PREFACE

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A. BACKGROUND

1. THE COUNTRY

The Republic of Palau is an archipelago which is made up of about 340 islands and islets of which only nine are inhabited. The archipelago lies between 2° and 8° north latitude and 131° and 135° east longitude in the western corner of the north Pacific Ocean. Four types of geological formation are found on the islands. These include volcanic; high limestone, low platform and coral atoll formations. The volcanic islands include the largest island in the archipelago, Babeldaob, and Arakabesang, Malakal, the western part of Koror, and some of the smaller islets. The Rock Islands are limestone; Peleliu and Anguar are low platform islands; while the Southwest Islands are reef flats from geological uplift with Kayangel as a classic coral atoll. The archipelago is mostly encircled by a 246 mile (400 km) long barrier reef system encompassing a lagoon estimated to be 560 sq. miles (1,455 km^2) (Perron *et. al*., 1983; Nichols, 1991). The total land area has been estimated to be 170.4 square miles (441 km^2).

The climate in Palau is that of a maritime/tropical one, characterised by little seasonal and diurnal variation. The temperature averages between 83°F (28.3°C) in the hottest month and 81°F (27.2°C) in the coolest months giving an annual average of 82°F (27.8°C). Annual rainfall is over 150 inches (3,810 mm) with rain occuring throughout the year. However, the heaviest rainfall season occurs from May to January with a peak in the June-July period. The slightly drier period is from February to April. Humidity is approximately 82 per cent throughout the year.

The Marine Protection Act of 1994 defines the fishery zones of the Republic of Palau *as Internal Waters*, *Territorial Sea* and *Exclusive Economic Zone*. Title 27, Division 1, Chapter 1, Subchapter III, § 142 (b) of the Palau National Code defines *Internal Waters* as waters landward of the baseline, including the lagoons of atolls or islands. The Marine Protection Act of 1994 defines the *Territorial Sea* as the area 12 nautical miles seaward of the land baseline and the *Exclusive Economic Zone* (EEZ) as the area from the seaward (outer) boundary of the Territorial Sea up to 200 nautical miles seaward measured from the land baseline. Palau's 200-nm EEZ has been estimated to be approximately 243,380 sq. miles (630,400 km^2).

2. THE PEOPLE

The people of Palau are basically of Micronesian stock, with the original settlers been assumed to have come to Palau as drift voyagers from Indonesia around 2,500 B.C. A complex and highly organised social system with an extensive network of villages in Palau had well been established as reported at the time of Captain Henry Wilson's shipwreck in 1783 (Palau Economic Development Plan, 1995-1999).

Due to influences of different life styles brought in by outside administrations, the traditional Palauan social system has faced and undergone changes. However, what has remained of the culture still has a strong influence on the lives and attitudes of Palauan people (Palau Economic Development Plan, 1995-1999). One such system is the clan system in which every individual has a definite rank in the village, clan, and the family, starting from the moment of birth. Although the rank is based on family lineage, advancement based on individual merit is possible. Within each village, the clans are accordingly ranked with the head of the highest ranking clan serving as the chief of the village. " The chief, who is not a sole ruler, does not dictate but discusses and has to win the support of the number two ***rubak***. The relationship between a chief and his fellow villagers is a relationship with rights and duties for each " (Republic of Palau Economic Development Plan, 1995-1999). The clan system is well in the formal political system and that a Council of Chiefs, pursuant to the Constitution, advises the President of the Republic on traditional and customary matters.

In 1783, the population on Palau was estimated at 40,000-50,000. However, the arrival of Europeans brought epidemics of cantagious diseases which resulted in a rapid decline of the population and abandonment of villages. The Palau population estimated in 1901 by the German Administration was only 3,700. However, the population started to grow steadily in the 20th century. The population increased very rapidly during the Japanese occupation due to the large inflow of Japanese that during the 1920's and 1930's, Palauans were outnumbered by Japanese. In 1935, the Japanese population in Palau was estimated to be 25,760, which was four times more than the Palauan population. By 1990, the total population on Palau was estimated at 15,112 of which 12,321 (81.5 per cent) were Palauan citizens and 2,801 (18.5 per cent) were recorded as aliens, which comprised mainly of Filipinos working on the islands.

Table 2.1: Population estimates for Palau for some years since 1783.

Year	**Palauans**	**Non-Palauans**	**Females**	**Males**	**Total**	**Annual Growth Rate (%)**
1783					40,000-50,000	
1901					3,700	
1958					8,884	
1967					11,365	2.7
1970					12,015	1.9
1973					12,673	1.8
1980					12,116	(0.6)
1986	12,244	1,528			13,772	2.3
1990	12,321	2,801	6,983	8,139	15,112	2.4
Projections						
1992					16,130	3.16
1994					17,158	3.03
1996					18,202	2.88
1998					19,256	2.74
2000					20,314	2.61
2020					30,326	1.54

The estimated and projected populations by state indicate that about 70 per cent of the whole Palau population live in Koror. The second most populous state is Airai with a population making up about 8 per cent.

Table 2.2: Estimated and projected population distribution by state.

State	1986	1990	1996	2000
Aimeliik	283	439	528	590
Airai	1,021	1,234	1,485	1,658
Anguar	214	206	248	277
Hatohobei	35	22	26	30
Kayangel	115	137	165	184
Koror	9,442	10,501	12,640	14,106
Melekeok	254	244	294	328
Ngaraard	468	310	373	416
Ngardmau	157	149	179	200
Ngaremlengui	301	281	338	377
Ngatpang	219	62	75	83
Ngchesar	271	287	345	386
Ngarchelong	277	354	426	476
Ngiwal	218	234	282	314
Peleliu	545	601	723	807
Sonsorol	42	61	73	82
Total	**13,873**	**15,122**	**18,202**	**20,314**

Table 2.3(a) indicates that in 1990, approximately 30 per cent of the Palau population were under 15 years of age and about 9 per cent were 60 and more years of age. The overall sex ratio recorded was 116.6 males to 100 females. However, at the age of 60 years and over, the relative sex ratio reverses with more females than males. [This could indicate a longer life expectancy for women or/and higher migration rate for older males].

Table 2.3(a): The Palau 1990 population breakdown by age and sex. Projection.

Age group (years)	Total Number	Per cent of Total Population	Male	Female	Male Per 100 female
Total	15,122	100.0	8,139	6,983	116.6
< 05	1,513	10.0	766	747	102.5
05-09	1,529	10.1	793	747	107.7
10-14	1,534	10.1	807	727	111.0
15-19	1,464	9.7	795	669	118.8
20-24	1,340	8.9	738	602	122.6
25-29	1,403	9.3	799	604	132.3
30-34	1,338	8.8	768	570	134.7
35-39	1,243	8.2	720	523	137.7
40-44	873	5.8	514	359	143.2
45-49	666	4.4	375	291	128.9
50-54	513	3.4	279	234	119.2
55-59	403	2.7	208	195	106.7
60-64	387	2.6	181	206	87.9
65-69	332	2.2	154	178	86.5
70-74	249	1.6	117	132	88.6
75+	335	2.2	125	210	59.5
Median Age	25.7		26.1	25.1	

Table 2.3(b): Rates Summary for 1990 Population Projection

Item	Rate
Crude Birth Rate (per 1,000)	22.02
Crude Death Rate (per 1,000)	7.14
Net Migration Rate (per 1,000)	18.52
Rate of Natural Increase (per cent)	1.49
Growth Rate (per cent)	3.34

Two distinct native languages are spoken in Palau. They are Palauan and Sonsorolese-Hatohobian. The latter language is spoken in the Southwest Islands. Palauan is the official language and is most commonly spoken along with English (Palau Economic Development Plan, 1995-1999).

3. THE GOVERNMENT

The following information was directly reproduced from the Republic of Palau Economic Development Plan (1995-1999).

