 166°E longitude. The islands vary from large, high mountainous islands of volcanic origin to small coral atolls. The total land area is only 270.6 square miles, with 2,776 square miles of lagoons, and an Exclusive Economic Zone (EEZ) of over 1,149,508 square miles. Approximately 59 of the islands/atolls are inhabited. The climate is tropical, with relatively uniform temperatures throughout the year (average 80° F or 27° C). Most islands have pronounced wet and dry seasons. The average annual rainfall varies from 110 inches (2,794 mm) in Yap to 180-330 inches (4,572-8,382 mm) in Pohnpei.

FSM is divided into four states: Kosrae, Pohnpei, Chuuk and Yap. **Kosrae State** is the eastern most and consists of one island formation (of five very closely situated islands), with 43.2 square miles of land and no lagoons. The state is largely mountainous with the interior densely forested and only the coastal areas inhabited.

Pohnpei State is composed of the main island, Pohnpei proper, which consists of a single large volcanic island with 25 smaller islands, within a barrier reef, and 137 widely scattered outer islands grouped in six atolls: Sapwuahfik (Ngatik); Nukuoro; Kapingamarangi; Mwoakilloa (Mokil); Pingelap; and Oroluk. Total land area of the state is 132.2 square miles, of which only 3.2 square miles are outer islands. Pohnpei proper has a narrow littoral zone where most people live, mangrove fringes around most of the island, a large lagoon and a circumferential barrier reef.

Chuuk State consists of five major island groups. The centerpiece is Chuuk lagoon containing 19 high islands of volcanic origin and over 70 small flat islets, enclosed by 125 miles of barrier reef. Total land area of Chuuk lagoon is 38.7 square miles and has over 800 square miles of lagoon area. Chuuk's widely scattered outer islands are divided into four groups: the Hall Islands; Namonuito Atoll; the Western Islands; and the Mortlock Islands. The total land area of the outer islands is only 10.6 square miles, all being low islands or coral atolls.

Yap State is the western most state and consists of Yap proper, which includes four very closely associated high islands and seven smaller ones surrounded by a barrier reef, and 15 outer atolls and islands spread over some 40 percent of the FSM sea area. Yap proper has a total land area of 38.7 square miles and the outer islands only 7.3 square miles.

A.2 THE PEOPLE

FSM people are mainly of Micronesian descent although the inhabitants of Kapingamarangi and Nukuoro in Pohnpei State are of Polynesian origin. The cultural diversity of FSM is reflected in the existence of eight major indigenous languages. Traditional extended family and clan systems are still prominent, but the influence of western customs since World War II has been significant.

FSM is a democratic constitutional federation of the four states. It came into being as a distinct political entity in 1979, became an independent nation in late 1986, and was accepted into the United Nations in 1991. Under a Compact of Free Association with the United States, FSM is responsible for its own internal and foreign affairs, while the US has been delegated the responsibility for defense. Prior to this FSM was part of the United Nations Trust Territory of the Pacific Islands (TTPI) administrated by the US since 1947. Before that the region was administrated by a succession of

colonial administrations under Spain, Germany and Japan.

Three levels of government operate in FSM: the National, State and Municipal. The National and State governments are divided into the executive, legislative and judicial branches. Traditional controls continue to play a major role. The National government is based in Palikir, Pohnpei, and is headed by a President and Vice-President elected by the FSM Congress from among its 14 Senators, who are popularly elected to represent each state. Governors and Lt Governors are popularly elected to head each state. State legislatures are also popularly elected.

In 1990 FSM population was estimated to be 100,520, with the breakdown by states given in Table 1. The national population growth rate has exceeded three percent per annum over much of the last 40 years. In recent years approximately two percent of the population has been leaving to Guam, Hawaii and the US mainland each year resulting in a domestic annual growth rate of below one percent.

Table 1: FSM population: censuses results and 1990 estimates.

	Kosrae	**Pohnpei**	**Chuuk**	**Yap**	**FSM**
1990 estimate	7,435	33,346	48,853	10,886	100,520
(% of total FSM)	(7.4)	(33.1)	(48.7)	(10.8)	(100)
Census results (year)	6,607 (1986)	28,671 (1985)	47,871 (1989)	10,147 (1987)	
(% outer islands)	(-)	(8.6)	(19.9)	(34.5)	

Currently 47 percent of FSM population is under 15 years of age. A considerable proportion of the population is concentrated on the main islands (Table 1). These patterns will have significant implications for the demand of social services and the need for economic development.

A.3 MARINE RESOURCES

A.3.1 Institutions

There are a considerable number of government and semi-government agencies involved with marine resources exploitation and management at the national as well as state levels. A number of these agencies appear to have overlapping responsibilities, and there is often little coordination or cooperation within or between states. The states, for all intents and purposes, operate independently in fisheries matters. The following are outlines of the various agencies' responsibilities and current activities.

FSM Government: The National government's **Marine Resources Division (NMRD)** of the Department of Resources and Development is responsible for providing the governments (national and state) with technical information, coordinating training, advisory services and support for development and management activities in marine resources including fisheries, aquaculture and coastal resource management. It is additionally responsible for non-living marine resources within the 200 mile EEZ. A major function is to liaise (through the Department of External Affairs) with foreign and international agencies concerning marine resources, for the purpose of exchanging information on opportunities for training, marketing, project funding and related matters.

One of the NMRD responsibilities is administering the **National Aquaculture Center (NAC)** based in Kosrae. The NAC was set up to provide expertise and a focal point for demonstration, training, research and advisory services for all types of aquaculture in FSM. It began operating in 1991 with a small hatchery and quarantine system for giant clams. An expatriate hatchery manager was recently recruited. Also stationed at the NAC is an aquaculture extension agent for the US affiliated Pacific islands funded by the US government. The priority and exclusive initial activity of NAC is to establish giant clam spawning for the production of seed. A demonstration grow-out farm is being established on the adjacent reef.

The **Micronesian Maritime Authority (MMA)** was established to regulate the use of and to manage and conserve the resources within the 200 mile EEZ. It is a semi-autonomous government body headed by an Executive Director reporting to a Board of Directors. MMA's functions include:

- To adopt and promulgate regulations for the conservation, management, and exploitation of all living resources in the EEZ.

- To negotiate and execute foreign fishing agreements.

- To issue foreign fishing permits.

- To participate in the planning and execution of programs relating to fisheries, or fishing in the EEZ in which any agency of the Government has a propriety interest, direct or indirect, by way of stock ownership, partnership, joint venture, or otherwise.

- To provide technical assistance in the delimitation of the EEZ.

- To perform such other duties and functions as may be necessary to carry out the purposes of Title 24 of FSM Code.

MMA's major activities include: data collection; an observer program; access fishing negotiations; fee collection; and regional and international involvement. Fishing access fees for 1989 contributed more than 61 percent of FSM domestic revenue and 25 percent of total national revenue. Fees in 1990 raised US$14.63 million.

The **Division of Marine Surveillance**, Office of the Attorney General, is responsible for the surveillance and enforcement of the FSM EEZ. The Division currently operates two patrol boats supplied by the government of Australia.

The **National Fisheries Corporation (NFC)** is the business arm of the national government and has the responsibility of promoting the development of the pelagic fisheries and related industries within the EEZ. The NFC is managed by an Executive Director and is under the policy control of a Board of Directors. The NFC is authorized to engage in all commercial fishing activities, enter into joint ventures, and to invest in the expansion and improvement of FSM fishing industry. NFC is currently involved in a number of joint venture agreements with the states to develop a domestic tuna longlining industry and associated shore facilities. NFC is also involved with two joint ventures with Yap and Pohnpei states, both of which involve purse seiners.

Kosrae: The **Marine Resources Division (KMRD)** of the Department of Conservation and Development is the only state agency responsible for the management and development of marine

resources. Its functions include the collection, collation, processing and analysis of statistics, the promotion of marine resource conservation through public education, sanctuary maintenance and marine park establishment, and for recommending regulations for the conservation and protection of marine resources. KMRD also operates an outboard engine and mechanical workshop. Additionally, KMRD is involved with developing a domestic longlining operation, and the operation of the new fisheries complex and its two substations.

Pohnpei: The **Marine Resources Division (PMRD)** of the Department of Conservation and Resource Surveillance is responsible for the conservation and management of the state's marine resources, administration, extension, advice and training, the collection of resource statistics, and the research and development of artisanal, aquaculture and small scale fisheries. As one of PMRD's functions it operates a small giant clam hatchery.

The **Economic Development Authority (EDA)** is responsible for promoting economic development through expansion of agriculture, marine resources, tourism, industry, energy development, banking, transportation and community development in the state. The EDA has authority to be the sole entity to promote, develop, and support commercial utilization of living marine resources of the state. It is currently involved with a joint venture with NFC and an Australian company to operate three purse seiners.

Chuuk: The former Truk Maritime Authority and the Division of Marine Resources were combined in 1990 into the **Department of Marine Resources (CDMR)**, which consists of the Division of Fisheries Research and Development (FRD), the Division of Conservation and Management (C&M), and the Division of Operation and Technical Support (OTS). The CDMR is responsible for the conservation, promotion, development, marketing, economic viability and support of mariculture products, fisheries, and commercial utilization of marine resources in the state. FRD currently assists with the Overseas Fishery Cooperation Foundation (OFCF) baitfish project, and is responsible for collecting fisheries statistics. C&M patrol the lagoon to check for illegal fishing activities, such as dynamite fishing, trochus poaching, and turtle harvesting out of season. OTS assists the municipalities with the technical aspects of fisheries operations, including engine and refrigeration repairs. The CDMR operates one 14 g/t longline vessel which was provided through Japanese aid. The Chuuk government owns 19 vessels from 10 to 22 m which are leased to the municipal governments and private operators. Small cold storage and ice making facilities have been provided to a number of municipalities, and a 170 ton cold storage facility was built on the island of Tonowas.

Yap: The **Marine Resources Management Division (YMRMD)** of the Department of Resources and Development is primarily responsible for conservation, assessment and management of the states's marine resources. Its functions include carrying out basic marine biology studies, stock assessments, fisheries development, aquaculture, education and extension, marine environmental protection, and collecting and recording traditional marine knowledge. Current projects include the implementation of a marine resources and coastal management plan, turtle tagging and management project, giant clam reseeding, trochus transplanting, a reef management demonstration project, and market and export surveys.

The **Yap Fishing Authority (YFA)** is a semi-autonomous government agency responsible for the development of commercial fisheries, as well as the conservation, management, and exploitation of the state's marine resources. The overlap of responsibilities with YMRMD is currently being addressed (Smith & Dahl, 1991), but generally YMRMD has taken responsibility for the state's internal waters, and YFA the state fishery zone (which is from the island baseline out 12 miles). YFA's main activities are the servicing of foreign longlining vessels, transhipping, longlining for sashimi grade tuna with two 14 g/t vessels, and some bottom fishing and trolling for export by its

smaller boats. It is currently involved with a number of joint venture agreements.

Joint-ventures: There are currently a number of joint ventures operating or being formed in FSM, all of which relate to the tuna fishery.

Chuuk Fresh Tuna - Chuuk State and NFC; development of a tuna longline base in Weno.

Sanko Bussan - Japanese company with a transshipment agreement with the Chuuk Government to tranship fresh sashimi grade tuna to Japan.

Pacific Tuna Industries - Kosrae State and a foreign partner; to develop a tuna loining plant and cannery and a base to service foreign purse seiners and longliners.

Caroline Fisheries Corporation - Pohnpei State, NFC and an Australian company; purse seine operation with three vessels.

Yap Fishing Corporation - Yap State, NFC and a US company (Gemini); purse seining operation with four vessels.

Yap Fresh Tuna - YFA and NFC; transshipment facility for longline vessels.

Micronesian Fresh Tuna - NFC; temporary company set up to operate four longliners out of Yap and possibly Chuuk.

YFA and Ting-Hong & Oceanic Company; YFA and Okinawa Fisheries International - transshipment agreements for longline vessels to operate out of Yap.

A.3.2 Educational Institutions & Non-Government Organizations

The **Community College of Micronesia (CCM)** in Kolonia , Pohnpei, has a two year Associate Sciences degree in Marine Resources. To date, two students have graduated and a further six are undertaking the course.

The **Micronesian Maritime and Fisheries Academy** in Yap is operated by Pacific Missionary Aviation (PMA) and was established in 1990. FSM government and the four states have endorsed the academy and formed an advisory board to establish goals and objectives. The present approach to training is to service the existing needs of the fishing sector through the operation of skipper, deckhand and marine engineer courses. The proposed Asian Development Bank funded fisheries development project would provide considerable assistance to the Academy.

The **Micronesian Island Conservation (MIC)** is a non-government organization (NGO) whose purpose is to help educate the people of Micronesia about the importance of natural resources conservation and to sponsor activities aimed at protecting and understanding Micronesia's unique natural environment. Current membership is 45. It is based at CCM in Pohnpei.

The **Yap Institute of Natural Science** in Colonia, Yap, is a small, local nonprofit organization engaged in the collection of ethnobiological knowledge and research in natural history, adaptive technology and ecodevelopment, making applications where possible. It has recently been involved in recording Yap State's traditional fishing methods and management systems.

A.3.3 Management & Development Plans

FSM: The national government is currently reviewing a draft of a specific fisheries policy prepared for FSM. No details are available.

The Second National Development Plan covers the period 1992-1996 (OPS, 1992). The fisheries sector objectives and policies are broken down into commercial fisheries, artisanal fisheries and aquaculture.

Commercial fisheries - The objectives are: (i) substantial domestic involvement in the tuna fishery should be attained within ten years; (ii) tuna-related on-shore capital investment, including processing, should be made in each state; (iii) tuna resources should be managed for long term sustained yield; and (iv) liaison should be further developed between the states, the MMA, the national government and the NFC, and other involved entities. The government's policy is: to enter the purse seine industry by purchasing vessels; to enter the longline industry by attracting foreign longliners to relocate to FSM ports thus building up a FSM-based air freight service while the domestic longline fleet increases; and to construct shore facilities in each of the four states to support tuna transshipment operations which will concentrate on the Japanese market, and, where commercially viable, tuna canning or other processing.

Artisanal fisheries - The objectives are: (i) increase the artisanal harvest and local consumption of marine products; (ii) manage marine resources for long-term benefits; and (iii) enhance artisanal fisheries marketing, including export sales where appropriate. The government's policy is to avoid direct participation in the artisanal fisheries sub-sector, preferring to assist the industry by providing support facilities such as FADs, market outlets, collector vessels and fisheries depots.

Aquaculture - The objectives are: (i) to develop or import viable aquaculture technologies; (ii) to transfer those technologies to the private sector, either at the subsistence or commercial level; and (iii) where practical, to use aquaculture technologies to introduce species or re-stock depleted areas. This will be accomplished by creating central resource facilities that can provide seedstock and extension services.

Chuuk: The government is intent on economic development and on stemming the out migration by creating employment opportunities. Within the economic development sector, fisheries is the priority sub-sector, with longlining as the priority fishery. The proposed objectives for the marine resources sector for Chuuk State during 1992-1996 are (DPS, 1992): (i) develop capabilities to harvest, process, and market pelagic fish resources; (ii) establish a domestic fish distribution and marketing system and necessary infrastructures to stimulate commercial activities in the sector; (iii) provide training at both managerial and technical levels to compliment development in the sector; (iv) support development of artisanal fisheries through technical assistance and resource enhancement programs; (v) develop under-utilized marine resources to broaden the state marine resources base; and (vi) promote conservation and management of renewable marine resources. The three primary goals are: (1) vertical integration of artisanal and pelagic fisheries; (2) development of under-utilized marine products for domestic and export markets; and (3) effective conservation and management of valuable marine resources.

Pohnpei: The First State Development Plan for the period 1987-1991 stated the marine resources development objectives were to promote import substitution and the strict conservation of lagoon and inshore fisheries through: (i) improving the state's understanding and knowledge of marine resources; (ii) ensuring better enforcement of conservation laws to restrict commercial fishing in reef and lagoon areas; (iii) investigating the feasibility of a small cannery aimed at import substitution for canned tuna

and other canned fish products; (iv) introducing fish processing and handling systems in outer islands that are appropriate to the technical skills and available support; and (v) upgrading artisanal fisheries by providing the necessary facilities, training and other promotional support to local fishermen and fishing organizations.

Yap: The draft Yap State Second Five-Year Development Plan 1991-1994 has designated the fishing industry as the top priority sector in terms of economic development. In pursuing fisheries development a distinction is made between artisanal and large scale commercial fisheries. Artisanal fishing will have absolute priority in inshore waters and reefs of the inhabited islands, or close to them. Traditional fishing rights are to be respected and not encroached upon by the corporate type commercial fishing. Traditional authorities are encouraged to supervise the harvesting of reef resources and regulate access to them in such a way as to properly maintain the stocks. In Yap proper, retail sale of reef fish, through stores and restaurants, should in principle be left to local individual fishermen. The development of larger scale commercial fishing, as pursued by YFA, aims at export markets and uses mostly resources from high seas and outlying submerged reefs. The top priority area of commercial fishing in Yap State is to be longlining for tuna, aiming at the sashimi market in Japan. In fishing as in other industries, the State government prefers to promote private entrepreneurship rather than public operations.

Coastal management plans: Both Yap and Kosrae States have prepared coastal management plans which they are in the process of reviewing and implementing. Pohnpei State had a draft coastal management plan prepared (Holthus, 1987) but was never implemented.

A.3.4 The Fisheries

The majority of fishing in FSM is conducted at the subsistence or artisanal level, with outer islands virtually self-sufficient in their requirements for marine produce. Numerous small-scale fishermen operate on the main islands of each state, selling their catch (often only what is surplus to their subsistence requirements) through family and other retail outlets in the main urban centers. A few fishermen and retailers also export reef fish and pelagics on an irregular basis. These fisheries mostly rely on the inshore marine resources which are susceptible to over-exploitation. The most common fishing methods are: spearfishing (both at night with flashlights and during the day); trolling from small (15-25 feet) outboard powered boats; handlining; gillnets; and cast-nets. Unfortunately, dynamite fishing still occurs in Chuuk lagoon. Ownership and control of the inshore areas varies from State ownership in Kosrae and Pohnpei to traditional control in Chuuk and Yap.

Japan and the US Government have financed small (under 30 feet) fishing vessels in Chuuk and Kosrae states which have been leased or given to private individuals and municipalities. These aid projects were designed to encourage the small-scale commercial fisheries but have not been successful. Marketing problems have been a major contributing factor to their failure. Small scale commercial fisheries development in the past has been hampered by the somewhat piecemeal manner with which a range of unrelated projects have been promoted, rather than an integrated plan for overall development.

The EEZ contains substantial tuna stocks which are fished primarily by foreign longline, purse seine and pole-and-line vessels on a year round basis. Significant revenues are derived from licensing these vessels but the ultimate aim of the national government is for greater domestic participation in harvesting and processing these tuna resources.

The state and national governments have had great expectations for the commercial development of aquaculture and mariculture products. To date there has been minimal success. With the exception of

irregular trochus harvesting, where transplanting has been undertaken since the Japanese administration, there have been no commercial successes. Aquaculture projects recently and currently attempted include: trochus reseeding and transplanting; clam farming/grow-out and reseeding; seaweed; blacklip pearl oyster; and sponges. A review of FSM aquaculture sector (APTA, 1990) found that the prospects for commercial activities have been exaggerated, and that the evidence suggests that the sector will not be a significant revenue earner for FSM. They suggested that the aquaculture of giant clams be given top priority for research and development, with sponge growth, production and marketing receiving second priority, and thirdly trochus research.

B. MARINE RESOURCES PROFILES

1. CRUSTACEANS

1.1 MANGROVE (MUD) CRABS

1.1.1 The Resource

Species Present: The mangrove or mud crab, *Scylla serrata*.

Distribution: The mangrove crab is found on all the high islands in FSM: Kosrae, Pohnpei, Chuuk lagoon and Yap proper.

Biology & Ecology: Mangrove crabs become sexually mature at about 4.7 inches (120 mm) carapace width, around two to three years of age. Perrine (1978) recorded a lunar periodicity of the seaward movements of spawning females at Pohnpei, with a peak around the new moon. Except for those migrations, the crabs in the study did not move more than 0.6 mile (1 km). Each female will produce around 5 million eggs per spawning. These hatch to produce planktonic larvae, which flow back on the tide and are recruited to the mangroves near the parental biomass (Nichols, 1991). Juveniles (20-80 mm carapace width) remain in the mangroves at low tide. Sub-adults (80-120 mm) and adults (>120 mm) migrate to intertidal habitats at high tide, retreating again at low tide (Nichols, 1991; Perrine, 1978). Perrine (1978) found that burrows were used primarily by male crabs for temporary shelter.

1.1.2 The Fishery

Utilization: The mangrove crab is highly considered as a subsistence food on all islands where it occurs. There is also a commercial demand locally, especially from restaurants, as well as an export demand.

On Pohnpei, crabs are mostly caught in the mangroves during the day at low tide, primarily by extracting them from burrows, but are also caught amongst the mangrove roots or in the open. Crabs caught in this way were 84 percent male in Perrine's (1978) study. A smaller amount of crabs are caught at night, during very low tides, on the sandy reef flats extending out from the mangroves. These crabs are caught by hand amongst the seagrass, and are usually 50 percent female, depending on the lunar phase (Perrine, 1978). Small numbers are also speared. There has been some limited trapping.

In Kosrae, mangrove crabs are caught mostly by the women either by hand in the mangrove swamps and the adjacent reef flats at low tide during the day, or by using baited lines from adjacent rivers or estuarine waters (Lal, 1989; Rochers, 1989). April through July are the best months to catch crabs (Rochers, 1989).

Production & Marketing: The data available on mangrove crab production and marketing is sparse. No information is available on the subsistence or commercial harvests of mangrove crabs on Yap or Chuuk.

In 1989 on Kosrae, the average number of crabs retailed locally per month was at least 625 pounds (283 kg) at a value of US$938, plus some direct sales by households (Lal, 1989). The amount of crabs shipped to relatives and friends during the first six months of 1989 was 1,496 pounds (679 kg), but does not include those taken on board as personal luggage (Lal, 1989). Mangrove crab exports from

Kosrae for 1986 to mid-1989 are given below:

Year	Weight (lbs)	Value ($)
1986	258	279
1987	1,554	2,211
1988	2,426	11,779
1989(Jan-June)	909	2,554

The 1987-88 period was when the now defunct fishing cooperative operated. The 1988 shipments were of frozen crabs to a single company in Saipan. The export price was US$2.25/lb FOB (Lal, 1989). Currently there are only shipments to relatives.

For Pohnpei, Perrine (1978) lists the retail sales of crabs for 1977 as 10,703 pounds (4,855 kg), and for the first five months of 1978 as 5,385 pounds (2443 kg). The catch through the public market and the estimated subsistence catch is given below (PMRD statistics):

	1986	1987	1988	1989	1990	1991	
Market (lbs)	10,687	13,844	1,302	10,582	?	3,736	
Subsistence (lbs)		2,000	2,474	1,224	6,614	?	?
Total:	12,687	16,318	2,526	17,196	?	3,736	

1.1.3 Status Of The Stocks

There have been no recent assessments of mangrove crab stocks. Perrine (1978) estimated Pohnpei's mangrove channels to have populations of 2 to 80 crabs each.

Kosrae plans to conduct a mangrove stock assessment project within the coming year to assist in estimating a safe domestic harvest level, and to assess the feasibility of exporting (KMRD files).

1.1.4 Management

Current Legislation/Policy Regarding Exploitation: Pohnpei is the only state with legislation concerning mangrove crabs. Pohnpei State Law 2L-223-71 makes the export for sale of mangrove crabs illegal (penalty: up to two years in jail or a maximum of US$1,000 fine). An amendment was passed in 1977 at the request of PMRD to exempt mangrove crabs from this prohibition for a period of one year. In 1978 a proposal was submitted the permanently exempt mangrove crabs from the export ban, but was not acted on (Perrine, 1978).