Spain controlled Palau from 1885 to 1899 and was mainly responsible for the introduction of Christianity. Following Spain's defeat in the Spanish-American War, Palau, along with the rest of the Caroline's Islands and the Northern Marianas, was sold to Germany. Japan assumed control over Palau at the beginning of World War I in 1914 until in became a strategic Trust Territory of the Pacific Islands (TTPI) in 1947. The United Nations entrusted the direction of the islands to the United States of America as the administering authority. " In 1980's, Palauans approved and ratified the sonstitution of the Republic of Palau and the first constitutional government was instituted on January 1, 1981. Palau, Marshall Islands and Federated States of Micronesia then initiated separate negotiations with the US for " compacts " or " free association ". For Palau, the compact was approved by the people through a plebiscite in November, 1993. The Republic of Palau celebrated its independence in November, 1994.

The Government of the Republic of Palau consists of three separate branches which include; the Executive, the Legislative and Judicial.

The Executive Branch is headed by the President and assisted by eight ministers of departments appointed by the President. The ministers do not serve as members of the legislature. The President is

elected nationally every four years but one cannot serve for more than two conservative terms. The Vice-President serves as one of the ministers heading a ministry.

The Legislature is known as the ***Olbiil Era Kelulau*** (OEK) which has two houses, a Senate of 14 members elected from senatorial districts and the House of Delegates comprising a delegate elected from each of the sixteen states (Campell and Lodge, 1993). Both Senators and Delegates have the same four-year term but Delegates lack the advice and consent authority for Presidential appointments reserved for Senators by constitution.

The Judicial Branch is comprised of the Supreme Court, the National Court and the lower Court of Common Pleas. Judges are appointed by the President from a list of nominees recommended by the Judiciary Nominating Commission.

A federal system of government is also present in the Republic of Palau. This exists on two levels, National and State, with the state governments having their own constitutions and elected officials.

4. THE ECONOMY

The economy of Palau, as reflected by the Gross Domestic Product (Table 4.1) has been dominated by the services sector which, in 1992, made up 60 per cent of the total. Government and trade were the major components of the services and each made up 16 per cent of the GDP. However, for single items within each economic sector, fishery contributed the largest portion, 26 per cent, of the total GDP in 1992. Fishery has also been earmarked as having a great potential for growth.

Table 4.1: Republic of Palau's Gross Domestic Product (GDP) by economic activity for 1975, 1977, 1983 and 1990-1992. Values are in US$1,000 at current prices. (Source: Republic of Palau Economic Development Plan, 1995-1999).

Economic activity	**1975**	**1977**	**1983**	**1990**	**1991**	**1992**
Agriculture & Fishery						
Agriculture			3,080	2,296	2,496	2,647
Crops				1,665	1,839	1,960
Poultry & Livestock				631	657	687
Fishery			2,219	17,647	21,093	23,202
Total Agriculture & Fishery			**5,299**	**19,943**	**23,589**	**25,849**
Industry						
Manufacturing			117	528	633	818
Construction			3,982	8,522	7,015	6,688
Residential				708	1,103	743
Commercial				1,517	1,508	2,375
Government				6,297	4,404	3,570
Electricity						
Utilities				2,849	3,709	4,472
Total Industry			**4,693**	**11,899**	**11,357**	**11,973**
Services						
Trade			5,247	12,014	13,798	14,062
Hotel & Restaurant			539	6,258	6,802	8,717
Transport & Communication			729	3,371	3,397	4,087
Finance & Insurance			549	3,112	3,175	3,271
Real Estate & Bus. Services			260	3,313	3,735	3,702
Government Services			11,651	14,212	15,024	14,356
Other Services			2,004	2,767	2,978	3,723
Total Services			**20,979**	**45,046**	**48,909**	**51,918**
GROSS DOMESTIC PRODUCTS	**14,500**	**17,400**	**30,971**	**76,888**	**83,855**	**89,740**

During the 1914-1945 control by Japan, tapioca, sweet potatoes and taro, phosphate, fish, trochus shells, turtle shells, copra and lumber were exported from Palau. The exports were valued at 7.9 million yen in 1937 (Economic Developemnt Plan, 1995-1999). Fish export was sank by the war.

However, this was revived by the entry, in 1964, of the Van Camp Company which operated a processing plant. Annual exports of 10,000 tons, valued at US$3 million, were achieved during the operation. Closure of the processing plant in 1982 resulted in low exports in the 1983-1984 period. No complete set of data on the foreign trade statistics exists in Palau. Table 4.2 shows private commercial exports and imports based on data from Customs and Immigration Office and other sources as reproduced from Palau's Economic Development Plan (1995-1999). Of significant importance is the large increase in fish exports from US$97,000 in 1983 to US$27,121,000 in 1992.

Table 4.2: Exports and Imports, in US$1,000 FOB values, of commercial commodity by the private sector for four years between 1983 and 1992. (Source: Republic of Palau Economic Development Plan, 1995-1999).

	Item	1983	1984	1989	1992
Exports					
	Fish (fresh & frozen)	97.0	125.0		27,121.0
	Others	211.0	339.0		2,644.0
TOTAL	**EXPORTS**	**308.0**	**464.0**	**556.0**	**29,765.0**
Imports					
	Food	3,382.3	4,280.8		2,873.7
	Beverages & tobacco	2,065.0	2,105.5		2,075.2
	Fuel & lubricants	2,143.0	2,143.0		16,750.8
	Other	5,961.2	14,496.5		16,750.8
TOTAL	**IMPORTS**	**13,551.5**	**23,025.8**	**24,007.0**	**34,219.0**
TRADE	**BALANCE**	**-13,243.5**	**-22,561.0**	**-23,451.0**	**-4,454.0**

The Palau Economic Development Plan (1995-1999) quoted estimates made by a UN team of the total exports and imports from 1990 to 1992. Accuracy of these estimates are questionable but are as follows:

	1990	1991	1992
Imports (US$)	36.5 m	43.0 m	45.0 m
Exports (US$)	27.5 m	37.7 m	42.4 m
Trade deficit (US$)	9.0 m	5.3 m	2.6 m

Attempts have been made to estimate the proportions of the population which are economically active in various activities using the age range of 16 years and over. However, due to varying concepts and definitions used for subsistence activity and unemployment, statistics relating to labour market characteristics were not comparable. Table 4.3 records the different definitions, using both paid employment and subsistence as parts of the labour force defininition as reproduced from Table 7.9 of the Republic of Palau Economic Development Plan (1995-1999).

Table 4.3: Work status of the potentially economic active population in Palau from 1973 to 1992. (Source: Republic of Palau Economic Development Plan, 1995-1999).

	1973	1980	1986	1990	1991	1992
Potential economiclly active population	6,933	6,966	9,024	10,238	8,128	7,968
In Labour force						
Paid work only	2,625	1,804	4,539	5,131	3,404	3,776
Paid and subsistence		941		468	276	928
Subsistence	551	2,158	603	448	596	184
Unemployed	896	143	1,180	471		
Unemployment rate (per cent)	22.0	2.8	18.7	7.2		
In labour force total	4,072	5,046	6,322	6,518	4,276	4,888
Per cent	58.7	72.4	70.1	63.7	52.6	61.3
Not in labour force	2,861	1,920	2,702	3,720	3,840	3,080

The total labor force population breakdown by state estimated for 1990 is presented in Table 4.4(a) and that by birthplace in Table 4.4(b).

Table 4.4(a): Labour force population breakdown by state as recorded for 1990. (Reproduced from Republic of Palau Economic Development Plan, 1995-1999).