Pohnpei State Law 2L-106-81 Title VI prohibits the taking, by any means, or the possession of, mangrove crabs carrying eggs. Criminal penalties of up to one year in jail or fines of not more than US$1,000, or both apply. In additional, civil penalties of 10 times the market value of the crabs carrying eggs will apply.

Recommended Legislation/Policy Regarding Exploitation: Until adequate stock assessments are conducted and estimates of harvesting obtained, it will be difficult to set management policies. Until such studies are conducted, the states should consider prohibiting, or at least limiting, the export of

mangrove crabs. In addition, the protection of mangrove habitat is of prime importance to the maintenance of mangrove crab stocks.

Kosrae MRD have recommended the following regulations for mangrove crabs:

- a legal harvestable size not less than six inches (153 mm) carapace width;

- prohibiting the take of females with eggs.

Perrine (1978) lists the following options for protective legislation:

1. Closed seasons - with closures related to either peak season for molting or spawning;

2. Prohibition of landing soft-shelled crabs;

3. Prohibition of taking females or females with eggs - to conserve breeding stock;

4. Minimum size limits;

5. Establishment of sanctuaries;

6. Prohibition or regulation of certain types of gear;

7. Licensing of fishermen, allocation of fishing areas, and limits on catch and/or gear;

1.2 LAND CRAB

1.2.1 The Resource

Species Present: *Cardiosoma* species. No references to the exact species present could be found.

Distribution: Land crabs are found throughout FSM.

Biology & Ecology: Adult land crabs live in the inland areas of islands amongst the ground cover vegetation, and come out at night to feed. Several days before the full moon, especially during the summer months (May-June) they undertake mass migrations to the sea. The crabs emerge at dusk, around two days before the full moon and make their way to the shore. The larvae are released from the eggs into the waves by vigorous flapping of the abdomen. Release of larvae at spring tides presumably maximizes dispersal along the coast (Nichols, 1991).

1.2.2 The Fishery

Utilization: Land crabs are used primarily for subsistence purposes, and are mainly consumed as a change of diet. They are caught alive by hand at night, especially during their spawning migrations. There is some use of land crabs in local restaurants.

Production & Marketing: There are no data available on land crab production in FSM. Graham's (1991a) study of Air Micronesia's air freight records out of Yap indicate that the export of land crabs is on the increase. He found a marked seasonality in crab (land, mangrove and coconut crabs) exports during both 1990 and 1991, with a peak in May-June probably reflecting the availability of land crabs. In the first nine months of 1991 crab exports were running at roughly twice the 1990 rate. These figures are given below:

		Jan-June		Jul-Dec	Jan-June	Jul-Sept
Total:	**1990**	**1990**	**1991**	**1991**		
Crabs (lbs):	4,000	2,400	10,000	2,700		
By species:						
Unknown (%):	82	78	76	66		
Land (%):		18	22	22	30	
Coconut (%):	0	0		2	4	
Mangrove (%):		?	?		?	?

Freight documentation only rarely recorded crab species, but Graham (1991a) suggests that land crabs made up about 70 to 90 percent of all crab exports.

Saipan received twice as much crab from Yap as Guam during 1990, but in 1991 Guam received more than three times as much as Saipan. Palau received 15 and 10 percent during these years. No crabs were sent to any other destination, except a nominal amount to Pohnpei in 1990. Two individuals shipped 35 percent of all crab during 1990 and 1991, and two received the same amount, both in Guam (Graham, 1991a). Live and cooked product dominated in shipments, with small amounts being frozen (notably coconut crabs), figures are shown below:

Crab:	**Live**	**Frozen**	**Smoked**	**Cooked**	**Unknown**
Unknown (%):	52	4	<1	11	33

Land (%):		26		0	0		75		0	
Mangrove (%):		?		?	?		?		?	
Coconut (%):	5	95	0		0		0			

1.2.3 Status Of The Stocks

No data is available for stock estimates anywhere in FSM.

1.2.4 Management

Current Legislation/Policy Regarding Exploitation: There is currently no legislation in any of the states concerning land crabs.

Recommended Legislation/Policy Regarding Exploitation: Until more information is collected concerning exploitation and some estimates of stocks are available, it will be difficult to recommend any legislation or policy. A check should be kept on the levels of exports from Yap, and a first step in management policy should be a control over export. Currently, no marine resources personnel in any of the states consider there to be any problem based on their observations.

1.3 COCONUT CRAB

1.3.1 The Resource

Species Present: The coconut crab, *Birgus latro*.

Distribution: Coconut crabs have a wide Indo-Pacific distribution, from the Seychelles to Tuamotu Archipelago in the eastern Pacific. In FSM they are found on the high islands (but not on Pohnpei proper) and many atolls.

Biology & Ecology: Coconut crabs are omnivorous scavengers. The species is the largest and least marine dependent of the land crabs. Growth is very slow and heavily influenced by environmental factors, which is a key reason why the species cannot be commercially cultured. Large adults may attain 8.8 pounds (4 kg) weight (Brown & Fielder, 1988). Reese (1971) estimated that size at maturity is around three to five inches (7.6-12.7 cm) carapace width for crabs on Eniwetok, at an age of four to eight years. Fletcher (1988), working in Vanuatu, estimated a 1.3 pound (600 g) crab to be 12 to 15 years old. Molting takes about a month and is carried out in a shallow hole plugged with earth forming a visible hump on the surface. Mating occurs in summer months (May to September), with a peak in July to August (Reese, 1971). The female carries the eggs under her abdomen attached to hairs. After about one month the female moves to the shore and releases the eggs into the sea. After hatching, the larvae remain planktonic for around four to five weeks before settling, developing a shell and becoming amphibious. The young crab will carry a shell for around nine months, becoming increasingly terrigenous (Brown & Fielder, 1988). As they grow they move further inland away from the coast.

Fletcher (1988) found recruitment to be low and highly variable. Replenishment of heavily exploited populations is therefore slow.

1.3.2 The Fishery

Utilization: Coconut crabs are collected and eaten as a delicacy throughout Micronesia (Reese, 1971). Collection is primarily for subsistence purposes, but there is some commercial harvest for both local and export markets.

Coconut crabs are caught at night with coconut meat baits laid in the bush, or by searching for burrows with pointed sticks during either day or night. Coconut crabs can be kept alive, with their claws and legs bound, for days if undamaged and kept cool. Whether for local consumption, domestic or export markets, by keeping the crab alive the need for ice or freezing is eliminated.

Production & Marketing: The subsistence harvest of coconut crabs is unknown, nor is the amount entering the domestic or export markets. In Kosrae, there is only a very low subsistence take (Molina, pers. comm., 1992). In Chuuk there is only a subsistence harvest, with some export to relatives in Guam (CDMR staff, pers. comm., 1992). In Pohnpei, they are brought in from Ant Atoll and the outer islands, but are not sold in the markets, an unknown quantity are, however, exported (Ludwig & Curren, pers. comm., 1992). Yaps's harvest is mostly subsistence, with some small amounts exported. Air Micronesia's air freight records for Yap show that about 308 pounds (140 kg) of coconut crabs were exported in the first nine months of 1991 (Graham, 1991a). This is a minimum figure as 76% of the 19,100 pounds of crab exports (land, mangrove and coconut crabs) for the 21 months from January 1990, were not identified by species in the records. Graham (1991a) estimates that 70 to 90 percent of all crab exports are of land crabs.

1.3.3 Status Of The Stocks

Current coconut crab stock status is unknown for any area of FSM.

1.3.4 Management

Current Legislation/Policy Regarding Exploitation: Only Pohnpei and Yap States have legislation concerning coconut crabs.

Pohnpei State Law (2L-223-71) prohibits the export of coconut crabs for sale or exchange for value. Penalties of up to two years jail or a fine not exceeding US$1,000 apply.

Yap State Code (Title 18, section 1004) prohibits:

- the take of coconut crabs less than three inches "in diameter measured at the base";
- the take of any crabs from June 1 to September 30;
- their commercial sale in any wholesale or retail store.

Penalties are a fine up to US$100, or imprisonment for not more than 30 days, or both.

Recommended Legislation/Policy Regarding Exploitation: Kosrae MRD has recommended the protection of their coconut crabs through setting a minimum harvestable size of two inches (5.1 cm) in tail length, and a prohibition on the taking of females with eggs.

Until there is some coconut crab stock assessment information available for FSM, all domestic and export sales should be stopped. Coconut crab biology (low and highly variable recruitment and slow growth) does not lend to commercial exploitation of this species.

Reese (1971) suggested a three step plan to manage and control coconut crab exploitation in Palau, Yap, Saipan and Guam, noting that enforcement of steps 1 and 2 would be a major problem:

Step 1:

- prohibition of the collection of crabs with a carapace width less than three inches at any time;
- no collection of egg carrying females at any time;
- no collection of crabs during the breeding season (June 1 to August 31).

Step 2:

- set up protected areas where harvesting is initially prohibited, with controlled harvesting at a later time as populations build up;
- establish nature trails in such reserves for education of local people and tourists.

Step 3:

- establish a hatchery to enhance recruitment to natural populations.

1.4 LOBSTER

1.4.1 The Resource

Species Present: The two species of rock lobster with commercial value in FSM are *Panulirus penicillatus* and *Panulirus versicolor*. A less abundant species of low commercial value, *Panulirus longipes femoristriga*, is also present. The ornate lobster, *Panulirus ornatus*, may also be present but in very low numbers. The slipper lobster, possibly *Scylarides neocaledonicus*, occurs in low numbers.

Distribution: All species are distributed throughout FSM.

Biology & Ecology: MacDonald (1971b, 1979) provides a comprehensive study of the Micronesian rock lobsters, but concentrates on Palau.

P. penicillatus is the most abundant and largest (up to 5 lbs) species, but occupies a limited range of habitats. It is most commonly found on the outer reef slope in the sectors most often exposed to the prevailing winds (north-easterly). They are found from one foot (0.3 m) to 16 feet (4.9 m) deep, but their greatest concentration is from 4 to 6 feet (1.2-1.8 m) deep. This species is gregarious, especially sheltering under plate corals (*Acropora spp*), along surge channels and under ledges. It is also found in the wave washed zone on the reef flats, and to a lesser extent it is present within lagoons, but only where the wind and wave action is sufficient.

P. versicolor is a smaller species (< 4 lbs) and prefers calm water inside and outside the lagoon to a depth of 70 feet (21 m). The species is often found under *Porites lutea* coral heads. It is not gregarious, with adults rarely sharing the same shelter.

P. longipes femoristriga is small (< 1.5 lbs) and occupies a habitat intermediate to the above species. It occupies clear water just on the lagoon side of active reef edges amongst dense coral growth. In Pohnpei and Chuuk it has been reported from shallow water below the surge zone outside the reefs.

P. ornatus is a large species and there are unconfirmed reports of it from deeper waters (30 - 100 feet) throughout FSM. The slipper lobster, *Scylarides neocaledonicus* is uncommon and occupies the surge zone with *P. penicillatus.*

Carapace size at sexual maturity for *P. penicillatus* in Palau is 10 cm and in the Solomons 7.5 - 7.9 cm; for *P. versicolor* in Palau it was around 8.2 cm (MacDonald, 1982 in Nichols, 1991; Skewes, 1990). *P. penicillatus* and *P. versicolor* at Palau reproduce throughout the year, with about 40 percent of females being ovigerous (bearing eggs) in any month (MacDonald, 1979). The total standardized crude reproductive rate of female *P. versicolor* is much greater than that of *P. penicillatus* (MacDonald, 1979). Larvae of tropical lobsters remain planktonic for many months, perhaps as long as six to ten months (MacDonald, 1971b). Therefore recruitment may occur from spawning adult populations a considerable distance away.

1.4.2 The Fishery

Utilization: Spiny lobsters are exploited as a subsistence food resource throughout FSM. They have been commercially fished in Chuuk since at least 1968 (MacDonald, 1979).Trap fishing is not successful as *P. versicolor* does not enter traps and the habitat of *P. penicillatus* is unsuitable for trapping (MacDonald, 1971b). Spiny lobsters are most often speared by divers, mostly during the day but also at night with flashlights. In many of the outer islands and also Chuuk, *P. penicillatus* can be

caught by hand on the reef flats at night during the full moon at low tide.

Production & Marketing: Commercial lobster catches in Chuuk and Palau have tended to be seasonal, with the seasonal north-east trade winds affecting accessibility to the lobsters (MacDonald, 1979). There is no information available on the level of subsistence harvest in FSM.

The following figures are for the commercial catch of lobsters in Chuuk (Anon., 1991a):

		1986	1987	1988	1989	1990
Qty (lbs):	6,681	217	185	217	2,252	
Value (US$):	8,400	253	148	217	2,800	

Yap State has recently started compiling data on the export of marine products from Yap by examining Air Micronesia's cargo records (Graham, 1991a). During 1990, 100 pounds were exported to Guam (25%) and Saipan (75%); and for the first nine months of 1991, 900 pounds were sent to Guam.

Lobsters are sold in Pohnpei markets and restaurants, and some are exported (Ludwig & Curren, pers. comm., 1992). The Pohnpei market figures are given below (PMRD statistics):

	1986	1987	1988	1989	1990	1991
Market (lbs)	1,385	6,116	1,033	3,307	?	2,373

Kosrae also sells lobsters in their market, and there is interest in exporting, but to date only one shipment has been sent (Molina, pers. comm., 1992).

The catch is currently primarily subsistence and for the domestic market, with only some export.

1.4.3 Status Of The Stocks

In 1985, MMA authorized a survey of commercial lobster species n the submerged reefs between Chuuk and Yap. After a 20 day trip no lobsters were caught (MMA, 1990).

There is no information available on the status of the spiny lobster stocks for any states in FSM. There is no evidence to suggest that they are being over-harvested. Kosrae MRD proposes to conduct a mangrove crab and lobster stock assessment project in the coming year, with the aim of establishing a safe sustainable level of harvest for local consumption, and to evaluate the viability of exporting.

1.4.4 Management

Current Legislation/Policy Regarding Exploitation: The only legislation regarding lobsters anywhere in FSM is a Pohnpei State law (2L-223-71) prohibiting the exportation of lobster for sale or exchange for value. The penalty is imprisonment of up to two years or a fine of up to US$1,000.

Recommended Legislation/Policy Regarding Exploitation: There is very little information on which to formulate policies. Of prime importance is the collection of catch, market and export data.

Kosrae MRD has recommended regulations to protect the three main species of spiny lobster by suggesting a minimum harvestable size (1 lb or 3 inches carapace length), and for the taking of females with eggs to be prohibited (KMRD files).

MacDonald (1971b) argues against regulations prohibiting the taking of females with eggs. He asserts that the number of mature females is not the limiting factor for lobster population size, but that the lack of suitable habitat for larval settlement is (especially in Micronesia). He further suggests that even heavy removal of mature females will leave enough spawners to provide sufficient young to maintain high population levels. The inaccessibility of the lobsters' habitat due to strong winds and heavy surf for half the year provides enough protection to maintain stocks. He believes that the variation in stocks that occur have resulted from favorable or unfavorable marine environmental conditions regardless of the size of the spawning stock.

In relation to minimum size limits, MacDonald (1971b) recommends that if imposed, they should not serve to insure that lobsters spawn at least once but should rather exist as an economic regulation to prevent harvest of unmarketable individuals and/or as a biological regulation to maintain maximum sustainable yield. Further, he considers that management proposals to discontinue spearing are not warranted unless the market value can be substantially improved by alternate methods or unless the quality of the product is jeopardized through rapid spoilage after spearing.

1.5 DEEP-WATER SHRIMP

1.5.1 The Resource

Species Present: The caridean shrimps *Heterocarpus laevigatus* (smooth nylon shrimp) and *Heterocarpus ensifer* (armed nylon shrimp). Other species are also present, but are of minimal significance commercially.

Nautilus species are also caught in deep-water shrimp traps and may represent a valuable by-catch. The deep-sea red crab, *Geryon spp.*, is of commercial value in the US and is caught in depths greater than 330 fathoms (600 m)(King, 1986).

Distribution: Small numbers of these caridean shrimps were found during preliminary surveys of Yap and Kosrae (Saunders, 1987, 1988).

Their distribution is highly depth related, with species occupying different but overlapping depth ranges. Medium sized *Heterocarpus* species predominate in catches over 220 fathoms (400 m), and the largest, *H. laevigatus* is common below about 270 fathoms (500 m)(King, 1986). Trapping tests indicate that the depth distributions of these species may change seasonally (King, 1986).

Biology & Ecology: *H. ensifer* is a medium sized shrimp, ranging from 20-45 g weight and up to a carapace length of 1.1 inches (29 mm) (4.9"/125 mm total length). *H. laevigatus* is larger and can exceed 90 g weight and up to a carapace length of 2.2 inches (56 mm) (about 8.5"/217 mm total length)(King, 1986; Nichols, 1991).

Very little is known of the biology of caridean shrimps. Analysis of length-frequency data of *H. laevigatus* has provided some growth estimates. Data suggest a mean age for first capture of about 1.2 years (16 mm carapace length) and sexual maturity at approximately 4 to 5 years (40.5 mm carapace length)(King, 1986). A combination of slow growth rates with high natural mortality rates suggests that the biomass of shrimps from a given recruitment is maximized at an early age. After which the available biomass rapidly declines (King, 1986).

1.5.2 The Fishery

Utilization: Deep-water shrimp are specialty food items suitable for local tourist restaurants or export (frozen or iced).

Production & Marketing: There is no deep-water shrimp fishery in FSM. Preliminary surveys were conducted in Yap and Kosrae using a small number traps and sets of 6.6' x 3.3' x 3.3' (2 m x 1 m x 1 m) rebar and chicken wire traps at 137-350 fathoms (250-640 m)(Saunders, 1987, 1988).

In Kosrae, one trap set for two nights (45 hours) at 350 fathoms (640 m) yielded 57 specimens of *H. laevigatus*, for a total weight of 6.4 pounds (2.92 kg), which was higher than the average yield in Palau (about 1 kg) for similar effort (Saunders, 1988).

In Yap, five trap sets at depths of 254 m (1), 340 m (2) and 560 m (2), yielded: 20.6 pounds (1,347 specimens) of *H. ensifer*; and 5.1 pounds (45 specimens) of *H. laevigatus* (Saunders, 1987).

In both cases Saunders recommended that systematic studies be undertaken to assess the potential of the resources. However, the potential for this fishery appears to be limited.

Due to the limited markets in Yap and Kosrae, most produce would need to be exported. Markets for caridean shrimps already exist in Guam and Hawaii. Saunders (1988) suggests that *H. laevigatus* could bring about US$7-8/lb at market.

1.5.3 Status Of The Stocks

There is no information available on the status of deep-water shrimp stocks in FSM.

1.5.4 Management

Saunders (1987) urges that no serious effort at exploiting the deep-water shrimp potential of Yap be undertaken without first conducting a careful survey of the resource's potential and careful monitoring of catch statistics. It appears that these species are particularly vulnerable to even moderate trapping (King, 1986).

2. MOLLUSCS

2.1 TROCHUS

2.1.1 The Resource

Species Present: The trochus shell, *Trochus niloticus*.

Distribution: The natural distribution of trochus is on tropical reefs from the Andaman Islands in the Indian Ocean to the islands of Fiji and Wallis in the Pacific (Bour, 1990). Within FSM trochus was only endemic to Yap, however, since 1927 there have been a number of successful transplants to other regions within the country (see Table 2). Trochus is currently found in all four states, although in most outer islands their populations are too low to harvest or they are absent altogether.

Biology & Ecology: Trochus prefer to live on the ocean side of reefs where the wave action is greatest. The larger shells are generally found in 2 to 20 feet (0.6 - 6 m) of water, and the smaller trochus on the inter-tidal reef-flats (Bour, 1990). Trochus are rarely found below 40 feet (12 m). The ideal trochus habitat in Palau has been characterized by Heslinga *et al* (1984) as having an unobstructed exposure to surf caused by the northeast trade winds, a gently sloping bottom, a wide boulder strewn reef-flat that is exposed at low tides, a substrate that is predominantly pavement, and an abundance of coralline algae and low filamentous algae at three to ten feet (0.9 - 3 m) depth.

The sexes are separate but cannot be determined by any secondary external sexual features. Fertilization occurs externally, the eggs and sperm being released into the surrounding water at night, usually a few days before the new moon (Bour, 1990). Spawning appears to be initiated by males (Curren, pers. comm., 1992). It is believed that spawning takes place throughout the year at each new moon but with different females; and each female spawns about every two to four months (Bour, 1990). The fertilized eggs become planktonic larvae after 9 to 10 hours, and settle out as juveniles on the reef flat after a few days. Trochus show rapid growth during the first three to four years, the rate being strongly determined by environmental conditions. Trochus spawned at the Pohnpei hatchery grew to about 0.6 inches (15 mm) in six months (Curren, pers. comm., 1992). Sexual maturity in Palau is reached at 2.2 to 2.6 inches (55-65 mm) basal diameter size, which is approximately two years of age (Bour, 1990). Fecundity is high and increases with size. At three inches (8 cm) the gonads are about 2.3 times larger than 2.4 inch (6 cm) animals.

2.1.2 The Fishery

Utilization: Trochus have been harvested for subsistence purposes in Yap since before western contact. Trochus has been

Table 2: FSM trochus transplants & reseedings (modified from Gillett in Bour, 1990).

Date	Area	Details
Before 1927	Palau to Chuuk Palau to Pohnpei	Unsuccessful attempt
1927-1931	Palau to Chuuk	Total of 6724 shells transferred in bait wells of skipjack boats; 5 years elapsed before judged successful. First harvest 1939.
1939	Palau to Pohnpei Palau to Satawan	6745 shells transferred; successful. 5000 shells transferred; success not known.
1939 or 1940	Yap to Ulithi	Very successful.
1930	Palau and Yap to	Japanese Govt. & private companies transferred shells to many various sitesislands including Ngulu, Ngatik, Mokil, Pulawat. Transfers to Sorol, Woleai, Ifaluk, Kapingamarangi and Nukuoro not successful.
1940s or early 1950s	Pohnpei to Kosrae	Unsuccessful operation.
1959	Pohnpei to Kosrae	500 trochus released at 13 locations.
1983	Yap to Woleai	2000 transplanted. All died in transit.
1984	Yap to Woleai & Faraulep	4708 transferred, 12 died en route.
1985	Yap to Ifaluk & Eauripik	3000 transferred, 900 died en route.
1985-1986	Chuuk lagoon	26000 transplanted from areas of high densities to 26 sites within Chuuk lagoon.
1986	Yap to Eauripik, Elato, Lamotrek & West Fayu	3125 transferred, 22 died en route.
1989	Pohnpei to Nukuoro & Kapingamarangi	1000 transplanted, success unknown.
1989	Guam to Pohnpei	5000 juveniles from UOG to Pohnpei hatchery.
1990	Pohnpei to Pingelap	3000 juveniles reseeded, success unknown.
1990	Pohnpei	500 juveniles reseeded from hatchery, success

unknown.

1990	Kosrae	3531 transplanted from sanctuary to 11 sites around the island.
1991 unknown.	Pohnpei	500 juveniles reseeded from hatchery, success
1991	Pohnpei to Nukuoro & Kapingamarangi	1000 transplanted, success unknown.
1991	Woleai to Elato & Lamotrek	1010 transferred, 156 died en route.
1991	Ulithi to Sorol	514 transferred, 3 died en route.

harvested commercially in Yap since German colonization (1898-1914), and catch statistics are available since 1915 (Asano, 1938, translated in Izumi, 1987). Sporadic commercial harvesting currently occurs in Yap, Ulithi, Chuuk lagoon, Pohnpei and Kosrae. Harvesting is primarily for the shell which is used in the production of buttons, jewellery and marquetry. With the exception of a button blank factory in Pohnpei, all shell is exported unprocessed. The extracted meat is used as a subsistence item, some is sold locally (fresh and frozen), very little exported, and a lot discarded.

All states have limited seasons during which harvesting is permitted. The trochus is collected by hand on the reef by rural fishermen diving with face masks from small boats, canoes or rafts. The use of SCUBA equipment is not permitted for trochus harvesting in all states. The meat is extracted from the shell by using a specially formed corkscrew-shaped wire or through parboiling.

Production: Asano (1939) and McGowan (1958) provide historical catch data for Yap, Chuuk and Pohnpei. The catches for Yap (1915-1938) ranged from 0.18 tonnes to 65.8 tonnes, with a mean of 23.8 tonnes. By 1923 the stocks had been overfished and season and size restrictions introduced. The first harvest in Chuuk was in 1939, but further harvests were interrupted by the war. Commercial harvesting resumed in the late 1940s at both Chuuk and Pohnpei. The greatest annual harvests were 208.6 tonnes[1] (in 1952) from Chuuk, and 163.3 tonnes (1951) from Pohnpei (McGowan, 1958). In all three states a significant decline in catches occurred after each of the peak harvests, indicating overfishing occurred.

The most recent commercial harvest figures are given in Table 3. All states conduct stock surveys annually to determine if harvesting will be permitted. Currently Pohnpei is the only state that is harvesting almost annually, but at the same time have had to drastically reduce the length of their harvest season (8 hours in 1991 and 6 hours in 1992).

The domestic value of the trochus harvests have increased considerably in recent years. Pohnpei's 1988 harvest resulted in a revenue of US$506,400; Yap's most recent harvest generated (US$142,540) for the harvesters. The intermittent harvesting, coupled with the general decline in catch levels, does make trochus an unstable, although lucrative, source of revenue for fishermen. Concerns over the capricious nature of trochus harvesting has resulted in a greater degree of management by the states.

Marketing: The regulations, as well as the buying systems vary between the states. All states require the trochus to be brought in live to special buying stations for checking by

Table 3: FSM Trochus Harvest[1] - metric tonnes (domestic value where known US$000)

Year	Yap	Chuuk	Pohnpei	Kosrae	FSM Total
1973		60.7($25.4)	93.4	154.1	
1974		48.7($10.7)		48.7	
1975			182.3	182.3	
1976		65.8($20.6)	27.2	93.0	
1977		39.0($16.3)	91.6	130.6	
1978		24.0($15.9)	78.9	102.9	
1979	16.5	35.7($23.6)	109.8	145.5	
1980	16.9	?		16.9	
1981			97.1	97.1	

[1] Figures based on the assumption that McGowan's (1958) figures were 'short tons' (= 0.907 tonnes).

1982	19.0		62.6		81.6
1983	9.0				9.0
1984	?		135.2($223.5)	8.1	143.3
1985				16.1	16.1
1986	66.0($103.0)	110.1($138.5)	181.4($460.0)		357.5
1987	16.8($25.0)				16.8
1988			187.8($506.4)	10.2	198.0
1989					
1990	40.2($142.5)		86.2	5.5	131.9
1991			60.8		60.8
1992			36.3		36.3

[1] Sources: Yap - Smith (1990); Office of Planning & Statistics draft Statistics Yearbook (unpublished).
Chuuk - Truk Maritime Authority computer printout of commercial landings of trochus.
Pohnpei - MRD Annual Report of FY1983 to 1991; Curren, pers. comm., 1992.
Kosrae - MRD trochus harvest file.

management personnel prior to being sold. The prices paid for shell vary considerably from state to state and season to season. Some recent prices were: Kosrae (1990) $2.40/lb; Chuuk (1986) $0.50/lb; Pohnpei (1990) $2.20/lb; Yap (1990) $1.25-$1.50/lb.The main buyers are from Japan, Korea and Taiwan; the dominant market outlets for the shell and button blanks are Japan, Korea and Europe. The irregular harvesting, due to periods of over-harvesting followed by recovery periods, have resulted in lower prices being paid to fishermen, as well as a decreased yield (Curren, pers. comm., 1992).

2.1.3 Status Of The Stocks

Each state currently conducts surveys to estimate trochus densities for comparisons both spatially and temporally. Methodologies vary between states, making density comparisons difficult.

Yap: Density surveys are conducted annually at 32 standard sites around Yap proper. Transects 100 m x 2 m set parallel to the reef front are swum by two SCUBA divers who count and measure all trochus found within the 200 m^2. An average density for all sites combined is then compared to previous years, and that, combined with the mean size of trochus found, are used to determine if harvesting will be permitted. Surveys are also conducted in the outer islands, especially Ulithi and Woleai.

Average trochus densities (per m^2) for Yap proper have been (MRMD 1990, 1991):

1989	0.0148	148 tr/ha	(25 sites)
1990	0.0391	391 "	(32 sites; n = 511; mean size = 3.9")
1991	0.0221	221 "	(26 sites; n = 230; mean size = 3.0")

Chuuk: Surveys using line transects and spot checks at various sites throughout Chuuk lagoon and along the barrier reef were conducted from 1986 through to 1989 (Truk Maritime Authority, 1986b,

1987b, 1988b, 1989b). No more recent reports could be located.

Pohnpei: For the last three years, assessment has been performed by SCUBA dives along measured transect lines. The density estimates are compared with the previous years to make management decisions (Curren, pers. comm., 1992).

Kosrae: In 1990 KMRD conducted a survey of their sanctuary area in preparation for transplanting to other reefs around Kosrae. Transects 50 m x 2 m were surveyed parallel to the reef front at depths of 5, 10, 20 and 30 feet (1.5, 3, 6 & 9 m), and perpendicular to the reef from 5 to 30 feet. The mean densities per square meter were:

5'		0.45	(6 transects)	4,500 tr/ha
10'		0.81	"	8,100 "
20'		0.16	"	1,600 "
30'		0.05	"	500 "
5'-30'	0.34	(10 transects)	3,400 "	

Catch per unit effort statistics for trochus harvesting within FSM are lacking, although Pohnpei does request basic fishing effort information at the buying stations. Yap is also proposing to collect catch effort data. No standing stock or biomass estimates have been made for any of the states.

2.1.4 Management

Trochus is a resource which requires a greater degree of management than is currently occurring within FSM if it is to be sustainably harvested on an annual basis. Historical records from Yap, and to a lesser degree Pohnpei and Chuuk, indicate that the resource can be easily overfished without an adequate management regime.

Kosrae and Pohnpei currently have sanctuary areas within which harvesting is not permitted. Pohnpei originally had a number of small sanctuaries, which were marked by piles of rocks and mangrove stakes. Confusion due to missing or damaged markers led to the establishment of larger, self-defined sanctuaries. During the 1988 trochus season, the Kolonia sanctuary was abandoned due to lack of adequate manpower for patrols (Curren, pers. comm., 1992). Kosrae has used the stocks from their sanctuary area to replenish other areas by transplanting. Chuuk had nine sanctuary areas during the 1980s, at least one of which was retained during the 1986 harvest. Yap is unable to declare sanctuary areas due to the nature of the traditional reef ownership system.

The density surveys used in each state should, if possible, be standardized to enable comparisons between states and from year to year. Bour (1990) notes some simple rules which should be observed when designing a sampling plan:

- sampling sites should be distributed at random throughout the trochus biotype and not concentrated in on patches of great abundance known to fishermen;

- the surface area surveyed should be estimated as accurately as possible;

- if possible the same transect should be examined by two divers to limit the "observer effect";

- the hidden fraction of the trochus population must be assessed (night diving) and a minimum size for counting should be determined beforehand (generally 30 mm (1.2")).

Counts should also be supplemented by measurements to enable the calculation of densities by weight from a size/weight ratio. An SPC workshop on trochus held in Vanuatu in 1991 was attended by FSM, Pohnpei and Yap MRD people. At that workshop a standardized survey method was suggested. If possible, all states should adopt that method to permit comparisons and population estimates to be made.

During harvesting greater efforts need to be made to collect catch per unit effort (CPUE) data. As all states inspect the catch prior to it being sold, this should be the time to collect such data.

Pohnpei MRD has been experimenting with the production of juveniles for reseeding at their Lenger Island hatchery. They produced 3,000 trochus to release size in 1991, but 95 percent were killed in the tanks due to typhoon damage. In 1992, an estimated 10,000 settled from spawnings in January and February (Curren, pers. comm., 1992).

Current Legislation/Policy regarding exploitation: Each state has their own legislation concerning trochus harvesting, and is also covered in FSM Code.

FSM: The section of FSM Code covering trochus exploitation (Title 23, section 108-115) consists of the former Trust Territory (TTPI) Code, and has yet to be updated. The main regulations are:

- Designation of the season: open season(s) may be declared during May through September.

- Only citizens of the TTPI may harvest trochus.

- No trochus less than 3" (76 mm) basal diameter may be taken.

- Authorization for removal and transportation for the purpose of introduction to other reefs, islands, or atolls can be obtained.

As the control of trochus harvesting comes under the states' control it would appear unnecessary to have national legislation for trochus. As it still refers to the TTPI districts and commissioners, if it needs to be retained, then it requires updating. As far as could be determined, its only use is by Chuuk State which as yet doesn't have its own trochus legislation in place.

Yap: The Yap State Code (Title 18 section 1009) provides the Governor with the power to determine whether to allow harvesting or not, the timing of the harvest season, the areas to be harvested, the size and/or other restrictions and the penalties to be imposed. For the 1990 harvest the following restrictions were imposed:

- The season was for one week only;

- A minimum basal diameter size limit of 3 inches (76 mm);

- A maximum basal diameter size limit of 4 inches (102 mm);

- All trochus had to be brought in alive to the weighing stations to allow over- and under-sized trochus to be returned to the reef;

- The use of SCUBA was not permitted.

A committee formed by the Governor is currently reviewing the surveying, harvesting, monitoring

and purchasing systems for future harvests. Some of the recommendations include the registering of harvesters and buyers; that harvesters provide catch-effort information; and that better record keeping of harvest information be made.

Yap's management policy is based upon the annual density surveys and through enforcing the three to four inches (76-102 mm) size restrictions. Yap has been unsuccessful in prosecuting harvest regulation violators.

Chuuk: Trochus harvest laws for Chuuk were unclear. Both the Legislative Counsel and CDMR produced the trochus laws from FSM Code as those in effect for Chuuk, but amendments to a "Trochus Harvest Act" were located in CDMR files. Limited time did not permit resolution of what laws were in effect.

Chuuk's last harvest in 1986 occurred after a seven year closure. That season was for 30 days, and at least one of the former sanctuary areas was retained during the harvest. There was a minimum size limit of three inches (76 mm) basal diameter.

Density surveys up to at least 1989 recommended against harvesting due to low trochus levels. There was no indication by CDMR staff as to when another harvest was expected.

Chuuk's current management policy is uncertain, but would at least involve density surveys prior to determining if a harvest would be permitted.

Pohnpei: Pohnpei State Law (No. 2L-106-81 and amendment No. 2L-152-82) mirrors FSM Code, with the Director of the Department of Conservation and Resource Surveillance designating the open season(s), not to exceed 60 days, and the areas in which harvesting may occur. Only FSM citizens may harvest. A minimum three inches (76 mm) basal diameter applies. For the 1992 season, a maximum size of four inches was also used.

Other requirements of the harvest are that trochus must be brought in alive to the inspection stations for weighing and a receipt issued. The receipt notes the live weight of trochus collected, the number of dead and undersized shells, and the allowed selling weight of clean trochus (about 80% of live weight). Harvesters are responsible for cleaning their own shells.

The duration of Pohnpei's seasons have been progressively reduced:

1986	1 month
1987	no season permitted
1988	3 days
1989	no season permitted
1990	24 hours
1991	8 hours.
1992	6 hours and 4" maximum size.

This has been necessitated by the low survey densities and declining catches.

Pohnpei's management policy is based upon density surveys, sanctuary areas, limiting the duration of the harvest season and now both minimum and maximum shell sizes. Pohnpei is also having difficulty obtaining convictions of harvest regulation violators.

Kosrae: The Director of the Department of Conservation and Development has the power to regulate

the time, place and method of trochus harvesting by a permit system, and to set minimum and maximum shell size or other limitations in harvesting (Kosrae State Code, Part II, section 11.1101). The state also has a sanctuary area within which no harvesting is permitted at any time, although there is provision for KMRD to transport trochus to and from the sanctuary for the purpose of development, enhancement or preservation of trochus stocks.

The regulations for the 1990 trochus harvest were:

- harvesters must register;
- no SCUBA to be used;
- only 3"-4" basal diameter size shell to be harvested;
- must be brought in alive to be counted and certified by KMRD;
- two week open season.

Kosrae's management policy is based on density surveys, a sanctuary area, minimum and maximum size limits, and a restricted season.

Recommended Legislation/Policy Regarding Exploitation: Bour (1990) summarizes the main management options available for trochus. They are:

- Size limitations - these have the advantage of being relatively easy to enforce. He suggests the smallest size should not be less than 8 cm (3.2") diameter in order not to disrupt production of juveniles. In addition, a maximum size of not more than 12 or 13 cm (4.7-5.1") is suggested in order to leave some brood stock whose shell is of less value but whose potential fertility is still high.

  Currently all states have a minimum size limit of 3", and Yap, Kosrae, and since 1992, Pohnpei, have maximum size limits. Chuuk should consider introducing maximum size limits in the 4-5" range.

- Catch quotas: this option requires CPUE data over an extended period of time to be able to set realistic quotas.

  This option is not recommended for FSM as there is insufficient CPUE information and no standing stock estimates available.

- Fisheries closures: this involves prohibiting harvesting in certain areas or for time periods. Experience in other areas has shown that enforcement is difficult, and the irregular production of shell affects export potential.

  Open seasons are used in all states. Pohnpei uses season duration to regulate the fishery. Open seasons should be retained, but their duration more closely related to stock densities. The combination of limited open seasons with minimum and maximum size limits would provide an appropriate management policy for all states.

- Sanctuaries: These protected areas serve as brood stock reservoirs to supply adjacent reefs with trochus through larvae dispersal.

Only Pohnpei and Kosrae have sanctuary areas; Chuuk recently had them and should re-impose them; Yap has the ability to impose them through its present legislation, but the reef tenure system will make this extremely difficult to introduce.

2.2 CLAMS

2.2.1 The Resource

Species Present: *Tridacna gigas, T. derasa, T. squamosa, T. maxima, Hippopus hippopus*. *Tridacna crocea* may also be present, but could not be found listed in any surveys reviewed.

Distribution: Tridacnid clams are restricted in their distribution to the Indo-Pacific region. In many areas populations of the larger species have been significantly reduced due to subsistence harvesting.

Within FSM only *T. maxima*, *T. squamosa* and *H. hippopus* are found in the wild, the latter two species in low to very low numbers. *T. gigas* shells are frequently dredged up in all states indicating that they were once spread throughout FSM.

Within the last ten years all four states have received hatchery raised *T. derasa*, *T. gigas* and *H. hippopus* from the Micronesian Mariculture Demonstration Center (MMDC) in Palau.

Biology & Ecology: The tridacnid clams include the largest bivalve molluscs in the world. A unique feature is the thick fleshy mantle containing colorful symbiotic algae, called zooxanthaellae, which provide the animal tissue with by-products of photosynthesis (sugars, oxygen and proteins). The contribution of the zooxanthaellae to the energy budget of the clam is considerable. Sunlight required for the zooxanthaellae to photosynthesize restricts the clams to relatively shallow, clear water environments.

Growth and reproductive biology are well known for the larger species. Growth is rapid at up to four inches/year (10 cm/yr) for *T. gigas*. Giant clams are initially male, but after maturing at about two years of age, become hermaphrodites, and spawn by releasing their sperm and eggs at different times. Large clams may produce hundreds of millions of eggs. After hatching, the larvae drift in the water column and settle on the substrate within ten days. Natural mortality rates are low for clams above four inches (10 cm). Recovery of overfished areas is slow, indicating low recruitment rates.

2.2.2 The Fishery

Utilization: Clams are an important traditional resource throughout FSM. They are primarily collected as a food resource but the shells are also valuable as tourist curios (ashtrays, soap holders, decorations, etc). In former times the shells were used in the construction of tools. Over-harvesting of *T. gigas* in the past for subsistence purposes has resulted in its local extinction.

Clams are collected while swimming or wading over the reefs. The smaller attached clams are removed by severing the byssal threads by inserting a knife or a long, thin piece of metal through one of the siphons. With the exception of the kidney, all the meat and viscera of the clam are edible.

Commercial exploitation of wild stocks elsewhere in the region has been solely for the adductor muscle, primarily for the South-East Asian markets. Markets exist for four other types of giant clam products: aquarium specimens, seed stock, broodstock and shell (Shang, *et al*, nd).

Production: There are no estimates available for subsistence harvest levels of wild clam stocks in FSM. Figures for the domestic sale of clams are only available for Chuuk State, although Kosrae collects data on "reef gleaning" which includes clams. Statistics collected from Chuuk's main markets are shown below (Anon., 1991a):

	1986	1987	1988	1989	1990
Quantity (lbs):	2,480	6,702	4,132	4,646	8,076
Value (US$000):	1.6	3.3	8.3	3.0	8.9

The subsistence harvest for Chuuk can be expected to be much higher than the above figures.

Yap State: The state's Marine Resources Management Division began a long-term giant clam reintroduction project in 1984. Since then approximately 12,000 *T. derasa* have been purchased from the MMDC clam hatchery in Palau, and air freighted to Yap in three phases. These juveniles were reared in predator exclusion cages at a nursery site for varying periods before being distributed to community sites (Lindsay, 1991).

Phase I consisted of 1,000 15-month old *T. derasa*, these were reared for two years at the nursery site, and in January 1986 were distributed to 31 sites around Yap proper. The overall survival rate by May 1988 was 47.6 percent. In phase II, 1,000 21-month old juveniles were obtained in December 1985 and reared for one year, then 674 were transported to 22 sites in the outer islands. Overall survival as of 1988 was 44.8 percent. For phase III, 6,000 18-24 month old clams reared for about six months from January 1987, then distributed to 53 sites around Yap proper and 26 sites in the outer islands. Average survival rates as of April 1988 was 96 percent for Yap proper and 63 percent for the outer islands. Data from two partially incomplete surveys in 1990 and 1991, were combined to give a mean growth rate and percent survival for phase I clams on Yap proper of 2.6 cm/year and 69.7 percent respectively; and 3.6cm/year and 77.0 percent for phase III clams (Lindsay, 1991). Yap State's strict reef tenure system has helped keep losses through poaching to a minimum. These clams are now of reproductive age but no spawning or recruitment have been recorded.

Yap is currently participating in MMDC's "Regional yield trials for commercially valuable giant clam species" project. The objectives of this project are to compare growth, survival and yields of three giant clam species throughout Micronesia. Phase I compares *T. derasa* with *T. gigas*, and phase II compares *T. derasa* with *H. hippopus*. In April 1991, Yap received 2,000 of each of the phase I species, and in November 1991 received 2,000 of each of the phase II species.

There is a project proposal submitted by MMDC to the Pacific Aquaculture Association to re-introduce 10,000 2-year old *T. gigas* into Yap from MMDC's hatchery.

Chuuk: The first shipment of clam seeds received from the MMDC was destroyed by a typhoon in 1987 (Shang, 1989). In July 1988, an additional 800 clams were received and placed in nursery trays. Their current survival rate is unknown.

Chuuk is also participating in MMDC's yield trials; receiving their phase I clams in May 1991, and the phase II clams in December 1991.

Pohnpei: The Marine Resources Division operates a small giant clam and trochus hatchery on a small island near Kolonia. It reportedly has a capacity to produce 25,000 seed clams annually. *T. derasa* and *H. hippopus* have been reared there. In 1983, 1,000 *T. derasa* juveniles were imported from MMDC, and in 1984 a further 5,000 were brought in to stock the hatchery. Of these 50 were distributed to each outer island, but none have survived. In 1988, 24,000 *H. hippopus* were produced through induced spawning at the hatchery. In 1990, 10,000 *T. derasa* were imported from MMDC for reseeding. In 1992, the hatchery had an estimated 15,000 *T. derasa* (spawned in February) and 15,000 *H. hippopus* (Curren, pers. comm., 1992). There are currently about 5,000 cultured clams at six sites and additional clams adjacent to the hatchery. No information was available on survival rates.

Three giant clam farms were established in 1989 around Pohnpei - two with 500 *T. derasa*, and the other with 1,000. In 1991, *T. derasa* were also distributed to two sites around Pohnpei (528 each) and 64 were placed at Ant Atoll (PMRD, 1991).

Kosrae: In September 1986, KMRD received 1,000 *T. derasa* from MMDC. Up to June 1987, the survival rate was 60 percent (Shang, 1989).

The new National Aquaculture Center (NAC) based in Kosrae is concentrating on culturing giant clams and developing extension services. Giant clams were chosen as the first animal to culture because they are technically easy to culture, acceptable food items, and are a potential commercial resource for local and export markets (Anon., 1991c).

The NAC achieved their first spawning in 1991 (Lindsay, pers. comm., 1991). NAC currently has the following stocks:

	Species	**# clams**	**Source**
Broodstock:	*T. derasa*	10	MMDC
	T. gigas	40	Rep. Marshall Is.
	H. hippopus	40	Pohnpei
Raceways:	*T. derasa*	25,000	MMDC; RMI
	T. gigas	1,000	MMDC
Growout areas:	*T. derasa*	2,928	MMDC
	T. gigas	3,548	MMDC
	H. hippopus	3,720	MMDC
Distributed around Kosrae:	*T. derasa*	100	MMDC
	T. gigas	100	MMDC
	H. hippopus	300	MMDC

NAC's production aim, with their current facilities, is 100,000 clam seeds per year. Their long-term objective is to assist in the establishment of 20 farms in FSM, aiming at supplying the local market first, and later for export.

A number of studies and reviews have identified giant clam farming as having the best aquaculture potential in FSM (APTA, 1990; Shang, 1989; Anon., 1986). As yet there are no private farms producing clams.

Marketing: The IUCN has placed *T. gigas* and *T. derasa* on its endangered species list, and most

species are also protected in international trade by CITES (Convention on International Trade in Endangered Species) prohibitions. Shipments into the US mainland for the aquarium trade, or into Hawaii, Guam, or other US Territories for the sushi/sashimi trade will require CITES clearance and permits. Shipments into Okinawa will also require CITES clearance and permits (Anon., 1991c; Shang, *et al*, nd).

Shang, *et al* (nd) note that export markets exist for five types of giant clam products: food, aquarium specimens, seedstock, broodstock and shells. They conclude that the seedstock and broodstock markets appear to be short-run oriented, with a declining demand expected. In Taiwan, a market exists for adductor muscles in fresh or frozen form, with a market potential of 240 tonnes annually. However, muscles from five year old clams or older are preferred. There is an existing market in Okinawa for whole clams for the sashimi and sushi trade. *T. crocea* is the preferred species, and cultured *T. derasa* is unknown and would require considerable test marketing to evaluate consumer acceptance. A limited market potential exists for giant clams as aquarium specimens in the US and Japan.

The local market for sale of fresh clam products within FSM population centers would not appear to be a problem (APTA, 1990; Anon., 1991c). Collection and distribution systems would need to be developed for remote farmers, especially in the outer islands.

The identification and establishment, and/or penetration, of both export and local markets remains one of the main obstacles in developing commercial/artisanal giant clam farming. A detailed marketing and production study is urgently needed for FSM.

A number of preliminary marketing reviews have been conducted for the region (APTA, 1990; Anon., 1991c; Shang, *et al*, nd). All emphasize that care must be taken in interpreting market forecasts for giant clams, as there is little information available on product demand, production costs, or the level of potential competition from other farms and hatcheries within the region.

APTA (1990) calculated estimated cash flows for a farm of 10,000 clams, and concluded that a commercial operation would not be feasible, but that subsistence or artisanal farming may well be.