State	Persons aged 16 years and over	Total number NOT in labor force	Total number IN labour force	Per cent in labour force	Total number employed in labour force	Total number Unemployed
Aimeliik	280	161	119	42.5	115	4
Airai	840	337	503	59.9	463	39
Hatohobei	15	3	12	80.0	12	0
Kayangel	81	58	23	28.4	18	5
Koror	7,251	2,472	4,779	65.9	4,533	245
Melekeok	152	89	63	41.4	57	6
Ngaraard	187	117	70	37.4	46	24
Ngardmau	95	60	35	36.8	29	6
Ngaremlengui	166	106	60	36.1	43	17
Ngatpang	44	25	19	43.2	19	0
Ngchesar	179	113	66	36.9	57	9
Ngarchelong	222	179	43	19.4	38	5
Ngiwal	150	68	82	54.7	33	49
Peleliu	402	257	145	36.1	83	62
Sonsorol	35	19	16	45.7	16	0
Total	10,238	4,166	6,072	59.3	5,599	471

Table 4.4(b): Republic of Palau labour force breakdown by birthplace. (Source: Republic of Palau Economic Development Plan, 1995-1999).

	Total	Number **not** in labour force	Number **in** labor force	Percent in labor force	Number employed	Number unemployed
Total aged 16 years and over	10,238	4,166	6,072	59.3	5,599	471
Birth-place						
Palau	7,873	3,712	4,161	52.8	3,711	448
Other Total	2,013	320	1,693	84.1	1,676	17
Other breakdown						
Philippines	1,421	76	1,345	94.7	1,341	4
FSM	272	195	77	28.4	64	13
China	180	8	172	95.6	172	0
United States	141	42	99	70.2	99	0

5. INSTITUTIONS/AGENCIES

5.1 States

Article 1, Section 2 of the Constitution assigns the exclusive ownership of marine resources extending out 12 nautical miles to the states.

5.2 Division of Marine Resources

The Executive Order #9, 1982 established the mandate for the Division of Marine Resources within the Bureau of Resources and Development. It is to manage and develop the inshore marine resources of Palau and to:

- conduct a pilot program on fishery development projects with the aim toward promoting and developing commercialisation of fisheries and fishery products;
- maintain and operate the Micronesian Mariculture Development Centre (MMDC) as a site for marine biological research, study and experimentation of mariculture as a site for marine biological research, study and experimentation of mariculture and aquaculture fisheries;
- conduct hatchery and rearing of certain species of fish, molluscs, crustaceans, and turtle to be placed back in the natural habitats at maturity as a means of preventing the depletion of important marine resources:

- assess and evaluate commercial potential of reef and deep-water fish, baitfish, mollouscs, cruataceans, turtles etc from catch records, census and quantitative field measurements;
- formulate, establish and implement guidelines and conservation measures to safeguard against over-exploitation in harvesting of fish and other marine resources:
- provide technical assistance and administrative assistance to the Board of Directors of Palau Fishing Authority upon request and on the basis of staff availability.

(Source: Diplock, 1993).

Informal strategies adopted under the mandate include the following as listed in Diplock (1993):

- initiatives to increase private sector employment and income generating opportunities;
- development of environmentally sensitive resource management policies;
- diversion of fishing effort from inshore to offshore activities;
- resource survey and product development to expand the export base;
- development of marine conservation awareness programs;
- improved methods of product handling and processing;
- encourage active participation by State governments in marine resource development, management and conservation;
- encourage rationalisation of shore based infrastructure;
- increase local personnel training opportunities.

5.3 Palau Maritime Authority (PMA)

PMA is mandated under Title 27, Division 1, Chapter 1, Subchapter II, of the Palau National Code (PNC), and is basically responsible for the control and regulation of foreign fishing in the fisheries zones of Palau. Its functions and duties are:

- to adopt regulations for the conservation, management and exploitation of all living resources in the extended and exclusive fishery zones;
- to participate in the delimitation of the extended fishery zone;
- to negotiate and conclude foreign fishing agreements;
- to issue foreign fishing permits.

The Authority has the duty to determine the allocation among foreign nations of the total allowable level of foreign fishing.

5.4 Palau Fishing Authority

The mandate for this authority is established under Title 27 of the PNC, Division 2, Chapter 11, also known as the Palau Fishing Authority Act of 1980, " to create a legal entity to promote, develop and support commercial utilization of living marine resources within the internal waters of the Palau. The main duties of the Authority are as follows:

- make recommendations to provide guidance to the the national government in establishing marine resources development policy in any internal waters of Palau;
- serve as a conduit for public funds to establish and operate facilities required for commercial fisheries development, to conduct pilot fishing operations and to participate in large scale commercial fishing, including joint ventures and related activities which are not suitable for investment by the private sector;
- establish and support programs to promote, support and guide fishing cooperative associations with respect to activities involving fishing in internal waters;
- help finance and support the development of locally owned private fishing in internal waters, including making loans where possible;
- act as an agent to sell or lease supplies to local and foreign fishing vessels.

5.5 Division of Conservation/Entomology

The mandate of the Division of Conservation/Entomology is established under the Executive Order #70, to develop and implement national conservation policies. The division mission is to:

- prepare plans and directions for the Republic-wide conservation program involving soil, resources, water, archaeological remains, flora, and fauna;
- provide technical assistance and guidance to the three branches of the national and state governments, and their agencies, in matters relating to conservation,
- recommend policies for the enforcement of conservation laws and regulations;
- develop education programs concerning conservation and entomology for schools, museums, and other groups and organisations.

5.6 Office of the Attorney General (through the Bureau of Public Safety)

Under Title 27, PNC 187, offshore marine surveillance is vested in the Office of the Attorney General through the Bureau of Public Safety.

5.7 Environmental Quality Protection Board (EQPB)

Under Title 24 of the PNC, EQPB is given the specific responsibility to protect marine resources. Its mandate is to oversee the administration of permit and monitoring systems for the discharge of any pollutants on the land, air or water in Palau. The Board promulgated the Marine and Fresh-water Quality Standard Regulations which include:

- uses for which the various waters of Palau shall be protected;
- specifications of water quality standards to be maintained in designated areas;
- prescription of regulations and implementation of programs to maintain specified water quality standards.

6. FISHERIES (MARINE) RESOURCES LEGISLATIONS

6.1 Title 27 of the Palau National Code

This is the basic fisheries law in Palau and creates two distinct authorities, the Palau Maritime Authority and the Palau Fishing Authority (Campell and Lodge, 1993).

Division 1, deals with Foreign Fishing; Division 1, Chapter 1, deals with Fishery Zones and Regulations of Foreign Fishing.

Subchapter II establishes the Palau Maritime Authority with its functions and duties as detailed under 5 (Institutions/Agencies) above.

Subchapter III defines the parameters and fisheries zones in Palau.

Subchapter IV regulates Foreign Fishing within the fisheries zones of Palau.

Subchapter V deals with Enforcement and Penalties.

Division 2, deals with Domestic Fishing;

Chapter 10 deals with District Entities for Development of Marine Resources. § 1001 authorizes district governments to establish, by law, an entity to promote, develop, and support commercial utilization of living marine resources within its jurisdiction.

Chapter 11 (or the Palau Fishing Authority Act of 1980) creates the Palau Fishing Authority.

6.2 Title 24 of the Palau National Code

This law concerns with Environmental Protection.

Division 2 deals with Wildlife Protection and Protected Sea Life is covered under Chapter 12;

Subchapter I regulates the taking of turtles and prohibits the taking of eggs;
Subchapter II controls the harvesting of sponge;
Subchapter III controls the harvesting of mother-of-pearl oysters;
Subchapter IV prohibits the harvesting of dugongs except with a permit from the President;

Subchapter V regulates the harvesting of trochus;
Subchapter VI prohibits the export of giant clam meat.