2.2.3 Status Of The Stocks

No quantitative surveys of wild giant clam stocks have been conducted in FSM. Pohnpei State has been monitoring clam populations at various sites on an irregular basis. During the last six years, the stocks showed a rapid decline in 1985-87 (when markets first offered $0.50/lb for clam meat), and a slower decline to the present (Curren, pers. comm., 1992). From general marine environmental surveys and discussions with marine resources staff, the status of the stocks are:

T. maxima - this is the most common species throughout FSM and is the mainstay of the subsistence harvest. In some areas of high exploitation, e.g., Chuuk lagoon and Kosrae, there appears to be a decline in population levels.

T. squamosa - still found throughout Yap, Chuuk and Pohnpei states, but in low to very low numbers. There is only unconfirmed reports of its shell from Kosrae.

T. gigas - There are no reported wild stocks remaining in FSM, although they may still be present on some remote atolls. Shells, including fossilized ones, have been found in all states indicating that they previously ranged throughout FSM. The species is currently being re-introduced from MMDC and the Marshall Islands to Yap, Chuuk and Kosrae.

T. derasa - No record of wild stocks within FSM were found. The species has been introduced for seeding and farming purposes in all states.

H. hippopus - Wild stocks are present throughout out FSM, but are in very low numbers in Yap, Chuuk and Pohnpei, and rare in Kosrae. Re-introductions are currently occurring in all states.

2.2.4 Management

Management in all states has involved giant clam reintroduction using seed from MMDC in Palau. Pohnpei has produced some seed for local reintroduction.

NAC in Kosrae is concentrating its efforts into producing seed for subsistence/artisanal farmers, and into developing its training and extension services.

Current Legislation/Policy regarding Exploitation: There is no national legislation concerning giant clams. Only Yap and Kosrae states have laws.

Yap State Code, Title 18, section 1006, Protection of clams, states:

- The Governor is authorized to declare a harvesting season and to set a size limit for the taking or harvesting of clams. Clam meat shall not be sold commercially by any wholesale or retail store licensed to do business in the State.

- Penalties: fine of not more then US$500, or sixty days imprisonment, or both.

To date no season has been declared, nor has the law been enforced.

Under Kosrae State Code Section 13.523 a sanctuary area is declared adjacent to the NAC for the purpose of protection of giant clams and to promote the expansion of the giant clam population in the state. The penalty for illegal harvesting is imprisonment not exceeding 12 months, or a fine not exceeding US$1,000, or both.

Recommended Legislation/Policy Regarding Exploitation: If necessary, at both the national and state levels there are Endangered Species Acts under which endangered or threatened species can be listed. There are, however, exemptions in the Acts for subsistence harvest and controlled farming.

The subsistence harvest of giant clams would be difficult to regulate or enforce, except through customary marine tenure and use rights, where they are still strong.

Once farms are established legislation will be required to prohibit poaching. To encourage farming, only farmed clam products should be allowed to be exported. This will be necessary anyway to send to countries that are signatures of CITES. At present clam meat is sent to relatives, especially in Guam, for home consumption.

2.3 PEARL OYSTER

2.3.1 The Resource

Species Present: The blacklip pearl shell, *Pinctada margaritifera*.

Distribution: The blacklip pearl shell is widespread throughout the Pacific, and is found in all of FSM states, but not in large quantities.

P. margaritifera is found down to around 130 feet (40 m), but is naturally abundant just below the low-water mark.

Biology & Ecology: Blacklip pearl shell exhibits fast initial growth rates reaching a shell diameter of 3.9 to 4.7 inches (10-12 cm) in two years. Maximum sizes have been calculated as 5.5 to 6.7 inches (14-17 cm) shell diameter. Like many bivalves, they are hermaphrodites, reaching maturity in their second year of growth, but with an uneven sex ratio until that time. Growth rates of juveniles measured on Nukuoro showed oysters reaching mature size in about two years (PMRD, 1991). Spawning is often not limited to distinct seasons and a planktonic larval stage occurs lasting two to four weeks prior to settlement (Sims, 1988).

2.3.2 The Fishery

Utilization: During the Japanese administration their pearling fleet was based in Palau, but it was thought some of the harvest occurred elsewhere (Smith, 1947). Possibly areas in FSM were harvested. In recent years some commercial exploitation has occurred in conjunction with trochus harvesting in Chuuk.

Most mother of pearl (MOP) shell is exported for the manufacture of buttons and other clothing and jewellery items.

Production: The only recent harvest figures that could be located were for Chuuk lagoon: 26,435 lbs in 1979 and 17,190 lbs in 1986 (CDMR Trochus file).

Marketing: The MOP harvested in Chuuk in 1986 was bought from harvesters for US$1/lb, and was exported for US$1.35/lb, an export value of US$23,207 (CDMR Trochus file).

2.3.3 Status Of The Stocks

No stock assessment information could be located.

2.3.4 Management

Pohnpei MRD established spat fall collecting stations from 1988 to 1991 at Ant, Nukuoro and Kapingamarangi atolls. The project reported insufficient densities of spat settling to indicate the viability of gathering wild spat to support a pearl culture industry (PMRD, 1991; APTA, 1990).

Current Legislation/Policy Regarding Exploitation: FSM Code includes legislation transferred from the former TTPI Code controlling the harvest of blacklip pearl shell (Title 23, section 107):

- No *Pinctada margaritifera* can be taken from August 1 to December 31.

- No shell less than six inches may be taken.

- Any size shell may be taken at any time for scientific purposes when authorized.

- Penalties: up to six months imprisonment, or not more than US$100 fine, or both.

The Kosrae State code, Section 13.523, is the same as FSM law. The other states do not have specific legislation covering pearl oysters.

Recommended Legislation/Policy Regarding Exploitation: With the exception of previous harvests in Chuuk, there is no commercial exploitation of the shell, so no management measures are currently required.

2.4 ORNAMENTAL SHELLS

2.4.1 The Resource

Species Present: Collectors' shells of the classes Gastropoda (sea shells), Pelecypoda (bivalves), Scaphopoda (tusk shells) and Cephalopoda (nautilus) are present throughout FSM. Kay and Smalley (1989) identified about 500 species of shell occurring in Yap State. of the 231 species listed for the shell trade of the Philippines and Papua New Guinea, 36 percent are recorded from Yap proper (Kay & Smalley, 1989).

Distribution: Shells occur in all of the world's seas but their center of distribution, and maximum diversity, is generally considered to be that area of ocean bordered by Indonesia, Papua New Guinea and the Philippines. Shells can be found in every type of marine habitat, from coral reefs and sand to silt and mud. Most species are habitat specific.

Lists of species found throughout FSM can be found in Kay and Smalley (1989), USACE (1986 & 1989), Orcutt, *et al* (1989), Eldredge, *et al* (1979) and Tsuda (1978).

2.4.2 The Fishery

Utilization: Five categories of shells are recognized in the shell trade: ornamental shells (e.g., cones and cowries); shells used in shell craft (e.g., money cowries and helmet shells); specimen and rare shells (e.g., golden cowry); commercial shell (e.g., trochus, pearl oyster); and shells used for food (Kay & Smalley, 1989).

Marine shells have been extensively used throughout FSM for subsistence purposes, including tools, ornaments, food, and as a medium of exchange. Currently they are also used for the tourist trade, either in the production of handicrafts or the sale of the shells themselves. Except for a brief period in the 1980s in Chuuk, no records of export to shell traders could be found.

Shells are collected by people walking over areas of sand or coral at low tide, and by looking under rocks, or by searching through areas of sand or mud. Shells in deeper water, such as *Cassis cornutus* (helmet shell), *Charonia tritonis* (giant triton) and *Lambis lambis* (spider shell) require diving.

The larger shells (except for cowries) can be boiled to extract the meat, but smaller species should be left to decompose buried in the sand.

Production & Marketing: The only production figures that could be located were for Chuuk State: in 1989 sea shells with a value of US$300 were sold and in 1990 US$720 worth were sold (Anon., 1991a). In the first nine months of 1991, 50 pounds of shells were exported from Yap (Graham, 1991a).

Currently in FSM there is only the tourist market for ornamental, rare and shell craft shells.

2.4.3 Status Of The Stocks

There are no estimates of ornamental shell stocks in FSM. For Yap, Kay and Smalley (1989) found the average abundance for most common reef shells such as cones, cowries and strombids to be low. They also found the mean sizes of the common shells to be smaller than recorded elsewhere in the Pacific.

2.4.4 Management

Current Legislation/Policy Regarding Exploitation: There is no legislation at either FSM or State level regarding ornamental shell exploitation.

Recommended Legislation/Policy Regarding Exploitation: Kay and Smalley (1989) recommend against an export shell trade for Yap. They do suggest that the harvest of shells by Yapese for shellcraft or ornamental shells for sale on Yap could be possible , but harvesting areas should be restricted and rotated annually, with no SCUBA or dredging permitted. In addition, licensed and limited shell collection by tourists could be permitted with certain limitations imposed.

The collection of shells currently listed as threatened in the IUCN Red Data book should be prohibited, especially the giant triton, *Charonia tritonis*.

2.5 MANGROVE CLAMS

2.5.1 The Resource

Species Present: The mangrove clam, *Anodontia edulenta*. There may be other species, for example, the Yapese mangrove clam "*yungwol*" has yet to be properly identified (Falanruw, pers. comm., 1992).

Distribution: They are distributed throughout the mangrove areas of FSM, but not in large numbers (USACE, 1986, 1989; Rochers, 1989; Devoe & Falanruw, 1991). The species are known to be more common in certain locations. For example, in Chuuk lagoon, Tol island is known to have them (CDMR staff, pers. comm., 1992), and in Kosrae it is only found in one small area between Lulu Nefalil and Lulu Utwe (Rochers, 1989).

Biology & Ecology: These bivalves live buried two to three feet below the surface of mud flats and on the periphery of mangroves.

2.5.2 The Fishery

Utilization: Harvesting is usually conducted by small groups of women at low to mid-tide. Searching involves feeling in the mangrove mud with their feet to locate the clam holes or the clam itself (Rochers, 1989; Falanruw, pers. comm., 1992).

Production: No data are available on mangrove clam production. Several of Rochers' (1989) informants stated that they could collect up to fifty clams in a one hour period while several elders claimed that in their time they could collect hundreds of them.

Devoe and Falanruw (1991) comment that attempts are being made to culture the bivalve *Anadara*, which has a very heavy shell, and suggest that perhaps the Yapese clam "*yungwol*" might be more suitable to cultivate. It has a very thin shell which may result in more energy going into the production of meat rather than shell.

Marketing: The majority of mangrove clams are collected for subsistence purposes. Some are sold through the market in Pohnpei, often salted (Ludwig & Curren, pers. comm., 1992).

2.5.3 Status Of The Stocks

No information of the status of the stocks could be located. Habitat destruction, through removal of mangroves, siltation, and pollution, is the greatest threat to the resource. Devoe and Falanruw (1991) note that well worked clam beds exist along the causeway at Wuluu' in Yap, however, these beds are receiving silt runoff from a large pile of road-fill above the village, threatening the resource.

2.5.4 Management

Current Legislation/Policy Regarding Exploitation: There is no legislation controlling mangrove clam exploitation.

Recommended Legislation/Policy Regarding Exploitation: As mangrove clams are primarily a subsistence resource, there does not appear to be a need for regulation. However, there does appear to be a need for mangrove habitat management.

2.6 OCTOPUS & SQUID

2.6.1 The Resource

Species Present: None of the literature reviewed identified which octopus species are presently exploited in FSM. The common octopus, *Octopus cyaneus*, is commonly found throughout the Indo-Pacific region.

The Japanese Overseas Fishery Cooperation Foundation (OFCF) baitfish project in Chuuk have tentatively identified the squid they are catching as *Loligo oualaniensis* (OFCF, 1991).

Distribution: Octopuses are found throughout FSM, both intertidally and subtidally around reefs and rocky areas.

Squid are also distributed throughout FSM, but in the oceanic and lagoon waters.

Biology & Ecology: Octopuses are active predators feeding mainly on crustaceans and molluscs. Sexes are separate in cephalopods, and prior to mating there is often an elaborate mating ritual involving color changes and touching of tentacles. One of the male's tentacles is modified to carry the sperm to the mantle cavity of the female. In octopuses the eggs are usually brooded and develop directly into a tiny adult form.

Octopuses are usually solitary whereas squid form schools. Squid are known to carry out diurnal vertical movements between the surface at night and deeper layers during the day. Little is known about seasonal migrations.

2.6.2 The Fishery

Utilization: Within FSM octopus is used as a food as well as a bait for handline fishing. Octopus are most often caught by using a hooked piece of metal or wire to remove them from their lairs, they are killed by biting them between the eyes. They are also caught by spearing. They can be taken while walking on the reef flat at low tide or by diving in deeper water.

Squid are only caught incidentally. OFCF is currently conducting squid fishing trials with handlines and squid jigs around the outside of Chuuk lagoon, as part of their baitfish project.

Production & Marketing: There are no estimates of the subsistence harvest of octopus for any areas of FSM. The level of subsistence harvest in some areas is quite high, for example, on Fais and Satawal (Yap State) it is a significant food resource, and on Woleai (Yap State) it is the only bait permitted for most types of bottom fishing.

Catch estimates for the subsistence and artisanal harvest of octopus on Kosrae are: 1987 - 641 lbs; 1988 - 934 lbs; 1989 - 5,078 lbs (KMRD statistics).

On Pohnpei and Chuuk octopus is sold in the markets. For the 1991 financial year (Oct. 1990 - Sept. 1991) PMRD recorded 36 pounds sold (PMRD statistics). Market figures for Chuuk, 1986 to 1990, are (Anon., 1991a):

	1986		**1987**		**1988**		**1989**		**1990**
Qty (lbs):	10,680	11,701	2,313	6,071	32,328				

Value (US$): 6,900 7,500 4,600 3,900 35,600

Squid has been reported as quite abundant around Kosrae, but there is no fishery (Molina, pers. comm., 1992). Wailani, *et al* (1990) noted relatively abundant squid resources in the deeper waters off Chuuk lagoon.

In the first six months of the OFCF baitfish project, the catches of squid have been very disappointing (Kawakami, pers. comm., 1992). From July to December 1991, 21 trips resulted in a total of 163.1 lbs of squid being caught, at a monthly average of 27.2 lbs. The highest catch was in November (66.6 lbs) (OFCF, 1991).

2.6.3 Status Of The Stocks

There is no information on the status of octopus or squid stocks in FSM.

2.6.4 Management

Current Legislation/Policy Regarding Exploitation: There is no legislation regarding octopus or squid exploitation at either the national or state level.

Recommended Legislation/Policy Regarding Exploitation: As there are no estimates of stock size or of harvest levels, no recommendations can be provided. Discussions with marine resources and fisheries personnel indicated there is currently no problem with harvest levels.

2.7 POTENTIAL RESOURCES

2.7.1 GREEN SNAIL

2.7.1.1 The Resource

Species Present: The green snail, *Turbo marmoratus*, is currently not found in FSM, but there are plans to introduce it in the near future. A related species, *Turbo argyrostomus*, is found throughout FSM, but is of no commercial value.

Distribution: The green snail is distributed from western Indian Ocean localities such as Kenya and the Seychelles to the western Pacific and south-east Asian countries such as Vanuatu, Solomon Islands, Papua New Guinea, Indonesia, Malaysia and the Philippines and upward to the Ryukyus (Yamaguchi & Kikutani, 1989).

Biology & Ecology: There is a lack of life history knowledge of wild stocks of green snail. The sexes are separate, and size at first maturity has been estimated at about six inches (15 cm) shell diameter (Yamaguchi, 1988).

Green snail is a large herbivorous marine gastropod (Family Turbinidae) which grows to eight inches (20 cm) or more in shell length and a total weight exceeding 6.6 lbs (3 kg). Juveniles are found in crevices on the reef crest zone. Larger juveniles and small adults are found in the upper reef slope, usually cryptic in daylight hours. The larger adults are less cryptic but usually found under ledges and in caves on the reef slope down to about 30 feet (10 m) or more (Yamaguchi & Kikutani, 1989).

It appears that green snail has similar habitat requirements as trochus, though generally it is found in deeper water. A survey of suitable habitat sites in Pohnpei and Kosrae found that green snails may compete with *Turbo argyrostomus* and possibly trochus (Yamaguchi & Kikutani, 1989).

2.7.1.2 The Fishery

Utilization: Green snail are harvested for their shell in a similar manner to trochus. The shell is primarily used for buttons, jewellery and handicrafts.

Production & Marketing: The introduction and ultimate harvesting would be for the purpose of providing an export product for FSM. The primary markets are in Japan and Korea. Prices have increased recently due to a limited supply.

2.7.1.3 Status Of The Stocks

The National Aquaculture Center in Kosrae has submitted a proposal to the Pacific Aquaculture Association to introduce green snail brood stock from the Akajuma Marine Science Laboratory in Japan to the NAC. The aims of the introduction are to monitor survival and growth, to spawn the brood stock and to supply seed to other areas in FSM.

2.7.1.4 Management

Current Legislation/Policy Regarding Exploitation: The is no legislation at either the national or state level concerning green snails.

Recommended Legislation/Policy Regarding Exploitation: If green snail is successfully introduced

then legislation similar to that for trochus will be required.

Legislation, or at least a policy, concerning the introduction of marine organisms and quarantine procedures should be prepared at both the national and state levels.

2.7.2 GREEN MUSSEL

2.7.2.1 The Resource

Species Present: The tropical green mussel, *Perna viridis*, is not presently found in FSM.

Distribution: The green mussel has been introduced to a number of Pacific countries: from the Philippines to New Caledonia (1972), Fiji (1975) and Tonga (1978); Malaysia to Tonga (1976); and New Caledonia to French Polynesia (1978)(Hickman, 1989).

Biology & Ecology: Green mussels live in typically estuarine or coastal waters and can tolerate short periods of extremes of temperature, salinity and turbidity. They require suitable substrate for larval settlement and attachment.

2.7.2.2 The Fishery

Utilization: If introduced, the green mussel would be grown as an additional source of fresh protein. Both on-bottom and off-bottom farming techniques can be used (Hickman, 1989).

Production & Marketing: Hickman (1989) recommends that any development of green mussel farming should be clearly aimed at domestic consumption, either at a subsistence or cash-crop economic level. For farming to be biologically feasible, there needs to be: a reliable source of spat; phytoplankton production must be sufficient to sustain rapid growth in high densities; mortality from disease and predation must be low; and the mussel meat must be of high quality and free from pollution (Hickman, 1989).

2.7.2.3 Management

The introduction of green mussels to FSM should be a very low priority. Considerably more research is required on the biological, social and marketing feasibilities of its introduction before any trials be considered.

3. MISCELLANEOUS INVERTEBRATES

3.1 SEA CUCUMBERS (BECHE-DE-MER)

3.1.1 The Resource

Species Present: There are about 1,200 species of holothurians (also known as sea cucumbers, beche-de-mer and trepang) distributed world wide. About 12 species are considered of commercial value (Anon., 1979). The species of commercial or subsistence value that have been recorded from FSM are listed in Table 4. A number of other species of no or very little commercial or subsistence value have been recorded from within FSM, but are not included here.

Distribution: Table 4 indicates the species of commercial or subsistence value that have been recorded within each state.

Table 4: The species of holothurians of commercial or subsistence value recorded from FSM and their distribution.

Species	Common Name	Yap State	Chuuk State	Pohnpei State	Kosrae State
Actinopyga lecanora	stonefish		x		
Actinopyga mauritiana	surf redfish	x		x(s)	x	
Actinopyga sp.	blackfish	x			
Bohadschia argus	leopard (tiger) fish		x	x	x(s)	x
Bohadschia marmorata	brown sandfish	x	x	x(s)	
Holothuria (Halodeima) atra	lollyfish		x	x	x	x
Holothuria (Halodeima) edulis	pinkfish			x	x	
Holothuria (Microthele) axiologa	elephant's trunk fish		x	x	x(s)	
Holothuria (Microthele)fuscogilva	white teatfish		x			
Holothuria (Microthele) nobilis	black teatfish	x	x	x		
Holothuria (Thymiosycia) hilla	*lisop* [Pohnpeian]				x(s)	
Stichopus chloronotus	greenfish	x	x	x	x	
Stichopus horrens					x(s)	
Stichopus variegatus	curryfish	x	x	x	x(s)	
Synaptula spp.	*mahsen en lahd* or *mwasu* [Pohnpeian]			x(s)		
Thelenota ananus	prickly redfish		x	x	x	
Thelenota anax	giant beche-de-mer or amberfish	x	x	x		

Notes: x = species present; (s) = subsistence consumption
Sources: Anon., ?1987; David, 1991; Moore, 1986a, 1986b; Moore, *et al*, 1985; Richmond & Smith, 1988; Rochers, 1989; USACE, 1986, 1989.

Biology & Ecology: Relatively little is known about the biology of sea cucumbers, most research to date has concentrated on taxonomy. A study at the University of Guam Marine Laboratory on the sea cucumber fisheries development in Micronesia involves studies of the life history characteristics, determination of reproductive timing, research on larval rearing and other aspects of sea cucumber

ecology and physiology (Richmond, 1991). Results show distinct periods of reproductive activity, two to three years to attain the age of first reproduction, and relatively low levels of natural recruitment (Richmond, 1991). Some species are known to undergo asexual fission and a few species are hermaphroditic, but the majority are dioecious (Cannon & Silver, 1986). Most species release their eggs and sperm into the water and fertilization is external. Most species reach their peak spawning period during the summer and some species have a second winter peak (Cannon & Silver, 1986).

Sea cucumbers are primarily detritivores, feeding on the organic content of sand, mud and surface films.

3.1.2 The Fishery

Utilization: The current harvest is for subsistence consumption only. Some pickled sea cucumbers are sold in Pohnpei's market (Ludwig & Curren, pers. comm., 1992). Table 4 indicates the species that have been recorded as being consumed on Pohnpei (USACE, 1986).

In Kosrae, only one species, *Stichopus variegatus*, is collected and the internal organs eaten (Rochers, 1989; USACE, 1989). There is a small subsistence consumption of sea cucumbers in Chuuk, and some (by Palauan expatriates only) in Yap.

Processed sea cucumbers are relatively high in protein while low in fat. The processing involves gutting, boiling and finally drying. Properly produced beche-de-mer requires no refrigeration and can be stored for many months if kept dry and well ventilated.

Production: Sea cucumbers represent a commercially valuable marine resource that is presently under-utilized. The history of sea cucumber fisheries in this region has been basically boom and bust due to over-harvesting. Sea cucumbers were extensively harvested late last century as well as during the Japanese mandate. During the Japanese administration in the early 1940s, as many as one million pounds of beche-de-mer were exported annually from Chuuk (Beardsley, 1971). Smith (1947) provides the sea cucumber catch and the dried production figures for 1941:

	Wet Weight (lbs)	**Dry Weight (lbs)**
Yap:	68,952	6,899
Chuuk:	1,143,779	31,869
Pohnpei:	201,784	20,178
Total:	1,414,515	58,946

No information is available concerning the subsistence harvest in FSM, but all indications are that it is very low. In 1991, 150 pounds were exported from Yap (Graham, 1991a).

Marketing: Very small amounts of pickled sea cucumbers are occasionally sold in Pohnpei's markets (Ludwig & Curren, pers. comm., 1992).

Reliable markets for sea cucumbers already exist, chiefly in south-east Asia, with Hong Kong and Singapore dominating. The Chinese consider sea cucumbers as a culinary delicacy, ensuring markets exists wherever large Chinese communities occur. Top quality products sell for up to US$28/kg ($13/lb) dry weight (Infofish Trade News, No.7/91, 15 April, 1991). During 1988, species found in Micronesia were selling for US$8 - $12/lb dry weight in Hong Kong, while in San Francisco's Chinatown, prices were from US$11 - $13/lb (Richmond, 1991).

3.1.3 Status Of The Stocks

The surveys conducted in Yap's outer islands (Moore, 1986a, 1986b; Moore, *et al*, 1986) were only semi-quantitative and provided no stock estimates. They indicated that *T. ananus* followed by *H. nobilis* were the most abundant of the commercially valuable species.

A brief survey of Mwoakilloa and Pingelap atolls in Pohnpei State reported that *H. atra* was the most abundant at both atolls, and *Actinopyga mauritiana* next at Pingelap (David, 1991). No stock estimates were provided.

No detailed stock assessments could be located for Chuuk or Pohnpei. A survey was conducted in Chuuk lagoon by the University of Guam Marine Laboratory and CDMR, but no report could be located.

3.1.4 Management

For over four years the University of Guam Marine Laboratory has been involved in a project, "Sea Cucumber Fisheries Development in Micronesia". This project has identified the critical biological parameters needed to support the development of a sustainable fishery in Micronesia (Richmond, 1991). According to Richmond (1991) the reproductive cycles have been defined, techniques for assessing resources have been developed, the ability to spawn individuals in captivity has been perfected, and a system for raising the larvae is under development. He believes that the final and critical stage is the establishment of a plan for exploitation at a sustainable level.

Current Legislation/Policy Regarding Exploitation: There is no legislation or policies at either the national or state levels concerning sea cucumber exploitation.

Recommended Legislation/Policy Regarding Exploitation: The history of sea cucumber exploitation throughout the Pacific region has not been one of successful resource management. For a commercial sea cucumber fishery to be re-established in FSM, and operated as a sustainable fishery, there is a need for regional cooperation.

Richmond (1991) considers enough biological data now exists to develop a set of guidelines for sustainable exploitation. They include: establishment of seasons for collecting, size limits, and incorporating some low-technology mariculture. He believes the problem is to determine the maximum sustainable yield (MSY) and to cooperate on a regional basis to maximize the economic return. He lists the key considerations as:

- Price is directly related to sea cucumber size - larger equals higher quality. A restriction on size increases the value of the resource while also allowing individuals to become reproductive prior to collection.

- Buyers wish to come into the islands and get as much resource as possible, as quickly and as cheaply as possible. Dealing through such middle men reduces the income into the islands that possess the resource. A better approach would be for the islands to sell quality product at the markets.

- Each of the island groups possess a finite quantity of valuable marine resources. None has enough to sustain a profitable fishery for more than three to five years.

- Competition among the islands will cause a lowering of prices, and increased harvesting to

maintain the same economic benefit.

3.2 SPONGES

3.2.1 The Resource

Species Present: There is only one species of sponge currently exploited commercially within FSM: tentatively identified as a variety of *Spongia officinalis* ("Pacific wool sponge"). There are at least two other unidentified species around Pohnpei which may have commercial prospects (Croft, 1992, pers. comm.). Worldwide only about 15 of the more than 5,000 species of sponge have some commercial value (Josupeit, 1991).

Distribution: The Pacific wool sponge has so far been located around Pohnpei, Ant Atoll, Chuuk lagoon, Ulithi, Faraulep, Elato and Kosrae (Croft, 1990; Croft, pers. comm., 1992; Bridgeland, pers. comm., 1992). At the time of writing surveys were underway around Yap proper and the Yap outer islands.

The Pacific wool sponge is found in waters from 5 to 100 feet (1.5-30 m) deep and in a wide variety of habitats, but are not found in areas of brackish water or extreme silt (Croft, pers. comm., 1992). Croft (1990) found no relationship between geographical and/or oceanographical features and sponge growing areas.

Biology & Ecology: There are a number of factors that favor Pacific wool sponges as a commercial resource. They have no known predators; no locally reported sponge blights (both the Mediterranean and Caribbean stocks have recently been affected by disease); they can grow in a variety of habitats and depths; can regenerate from cuttings; they are non-motile; and are filter-feeders. On the negative side they are slow growing; have low recruitment; and there are limited wild stocks.

Japanese studies in Palau estimated a minimum of 1.5 to 2 years for a cut sponge to reach minimum commercial size ("fist size") (Cahn, 1948). Croft (1990) has found a growth period of two to three years is required to reach commercial size in Pohnpei.

3.2.2 The Fishery

Utilization: In Pohnpei, sponges from wild stocks have long been used for bathing and especially for washing babies, resulting in the depletion of the easily accessible stocks. A coarser, unidentified species found on the reef flat has also been used for scouring pots.

Natural sponges are primarily used in hospitals (able to withstand high sterilization temperatures), in industry (lubricant applicators), by artisans and craftsmen, for applying and removing cosmetics, and for general household use (Croft, pers. comm., 1992).

Prior to World War II the Japanese experimented with culturing commercial sponges in Pohnpei and Chuuk with some success, but were interrupted by the war. Since 1985 there has been a pilot commercial sponge farm operating at Pohnpei, and one private farm.

Both the Pohnpei demonstration farm and the private farm use a submerged culture method. Each culture unit consists of 20 to 30 nylon lines measuring 60 to 70 feet (18-21 m) long with a breaking strength of 150 lb (68 kg). These lines are attached to quarter inch (0.6 cm) polypropylene lines of 30 to 50 feet (9-15 m) length, tied between large coral heads in about 30 to 40 feet (9-12 m) deep water and about 4 to 6 feet (1.2-1.8 m) above the bottom. Sponge cuttings are strung on the 150 lb test nylon lines. In May 1991 there were more than 10,000 sponges under cultivation in the private farm, and more than 4,000 in the demonstration farm. For the last 2 to 2.5 years, growth and survival rates have

been measured. The current survival rate is in excess of 95 percent (Croft, 1991). The initial investment for sponge culture is low and is estimated to be about US$105 per culture unit with an annual depreciation of about US$15 per culture unit (Shang, 1991). Labor requirements for sponge cultivation (mainly for seeding, harvesting and cleaning) is low, with two people being able to care for 40 culture units or 50,000 sponges (Shang, 1991). In addition, the type of work required is culturally appropriate to Micronesians. It is essentially a 'plant it and leave it' style of mariculture.

Surveys in Pohnpei (Croft, 1990; Stevely, 1989; Wilkinson, 1989), Chuuk (Croft, pers. comm., 1992) and Yap State (Bridgeland, pers. comm., 1992) found wild stock levels insufficient to support commercial exploitation. It is therefore necessary to farm sponges on a total replacement basis if commercial farms are to be set up.

Production: The Mediterranean and the Caribbean are the main raw sponge producers, with the final processing being in Greece, France, Italy and Germany (Josupeit, 1991). Total world production oscillated between 160 to 270 tonnes during the 1980s (Josupeit, 1991). There are no figures available on the present cultured sponge production worldwide, but projects are underway in both the Caribbean and the Mediterranean (Josupeit, 1991).

As a large commercial farm has yet to be set up, there are only estimates of potential output available. The demonstration farm/nursery is currently expanding its size to 10-12,000 cuttings. Training of four potential private farmers is about to commence. Their training will include planting 2,000 sponges, learning how to cut, string and select suitable grow-out sites. After training they will receive 500 sponges a month for four months - enough to produce 8,000 cuttings. After 12 months they will receive assistance in re-dividing the sponges to expand their farms, and also when the 2-year old sponges are ready for harvesting.

The operating costs for a two-year growing period is estimated at US$269 per culture unit. At 95 percent survival, one unit can produce about 1,188 sponges.

Marketing: In 1986, France accounted for about 37 percent of world sponge imports, followed by the USA (26%), Japan (10%), Italy (9%), Spain (8%), Germany (6%) and Greece (4%) (Shang, 1991). In the 1980s total world sponge imports varied between 260 to 300 tonnes (this figure exceeds the world production as some imported sponges are re-exported)(Josupeit, 1991). The world market is currently experiencing fluctuations due to over-harvesting and diseases, and if a high quality product can be obtained, then sponge farming in the Pacific region could fill the supply gap (Shang, 1991).

The cost of production per sponge was estimated by Shang (1991) to be US$0.23, or about US$3 per kilogram ($1.36/lb). At the market price range of US$5-25 per kg of raw sponge in the US, the profit potential is there. Sample product was sent to the US and favorable responses from buyers was received, expressing interest in obtaining from 12,000 to 200,000 sponges per year. The Pacific Aquaculture Association has recently approved funding for a marketing study aimed at the Japanese tourist markets in Guam and Saipan.

Some cultured sponges from the private farm are being sold locally in several Pohnpei stores, most being bought by tourists. The average price is around US$6 per sponge, which is much higher than the world market price quoted on the samples sent off island. However, the demand is limited on Pohnpei.

3.2.3 Status Of The Stocks

The recent surveys of Pohnpei and Chuuk were qualitative. The current survey of Yap State is more

quantitative, but densities are not yet available.

A brief survey of Kosrae found only one small Pacific wool sponge in the harbor, but more extensive surveys may locate more. Pohnpei, Chuuk, Ulithi and Elato have wild stocks that may be sufficient for the initial stocking of a nursery farm, but insufficient for harvesting of the wild stocks (Croft, pers. comm., 1992; Bridgeland, pers. comm., 1992).

3.2.4 Management

The Pohnpei demonstration farm is in its fourth year of funding from the Center for Tropical and Subtropical Aquaculture. The current phase will concentrate on training extension agents. The project has five phases: survey local sponge populations and establish a nursery; nursery expansion; training and extension support; survey other areas; and technology transfer to other areas (Croft, 1991).

An associated Saltonstall-Kennedy grant (NOAA) project about to enter its second year, aims to: train farmers; prepare a long range development plan; conduct an indepth economic study; and to carry out a sociological study of buyers and the market (Croft, pers. comm., 1992).

Current Legislation/Policy Regarding Exploitation: The only legislation regarding sponges is in FSM Code (Title 23, section 106) which was taken from the Trust Territory Code and has yet to be updated. It reads:

> Control of sponges - No sponges artificially planted or cultivated shall be taken or molested, except by permission of the High Commissioner.

Recommended Legislation/Policy Regarding Exploitation: The commercial exploitation of sponge resources within FSM shows considerable potential. However, all surveys to date have indicated that the wild stocks are inadequate to support direct commercial harvesting, but in some areas they are sufficient to supply nursery farms, from which commercial farmers could obtain their cuttings.

Legislation is therefore needed in all states to protect wild stocks from commercial exploitation. Provision should be made for collecting wild sponges to stock nursery farms. Legislation will also be required to permit only cultivated sponges to be exported or sold locally.

Croft (pers. comm., 1992) suggested that regulations may be needed to exclude people from sponge farms to minimize poaching.

3.3 CORALS

3.3.1 The Resource

Species Present: Species of corals sought for ornamental or curio purposes, such as branching corals (*Acropora*, *Seriatopora*, *Pocillopora*), stinging corals (*Millepora*, *Stylaster*), organpipe corals (*Tubipora*), brain corals (*Goniastrea*, *Euphyllia*) and mushroom corals (*Fungia*), are found throughout FSM. Black coral, *Antipathes spp.*, have been identified from Pohnpei and Kosrae.

Detailed species lists can be found in USACE (1986 & 1989), Orcutt, *et al* (1989) and Eldredge, *et al* (1979).

Distribution: Ornamental corals are most abundant in shallow reef waters. The semi-precious black coral is found at depths of 65 to 330 feet (20 - 100 m), generally in areas of strong current and clean hard substrate.

Biology & Ecology: Coral growth varies considerably, some branching corals grow rapidly (some *Acropora* can grow up to six inches (15 cm) per year) whereas others such as the *Favia* and *Porites* grow very slowly (Veron, 1986). Growth of black corals is very slow, less than two or three inches a year (Anon., nd).

Stony corals are subject to considerable damage by natural forces such as typhoons and in some areas crown-of-thorns starfish (*Acanthaster planci*). Regeneration occurs at variable rates, with some rapid recovery but complete regeneration may take 20 years for some species.

3.3.2 The Fishery

Utilization: Corals are collected for a number of purposes in FSM. In Yap, and to a lesser extent Pohnpei, corals (especially *Acropora* species) are collected and burnt for the production of lime. In all states corals are collected for the tourist trade. Corals are also used for road surfacing and as building materials.

In Pohnpei, black coral is collected to make jewellery and ornaments.

Production & Marketing: There is no information on stony coral or black coral production or marketing in FSM.

3.3.3 Status Of The Stocks

There are no data available on the stocks of black corals in FSM.

The main threat to stony corals appears to be around the urban centers of each state, through dredging, filling, siltation through runoff and various development projects. There have also been small outbreaks of crown-of-thorns starfish in the recent past in at least Yap and Kosrae.

3.3.4 Management

Current Legislation/Policy Regarding Exploitation: Only Pohnpei State has any legislation concerning black coral (2L-106-81, Title III):

- Harvesting without a permit is prohibited;

- The use, sale or transfer to anyone other than a licensed processor is prohibited;

- Closed seasons and/or areas may be designated by the Director of Resources & Development as deemed necessary;

- Harvesters and processors must maintain records of their activities and file quarterly reports with the State's fisheries officer;

- Criminal penalties: Imprisonment not to exceed one year, or not more then US$1,000 fine, or both.

- Civil penalties: Fines of three times the current market value of the black coral affected; ineligibility for harvesting or processing permits for three years; forfeit of the product to the State.

Recommended Legislation/Policy Regarding Exploitation: Provisions should be made at the necessary level (national or state) to prohibit the export of corals from FSM, unless specifically authorized.

Legislation and policy is needed to control the use of live corals (such as brain corals) for construction purposes, and to ensure that damage to coral reef areas through development is prevented or at least minimized.

4. REPTILES

4.1 TURTLES

4.1.1 The Resource

Species Present: *Chelonia mydas* (green turtle), *Eretmochelys imbricata* (hawksbill turtle), *Lepidochelys olivacea* (olive ridley turtle) and *Dermochelys coriacea* (leatherback turtle).

Distribution: Green and hawksbill turtles are distributed throughout FSM, with green turtles being the most abundant. Green turtles have been recorded nesting in all states. Hawksbill turtles nest on a number of islands in Chuuk lagoon. Both green and hawksbill turtles are found on and around the reefs and seagrass beds of both atolls and high islands.

Leatherback turtles have been recorded from Yap and Chuuk States. They inhabit the open waters, and are very rare in FSM. There have been unconfirmed reports of them nesting at some small islands adjacent to Ulithi Atoll (Kolinski, pers. comm., 1992).

Olive ridley turtles are rarely sighted in FSM waters, but there have been a number of confirmed reports from around Satawal Island in Yap State. They have not been reported nesting anywhere in FSM.

Biology & Ecology: The basic stages of the life cycles are similar for all species. The key biological aspects relevant to management are their very slow growth rates, the high mortality of hatchlings and juveniles, the long times to maturity, and their highly migratory nature. The following will concentrate on the green turtle as it is the major species for the region. Most of the life cycle of turtles is known, but there are some significant gaps.

The female turtle lays her eggs at night in a nest she digs in the sand. The size of the egg clutch depends on the number of times she has already laid that season, but is generally somewhere between 90 and 140 eggs. She can expect to lay about three to seven times, 10 to 15 days apart, during her nesting season.

The eggs take around 48 to 70 days to hatch, depending on the sand temperature. The sex of the hatchlings is determined by the temperature of the nest. If the nest is hot (e.g. laid in the open beach) then most turtles will be female; if the nest is cool (e.g. if the nest is laid under bushes) then the majority of hatchlings will be male. In the mid-temperature range, the sex ration can vary depending on the local weather conditions. Moving the eggs after about four to six hours after laying usually causes the embryo within the egg to die. Disturbing nests will reduce turtle hatching success by altering the nest structure and may increase its vulnerability to predation.

When the turtles hatch they do so as one group, or two or three smaller groups over one to three days. By hatching together the number killed by predators on the beach (e.g. ghost crabs, birds) and in the water (e.g. sharks and fish) are reduced, as the predators cannot eat all at once. The hatchlings locate the direction of the water by the lighter color of the water, so any lights inland of a hatching nest can disorient them. When they reach the sea the hatchlings immediately swim for the open ocean, only stopping after several days. Only then do the hatchlings rest and begin feeding on planktonic animals near the surface. Little is known of the pelagic stage of their life cycle. The small turtles sometimes take refuge amongst floating seaweed. How long they drift in the open ocean is unknown, but is thought to be several years. In that time they may make one or more circuits of the full ocean gyres before changing to a bottom dwelling existence around reefs and islands.

The sub-adult and adult green turtles are herbivores, eating mainly seagrass and algae. Hawksbills are primarily carnivores, eating mainly sponges. Loggerheads feed on jellyfish and other planktonic animals. In the wild turtles mature very slowly. It has been estimated that they take between approximately 25 years (Hawaii) and 30 years (Australia) to reach sexual maturity. Males that are sexually mature can be identified by the long tail protruding from under the shell. Once the turtles are mature they will commence their long migrations back to the area where they hatched. These journeys can be retraced by tagging turtles at their nesting beaches and receiving tag returns from their feeding grounds. The reverse, tagging at feeding grounds and returns from nesting beaches, is much less common. In FSM one female nesting turtle tagged at Oroluk in Pohnpei State was captured in Taiwan; another tagged in the islands in the north-east of PNG was captured at Kosrae; and last year, from females tagged nesting at Ulithi, one was caught in the Philippines and another in the Marshall Islands. Tagged turtles have been recorded making migrations of well over 1,000 miles in various parts of the Pacific.

Mating occurs in the vicinity of the nesting areas. The female is receptive to males for about one week, during which time she will mate with a number of males and store their sperm. The male is sexually active for about one month and mates with a number of females. After mating the males migrate back to their feeding areas. The females will move up to 60 miles to their nesting beaches. After completing her nesting cycle she will migrate back to her feeding area. The same female will not usually breed in successive years, but will wait from two to eight years (a three year cycle is common) before breeding again. As yet no one knows to what age turtles live, but is at least greater than 30 to 40 years.

Significant numbers of green turtles are known to nest on Ngulu, Ulithi, Gaferut, Olimarao, Elato, Pikelot and West Fayu in Yap State (Smith, 1991). In Chuuk State the key nesting area is on East Fayu (Pritchard, 1982). The only nesting area of importance in Pohnpei State is at Oroluk, and the numbers nesting have declined considerably in recent years. Kosrae has one remote beach where some green turtles nest (Johannes, 1986).

Hawksbill turtles are known to nest in Chuuk lagoon and the lower Mortlock Islands (Etal, Lukunor and Satawan) (Pritchard, 1982).

Nesting occurs all year round in FSM, but peaks in the summer months (April - August).

4.1.2 The Fishery

Utilization: Turtles have always played an important role in the nutrition, ritual and social lives of Micronesians living on the lower islands and atolls. Until recently, turtles were of lesser importance to those living on the high islands. The historical and cultural uses of turtles in this region have been documented and/or reviewed by McCoy (1974, 1982), Lessa (1983), Pritchard (1982) and Johannes (1986).

Turtles are caught by a number of methods. Most commonly they are caught by divers gaffing or harpooning them while resting, mating and occasionally swimming. A detachable hook or harpoon head is connected to a length of line which in turn is attached to a float. The hook or harpoon head is attached to a bamboo or wooden pole two to twelve feet (0.6 - 3.7 m) long, which is held by the diver. When a turtle is located, it is hooked or harpooned and the line used to pull the turtle to the surface. The next most common method is to catch the females when they come up to nest. The turtle is flipped onto its back, immobilizing it. Spearguns are also known to be used to capture turtles.

Green turtles are caught for their meat. Turtle eggs are also collected for food. Hawksbill turtles are primarily caught for their shell, both for the production of traditional articles (e.g. the lavalava belts for outer island women in the western Carolines) and for tourist curios.

Production: The level of exploitation of turtles within FSM is unknown. With the migration of outer islanders to the urban centers there is now a greater demand for turtle meat to be sold in the centers. Only Yap State has some information on the subsistence harvest level of turtles in their outer islands. These data are incomplete as they are provided on a voluntary basis by the islands, and so represent a minimum only.

Atoll/Island	Females	#	Males	# Unknown	# Total	Months	# Survey
Eauripik		7		3		10	11
Elato	65		72		137	21	
Faraulep		47		143	1	191	24
Lamotrek		10		20		30	13
Ngulu	16		1		17	4	
Olimarao				3		3	3
Satawal	30		7		37	17	
Ulithi	53		25		78	6	
Woleai	15		24	8	47	17	
'MV Micro-Spirit'	3				3	<1	
Totals:	246		298	9	553		

There is no information concerning the production of hawksbill turtle shell goods in any of FSM states.

Marketing: In the outer islands of Yap State turtle usage is still for subsistence purposes. On Yap proper turtles are occasionally sold privately. The price varies considerably depending on size and demand: a whole green turtle with a curved shell length of 36 inches (91 cm) sells for about US$60, and $10 for each additional inch (2.5 cm)(Smith, 1991). The meat is sometimes butchered and resold.

Green turtles are in high demand in the urban centers of Chuuk lagoon. This demand encourages turtles to be brought in from the outer islands. They are nearly always sold privately and prices reputedly can exceed US$200 for a whole, large turtle. On rare occasions meat is sold in the markets. Pritchard (1982) reported that hawksbill turtles could be obtained on demand within 24 hours.

Hawksbill turtle shell products can be found for sale in the stores selling handicrafts to the tourists in Yap, Chuuk and Pohnpei.

4.1.3 Status Of The Stocks

With over-harvesting and habitat (nesting beach) destruction, the world turtle populations are declining. The IUCN lists five of the seven species of sea turtles as endangered (including the hawksbill) and another as vulnerable. All species are on Appendix I of the Convention on International Trade in Endangered Species (CITES), which prohibits any commercial trade. FSM is not a signatory to the CITES agreement.

Yap State's Outer Island Turtle Project is currently into its third year. During the first year tagging was conducted at Olimarao Atoll for 4.5 months from late April 1990. A total of 33 adult green turtles (27 females; 6 males) and one immature hawksbill were tagged. During the 1991 summer, tagging was conducted at Gielop (adjacent to Ulithi Atoll) where 418 green turtles (416 females; 2 males) and two female hawksbills were tagged (Smith, *et al*, 1991). Phase III (1992) proposes to conduct tagging at Ngulu, Gielop/Iar, Gaferut and on feeding grounds around Yap proper (Kolinski, 1991).

There are no reports available on the status of turtle stocks in Chuuk State, however, anecdotal accounts indicate that stocks have declined considerably.

Oroluk is the only nesting ground of importance in Pohnpei State (Pritchard, 1982). Prior to 1973 it was uninhabited, but since a small number of people started residing there the number of nesting turtles has declined significantly (Pritchard, 1982). This has been attributed to harvesting of nesting turtles, egg collection, and human disturbances (use of campfires, lights on the island, and the construction of pig pens on the beaches)(Pritchard, 1982; Dahl, 1991). In the mid-1970s Oroluk was estimated to have between 9 and 15 turtles nest on an average night, with up to 20 on a very good night (Pritchard, 1982). In 1985 and 1986 turtle nestings averaged 2.3 nests/month and 3.4 nests/month, respectively (Edson & Curren, 1987). In one month (June) in 1991, four turtles nested on Oroluk (Hedson, 1991).

4.1.4 Management

Only Yap and Pohnpei States have turtle projects underway and/or proposed. Pohnpei MRD conducted a brief (one month) tagging trip in June 1991 (Hedson, 1991). There is also a turtle tagging and management program as part of the proposed Oroluk Marine Life Conservation Area Project (Dahl, 1991). Under this project it is proposed to station a PMRD conservation officer permanently on Oroluk to monitor nesting and enforce current laws.

The underlying objectives of YMRMD's turtle project is to devise management controls which will allow future generations to enjoy the traditional aspects of turtle usage, while recognizing the responsibility to ensure that turtles in the region are not hunted to low levels (Smith, 1991). The specific objectives for phases I and II were: to tag turtles and collect morphometric data; raise a small number of hatchlings for a limited time; assess the current catch rates; acquire, develop and disseminate educational materials on marine turtles; and provide realistic management suggestions (Smith, *et al*, 1991). For future phases (1992 & 1993) the same objectives apply with the addition of the collection of biopsy samples of turtle lesion tissue for analysis, and only hatchlings from females exhibiting abnormal lesions on their bodies will be raised (Kolinski, 1991).