Chapter 13 deals with Illegal Methods of Capture;

Subchapter I makes it illegal to fish using explosives, poisons or chemicals. The President, however, may grant written permission or when he determines that the purpose of obtaining the fish is to avoid waste or loss and the consumption of such fish is not harmful or hazardous. The use of local roots, nuts and plants are allowed.

6.3 Marine Protection Act of 1994

This Act, " to regulate the taking of certain species of marine and terrestrial organisms and to prohibit or limit certain fishing methods ", was passed in April, 1994 and became effective as of May, 1994. Its purpose " is to promote sustainably and develop the marine resources of the Republic while also preserving the livelihood of the commercial fishermen of the Republic ". The Act repeals RPPL No. 1-9 and RPPL No. 3-61.

The provisions of this Act and regulations or permits issued under the Act, are enforced by the Ministry of Resources and Development.

Section 4 deals with *prohibited acts* as detailed under relevant sections of the resources profiles.

Section 5 deals with permits for aquarium use, scientific research, maricultural research and medical research. Section 5 (b) prescribes the Minister to promulgate regulations, in accordance with Title 6 of the Palau National Code, regarding the taking and export of fish for aquarium purposes within 90 days of the effective date of the Act.

Section 6 authorises the Minister to promulgate regulations as deem necessary to protect species covered under Section 4 from overharvesting.

6.4 Proposed - Palau Maritime Authority Act

A Bill for a Palau Maritime Authority Act, has been proposed to establish a comprehensive law to provide for fishery zone regulations and agreements, to establish a Palau Maritime Authority, to authorize and appropriate funds and for other purposes.

7. MANAGEMENT OF THE MARINE (FISHERIES) RESOURCES

Inshore resources: The development and management of the inshore marine resources of the Republic of Palau is the responsibility of the Division of Marine Resources of the Bureau of Resources and Development under the Executive Order #9 of 1982. The Ministry of Resources and Development is responsible for the enforcement of the provisions and regulations of the Marine Protection Act of 1994.

Offshore resources: Under Title 27 of the PNC, the development and management of the offshore fisheries and adoption of regulations for conservation, management and use of all resources in the Extended and Exclusive Economic Zone, is the responsibility of the Palau Maritime Authority

8. DEVELOPMENT PLANS

The Economic Development Plan, 1995-1999, recognises that the ocean provides the most valuable resource which offers Palau the best potential for long-term economic growth and the attainment of

economic self-reliance. For the Plan period, the objectives listed under the marine resources use, include:

⇒ increase local participation in employment and other income generating opportunities in all commercial fishing, shore-based processing and servicing, export facilities, marine-based recreational ventures, mariculture and others;
⇒ develop long-term integrated resource management policies that take into account the principle of sustainable development and adherence to it by resource owners, managers and users;
⇒ explore further possibilities for local participation in the harvest of oceanic resources for sashimi markets;
⇒ increase export of cultured and under-utilised species;
⇒ introduce and demonstrate efficient methods for harvesting, handling, storage and marketing of marine products;
⇒ develop fishery support facilities at strategic locations and increase use of existing ones;
⇒ establish a marine export monitoring system and find ways to maximise net returns from them;
⇒ satisfy domestic demand for marine products.

The policies and strategies to be adopted by Government to achieve the goals fall under the following categories, listed with their respective components:

Private sector employment

* develop fisheries support infra-structure at the community level and create programs that provide long-term employment opportunities;
* improve domestic and foreign channels for marine products marketing;
* institute advisory and training programs involving harvesting, handling, processing and quality control of marine products with emphasis on deep-water and oceanic species;
* encourage the formation of locally-owned and joint ventures that favour employment of Palauans;
* encourage fishermen to get involved in income-generating marine tourism industries;
* provide opportunities for women to participate in fishery-related activities;
* encourage formal education for management level jobs in fisheries.

Effective and realistic resource management parameters

* conduct and fund surveys to identify and quantify resources to assist with management and policy development;
* encourage non-exploitative use of marine resources which maximises local benefits and minimises adverse impact on resources and environment;
* establish long-term programs to monitor the health of the marine environment and resources;
* establish national reserves and marine zone at key locations to ensure species recovery and long-term sustainability;
* support programs that protect reefs and other marine habitats;
* formulate plans and harvest regulations for major commercial and game species;
* encourage resource owers' participation in management decisions;
* delineate duties for surveillance and enforcement of marine resource regulations and upgade enforcement capabilities, including the prosecution procedures for violators.

Fishery information

Improve fisheries information base by:

* appointing a full time fishery statistician in the Marine Resources Division;
* expanding data collection to include imports and exports of all marine organisms and products;
* publishing an annual report of the Marine Division with data and analysis of production, export and import of marine commodities;
* packaging important fishery information and research results for public distribution.

Full and efficient use of existing infrastructure

The use of existing fishing ports and facilities will be maximised through development of land access.

Broader marine resource income base

* promote and maximise benefits from marine-related visitor industries and recreational activities;
* identify markets amd promote private involvement in the development of high-quality and high-value products;
* encourage and promote the production and export of mariculture species and related products;
* establish an aquarium as an income source and to support research objectives.

Strong development and management

* strengthen marine resources management capabilities and institute relevant programs and projects;
* upgrade marine resources positions and fill them with professional staff;
* upgrade support facilities.

9. FISHERIES BIBLIOGRAPHY

The bibliography listing all the references concerning fisheries, marine resources and related areas of Palau was produced in 1988 by the FAO/UNDP Regional Fishery Support Programme. The document was published as:

> Izumi, Masanami. (1988). ***Palau Marine Resources Bibliography***. *FAO/UNDP Regional Fishery Support Programme. Field document 88/2*.

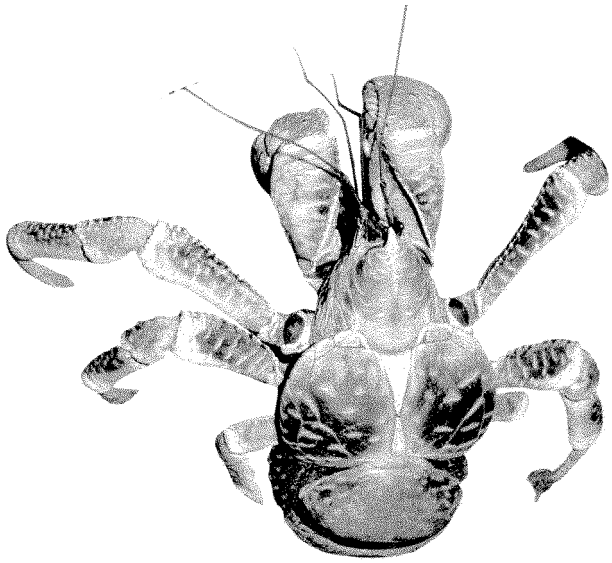
B. MARINE RESOURCES PROFILES

1. CRUSTACEANS

1.1 Coconut crab - *ketat*

1.1.1 The Resource

Species present: *Birgus latro* (coconut or robber crab - ***ketat***) is found in Palau.



ketat - *Birgus latro*

Distribution: Coconut crab is widely distributed from the Seychelles in the Western Indian Ocean to the Tuamotu Archipelago in the eastern Pacific. Its occurrence is restricted to island habitats and is virtually unknown in East Africa, the Indian sub-continent, mainland Asia and Australia probably due to the presence of large animal competitors and predators in these areas (Brown *et al*., 1991). However, several reports seem to indicate that the species' range appears to have somewhat diminished. Within certain localities, habitat destruction, uncontrolled exploitation and depredation by domestic and feral animals, have contributed to the declines and local extinctions.

In Palau, Reese (1971) reported low population levels of coconut crabs on Ngeruebtang Island during a survey carried out in the same year. During a survey in seven states in Palau on women's role in fisheries in 1991, only respondents from Airai State indicated coconut crab collection as a seafood collection method used by women.