Current Legislation/Policy Regarding Exploitation: FSM National Code (Title 23, section 105) has limitations on the taking of turtles incorporated directly from the former TTPI code:

- No hawksbill turtles or sea turtles shall be taken or intentionally killed while on shore, nor shall their eggs be taken.

- No hawksbill turtle shall be taken or killed except whose shell is at least 27 inches long; no green turtle shall be killed or taken unless the shell is at least 34 inches long.

- No turtles shall be taken or killed from June 1 to August 31, nor from December 1 to January 31.

- Not withstanding the above, the taking of sea turtles and their eggs shall be allowed for scientific purposes when specifically authorized by the High Commissioner.

- Violators face jail terms not exceeding 6 months, fines of not more than US$100, or both.

Chuuk State uses FSM's turtle laws in state controlled areas.

Kosrae State Code's Section 13.523 is identical to FSM turtle laws, with the exception that the first restriction above is omitted, as is the limitation on the taking/killing of green turtles of shell length less than 34 inches.

The Yap State Code's section on 'protection of turtles' (Title 18, section 1005) states:

> "Turtle meat and turtle eggs shall not be sold commercially by any wholesale or retail store licensed to do business in the State."

In 1986, the chiefs of Lamotrek, Satawal and Elato (Yap State) met with those from Puluwat, Pulusuk, Tamatam and Pulap (Chuuk State) to establish controls on obtaining turtles from Pikelot (Pik) and West Fayu (Pikelo). The memorandum of understanding resolved that:

- The people of the islands which are signatories may obtain turtles by transportation means belonging strictly to themselves.

- Turtles shall only be for subsistence use and not for commercial purposes.

- Anyone wishing to obtain turtles from Pikelot and West Fayu but is not a signatory must first obtain permission from the chiefs of Lamotrek, Satawal and Elato.

- Taking eggs from nests and spearing or hooking turtles are prohibited.

Recommended Legislation/Policy Regarding Exploitation: Enforcement of the current legislation is weak or non-existent. This partly stems from the fact that the legislation is derived from the former TTPI laws which were written over 30 years ago, primarily for hawksbill turtles.

FSM, Pohnpei, Chuuk and Kosrae legislation addresses harvesting, but not the sale of turtles and turtle products. Yap's legislation only considers the sale of turtle products in stores, but not by individuals; nor does it address harvesting.

Any turtle protection legislation for FSM states should, at a minimum, encompass the following topics (after Smith, 1991):

- definition of the species involved, using the scientific, common english, and vernacular names;

- the commercial sale of turtle products;

- the collection of turtle eggs;

- protection of hatchlings;

- turtle capture methods, including seasons;

- protection of turtle nesting habitat;

- the use of vessels, including government vessels, to facilitate turtle hunting; and

- customary usage and controls.

Any commercial usage of turtle products, whether by individuals or stores, places too great a pressure on the country's turtles. The sale of turtle shell products to tourists should be stopped as soon as possible. At the national level, FSM should consider becoming a signatory to the CITES convention to help prevent the trade in turtle products. There should, however, be allowances made for the

exchange/giving/sale of traditional implements within the country, but for customary purposes only. Obviously this involves a large "grey" area that can only be resolved through consultations between the governments and traditional leaders. Detailed education programs need to be developed to explain the need for regulation of turtle harvesting.

Assistance can be obtained for the development of turtle conservation and management programs from the South Pacific Regional Environmental Programme's Regional Marine Turtle Conservation Programme, contactable through FSM Marine Resources Division.

5. CHONDRICHTHYES (CARTILAGENOUS FISHES)

5.1 SHARKS

5.1.1 The Resource

Species Present: A diverse range of sharks are present in FSM waters. What harvesting occurs largely consists of carcharhinid sharks, but other families are also caught.

Distribution: Sharks occur from reef and inshore areas through to the open oceans, at all depths, and are widely distributed throughout FSM.

Biology & Ecology: Sharks utilize a variety of reproductive modes, but all fertilization is internal. Most species bear their young alive in broods ranging from a few individuals to nearly one hundred. As sharks produce so few young and because from the limited data available it is believed they are, in general, slow growing, their populations can be greatly reduced by heavy fishing. When these top level carnivores are removed from a community such as a reef system, adverse effects may result (Randall, *et al*, 1990).

5.1.2 The Fishery

Utilization: Sharks are used as a subsistence resource in Kosrae (Molina, pers. comm., 1992) and on Fais Island in Yap State. The only commercial use was one small-scale buyer in Chuuk offering US$15 per set of shark fins (6 pieces/set) (CDMR staff, pers. comm., 1992).

There is a by-catch of shark in the tuna longline and purse seine fisheries, but no information was available.

Commercial shark fishing is for the fins only.

In March 1989, a private Japanese-Yap business venture conducted one brief drift gillnetting survey for sharks and tunas. The low catch, combined with pressure from the Japanese Government and MMA fisheries management considerations, stopped the operation (MMA, 1990).

Production & Marketing: No information was located on subsistence, artisanal or commercial exploitation of sharks in FSM.

5.1.3 Status Of The Stocks

No information is available on shark stocks in FSM waters.

5.1.4 Management

Current Legislation/Policy Regarding Exploitation: There is none at either national or state levels.

Recommended Legislation/Policy Regarding Exploitation: Unless a commercial shark fishing operation develops, none seems to be required at present.

6. OSTEICHTHYES (BONY FISHES)

6.1 TUNA

6.1.1 The Resource

Species Present: Commercially important tuna species: skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*), bigeye (*Thunnus obesus*) and albacore (*Thunnus alalunga*). Tuna species that are also artisanally important: mackerel tuna (*Euthynnus affinis*), frigate tuna (*Auxis thazard*), bullet tuna (*Auxis rochei*) and dogtooth tuna (*Gymnosarda unicolor*).

Distribution: All species are found throughout FSM. The skipjack tunas form large near-surface schools; the smaller yellowfin also inhabit the near-surface waters, whereas the larger yellowfin and bigeye tunas dwell in the deeper waters above the thermocline. Dogtooth tunas are primarily reef dwellers, occurring in mid-water along steeply sloping lagoon pinnacles, channel walls and seaward reefs to depths of 55 fathoms (100 m).

Biology & Ecology: Despite being the basis of the world's largest fishery, there is still a lot of unknowns regarding the life history of tunas. Many tuna species migrate considerable distances, swimming continuously. They eat substantial amounts of food and have rapid growth. Many species maintain core body temperatures several degrees above the surrounding sea temperature. Open sea species feed largely on epipelagic fishes, squids, and crustaceans. Near-reef species also utilize the larval and early juvenile stages of reef fish and crustaceans as prey. Reef-associated species prey on large zooplankton or fish occupying the water above the reef (Myers, 1991).

6.1.2 The Fishery

Utilization: Tunas form a significant part of the subsistence, artisanal and especially the commercial fisheries of FSM. Tunas are still caught seasonally from traditional sailing canoes by pole and line fishing, as well as trolling, in the outer islands of Yap and Chuuk States. Gillett (1987) provides detailed information on traditional tuna fishing at Satawal. Tuna still form a major part of the subsistence diet for outer islanders in all states. Most catches are usually made by trolling from small outboard powered boats. In the urban centers tunas are sold fresh in the local markets.

Trial fishing of "ika-shi" and "palu-ahi" tuna fishing techniques were conducted in Chuuk, and although not successful, the Hawaiian master fishermen involved believed that the methods could be used to develop viable but seasonal fisheries (Wailani, *et al*, 1990).

Commercial pole and line fishing for skipjack has been carried out in FSM by the Japanese since the late 1920s, catching bait in Chuuk and Pohnpei (Smith, 1947). The fishery was interrupted by World War II and resumed in the late 1950s. Also in the 1950s the Japanese began longlining for yellowfin tuna, with the Koreans and Taiwanese following in the late 1960s. The Japanese and the United States both conducted several purse seine pilot studies in the early 1970s (Diplock, 1991a, 1991b). The commercial tuna fishing in FSM in recent years has been by pole and line, longline and purse seine methods.

The pole and line fishery in FSM waters has been dominated by the Japanese, but fleet size has decreased from a high of about 200 vessels in 1979 to less than 58 vessels in 1989 Diplock, 1991b). With improved automation and poling machines the fleet efficiency has improved, but vessel numbers are still expected to decline as they are not being replaced (Diplock, 1991a).

Pole and line vessels target the surface skipjack schools with a small by-catch of yellowfin (1%). Diplock (1991b) reports that the fishery is seasonal with most fishing from February to March and minimal activity during the boreal summer (June to August). Effort is generally concentrated east of 150°E between 2°N and 10°N, but is variable from year to year.

Longlining is also dominated by the Japanese, with fleet size since 1979 varying from more than 320 vessels in 1981 to less than 130 in 1986. In 1989 approximately 250 Japanese and 60 Taiwanese longliners entered FSM Exclusive Economic Zone (EEZ) (Diplock, 1991b). The average number of hooks set by the Taiwanese vessels is about half that set by Japanese vessels.

The longline vessels target the deeper yellowfin and bigeye tunas. The Japanese fishery is seasonal with highest catches in the spring and summer (when demand for sashimi grade tuna is highest in Japan), whereas the Taiwanese operate mostly from July to December (Diplock, 1991a). The fishery is concentrated in the northern EEZ between 5°N and 10°N for both yellowfin and bigeye. The CPUE is reportedly highest for yellowfin in the eastern and southern portion of the EEZ between 150°E and 165°E, south of 5°N, whereas the CPUE for bigeye is more evenly distributed. The Taiwanese fleet mostly operate in the western EEZ between 3°N and 9°N as far east as 150°E (Diplock, 1991a).

The purse seine fishery is expanding rapidly in terms of both vessel numbers and catch. Vessels licensed for FSM EEZ have increased from 14 in 1979 to 112 in 1989, including 39 Japanese, 32 U.S., 18 Korean, 15 Taiwanese, 3 Indonesian, 3 Vanuatu and 1 Australian seiners (Diplock, 1991b).

The purse seiners target the large surface schools of skipjack and yellowfin, with the yellowfin catch comprising approximately 25 percent of the purse seine fishery. In FSM EEZ the fishery is seasonal with maximum activity between March and July when the Equatorial Counter Current moves north bringing more flotsam to the zone (Diplock, 1991b). Fishing effort is concentrated south of 6°N, with the Japanese and Taiwanese tending to operate in the western part of the EEZ, west of 154°E, but varies between years. The U.S. fleet mostly fishes in the south and eastern areas of the zone, while the Korean fleet operates south of 5°N between 150°E and 160°E (Diplock, 1991a, 1991b).

Production: Gillett (1987) provides an indication of production of the traditional subsistence tuna fishery for one particular island. From 6 November to 24 December 1983, 59 fishing days, resulted in a total catch of 377 tuna, estimated to comprise 60 percent yellowfin, 25 percent skipjack, 9 percent mackerel tuna, 5 percent bigeye, and 1 percent frigate tuna. The number of tuna caught per fishing day ranged from 1.1 to 17.0 and averaged 6.4. Gillett (1987) compares this with records of catch from six years previously, when 2,118 tuna were caught during a 51 day period (48 fishing days), an average of 44.1 tuna per fishing day.

Figures for domestic tuna production are unclear as most states combine pelagic species together. Estimates of the subsistence and artisanal tuna catches are available for Kosrae. The following are the estimated subsistence and artisanal catches by weight for fiscal years 1987 to 1990 (source: KMRD records). Weights are in pounds and the percentage of the total catch are in parentheses.

Species	**1987**	**1988**	**1989**	**1990**		**Mean**
skipjack		107,925	167,631	75,883	?	
		(33.7)	(35.9)	(26.9)	(16.3)	(28.2)
yellowfin		62,129	149,420	47,956	?	
		(19.4)	(32.0)	(17.0)	(25.1)	(23.4)

Of the estimated subsistence and artisanal trolling catch for Kosrae, the average (1987 - 1990)

contribution to the catch of skipjack and yellowfin were 43.8 percent and 41.2 percent, respectively.

For the period April 1988 to March 1989, the YFA catch of tunas is shown below (YFA records):

Species	Catch (lbs)	% of Total Catch
yellowfin	51,009	29.2
skipjack	7,058	4.0
dogtooth	3,252	1.9
mackerel tuna	20	<0.1

Tunas represented 35.2 percent of the total catch of pelagic and bottom fishes for that period.

The following figures for the commercial harvest of tunas in FSM EEZ are based on data for the period 1979 to 1989. Recent information is unavailable as it is confidential due to its use in negotiating access agreements. The following catch data are reported in terms of the fishing methods rather than the species caught. However, an approximate guide to catch composition, based on long term averages (1979 to 1989) are: pole and line - 99% skipjack and 1% yellowfin; longline - 69% yellowfin and 31% bigeye; purse seine - 75% skipjack and 25% yellowfin. It must be emphasized that the catch composition from year to year may vary considerably. In addition, there are deficiencies in the figures due to the lack of high seas data from Distant Waters Fishing Nations (DWFN) (Diplock, 1991b).

The annual tuna catches (in metric tonnes) from FSM EEZ are given below:

Year	Pole & Line	Longline	P. Seine	Total
1979	23,000	11,320	5,200	39,529
1980	21,000	12,756	5,800	39,556
1981	12,871	16,473	29,625	58,969
1982	3,066	7,977	33,030	44,073
1983	7,291	8,729	58,218	74,298
1984	17,683	13,350	79,173	110,206
1985	5,831	13,426	43,534	62,791
1986	32,616	7,621	73,301	113,538
1987	4,555	11,455	114,188	130,198
1988	14,065	14,893	162,000	190,958
1989	22,000	13,000	120,000	155,000
Total:	163,978	131,000	714,129	1,019,107

[Notes: The figures are based on catch statistics collected by MMA and the Catch Data Base at SPC, as reported in Diplock (1991a). Figures supplied in Diplock (1991b) differ slightly to those above. The above figures include estimates for Japanese L/L vessels based in Guam from 1987 to 1988. Purse seine catches are estimated for both the Taiwanese and Korean fleets.]

Pole and line fishery: Diplock (1991b) reports that the average catch rate is 6.4 tonnes per boat per day, and the present catch is about 15,000 tonnes per annum. Historical highs of 50,000 tonnes per annum (early 1970s) have been recorded.

Longline fishery: The average annual catches are 8,100 tonnes of yellowfin and 3,600 tonnes of bigeye (Diplock, 1991b). The trend in CPUE indicates that catch rates of bigeye will increase as that species is selectively targeted due to its high value on the sashimi market (Diplock, 1991a).

Purse seine fishery: This fishery has produced annual yields of 118,000 tonnes of skipjack (Diplock, 1991b).

Marketing: The artisanal catches of tunas are mostly marketed locally, as are some of the non-sashimi grade tunas from state fishing authorities.

Sashimi grade tunas (yellowfin and bigeye tunas from longline and pole and line vessels) are currently transshipped to Japan from some FSM ports. The quantity of tuna air freighted from Yap (1989 to 1991) through the Yap Fishing Authority is given in the section for deep-slope fish production. Transshipping is expected to increase as longline fishing bases are established in Yap and Chuuk, and as facilities to handle purse seine catches are completed in Kosrae and Pohnpei.

6.1.3 Status Of The Stocks

There is no information available on the status of the non-commercial species in FSM. Information is only available for skipjack tuna and, to a lesser degree, yellowfin and bigeye. The following stock assessment summary is taken from Diplock (1991b:19-29).

Skipjack tuna: The SPC's Skipjack Survey and Assessment Programme (SSAP) conducted surveys in FSM waters between 1979 and 1980. The results of the study for FSM had to be combined with regional (FSM, Palau, the Marshall Islands and Guam) data for analysis. The skipjack standing stock vulnerable to the fishery was estimated to be between 373,000 and 1,305,000 tonnes. The turnover rate (due to natural mortality, fishing mortality, emigration and growth out of the vulnerable size classes) was estimated to be 23 percent per month. Under normal conditions, this meant that between 103,000 and 252,000 tonnes of skipjack were moving through the fishery each month. The harvest ratio was estimated to be between 2 and 4.8 percent. The assessment of skipjack in Micronesian waters indicated a large resource with a standing stock of between 2,500,000 and 3,700,000 tonnes.

The 1989 skipjack catch by all fleets in FSM comprised only a small proportion of the estimated standing stock. Purse seine CPUE has been relatively constant since 1979. Pole and line CPUE is more variable with an increasing trend since 1985. The constant CPUE figures for the surface fishery are indicative of a healthy stock, although it is possible that some reduction in abundance could have been offset by increases in fleet efficiency.

Yellowfin and bigeye: The standing stocks of yellowfin and bigeye were not estimated by the SSAP and stock assessment must rely on the interpretation of catch and effort data. These show several long term declines in yellowfin CPUE including one since 1978. This cannot be convincingly ascribed to the effects of purse seining since it was evident several years prior to the expansion of the purse seine fishery. A possible cause is the fishing down of the stock by longlining although some later interaction effects with the purse seine fishery cannot be ruled out. Yellowfin CPUE has stabilized since 1984 and bigeye CPUE which was relatively stable up to 1983 has gradually increased. Substantial changes have taken place in fishing methodology with increased targeting on bigeye and management of either of these species will affect the harvest of the other.

Diplock (1991b) concludes by noting that there are major deficiencies in the knowledge of the biology of yellowfin and bigeye which preclude conclusive stock analysis. He further notes that the SPC Regional Tuna Tagging Project (RTTP) will provide much needed information on stock structure, migrations, growth and interactions to allow better stock assessments to be made in the future. However, on the basis of present data, no stocks of tuna within FSM appear to be overexploited.

MMA recognizes that although stocks appear healthy there are considerable uncertainties and limitations in the data (Diplock, 1991b, 1991b). They suggest the following harvest levels which are based on previous harvests and assume that current CPUE levels continue (harvests in tonnes):

Fishery	Yellowfin		Bigeye	Skipjack		Total
Longline	8,000		8,000			16,000
Purse seine	27,000			118,000	145,000	
Pole & line				32,000		32,000
Total:	35,000	8,000	150,000	193,000		

Purse seine fishery: Suggested annual harvests of 118,000 tonnes of skipjack and 27,000 tonnes of yellowfin at a CPUE of 14 tonnes per day of skipjack and 4.6 tonnes per day of yellow.

Pole and line fishery: Effort could be increased to 5,600 boat days to produce a yield of approximately 32,000 tonnes at a CPUE of 5.7 tonnes per day.

Longline fishery: Harvest levels of 8,000 tonnes of yellowfin and 8,000 tonnes of bigeye with an applied effort of between 36 to 44 million hooks could be maintained. The wide effort range is due to the different expected hooking rates for yellowfin and bigeye. The relatively large increase in the proportion of bigeye reflects the ability of longliners to selectively target that species (Diplock, 1991a).

6.1.4 Management

The currently running SPC RTTP is expressly designed to provide answers to questions concerning tuna fisheries interaction and tuna exploitation generally in the SPC region. The project aims to provide information on the population characteristics of yellowfin, skipjack and, to a lesser extent, bigeye.

Current Legislation/Policy Regarding Exploitation: The management of the tuna fishery in FSM EEZ is the responsibility of MMA under Title 24 of the national code. The control of tuna fishing in state waters comes under the various State fishery zone acts, and for foreign vessels is coordinated with MMA.

Recommended Legislation/Policy Regarding Exploitation: FSM national government is currently reviewing a draft national fisheries policy which will set out the future direction for fisheries in the EEZ.

One of the key problems facing MMA is obtaining reliable catch and effort data from the DWFN to assist in their stock and harvest assessments. In future, MMA will also assume responsibility for monitoring the domestic fishing vessels to ensure that the total EEZ catch is monitored (Diplock, 1991b).

6.2 OTHER PELAGICS

6.2.1 The Resource

Species Present: This category includes all the non-tuna pelagics: billfish - including blue marlin (*Makaira nigricans*), black marlin (*Makaira indica*), striped marlin (*Tetrapturus audax*), broadbill swordfish (*Xiphias gladius*), sailfish (*Istiophorus platypterus*) and others; wahoo (*Acanthocybium solandri*); mahimahi or dolphin-fish (*Coryphaena hippurus*); rainbow runner (*Elegatis bipinnulatus*); and barracudas (*Sphyraena spp*).

Distribution: These species are distributed throughout FSM and form an important part of the subsistence and artisanal fisheries. Some species, such as the billfish, form a part of the longline by-catch.

Biology & Ecology: All these species are predators, mostly of fish and squid. The billfish are solitary, and the others tend to form small to medium sized schools, although some of the larger barracudas are solitary. The billfish and dolphin-fish undergo migrations believed to be associated with spawning. Large barracudas are potentially ciguatoxic.

6.2.2 The Fishery

Utilization: Miscellaneous non-tuna pelagic fish form about half of the subsistence and artisanal trolling catch. The catches tend to be seasonal, partly due to the relative inaccessibility of the open sea by small boats during the north-east trade winds (boreal winter), and partly due to the seasonality of some species. Peak wahoo season, at least in the western FSM states, is around November to March; dolphin-fish are usually caught more frequently from December to April.

The gamefish species (billfish, tuna, wahoo, mahimahi, etc) are potential sport fishery resources which are currently not utilized. The development of such a fishery would require some capital outlay for dedicated vessels and specialized equipment. A brief study in Yap suggests a sport fishery may be possible as a part-time operation which doubles as a commercial fishing and other contract business (Gaffney, 1990).

Production & Marketing: The production figures for most states combine the tuna and other pelagic fishes together. Estimates for Kosrae are available for the subsistence and artisanal catch and are given below (catches in pounds; percentage of total catch in parentheses):

Species	1987		1988		1989		1990	Mean
wahoo	3,523	3,736	5,924					
		(1.1)	(0.8)	(2.1)	(9.6)	(3.5)		
mahimahi		2,242	9,339	846				
		(0.7)	(2.0)	(0.3)	(0.5)	(0.9)		
barracuda		2,242	1,401	2,257				
		(0.7)	(0.3)	(0.8)	(1.7)	(0.9)		
Total:	8,007	14,476	9,027					

Of the trolling catch, the four year average composition was 5.6% wahoo, 1.4% mahimahi, 1.3% barracuda and 6.7% miscellaneous, the other 85% were tunas (KMRD statistics).

Data are also available for YFA's catch from April 1988 to March 1989 (YFA statistics). These are given below:

Species	Catch (lbs)	% of Total YFA Catch
wahoo	42,794	24.5
rainbow runner	12,122	6.9
mahimahi	6,444	3.7
barracuda	3,599	2.1
black marlin	274	0.16
blue marlin	130	0.07
sailfish	101	0.06
Total:	65,464	37.5

Most pelagics are sold on the domestic markets, with some seasonal export of wahoo and mahimahi.

6.2.3 Status Of The Stocks

There is no stock assessment information available on the non-tuna pelagic fishes caught either for subsistence or commercial purposes. There is also no evidence to suggest that any species is being over-exploited.

6.2.4 Management

Current Legislation/Policy Regarding Exploitation: There is no legislation in place at either the national or state level specifically regarding the above species. The general government policies at both the national and state levels are to encourage greater effort in exploiting the pelagic species for commercial purposes, to relieve pressure on reef stocks, for which subsistence and artisanal fisheries have priority.

Recommended Legislation/Policy Regarding Exploitation: None is considered necessary at this time.

6.3 BAITFISH

6.3.1 The Resource

Species Present: Baitfish are small pelagic fishes from a number of families. The most commonly found species in FSM are *Decapterus spp*, *Selar crumenophthalmus*, *Rastrelliger kanagurta* and *Amblygaster spp*. Below are listed the species considered as small pelagics or baitfish in the South Pacific region (after Dalzell & Lewis, 1989):

Common name	**Genus**
Anchovies	*Stolephorus* spp, *Thryssa* spp.
Sardines	*Sardinella* spp, *Amblygaster* spp.
Round herrings	*Dussumieria* spp.
Herrings	*Herklotsichthys* spp, *Pelona* spp.
Sprats	*Spratelloides* spp.
Mackerels	*Rastrelliger* spp.
Scads	*Decapterus* spp, *Selar* spp, *Selaroides* spp, *Atule* spp.
Fusiliers	*Pterocaesio* spp, *Caesio* spp, *Gymnocaesio* spp.
Flying fish	Exocoetidae
Half beaks	*Hemiramphus* spp, *Hyporhamphus* spp.