Biology and ecology: Coconut crab is a "close relative of the hermit crab group and has evolved to become the largest and least marine-dependent of the land crabs" (Brown *et al*., 1991). It is an omnivorous scavenger and its primary foods include coconut flesh, fruits of the screw-pine (*Pandanus*), *Canarium* spp., sago palm, *Terminalia*, *Barringtonia*, and *Artocarpus*. Coconut crabs are slow-growing and for the Vanuatu stocks, they take at least ten years to reach legal marketable size (9 cm, CTL=43 mm)[1]. The growth coefficient, K, of the von Berterlanfy's growth equation, was estimated to be 0.05, which is very low (Brown, 1988). Fletcher *et al* (1991) estimated longevity to be between 40 and 60 years and the asymptotic thoracic length (L_∞) of 80 mm and 50 mm for males and females respectively. Growth in coconut crabs, as in other crustaceans, has two components, the increment of growth at each moult and the time interval between each moult episode (Fletcher *et al*, 1991). Moulting is normally once a year with the exception of smaller-sized crabs that are believed to be able to moult more than once a year. For protection from predation and to minimise the risk of dehydration the crabs burrow or hide in small crevices that provide the same conditions as burrows, prior to moulting. The ecdysis process takes from one to two hours to complete while the time between moulting and emergence from the burrows is about 1 month for small crabs and up to three months for the larger individuals (Fletcher *et al*., 1991).

Mature crabs mate on land in summer while both sexes are in the hard shell condition. In Palau, mating occurs between the months of May and September with a peak in the July-August period

[1][CTL=cephalothoracic length, TL=thoracic length]

(Reese, 1971). However, fertilisation may require seawater. Laying of eggs is assumed to take place soon after copulation as females do not possess seminal receptacles. The females carry fertilised eggs attached to their pleopods for approximately one month, while maturing, before migrating to the sea for their release. The release of eggs is accomplished using one of the four methods which is closely associated with the type of coastline present. Schiller *et al*. (1991) describe these methods in detail. 1. In cliff coastlines with narrow or no intertidal shelf, the berried crab climbs over the cliff edge and reorients itself so that it faces up the cliff. It then "slowly reverses down the cliff until a wet section, or wave splash, is encountered" at which point it "stops and flexes its abdomen away from the cliff face, letting the egg-bearing pleopods dangle loosely, thus exposing its entire egg mass". The crab moves further down if there is not sufficient splashes at any particular height until it is washed over by a wave which results in rapid hatching of the mature eggs and washing away of the newly eclosed zoea larvae. 2. In coastlines with intertidal shelf, the berried female walks rapidly across the shelf until it encounters a saltwater pool. It raises its abdomen to keep the egg mass clear of the water and only lowers it into the water with rapid backwards and forwards flexes of its abdomen in small rapid jerking movements, to facilitate eclosion of the eggs, when a wave swamps it. 3. The third method involves coastlines as that in 2 above but the release is not through a pool splashed by waves but a saltwater 'stream' draining the shelf. 4. The method used in coastlines having a sand or coral rubble beach is similar to that in 2 above. The crab moves down the beach into the water until it is swamped by a wave. "In each method, egg hatching/larval release is invoked by exposure of the eggs to moving water, usually via inundation by waves".

Mature eggs hatch immediately into the first zoea stage upon release into the ocean. The hatched eggs undergo four plantonic zoeal stages in approximately three weeks and the crabs (new recruits) emerge from the water as glaucothoe inhibiting small shells. The glaucothoe inhabit the wrack area above the high sea mark and are hard to find and be distinguished from other related coenobinids (Reese, 1987). "The glaucothoe subsequently metamorphose into juvenile crabs which maintain the shell carrying habit for one to two years" (Brown, 1988). Reese (1987, quoted in Schiller *et al*., 1991) postulated that the fossorial nature of coconut crab glaucothoe and juveniles makes them extremely difficult to find. Fletcher (1988 quoted in Schiller *et al*., 1991) using size-frequency data, calculated that satisfactory recruitment of glaucothoe and juveniles into Vanuatu coconut crab populations occurred every 5-10 years and could be considered both infrequent and unpredictable. Fletcher (1988) gave a possible explanation for the dearth of recruitment in Vanuatu as due to the rapid drop-offs close to shore and because of the benthic nature of the *Birgus* larvae, they merely sink to the bottom in depths beyond their capacity to return to a sandy beach from which they gain access to a terrestrial existence. Thus recruitment may only occur if the larvae become entrapped in a shallow embayment.

1.1.2 The Fishery

Utilization: Coconut crabs are treated as a delicacy throughout Micronesia.

The baited method of catching coconut crabs is known locally in Palau as ***omekang***. Collection is done either by women accompanied by their husbands or in groups. However, sometimes trapping is done by women alone (Matthews and Oiterong, 1991). Bait is mostly a coconut cut in half and hung where coconut crabs are likely to be, along the edge of the rocks toward the shore. Other trappers use graded (ground) coconut in the belief that the small crumbs will keep the crabs out of their hole for a long time. “Coconut crabs are also caught when the fruit of the seeded breadfruit tree, *Arpocarpus marianensis* (***ebiei***), and the football fruit tree, *Bangius edule* (***riamel***), are ripe” as coconut crabs are attracted to the ripe, fallen fruits of these trees (Matthews and Oiterong, cited above).

Coconut crabs are utilized both in the subsistence and artisanal fisheries. Some are exported, mostly to relatives in Guam and Saipan.

Production and marketing: Subsistence catch of coconut crabs in Palau is not known but is

believed to have been substantial. Reese (1971) reported three men on Ngeruebtang Island collecting 12 small coconut crabs (all below reproductive sizes) in two hours after heavy rain when the crabs should have been out. Matthews and Oiterong (1991) listed coconut crabs as one of the invertebrate species collected in the greatest numbers by Palauan women in Airai. Purchases data of commercial marine animals kept by PFFA for the 1976-1981 period recorded 88 lbs of coconut crabs (worth $98), in 1980, accounting for only 0.02 per cent of all marine product landing for that year. In 1985, coconut crab landing at PFFA was 3,169 pounds (or 1,440 kg). Coconut crab purchases as recorded at the main commercial markets, PFFA, Oh's and PMCI, during 1992 amounted to only 75 lbs, valued at US$305 (Division of Marine Resources Annual Report for 1992). Coconut crab landings at the same markets during 1993 amounted to only 11 lbs, worth US$44 which was at Oh's (Jan-May).

A survey in 1991 indicated that local market prices of coconut crabs sold by women was US$2.75 each, with average amount sold of 8 pieces per sale.

Coconut crab exports as reported on Continental Air Micronesia manifest forms for 1990 and the 1991-1992 period, as reported in Kitalong and Oiterong (1991) and the Division of Marine Resources Annual Report (1992) are recorded in Table 1.1.1. The "count" column is the number of individual shipments and weight (lbs) is the gross weight including container weight, ice and packaging. "Other" refers to taro, tapioca, betelnut and other goods. The 1990 figures do not include those for September.

Table 1.1.1: Export of coconut crabs as recorded on Continental Air Micronesia manifests for the 1990-1992 period.