Distribution: Baitfish are widely distributed throughout FSM, although more species tend to be found around the higher islands. Lewis, *et al* (1983) reviewed the catches of baitfish from the SPC's tuna program in the South Pacific, and the species found in FSM are given below (cited in Dalzell & Lewis, 1989):

Family	**Yap**	**Chuuk**	**Pohnpei**	**Kosrae**
Anchovies	3	0	4	5
Sardines & sprats	2	4	5	3
Silversides	2	2	5	4
Scads	0	1	4	2
Fusiliers	1	0	2	0
Mackerel			1	
Total:	**8**	**7**	**21**	**14**

Biology & Ecology: The majority of baitfish species are planktivores, form schools and are often seasonal. They occupy a range of habitats from estuarine waters, coral reefs and lagoons to the open ocean.

6.3.2 The Fishery

Utilization: Small pelagics have been used extensively in the subsistence fisheries of all states. Their use as baitfish has been minimal. Smith (1947) notes that baitfish were being caught in Chuuk during the late 1920s to supply the Japanese pole and line tuna boats. He notes, however, that stocks were not abundant. Currently there is an OFCF bait fishing project underway in Chuuk to assess the feasibility of supplying the tuna longline vessels to be based there.

Baitfish are commonly caught as bait for longlining or pole and line tuna fishing. They are usually caught by use of dip nets or bouke-ami nets. The fish are aggregated around lamps suspended from the boats at night. During the setting and hauling of the nets the lights are raised to near the surface

and dimmed to compact the baitfish schools (Dalzell & Lewis, 1989).

Small pelagics subsistence fisheries use a variety of methods including dip-nets, beach seines and handlines.

Production & Marketing: The SPC RTTP conducted two periods of pole and line fishing during 1990 in FSM EEZ. The availability of suitable baitfish species was found to be highly seasonal both in quantity and variety of species. In the two periods 481 and 1,565 buckets of baitfish were caught. Some atolls produced sufficient bait for the SPC to conduct tuna tagging operations, but it is doubtful that any could support commercial operations (Anon., 1991b)

Wailani, *et al* (1990) noted an abundance of *Decapterus* spp. and *Selar crumenophthalmus* in and around Chuuk lagoon while conducting "ika-shi" and "palu-ahi" fishing trials for the Truk Fresh Fish project (December 1989 - July 1990). They recommended further studies be conducted to assess the feasibility of commercially fishing the species.

The OFCF Chuuk baitfish project has been conducting such a feasibility study since April, 1991. The catch data for the six months July to December, 1991, for the Chuuk baitfish project are given in Table 9. Catches have not been up to expectation so far (Kawakami, pers. comm., 1992). The project is due to run until March 1993.

Table 9: Baitfish catches (kg) July to December, 1991, for the OFCF Chuuk baitfish project.

Species	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Mthly Mean**	**Total**
(# trips each month)	(10)	(20)	(9)	(32)	(12)	(12)		
Decapterus spp.	258	615	3,406	4,451	370	658	1,626	9,758
Selar crumenophthalmus		248	1,313	6	93	438	37	356 2,135
Rastrelliger kanagurta			21	718	418	42	200	1,199
Amblygaster spp.		213	122	21	81	489	123	175 1,049
Dussumieria spp.					46			46
miscellaneous		18		122				140

SPC did an analysis of the baitfishing catch, effort and species composition for Micronesia arising from their tuna project, to assess the differences between high islands and atoll lagoons (Anon, 1984). They found that the catch per effort was, on average, almost twice as high at high island sites than atolls, and the species composition at high islands was more varied. In addition, the degree of variability of catch per effort at atoll sites was greater than at high island sites. They concluded that atolls in general offer much less potential for commercial baitfishing than high islands (Dalzell & Lewis, 1989).

6.3.3 Status Of The Stocks

The status of FSM's baitfish stocks is unknown.

6.3.4 Management

Current Legislation/Policy Regarding Exploitation: Only Pohnpei State has legislation directly relating to baitfishing. State law 2L-239-71 prohibits the harvesting and use of baitfish taken from Pohnpeian waters by noncitizen owned or controlled business entities for use in commercial fishing operations. Penalties: not more than five years imprisonment, or a fine of up to US$10,000, or both. In addition, State law 3L-33-72 establishes provision for the collection of catch statistics, operational data and other such information from all vessels licensed to fish for live bait in Pohnpeian waters.

Baitfishing for commercial purposes would also come under the control of the various state fishery zone acts.

Recommended Legislation/Policy Regarding Exploitation: There is currently no commercial baitfish operations in FSM, and virtually nothing is known about the status of the stocks. The current state fishery zone acts should be adequate for the immediate future. However, with the planned increase in locally operated longline operations, especially out of Yap and Chuuk, specific controls on baitfish operations may be deemed necessary. At the minimum, catch and effort information will need to be collected from any operators.

6.4 INSHORE FISH

6.4.1 The Resource

Species Present: This category includes all the reef, mangrove and lagoon associated fish. As no studies or reports on specific inshore species could be located, all inshore fishes will be profiled together.

Myers (1991) lists the number of known fish species for Micronesia as:

Island	# Known species	# Reef fish species (<60m)
Yap	385	370
Ifaluk/Ulithi	416	413
Chuuk	208	205
Pohnpei	471	445
Kapingamarangi	437	434
Kosrae	363	351

Species lists of inshore fishes can be found in: Eldredge, *et al* (1979), Myers (1991), Orcutt, *et al* (1989), Tsuda (1978), USACE (1986 & 1989) and Wilson & Hamilton (1992).

The families most commonly caught include: snappers (Lutjanidae), emperors (Lethrinidae), groupers (Serranidae), parrotfishes (Scaridae), wrasses (Labridae), rabbitfish (Siganidae), surgeonfish (Acanthuridae), trevallies and jacks (Carangidae), mullets (Mugilidae), and soldierfishes and squirrelfishes (Holocentridae).

Distribution: Within Micronesia, the richest reef fish fauna occurs in the west (Palau) and diversity gradually decreases moving east to the Marshall Islands (Myers, 1991). Over 96 percent of the Micronesian fish fauna may be expected[2] at Palau (1,357 expected species; 1,223 reef fish species), followed by 82 percent in the Eastern Carolines (1,149 species, of which 1,040 are reef fish) and slightly less than 66 percent in the Marshalls (Myers, 1991).

Biology & Ecology: The multitude of species upon which the fishery is based have very divergent life histories and biological parameters. Myers (1991:17) provides a simplified breakdown of the Micronesian inshore fish fauna relative to major habitat, behavioral and trophic groupings:

[2] "Number of species expected" is based on interpolation of gaps in the known distribution of each species. These include species with "uncertain" distributions at island groups to the west of where they are known to occur by assuming they are not Pacific Plate endemics. The estimates do not consider species not yet known from Micronesia and are therefore conservative (Myers, 1991:14).

Habitat/behavioral group	Number of species by trophic category herbivore	omnivore	planktivore	carnivore		No. species	% of total fish fauna
diurnal reef	109	141	94	198		542	40.4
cryptic reef	48	6	15	319		388	29.0
nocturnal reef	0	0	73	51	124	9.3	
sand, mud, & rubble	11	6	4	105		126	9.4
mid-water reef	0	9	37	65	111	8.3	
pelagic	0	0	17	32	49	3.7	
Total no. species:	168	162	240	770		1340	
% of total fish fauna:	12.5	12.1	17.9	57.5	100		

The life histories of the different reef fishes is diverse, with spawning either demersal or pelagic. Pelagic spawning can be either in pairs or schools. After a pelagic larval phase, larvae settle back to the reef where they quickly develop into pigmented juveniles. Settlement sites vary among species, with some living amongst the mangroves or on flats as juveniles, then migrating to outer reef areas as subadults. Many species that normally live on coastal or inner reefs, migrate to specific spawning sites while others live in or near permanent spawning territories (Myers, 1991:20).

6.4.2 The Fishery

Utilization: The inshore fishery is of prime significance to the subsistence and artisanal fisheries sectors. In the more remote areas of FSM the subsistence inshore fishery provides the major portion of protein for the people. Around the urban centers the sale of inshore fish also provides a source of income to many fishermen.

Capture methods vary widely from the more traditional techniques to modern methods. Currently, the most commonly used methods include: spearfishing (both during the day and at night by flashlight); handlining; trolling; gillnetting and cast-nets. Illegal methods such as dynamiting (in Chuuk lagoon) and poisons (especially chlorine) are still used in some areas. Most artisanal fishing is done from wooden or GRP boats of 15 to 25 feet (4.6-7.6 m), powered by outboard motors mostly in the 15hp to 40hp range, but occasionally larger. There is still a significant use of traditional canoes (primarily paddling, but some sailing) and rafts (especially in Yap) used for inshore fishing.

In Kosrae and Chuuk lagoon a considerable portion of the inshore fishing is done by women. Rochers (1989) provides an overview of women's use of the nearshore zone in Kosrae. Falanruw (in prep) and Smith (in prep) have documented the traditional and current fishing methods for Yap proper and the Yap outer islands, respectively.

Production: The available information on inshore fisheries production is incomplete and often vague. A joint national and state fishery statistics project to establish a standardized data collection system in all states began in 1986. The major components of the project were to involve field surveys, interviews, collection of market data and length/weight sampling of certain species. The project was suspended in 1991 due to funding problems, which resulted in computer programs to analyze the data and output reports were not completed. At the time of writing the funding of the project was being reviewed. The data collected during the project is of uncertain reliability and/or incomplete for Pohnpei, Chuuk and Yap. Kosrae has continued with the data collection as a state project.

Kosrae: The production estimates for the subsistence and artisanal fisheries for Kosrae are given in Table 5 below.

Table 5: The contribution (weight in lbs and percentage) of various inshore fish to the estimated annual island-wide catch in Kosrae from subsistence and artisanal fishing during fiscal years 1987 through 1990 (note: weights back calculated from percentages; source - Kosrae MRD).

Fish	1987	1988	1989	1990	Mean	
surgeonfish	26,581 (8.3)	27,083 (5.8)	33,287 (11.8)	(7.8)	(8.4)	
rudderfish	37,470 (11.7)	25,682 (5.5)	21,157 (7.5)	(4.7)	(7.4)	
jacks	9,287 (2.9)	13,541 (2.9)	7,334 (2.6)	(2.5)	(2.7)	
parrotfish	10,568 (3.3)	3,736 (0.8)	12,130 (4.3)	(1.8)	(2.6)	
snapper	9,608 (3.0)	12,607 (2.7)	5,924 (2.1)	(2.8)	(2.6)	
rabbitfish	11,849 (3.7)	7,938 (1.7)	8,181 (2.9)	(1.0)	(2.3)	
mullet	8,647 (2.7)	8,872 (1.9)	7,617 (2.7)	(1.2)	(2.1)	
emperor	5,124 (1.6)	7,471 (1.6)	7,899 (2.8)	(1.8)	(2.0)	
grouper	6,725 (2.1)	9,806 (2.1)	3,385 (1.2)	(1.8)	(1.8)	
squirrelfish	8,006 (2.5)	7,938 (1.7)	3,385 (1.2)	(1.1)	(1.6)	
goatfish	3,203 (1.0)	2,802 (0.6)	7,617 (2.7)	(1.5)	(1.4)	
Total:	137,068 (42.8)	127,476 (27.3)	117,916 (41.8)			

The estimated catch rates for various fishing methods used are given in Table 6.

Table 6: Catch rates (lbs/gear-hour) for the major reef fishing methods employed in Kosrae during fiscal years 1987 through 1990 (after Wilson & Hamilton, 1992:27).

Fishing Method	1987	1988	1989	1990	Avg.
hook & line	5.07	3.97	2.87	3.75	3.92
spearing	5.51	12.57	6.83	3.97	7.22
gill netting	14.33	11.68	20.06	9.26	13.83
cast netting	16.09	8.38	19.40	5.73	12.40
reef gleaning	4.41	1.98	1.98	1.98	2.59
Average:	9.08	7.72	10.23	4.94	

Kosrae MRD is soon to conduct a reef fish stock assessment project. The objectives are to collect information to determine the existing levels of important species, to estimate the rate of natural increase, and to establish an estimate of the sustainable harvest for the subsistence and domestic markets (KMRD files).

Pohnpei: Much of the fisheries data now being collected on Pohnpei is thought to be unreliable (Devoe, 1991b). Only part of the information for the standardized data collection project is still being collected. In addition to current data collection, Pohnpei MRD, in conjunction with the U.S. Forest Service, is about to collect detailed information on five species commonly caught that are thought to be associated, at some stage in their life cycle, with mangroves. The species are: goatfish (*Parupeneus indicus*), giant trevally (*Caranx ignobilis*), flametailed snapper (*Lutjanus fulvus*), rabbitfish (*Siganus*

vermiculatus) and yellowtail mullet (*Liza vaigiensis*). The data collected will include quantities caught and sub-sampling of weight and length frequencies.

The harvest figures for Pohnpei group all reef fish together, but separate the estimated catch destined for subsistence. These figures are provided in Table 7.

Table 7: Reef fish caught in Pohnpei waters and estimated catch destined for subsistence - 1986 to 1991 (weights in pounds) (source: Pohnpei MRD).

	1986	**1987**	**1988**	**1989**	**1990**	**1991**
Public market:	46,491	105,435	814,523	292,600	?	149,085
(landed value US$)				(234,100)		(123,937)
Subsistence:	343,509	240,924	131,480	228,800	?	37,642
(%)	(88)	(70)	(14)	(44)		(20)
Total:	390,000	346,359	946,003	521,400		186,727

Chuuk: Chuuk DMR still collects the market receipts to determine fish flow through the market. The figures for reef fish are (Anon., 1991a):

Reef fish	**1986**	**1987**	**1988**	**1989**	**1990**
quantity (lbs)	170,998	246,133	109,467	91,345	268,916
value (US$)	111,200	189,200	93,100	59,400	259,800

A review of the former Truk Maritime Authority (now CDMR) annual reports for 1986 to 1989 indicated the following amounts of reef and bottom fish were exported as part of their Fresh Fish Export Project:

	1986	**1987**	**1988**	**1989**
Qty (lbs)	13,937	29,517	19,314	2,207*

[* amount exported through the Fresh Fish Export Project and includes ocean fish. Although unclear, the TMA annual report (1989) notes that an additional 109,596 lbs of reef fish were exported.]

The 1988 TMA statistician's annual report recorded a total of 164,133 lbs of fish went through the various markets, of which 69,978 lbs were reef fish and 12,138 lbs were bottom fish (what species comprised the bottom fish category was not stated).

A breakdown of total catch estimates for 1990 are given below (Anon., 1991b - supplied by TMA and derived from surveys and interviews):

Fishing method	**Catch (lbs - converted from kg)**
spearing	601,459
trolling	445,197

gillnet	101,130
cast-net	100,978
hook & line	17,149
bottom fishing	13,973

Total: 1,279,886

Yap: Graham (1991b) has summarized the available information on reef fish production estimates for Yap. Those estimates are from a 1986 household survey, which estimated total reef fish production at 1,275,000 lbs/year (MRMD/DFA, 1986), and a 1987 fishermen's survey which had an estimate of 510,000 lbs/year (MRMD, 1987). Yap's total reef area has been variously estimated as being from 130 km^2 (MRMD) to 184 km^2 (Sudo, 1984), which gives a 1986/87 production estimate of 1.3 to 4.8 tonnes/km^2/year (Graham, 1991b).

The MRMD (1987) fishermen's survey estimated that gillnets (used in setting, driving and surrounding) and spearfishing accounted for 68 percent of the fishing effort on the reef (in hours), and 88 percent of the catch (Graham, 1991b). No significant differences in effort (trips/month) were found from month to month for night or day spearing or for gillnets (except for surround netting, which had a 60 percent increase in effort from February to August), although that effort may have shifted spatially over the year (Graham, 1991b).

Graham (1991a) estimated that the rate of reef fish exports from Yap proper during the first nine months of 1991 to be around 30,000 pounds per year, or very roughly four percent of total production (based on a reef production estimate of 800,000 lbs/year, derived from MRMD/DAF (1986) and MRMD (1987)), up from about 10,000 pounds during 1990. He estimated the proportion of reef fish exports going to family and friends (versus commercially) was roughly 25 percent.

The amount of reef fish flowing through Yap's businesses (markets, stores and restaurants) has been surveyed through questionnaires and the rough estimates (due to varying methodologies) are: 1985 - 80,000 lbs/year (MRMD, 1986); 1986 - 171,000 lbs/year (Kusakawa, *et al*, 1987); and 1989 - 70,000 lbs/year (MRMD data; Graham, 1991b). These figures should be treated as indicative only.

FSM: Due to the various methods of estimating inshore fish (especially reef fish) production figures, and the uncertainties associated with the data collection, an estimate of inshore fish production for the whole of FSM is not possible. Table 8 summarizes the main production figures reported for each state.

Table 8: A summary of the various inshore/reef fish production estimates for each state (weights in pounds).

State	Estimate type	1986	1987	1988	1989	1990	1991
Kosrae	subsistence & artisanal[1]	?	137,068	27,476	117,916	?	?
Pohnpei	public market & subsistence[2]		390,000	346,359	946,003	521,400	? 186,727
Chuuk	markets[3]		170,998	246,133	109,467	91,345	268,916 ?
					(69,978)[4]		
	exported[5]	13,937	29,517	19,314	2,207[6]		

			(109,596)[7]	
Yap	domestic markets[8]	171,000	70,000	
	export[9]		10,000	30,000[10]
	surveys	1,275,000[11]	510,000[12]	

Notes:
1 Kosrae MRD data.
2 Pohnpei MRD data.
3 Anon. (1991a).
4 TMA (1988c).
5 TMA (1986a, 1987a, 1988a, 1989a)
6 TMA (1989a) - Fresh Fish Export Project; includes reef, bottom and ocean fishes.
7 TMA (1989a) - Fisheries Statistics Program.
8 Kusakawa, *et al* (1987); Graham (1991b).
9 Graham (1991a).
10 First 9 months only.
11 MRMD/DAF (1986).
12 MRMD (1987).

Marketing: The following marketing information is summarized from FSM Fisheries Development consultants' report (Anon., 1991b).

Kosrae: The local fish market in Lelu is run by the Kosrae Island Fisherman's Cooperative Association, but due to management problems it is currently barely functioning. The market sells both pelagic and reef fish. The new fisheries base with its substations is expected to increase the marketing of fresh fish. In early 1991, fresh fish retailed for about US$1 to $1.10 with fillets sold for $1.20 to $1.30 and the fishermen received 85 to 95 cents per pound. Most fish are sold to government employees, schools, the hospital and to restaurants, as well as the public.

Pohnpei: Virtually all the fish caught in the outer islands and most fish caught around Pohnpei island are utilized for subsistence purposes. Small scale family based fishing supplies the retail stores and fish markets of Kolonia. In early 1991, retail fish prices were commonly 90 cents to $1.25 per pound. Fishermen generally received about 70 to 80 percent of the retail fish price. Small scale fishermen in the rural municipalities of Pohnpei island had formed loose coalitions to supply EDA with fresh fish but this operation had ceased working by early 1991. In 1989, EDA purchased 37,000 pounds of reef fish from six local markets with an average price of 85 cents per pound. The prime markets for local fishermen are the major restaurants, the schools and the hospital. Four restaurants purchased 5,560 pounds of reef fish in 1989. Some reef fish are exported and an unknown quantity is sent to relatives in Guam and Saipan.

Chuuk: Virtually all inshore fish caught in the outer islands is for subsistence purposes. The urban center of Weno in Chuuk lagoon is well served by small scale fishermen who sell to a number of store owners. Retail fish prices vary greatly depending on supply, but ranges between 65 cents and $1.50 per pound, of which the fishermen receives 60 to 70 percent as the wholesale price. The commercial fish market also serves the domestic market. Some small scale commercial export to Guam and Saipan has been conducted in recent years, in addition to unknown amounts being sent to relatives.

Yap: All inshore fish caught in the outer islands are used for subsistence purposes. The state government and traditional leaders have a general policy of reserving reef fish for the subsistence and domestic markets only. On Yap proper there is an increasing demand for fish, but supply is variable.

Most fishermen are part-time, only selling fish when cash is required. The main demand comes from government workers, the Kingtex garment factory and a Korean construction company, small stores, restaurants and the public (especially outer islanders living in Colonia). Retail prices for reef fish are around $1 per pound. Some reef fish are exported, as well as an undetermined amount going to relatives in Guam and Saipan (often as personal luggage).

6.4.3 Status Of The Stocks

No reports on stock assessments of individual species or families of inshore fish in FSM could be located. Smith & Dalzell (1991) conducted stock reduction experiments at Woleai Atoll (Yap State), using a traditional leaf-sweep method and group spearfishing, to estimate the "fishable" biomass of the back reef areas. The estimates ranged from 5.6 to 25.5 tonnes/km^2 or 46,300 to 177,500 fish/km^2. For the purposes of calculating an overall fishable biomass estimate for the back reefs of Woleai the means of the four fishing experiments were used to estimate average densities of 12.6 tonnes/km^2 or 94,000 fish/km^2. The back reefs of Woleai lagoon cover an area of about 5 km^2 which gives an estimate of a total fishable biomass of 60 tonnes or 470,000 fish. Woleai Atoll is subject to subsistence fishing only.

As mentioned above, Kosrae MRD will be conducting a reef fish stock assessment project in the near future. Wilson and Hamilton (1992) note that the individual food fishes recorded during their survey were often relatively small in size and usually seen in relatively low abundances, indicating that these fishes are being heavily harvested, possibly even to the point of over-exploitation.

Graham (1991b) found that in interviews with Yapese fishermen there was a perceived depletion of reef fish stocks, largely attributed to the use/abuse of introduced fishing methods - primarily flashlight spearfishing and monofilament gillnets.

In Pohnpei the humphead parrotfish (*Bolbometopon muricatum*) was noted as having recently become rare, and this was attributed to night spearfishing as well as the species' low recruitment rate and long maturation time (USACE, 1986).

6.4.4 Management

Current Legislation/Policy Regarding Exploitation: The control of inshore fish resources lies with the states. The general state development policies concerning fisheries have been outlined in the background chapter.

All states have legislation prohibiting the use of explosives, poisons, chemicals or other substances that kill fish or marine life (e.g., YSC Title 18, section 1008; KSC Section 13.523 (7)). In addition, Kosrae prohibits procuring fish or other marine life from midnight Saturday to midnight Sunday (KSC Section 13.523 (8)).

Pohnpei State has specific legislation concerning bumphead parrotfish (*Bolbometopon muricatum*) and groupers (Serranidae). Bumphead parrot fish may not be taken by any means for sale. Both criminal penalties (up to one year imprisonment, fine up to US$1,000, or both) and civil penalties (fine up to five times the market value) apply (PSC 2L-106-81 Title IV). The taking for sale of grouper during the months of March and April is prohibited. The same criminal and civil penalties as above apply (PSC 2L-106-81 Title V).

Recommended Legislation/Policy Regarding Exploitation: Marine Resources staff in both Kosrae and Yap indicated that the uncontrolled use of monofilament gillnets were becoming a threat to the

reef fishery. Regulations should be introduced to at least set a minimum mesh size, and a further step could involve controlling the way they are used.

Another problem identified in most states, but especially Pohnpei and Yap, was the uncontrolled practice of flashlight spearfishing at night. This type of fishing can result in species such as parrotfishes being overexploited. Resolving this problem will present many difficulties, but should be given a high priority.

Consideration should be given to formalizing the policy of reserving the reef fishery for artisanal and domestic use first, and only when the local market is saturated (and if stocks permit) should the export of reef fish be permitted.