Declared Item	1990		1991		1992	
	Count	Weigh t	Count	Weigh t	Count	Weigh t
Coconut crab	7	302	0	0	2	139
Coconut crab (live)	1	38	0	0	4	177
Coconut crab/Other	2	101	2	125	0	0
Coconut crab and Bats	2	418				
Coconut crab (live)/Mangrove crab (live)	1	35	0	0	1	12
Coconu crab, Land crab & Bats	1	214				
Fish (frozen)/Coconut crab/Other			0	0	4	332
Fish/Coconut crab	3	1,458	6	1,103	0	0
Fish/Coconut crab/Bats			5	667	0	0
Fish/Coconut crab (live)			5	638	0	0
Fish/Mangrove crab/Coconut crab//Other			0	0	1	125
Frozen fish/Coconut crab	1	1,200				
Frozen fish/Coconut crabs/Others	1	37				
Fish, Coconut crabs/Mangrove crabs/ Others	1	132				

It was not possible to quantify the amount of coconut crabs exported due to the nature in which they were packed and shipped. Most of the exports recorded in Table 1.1.1 were sent to relatives in Guam and Saipan in coolers containing several food items. However, the Division of Marine Resources (Annual Report 1990) estimated 257 lbs (115 kg) of coconut crabs were exported as Continental Air Micronesia air cargo during January-November, 1990, excluding September.

In order to obtain better estimates of each item exported, Kitalong and Oiterong (cited above) made the following recommendations:

1. request Guam to provide information on the type of fish being imported over the past ten years from Palau and sharing information on items confiscated in Guam;
2. authorize local Customs Officers to make spot inspections of items, especially items not clearly described on manifest forms that are only intransit in Guam and therefore not subject to inspection;
3. begin field studies of the items that are getting exported of which no baseline information exists, such as mangrove crabs, clams, pigeons and sea cucumbers;
4. require exporters to obtaining business license that are screened by the Marine Resources

Division;
5. require that manifest forms accurately state what is being shipped such as frozen or smoked seafood;
6. impose an export tax on shipments for commercial sale elsewhere.

1.1.3 Stocks Status

No study has been conducted in Palau to assess standing stocks and status of the coconut crab populations present.

1.1.4 Management

Brown *et al*. (1991) write that;

> "the biological and population characteristics of coconut crabs conspire to make the species particularly vulnerable to exploitation. They are terrestrial, relatively easy to catch, slow growing, and their recruitment success seems to be highly variable. With intensive harvesting a coconut crab population can be depleted very quickly, and the stock may only begin to recover many years after collecting has ceased".

The phenomenon of irregular recruitment was found to be common in areas where studies have been initiated.

Current legislation/policy regarding exploitation: Section 4 (9) of the *Marine Protection Act of 1994* prohibits the buying or selling of any coconut crab smaller than four inches in the greatest distance across the width of its carapace. The buying or selling of berried female coconut crabs, of any size, is also prohibited under the same Act. Penalties for violation of this section of the Act are:

> Upon the first conviction, a fine of not less than US$250; upon the second conviction, a fine of not less than US$500.00 and a sentence to serve up to 30 days in jail; upon the third conviction, a fine not less than US$1,000.00 and a sentence of up to six months in jail; any conviction after the third conviction, a fine of US$5,000.00 and a sentence to serve up to a year in jail.

Recommended legislation/policy regarding exploitation: A step towards the management of this resource would be the initiation of efforts to assess stocks in areas where populations are known to exist and form an important component either at the subsistence and/or artisanal levels.

A system, whereby an export permit is required prior to the export of any marine product, would be necessary. The quantity of each species to be exported need to be specified on application for an export permit for any purposes.

Management measures taken in other countries to ensure the sustainable utilization of the coconut crab resource include:

Closed season: closed season during the breeding season (which is June-July in Palau). Under the same regulation, the Director of Marine Resources may grant permission upon application for the taking of crabs during the closed season for the purposes of scientific research.

Quota allowance: this would require stock assessment in the main areas of harvesting in Palau. Director of Marine Resources to have the power to halt collection of crabs in any area at any time if he believes that the quota has been exceeded or some other problem exists with the stocks.

Even though prohibition of the buying and selling of berried female coconut crabs can adequately cover this aspect, however, it would be necessary to make it clear that the removal of eggs from a coconut crab or buying and selling of those from which eggs have been removed, is prohibited under the same regulation.

Consistent collection of data from restaurants and stores is needed. This can be done by the Department by directing the operators to keep records of purchases and sales including details on numbers, weights and source area (islands).

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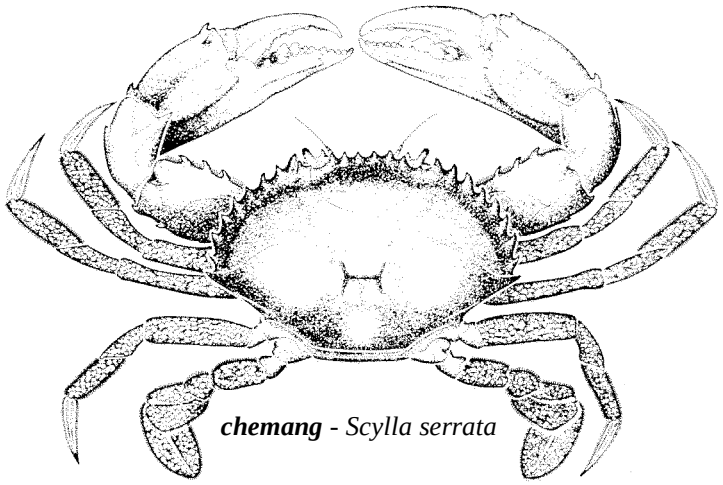
1.2 Mangrove (mud) crab - *chemang*

1.2.1 The Resource



chemang *- Scylla serrata*

Species present: *Scylla serrata* (mangrove crab - ***ketat***) is present in Palau. The mangrove crab is also known as mudcrab or Samoan crab in other regions. There is a belief in Palau that mangrove crabs found in one area could be a different species, as crabs there are normally smaller than those found in other places in Palau. However, the taxonomy of species of *Scylla* is still being debated, as several authors have suggested two other species and one variety of *S. serrata*. However, Brown (1993) suggests that extreme caution should be exercised in the use of names other than *S. serrata* for mangrove crabs in the Pacific region.

Distribution: Dickinson (1977, quoted in Brown, 1993) describes the natural range of the mangrove crab, *S. serrata*, as extending "from Mossel Bay in South Africa along the East African coast including Mauritius and Madagascar to the Red Sea. The range continues eastward to India and Sri Lanka and throughout Indonesia, the Philippines and Malaysia. In occurs in Thailand, China and Taiwan with its northern limit as the mouth of the Tone River in Japan. It is found along the Australian coasts from Broome, West Australia, north and east to the Northern Territory and Queensland, and New South Wales to Port Jackson. It also occurs in New Zealand and the South Pacific Islands including, Papua New Guinea, Palau, Caroline Islands, FSM, Mariana Islands, Samoa, Tuamotu, Solomon Islands, Vanuatu, Fiji, Tonga and Cook Islands. It is probable that any tropical Pacific island which is large enough to sustain a fluvial delta with associated mangrove forests will support a population of mangrove crabs.

The species is present throughout an estimated 45 sq. km. of mangrove habitat in Palau, especially around the large island of Babelthuap. Matthews and Oiterong (1991) listed mangrove crabs as one of the invertebrates collected in greatest numbers by Palauan women in Aimeliik, Airai and Ngeremlengui. Mangrove crab purchases at the commercial markets from 1990 to 1993 are presented in Table 1.2.1 by state. This indicates that the most important states involved with commercial sales of crabs are Ngerchelong, Ngeremlengui, Ngaraard, and Ngatpang. This could also be an indication of the abundance distribution of crab populations in Palau. Ngeremeduu Bay and adjacent mangroves shared by Ngetpang and Ngeremlengui States account for over 50 per cent of the total commercial mangrove crab landings (Maragos, 1994).

Table 1.2.1: Crabs purchases by the commercial outlets in Palau for the period 1990-1993.