6.5 DEEP-SLOPE FISHES

6.5.1 The Resource

Species Present: The deep-slope (also known as deep-bottom or deep-water) resources of FSM are dominated by the Lutjanidae (snappers), of which the subfamily Etelinae (deep-slope snappers) predominate. Other important components are the Lethrinidae (emperors) and the Serranidae (groupers). Other components of dropline fishing catches are given in Table 10 (Dalzell & Preston, 1991). Dominant species of the deep-slope catches include: *Pristipomoides filamentosus*, *P. auricilla*, *P. zonatus*, *Aphareus rutilans*, *Caranx lugubris*, *Lutjanus bohar*, *L. gibbus*, *Etelis coruscans*, and *Lethrinus rubrioperculatus* (Diplock & Dalzell, 1991; Dalzell & Preston, 1991).

Table 10: Percentage catch composition by numbers and weight from SPC dropline fishing in FSM (after Dalzell & Preston, 1991:7).

Family	Common Name		% by No.		% by Wt
Etelinae/Apsilinae	deep-water snappers	23.9		21.7	
Lutjaninae	shallow-water snappers	19.4	18.6		
Lethrinidae	emperors		9.3		4.4
Serranidae	groupers & coral trouts	12.2	7.4		
Carangidae/ Scombridae	trevallies, jacks, tunas & mackerels	18.9	18.5		
Gempylidae	oilfish & snake mackerel	1.5		2.4	
Sphyraenidae	barracudas	0.3		1.0	
Other teleosts			6.1		4.9
Sharks			8.6		21.2

Distribution: Deep-slope species are distributed throughout FSM around the islands, sea mounts and outer banks. Deep-water snapper are generally found between 44 and 220 fathoms (80-400 m). Dalzell & Preston (1991) found a decline in species number in the dropline catches from west to east in the Pacific, but little difference within FSM (Yap - 69 species; Chuuk - 88; Kosrae - 63).

Biology & Ecology: Deep-slope fish, especially snappers, tend to have slow growth, and recruitment may be low, resulting in their being highly susceptible to over fishing. They are usually top level carnivores.

6.5.2 The Fishery

Utilization: The deep-slope resources of FSM have only been exploited for subsistence use around islands and only in the upper depths. There have been some limited commercial fishing operations targeting deep-slope fish for export in Pohnpei and Yap.

The SPC Deep Sea Fisheries Development Project has conducted surveys in Kosrae, Chuuk and Yap, as well as short deep-bottom fishing training courses in Pohnpei (Mead & Crossland, 1979; Moana, 1988; Taumaia & Crossland, 1980; Chapman, in press; Mead & Crossland, 1980; Chapman & Cusack, in press). The SPC master fishermen used small vessels fitted with Samoan-type wooden handreels to conduct the deep-water dropline fishing (Dalzell & Preston, 1991).

Fishing on the deep slopes of Pohnpei and the two proximate atolls of Ant and Pakin was carried out over a three and a half year period and are summarized in detail by McCoy (1990, cited in Dalzell &

Preston, 1991). Most fishing was with electrically powered reels, although on occasion a wooden handreel was used.

Between 1989 and 1991, the National Fisheries Corporation (NFC) and the Overseas Fishery Cooperation Foundation (OFCF) of Japan surveyed the bottom fish stocks of the outer banks and sea mounts in waters between Yap and Chuuk States. Fishing was conducted using handlines (electric and handreels), and bottom set horizontal longlines (Diplock & Dalzell, 1991). The final report of this survey is due in early 1992.

Production & Marketing: The above surveys were conducted on almost exclusively unfished virgin populations, and therefore the following production figures would most likely over-estimate the catches available if commercially harvested.

The following summaries of the SPC and NFC/OFCF surveys was taken from Dalzell and Preston (1991) and Diplock and Dalzell (1991), respectively:

Kosrae: Average catch rates experienced during the SPC surveys ranged from 3.1 to 10.6 kg/line-hour (6.8-23.4 lb/line-hr) with an average of 6.9 kg/line-hour (15.2 lb/line-hr).

About one third of the catches from the Kosrae shelf area were eteline snappers, with a further eight percent of lutjanine snappers. The other major contribution came from carangid and scombrid fishes (36%), especially the trevallies *Caranx ignobilis* and *C. lugubris*.

Yap: Catch rates of deep slope fishes around Yap proper ranged from 4.6 to 5.0 kg/line-hour (10.1-11.0 lb/line-hr), with a mean of 4.8 kg/line-hour (10.6 lb/line-hr). The average CPUE at Ulithi Atoll was 14.4 kg/line-hour (31.8 lb/line-hr) whilst at Ngulu Atoll catch rates ranged from 10.4 to 13.2 kg/line-hour (22.9-29.1 lb/line-hr) with a mean of 11.8 kg/line-hour (26.0 lb/line-hr).

Eteline snappers formed almost 40 percent of the catches from around Yap proper, with other major contributions coming from the serranids (19.3%) and the carangids (21.9%). By contrast, eteline snappers made up only one to six percent of catches at Ulithi and Ngulu atolls. At each of these locations lutjanine snappers comprised 50 to 60 percent of landings (mainly *Lutjanus bohar* and *L. gibbus*). In common with catches at Yap proper, carangids and scombrids made important contributions to catch weight at Ulithi and Ngulu, forming between 19 and 35 percent of landings respectively. At all locations the carangid/scombrid catch was dominated by *Caranx lugubris*.

Deep-slope stocks have been only lightly exploited by the Yap Fishing Authority (YFA). Records for landings processed by YFA show that of the 63.4 tonnes landed over six months in 1988 to 1989, only six percent were demersal species. Graham's (1991a) survey of YFA's exports from 1989 to September 1991 provides the following:

Year	Species	Weight: kg (pounds)	%
1989	mixed*	20,949 (46,184)	64
	tuna	11,995 (26,444)	
Total:		**32,944 (72,628)**	
1990	mixed	67,237 (148,231)	43
	tuna	87,810 (193,587)	
Total:		**155,047(341,818)**	
1991 (9 mths)	mixed	4,777 (10,531)	6

	tuna	85,851 (189,270)
Total:	**90,628**	(**199,801**)

[* Note: "mixed" is a combination of deep-water bottom fish and some pelagics such as wahoo and mahimahi. No estimates were given of the relative proportions.]

Chuuk: Catch rates just outside Chuuk lagoon ranged from 5.0 to 5.9 kg/line-hour (11-13 lb/line-hr), with a mean of 5.5 kg/line-hr (12.1 lb/line-hr). At Ruo Island (Murilo Atoll) the average CPUE was 7.0 kg/line-hour (15.4 lb/line-hr).

Catches of eteline snappers around Chuuk lagoon comprised 12.5 percent of the total landings with major contributions coming from sharks (27%), lutjanine snappers (26%) and carangids (20%). Only a small proportion of the catch at Ruo was eteline snappers. About 70 percent of the landed weight of the catch was made up of sharks, with lesser contributions coming from carangids and scombrids (14%) and from lutjanine snappers (8%). The lutjanine snapper component at Chuuk lagoon was dominated by the three species *Lutjanus bohar*, *L. argentimaculatus* and *L. gibbus*, and at Ruo by *L. bohar*. By far the most important species of the carangid/scombrid group at both locations was *C. lugubris*, which formed between 60 and 80 percent by weight of this catch component.

Yap/Chuuk outer banks: Two methods were used in the NFC/OFCF project: bottom longlines and handline fishing. The fishing occurred at 27 different sites in Yap and Chuuk States.

Bottom longline fishing: A total of 146 sets were made for a soak time of 247.9 hours. This produced a catch of 4,360 fish weighing 11,114 kg (24,502 lb). The mean monthly CPUE, in terms of weight, varied from 0.95 to 7.24 kg/100 hooks/hour (2.1-16 lb/100 hks/hr), averaging 4.02 kg/100 hooks/hour (8.9 lb/100 hks/hr). A total of 87 species were caught, with the lutjanids comprising almost 60% (of which 85% were eteline snappers) of the catch.

Handline fishing: A total of 13,194 fish were caught, weighing 21,208.8 kg (46,757 lb). The average monthly CPUE ranged from 1.3 to 4.57 kg/line-hour (2.9-10.1 lb/line-hr) with an overall mean of 2.3 kg/line-hour (5.1 lb/line-hr). Lutjanids comprised 46 percent of the catch by weight, with the carangids, lethrinids, scombrids and serranids together comprising 53 percent.

In summary, 247.9 hours of longline fishing generated a catch rate of 44.83 kg/hour (98.8 lb/hr) with a longline containing on average 1,200 hooks. Similarly, 1,080 hours of handling fishing, where an average of eight lines with three hooks each were deployed, resulted in a catch rate of 19.6 kg/hour (43.2 lb/hr). This can be expressed as the catch divided by the product of the number of hooks and hours fished or 0.037 kg/hook hour (0.8 lb/hook hr) for the longline and 0.817 kg/hook hour (1.8 lb/hook hr) for handlines. Given the distinctly different depth regimes fished by these gears these catch rates are not comparable and essentially reflect the different efficiencies of the operating procedures in different locations (Diplock & Dalzell, 1991).

Pohnpei: Catch record information of deep-slope fishing around Pohnpei and the nearby Ant and Pakin atolls are provided by McCoy (1990, cited in Dalzell & Preston, 1991). The average catch rate for bottom fishing ranged between 3.9 and 5.5 kg/line-hour (8.6-12.1 lb/line-hr), with a mean of 4.5 kg/line-hour (9.9 lb/line-hr). About 45 percent of the catch was eteline snappers with other major contributions from the carangids/scombrids (17%), serranids (13.3%) and the lutjanine snappers (8.2%). Most of the eteline snapper catch comprised of *Pristipomoides auricilla* and *P. zonatus*, while *Etelis spp* were only incidental catches.

A small commercial fishing industry commenced during 1986 with average landings of 200 tonnes. In

1988, exploitation of the deep-slope resources began, with catches of fish made in depths of around 160 m (87 fathoms). About half the catch during 1989 comprised lutjanine snappers, particularly *Lutjanus argentimaculatus*, which formed nearly 40 percent of landings. Recent information is not available.

6.5.3 Status Of The Stock

The following information on the stocks was taken from Dalzell and Preston (1991) and is primarily based on the SPC Deep Sea Fisheries Development Project results:

Kosrae: Deep-slope stocks around Kosrae have been unexploited. If commercial fishing is pursued the CPUE at maximum sustainable yield (MSY) should decline to around 3.5 kg/line-hour (7.7 lb/line-hr). The total length of the 100 fathom contour around Kosrae is 25 nautical miles (nmi), which allows unexploited biomass of deep-slope species to be estimated at 1.5 tonnes/nmi or 36.6 tonnes in total. The MSY from this biomass would lie between 3.7 and 11 tonnes/year.

Yap: Deep-slope stocks in Yap have been lightly exploited but most commercial fishing activity is directed towards pelagic species. The total length of the 100 fathom isobath in Yap State is 364.2 nmi, 326.7 nmi of which are the atoll slopes. Catch rates at MSY would be expected to decline to around 2.2 kg/line-hour (4.9 lb/line-hr) around Yap proper and 5.9 kg/line-hour (13 lb/line-hr) around the associated atolls. An empirical estimate of 529.9 tonnes unexploited biomass of deep slope fishes is estimated for Yap State. The MSY from this biomass is expected to lie between 53 and 159 tonnes/year.

Chuuk: Commercial fishing in Chuuk State is presently confined to pelagic fishes and shallow coastal reef fishes. The recommendations of the NFC/OFCF deep-slope fisheries resources survey are due out in 1992, and should address the question of stock sizes and the feasibility of commercial fishing. The total length of the 100 fathom isobath in Chuuk State is 588.3 nmi, of which 85 percent is formed by the atoll slopes. For the islands that comprise Chuuk State the CPUE of deep-slope species might reasonably be expected to decline to between 2.8 and 3.5 kg/line-hour (6.2-7.7 lb/line-hr). An empirical estimate of the unexploited biomass for the component islands of Chuuk State is 567.8 tonnes. At MSY the yield from this biomass would be expected to lie between 56.8 and 170.3 tonnes/year.

Pohnpei: The 100 fathom isobath in Pohnpei State extends for 355 nmi, of which about 85 percent is formed by atoll slopes. The CPUE experienced by McCoy (1990, cited in Dalzell & Preston, 1991) refer to unfished stocks around Pohnpei, Ant Atoll and Pakin Atoll. Based on these data, the catch rate at MSY would be expected to decline to around 2.3 kg/line-hour (5.1 lb/line-hr). The empirical estimate of unexploited biomass of Pohnpei State is 314.6 tonnes, for which the annual MSY would lie between 31.5 and 94.4 tonnes/year.

FSM: Dalzell and Preston (1991) suggest that assuming the MSY estimates are realistic, then the estimated potential yield of deep-slope species from the whole of FSM probably lies between 145 and 434.7 tonnes/year.

6.5.4 Management

Current Legislation/Policy Regarding Exploitation: There is currently no legislation at the national or state level regarding deep-slope bottom fishing specifically. Pohnpei State's regulations (2L-106-81, Title V) concerning the take of serranids (groupers) would apply in state waters.

Control of deep-slope fisheries would come under each state's fishery zone act within state waters, and under FSM Marine Resources legislation (FSM Code, Title 24) in the EEZ. Control and/or rights to the banks and sea mounts is not yet resolved.

Recommended Legislation/Policy Regarding Exploitation: It appears that stocks of deep-water bottom fishes are not adequate to sustain heavy commercial exploitation on a sustained basis. There may be sufficient stocks to permit small scale (artisanal) level exploitation if carefully monitored. The present fisheries acts appear adequate to control deep-slope fisheries by foreign operations, but specific legislation may be required for domestic commercial fishing.

7. FLORA

7.1 SEAWEED

7.1.1 The Resource

Species Present: The potentially economic seaweeds *Eucheuma spp*, *Gracilaria salicornia* and *Gracilaria sp.*.

Distribution: *Eucheuma* was farmed for short periods in both Pohnpei and Kosrae. The two *Gracilaria* species were identified in a survey for potentially economic seaweeds in Yap lagoon (Tsuda, *et al*, 1987).

Biology & Ecology: Seaweeds can be grown intensively, requiring only sunlight and nutrients in the water. Damaged plants can be attacked by fungus (Anon., nd). Problems can be experienced with attacks by herbivorous fish, especially *Siganus spp* (rabbitfish).

7.1.2 The Fishery

Utilization: The major commercial use of seaweeds, especially *Eucheuma*, is as a primary source of phycocolloids for the production of agar and carrageenan, which are important stabilizing and suspension components in a variety of food, cosmetic, medicinal and other products.

Tests on the *Gracilaria* species found in Yap showed low agar yields and gel strengths, however, if farming techniques could be developed, there may be a market for *Gracilaria sp.* as a vegetable in Guam (Tsuda, *et al*, 1987).

There were no reported subsistence harvests of seaweeds in FSM. Production would therefore be for the export market only.

Eucheuma farming can be done by attaching cuttings to lines suspended off the bottom, or by raft culture. The rafts used in Pohnpei's farms measured 18 x 18 feet (5.5 x 5.5 m). They consisted of a bamboo framework with mangrove posts supported by four to eight floats. On the framework were nylon lines carrying the seaweed.

Under Fiji conditions, and using the stake and line method, the weed is best harvested after 10 weeks. A portion of the harvest is retained, the weed cut into pieces and used to replant the lines (Anon., nd). The harvested raw seaweed is sun-dried, pressed and baled, then shipped to processing plants. Production of the purified final product is a highly technical operation, but an intermediate level raw seaweed can be treated with an alkali (potassium hydroxide) to produce weed chips (Anon., nd).

Production: The major culture areas are Taiwan, Philippines, Indonesia and Fiji. About 17,000 tonnes of carrageenan and 7,000 tonnes of semi-refined product were produced worldwide in 1989.

Eucheuma farming started in Pohnpei in the early 1980s. The State's Economic Development Authority (EDA) assisted several private groups to establish farms, but all failed once the government ceased paying the workers subsidized salaries (Shang, 1989). In the late 1980s EDA started an experimental seaweed culture farm, this time using the bamboo raft culture technique instead of the stake and line method used before (APTA, 1990; Shang, 1989). This project recently ceased functioning due to personnel and marketing problems (Neth, Acting Director EDA, pers. comm., 1992).

Some 14 tonnes of dried seaweed was exported to Denmark in 1988. The buyer from Denmark wanted to purchase 10,000 tonnes/year at a price of US$400 per tonne (F.O.B.) (Shang, 1989). The EDA paid US$300 a tonne to local producers, and received FOB US$400 per tonne. This difference was used to cover the costs of collection and storage (APTA, 1990).

In a review of aquaculture projects in FSM, APTA (1990) found there was insufficient information available to allow a full evaluation of the project. They concluded that based on the data in Shang (1989), the EDA experiment was unlikely to prove commercially viable. They felt that further evaluation of the experiment was required before further decisions concerning seaweed farming be considered.

One major problem with seaweed farming in this region is predation by rabbitfish. The only options to minimize this problem would be fencing (too costly and labor intensive) or to develop a farm large enough that predation destroys only a small portion of the seaweed. Harvesting of rabbitfish may provide an additional income source.

The very small (1/3 acre) *Eucheuma* farm in Kosrae was started in 1985 and harvested 280 lb (127 kg) of dry seaweed five months later. Apart from marketing problems, it was found that the variety of seaweed used apparently had low carrageenan levels and the project stopped (KMRD files; Molina, pers. comm., 1992).

Marketing: *Eucheuma* prices have been very erratic over the last five years, ranging from US$350/tonne in 1987 to US$700/tonne in recent years (all prices are delivered Europe). Recent price increases have been partially attributed to new uses for carrageenan and a leveling of supply from the Philippines (APTA, 1990). How long the prices will remain at high levels is unknown. If prices should fall it will be the smaller producers that buyers will withdraw from first.

There is no local use for raw or processed *Eucheuma* in FSM, so any future production would be restricted to the export market.

7.1.3 Status Of The Stocks

There is currently no commercial seaweed production in FSM. Wild stocks of *Gracilaria* species are insufficient to support harvesting.

7.1.4 Management

Since the failure of the Pohnpei EDA experimental farm there has been no research conducted on seaweed production in FSM.

Current Legislation/Policy Regarding Exploitation: There is currently no legislation or policy regarding seaweed exploitation at either the national or state levels.

7.2 MANGROVES

7.2.1 The Resource

Species Present: The main mangrove species are: *Bruguiera gymnorhiza*, *Heritiera littoralis*, *Lumnitzera littorea*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Sonneratia alba* and *Xylocarpus granatum* (Devoe, 1991a & 1992; Devoe & Falanruw, 1991; Lal, 1989). For more detailed lists see Falanruw, *et al* (1987), MacLean, *et al* (1986) and Whitesell, *et al* (1987). Although not a mangrove tree, the nypa palm (*Nypa fruticans*) is included as a mangrove resource.

Distribution: Mangrove stands are found around all the high islands: Yap (2,894 acres or 1,171 ha), Chuuk lagoon (756 acres or 306 ha), Pohnpei (13,652 acres or 5,525 ha) and Kosrae (3,860 acres or 1,562 ha). The above species are found in Yap, Pohnpei and Kosrae. Information for Chuuk is incomplete as a copy of the vegetation survey for Chuuk could not be located.

Biology & Ecology: The ecological services provided by mangroves include: protection of coastline and infrastructure from the action of wind and waves; filtration of upland sediment, thereby protecting lagoon and reef systems; critical habitat for larval and juvenile fishes; habitat for other wildlife, especially birds and bats, and conservation of germplasm (Devoe, 1991a).

7.2.2 The Fishery

Utilization: In addition to the commercial and subsistence uses of the mangrove woods and nypa palms, there are a number of other marine resources which inhabit the mangrove swamps, such as mud crabs, mangrove clams and fish.

Devoe and Falanruw (1991) found that Yap's mangrove are not intensively exploited at present. There is no commercial exploitation of Yap's mangrove timber. House timbers, posts, poles and construction scaffolding appear to be the major wood products. Fuelwood is being removed for lime production in the village of Maa, nypa palm is removed for thatch where it is abundant, and very small amounts of *Xylocarpus granatum* are harvested for handicrafts. Various foodstuffs such as fish, mangrove clams, crabs and local medicines are also taken. The current level of exploitation appears to be well within the productive capacity of the resource, with the possible exception of nypa palm (Devoe & Falanruw, 1991).

In Pohnpei, mangroves are intensively used. Increased pressure is resulting from rising use in the areas of fisheries, timber for construction, furniture, fuel, posts, poles and other small-dimension lumber and craftwood, an for alternative uses of the land itself. These forests have been and are being disturbed by road-building, dredging, waste-dumping and the construction of homes, marinas and other structures. These uses are expected to intensify with the expanding population and economic activity, especially in tourism (Devoe, 1991a).

In Kosrae, the mangroves are moderately exploited, but fuelwood demand is large and growing (Devoe, 1992). Other uses include timber for house construction, wood for carving, nypa for thatching, and the harvesting of a number of resources living in the mangrove habitat (e.g., mangrove crabs and clams) (Lal, 1989). Several sawmills have operated from time to time (Wilson & Hamilton, 1992).

Production & Marketing: As most production is at the artisanal level, very little information is available. Lal (1989) provides an estimate of the quantity and value from the subsistence, artisanal and commercial use of mangroves:

Activity	Volume	Value ($)
Firewood:		
subsistence, semi-sub.		
commercial	60,000bdls*	
schools	4,500bdls	
Subtotal:	64,000bdls	129,000
Timber:		
lumber		8,400
traditional housing	9	3,600
handicraft: mangrove wood		20,000
pandanus (estimate)		15,000
Subtotal:		47,000
Total:		**176,000**

[* note: bdls = bundles of wood = 10 pieces 2.5'x3"x1" each piece]

7.2.3 Status Of The Stocks

The volume of timber in Yap's mangrove was estimated to be 71,000 m^3 $\pm$ 43,000 m^3 (Devoe & Falanruw, 1991). The total volume of mangrove timber for Pohnpei was estimated to be 1,180,905 m^3 (Devoe, 1991a). In Kosrae, the potential volume of timber from mangrove areas is 119,000 m^3 (Lal, 1989). No estimate was located for Chuuk.

7.2.4 Management

Current Legislation/Policy Regarding Exploitation: Legislation concerning exploitation of mangrove materials was not reviewed.

Recommended Legislation/Policy Regarding Exploitation: The maintenance of FSM's mangrove areas is of prime importance to the country's marine resources. Not only are they considered to be nursery areas for a number of fish species, but they contain considerable subsistence/artisanal resources such as mangrove crabs and clams. In addition, they protect the shoreline against erosion, and the reef areas against sedimentation from land-runoff.

Devoe and Falanruw (1991) found that Yap's mangroves are currently healthy and generally not over-exploited, but that there was a considerable threat to the mangroves and associated marine life due to the tremendous amount of earth-moving associated with road building. They recommend:

- That the clearing of mangroves between road and shore be prohibited where the mangrove is less than 250 m wide.

- That no clearing or thinning of mangroves be allowed within 50 m of streams or rivers.

- With regard to road construction, the bulldozing of new areas should not be allowed until grading, compacting and final surfacing have been completed in all areas where loose earth remain.

Devoe (1991a) proposes a system of 11 reserves totalling 4,734 acres (1,915 ha) to manage Pohnpei's mangrove resources. The following categories are proposed:

A. Preserve: access severely restricted. Uses limited to protective functions, wildlife habitat and non-manipulative research.
B. Sustainable Use: Class 1 Parks. Access unlimited, activities restricted: No harvesting; hunting and fishing by permit only.
B. Sustainable Use: Class 2 Demonstration and Production Forest. Access unlimited, activities restricted. Forest management to be conducted by Pohnpei State Division of Forestry; harvesting of marked timber by Permit (subsistence) or concession (commercial) granted by the Division of Forestry; hunting and fishing by permit only.

For Kosrae, Lal (1989) recommends that an integrated environmental planning process is required, as the maintenance of the mangrove habitat is largely dependent on the activities outside the mangroves, as inside them.

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