State	1990 Wt (lbs)	1991 Wt (lbs)	1992 Wt (lbs)	1993 Wt (lbs)	TOTAL (lbs)
Ngerchelong	1,212	2,669	6,442	7,816	18,139
Ngeremlengui	1,458	4,599	6,063	3,624	15,744
Ngatpang	6,675	999	985	4,675	13,334
Ngaraard	1,774	985	5,213	5,082	13,054
Ngiwal	628	1,071	1,021	1,108	3,828
Aimeliik	617	974	882	501	2,974
Airai	643	384	605	1,241	2,873
Koror	998	762	218	544	2,522
Unlisted	0	287	304	1,391	1,982
Melekeok	142	250	779	499	1,670
Peleliu	361	40	70	1,127	1,598
Ngchesar	313	305	350	350	1,318
Ngardmau	365	165	34	219	783
Kayangel	0	0	0	45	45
Angaur	0	0	0	18	18
TOTAL	**15,186**	**13,490**	**22,966**	**28,240**	**79,882**

[Note: 1990 data:-PFFA, Oh's (May-Dec), Eptison Cold Storage (all except February), and other markets and restaurants; 1991 data:-PFFA, PMCI and Oh's (10 months) and Melekeok Coop for Palau; 1992 data:-PFFA (all months), PMCI (all months except May), Oh's (all months except January, October and November); 1993 data:- PFFA (Jan-Sep),, PMCI (Jan-Sep), and Oh's (January-May).

Biology and ecology: Information in this section is taken solely from Brown (1993). The taxonomy of the genus *Scylla* is still debatable and the number of existing species unknown. On the basis of differences in colour patterns, relative size, cheliped spination, chromosome form, and gamete development, Estampador (1949, quoted in Brown, 1993) recognised three species (*S. serrata*, *S. oceanica* and *S. tranquebarica*) and one variety (*S. serrata* var. *paramamosain*) in Philippine waters. This classification was rejected by Stephenson and Campbell (1960, quoted in Brown, 1993) due to the rather qualitative nature of the criteria used. Although some studies seem to have results in support of specific distinction between some suggested species, the need for further justification before subdividing, is required.

S. serrata is frequently found in areas characterised by a muddy substrate associated with mangrove vegetation. It is the only portunid crab characteristically found in mangrove swamps and generally have a restricted home range (Brown, 1993). Burrows are used by subadults and adults as general refuges especially when in soft-shelled satge of the moulting and when mating. However, moulting and mating also occur outside burrows. Adults can tolerate salinities of 2 ppt for a few months and as high as 60 ppt. However, the pelagic zoeal larvae suffer high mortality at temperatures above 25 °C and salinities below 17.5 ppt. *S. serrata* is an opportunistic feeder feeding mainly on slow-moving or immobile prey organisms. It eats smaller injured or weak crabs of the same species as well as algae and decaying vegetable matter. It reamins buried during daylight and feeds at night, mainly in early evening and before dawn. During mating and the late intermoult period and when temperatures fall below 20 °C, mangrove crabs reduce or completely cease to feed.

Maturity in mangrove crabs may occur in the tropics at 18 months of age whereas those in more temperate regions may take up to 3 years. Mating occurs when the female's carapace is soft. Spermatophores are transferred into the female's sperm receptacle. Sperm cells can remain viable in their gelatinous packages for periods up to 7 months and still effectively fertilize ova as they pass along the female's oviducts to the exterior. "After emerging, the eggs (ranging from 2 to 6 million) are attached in a mass to a set of pleopods beneath the abdominal flap where they are tended and aerated by the female. Egg incubation takes about 10 to 17 days. Ovulating females migrate offshore to hatch their eggs in an oceanic environment more tolerable to the pelagic larvae stages. After hatching, the planktonic zoea undergoes up to five moults over a period of about three weeks during which time it is transported back to the estuarine environment by tidal currents. The final zoeal stage changes into a megalopa which settles out on a substrate and after five to twelve days becomes a

juvenile crab (Brown, 1993). Cultured crabs in Hawaii reach attained marketable size (500-700 g) in 18 months at 24° C while at 27° C they reached equivalent size in onlt 12 months. In Australia mangrove crabs can reach carapace width of 24 cm with the majority in the 15-20 cm range (Brown, 1993).

1.2.2 The Fishery

Utilization: McHugh (1980) writes that mangrove crab is a resource that is of value to all of Palau's municipalities that share the district's 9,200 acres of mangrove swamp. In addition, mangrove crabs have traditionally been valued for a variety of customary purposes but particularly as a reserve source of protein food (***odoim***) that could be gathered in the sheltered waters of the swamp when the waters of the lagoon are too rough to allow collection or catching of the more common resources such as clams and fish. For traditional customary occasions, mangrove crabs are preferred over lobsters (Kitalong *et al*., 1991). McHugh (cited above) wrote that the change from a barter to a cash economy has created an additional use of the resource as a primary or supplementary source of income for villagers on Babeldaob and Peleliu. The fishery was particularly attractive to isolated villages because of the relatively easy means of capture using no or home made gear, and that crabs can be kept alive for several days, allowing shipment to Koror where they can be sold at two to three times the value of fish. Traps, made of chicken wire or plastic mesh with a height and diameter of 2.5 feet and 3 feet in length, are usually set along the mangrove channels and at the outside edge of the mangroves. Bait used is normally fish, skipjack tuna, shark meat or canned mackerel (Matthews and Oiterong, 1991). The traps are visited every morning at high tide to collect crabs and put on fresh bait when the areas are accessible by bamboo raft.

In Ngerchelong, mangrove crab is one of the most important marine invertebrates for subsistence and commercial purposes, and is collected daily using traps. Ngeremduu Bay and adjacent mangroves shared by Ngetpang and Ngeremlengui States account for more than half of the commercial mangrove landings in Palau and thus the resource is important to both states. A complete ban on mangrove crab collection operates in Ngetpang from March-August (spawning season) and a permit is required for harvesting during the rest of the year. Mangrove crabs are especially sought after during the new moon in July (breeding and moulting season) in Ngeremlengui. The crabs are caught using traps and hooks, and at night with spears and flashlights (Rochers and Matthews, 1992). In Ngchesar, mangrove crab has been an important invertebrate resource from the surrounding waters. However, some residents interviewed by Rochers and Matthews (1992) believe that the mangrove crab population is very low now in Ngchesar due to increased predation by saltwater crocodiles. A large mangrove crab population is associated with Peleliu's mangroves (Maragos, 1994). The resource is important to the residents, and is sought after in April when 10 or more crabs are collected by women 2-3 times a week (Rochers and Matthews, 1992). Hooks are normally used to pull the crabs from their crevices in the mangroves.

Mangrove crab has become the most valuable inshore crustacean found within Palau's 45 km^2 of mangrove and has a higher demand at local restaurants and for export than lobsters (Kitalong *et al*., 1991).

Production and marketing: Perron *et al*. (1983) listed mangrove crab as one of the commercial marine animals in Palau. Matthews and Oiterong (1991) listed mangrove crab as one of the invertebrates collected in the greatest numbers by Palauan women in Aimeliik, Airai and Ngeremlengui in a survey of only 7 states. The same authors reported a woman in Airai who consistently caught mud crabs using 12 traps. Her average catch per trip (daily, in the morning) was eight crabs, but sometimes she caught as many as fifteen crabs. Kitalong and Oiterong (1991) noted that the states with the largest annual commercial landings of mangrove crab for 1990 were, in decreasing order, Ngatpang, Ngaraard, Ngeremlengui and Ngerchelong. Cumulative data from

commercial markets collected by DMR from 1990 to 1993 places Ngerchelong as the top supplier of mangrove crabs, followed by Ngeremlengui, Ngaraard and Ngatpang, all with more than 10,000 lbs for the four-year period. The crabs are ususally sold in the markets and to one hotel in Koror. However, sometimes the catch is sold to meet special requests or customary demands.

McHugh (1980) reported a commercial landing of 500 to 600 pounds of crabs per week during the six months the crab fishery was opened in Ngatpang in 1976. This is equivalent to 13,600-15,600 lb of crabs landed in Ngatpang alone for that year.

Records of mud crab purchases at the markets and outlets have indicated an increase in landings at commercial markets during the last decade. An estimated 1.1 mt of mangrove crabs were sold in 1980 as compared to about 10.4 mt sold in 1992, and 12 mt in 1993. An increase of 70 per cent in commercial landings was recorded from 1991 to 1992 but more than a 100 per cent increase in purchases was recorded from 1991 to 1993. Table 1.2.2 records available commercial mud crab landings at the markets and other outlets as compiled by DMR. The data for years before 1990 was from only one outlet, PFFA.

Table 1.2.2: Total commercial mangrove crab landings recorded for 1976-1989 at PFFA; for 1990 at PFFA, Eptison Cold Storage, and Oh's Market, and several smaller markets and restaurants;.for 1991 at PFFA, PMCI and Oh's (10 months) and Melekeok Coop for Palau, for 1992 at PFFA, PMCI (all months except May), and Oh's (all months except January, October and November); for 1993 at PFFA, PMCI and Oh's (January-May).

	Weight		Value	Average price	
Year	Lbs	Kg	US$	per lb	per kg
1976	1,502	681	1,136	0.76	1.67
1977	906	411	753	0.83	1.83
1978	465	211	425	0.91	2.01
1979	1,625	737	1,625	1.00	2.20
1980	2,614	1,186	3,040	1.16	2.56
1981	846	384	1,197	1.41	3.12
1982					
1983	528	240	1,197	2.27	5.00
1984	1,222	554	2,934	2.40	5.29
1985	3,169	1,437	7,573	2.39	5.27
1986	1,028	466	1,707	1.66	3.66
1987	286	130	691	2.42	5.33
1988	154	70	385	2.50	5.51
1989	2,375	1,077	7,590	3.20	7.05
1990	15,186	6,888	50,828	3.35	7.38
1991	13,490	6,119	53,967	4.00	8.82
1992	22,966	10,417	90,659	3.95	8.70
1993	28,080	12,764	111,225	4.00	8.80

Table 1.2.3 records mangrove crab commercial landings, by state, for each year for the 1990-1993 period as recorded by various outlets and compiled by MRD. The 1990 mangrove crab landings were dominated by Ngatpang (6,675 lbs) but declined to a little less than 1,000 lbs in the following two years, and increased again to more than 4,000 lbs in 1993. Greatest increases and high catches are noted for Ngeremlengui, Ngerchelong and Ngaraard.

Table 1.2.3: Mangrove crab purchases in the commercial markets as summarised in Table 1.2.1 but detailed here by State for each year. The States are listed in descending order of landings.

State	Mangrove area (km^2)	No. of fisher men	No. of trips	Landing (lbs)	Ave. (lbs/trip)	Product. (lbs/km^2 mangrove)
1990						
Ngatpang	6.3	7	237	6,675	29	1,060
Ngaraard	3.4	23	75	1,774	24	522
Ngeremlen.	4.0	16	46	1,458	32	364
Ngerchel.	2.1	13	38	1,212	32	577
Koror	1.6	22	51	998	20	624
Airai	7.9	12	38	643	17	81
Ngiwal	1.3	10	22	628	28	483
Aimeliik	2.8	12	29	617	21	220
Ngardmau	7.2	3	16	365	23	51
Peleliu	4.9	3	11	361	33	74
Ngchesar	1.8	11	18	313	17	174
Melekeok	1.7	6	9	142	16	84
Angaur	0.0	0	0	0		
Kayangel	0.0	0	0	0		

State	Mangrove area (km^2)	No. of fisher men	No. of trips	Landing (lbs)	Value (US$)	Ave. (lbs/trip)	Product. (lbs/km^2 mangrove)
1991							
Ngeremlen.	4.0	23	193	4,599	18,259	24	1,150
Ngerchel.	2.1	17	93	2,669	10,620	29	1,271
Ngiwal	1.3	8	39	1,071	4,203	27	824
Ngatpang	6.3	15	64	999	3,958	16	159
Ngaraard	3.4	18	60	985	4,048	16	290
Aimeliik	2.8	14	64	974	3,974	15	348
Koror	1.6	12	26	762	3,045	29	476
Airai	7.9	12	37	384	1,558	10	49
Ngchesar	1.8	9	18	305	1,215	17	169
Melekeok	1.7	4	17	250	958	15	147
Ngardmau	7.2	9	19	165	662	9	23
Peleliu	4.9	3	4	40	160	10	8
Angaur	0.0	0	0	0	0		
Kayangel	0.0	0	0	0	0		
Unknown		18	21	287	974	14	

Total/Ave.	45	138	590	15,186	24	338

TOTAL	45	162	655	13,490	53,634	18	410

Table 1.2.3 continued.

State	Mangrove area (km^2)	No. of fisher men	No. of trips	Landing (lbs)	Value (US$)	Ave. (lbs/trip)	Product. (lbs/km^2 mangrove)
1992							
Ngerchel.	2.1	40	189	6,442	25,150	34	3,068
Ngeremlen.	4.0	23	230	6,063	23,880	26	1,516
Ngaraard	3.4	31	178	5,213	20,773	29	1,533
Ngiwal	1.3	8	4	1,021	4,072	255	785
Ngatpang	6.3	14	47	985	3,911	21	156
Aimeliik	2.8	20	64	882	3,391	14	315
Melekeok	1.7	8	31	779	3,035	25	458
Airai	7.9	16	33	605	2,412	18	77
Ngchesar	1.8	13	26	350	1,386	13	194
Koror	1.6	12	19	218	880	11	136
Peleliu	4.9	3	4	70	277	17	14
Ngardmau	7.2	3	4	34	284	9	5
Unknown		19	19	304	1,208	16	
TOTAL		210	848	22,966	90,659	26	688

State	Mangrove area (km^2)	No. of fisher men	No. of trips	Landing (lbs)	Value (US$)	Ave. (lbs/trip)	Product. (lbs/km^2 mangrove)
1993							
Ngerchel.	2.1	50	242	7,816	30,864	32	3,722
Ngaraard	3.4	24	143	5,082	20,117	36	1,495
Ngatpang	6.3	13	155	4,675	18,527	30	742
Ngeremlen.	4.0	18	120	3,624	14,428	30	906
Airai	7.9	13	78	1,241	4,930	16	157
Peleliu	4.9	8	28	1,127	4,410	40	230
Ngiwal	1.3	10	39	1,108	4,377	28	852
Koror	1.6	26	31	544	2,181	18	340
Aimeliik	2.8	11	33	501	1,973	15	179
Melekeok	1.7	6	30	499	1,981	17	294
Ngchesar	1.8	5	21	350	1,391	17	194
Ngardmau	7.2	13	19	219	865	12	30
Kayangel	0.0	2	2	45	180	23	
Angaur	0.0	1	1	18	72	18	
Unknown		50	65	1,391	5,532	21	
TOTAL		250	1,007	28,240	111,828	24	762

Table 1.2.4 is derived from the same data used in Tables 1.2.2 and 1.2.3 but is sorted by state for the period 1990-1993, to give an indication of the trends in the commercial importance of the mangrove crab fishery to each particular state. Generally for most states, the quantity of mangrove crab landed depended on the number of fishing trips taken. The highest mean catch landed per trip was recorded for Ngiwal. However, this was due to an exceptional high catch in 1992 from only 4 trips. Apart from that, Ngerchelong had the highest overall (for four years) mean catch of 31.8 lbs per trip. This was followed by Ngeremlengi with 28.0 lbs/ trip, Ngaraard with 26.2 lbs/trip, Peleliu with 25.2 lbs/trip and Ngatpang with 23.8 lbs/trip. The rest of the states have less than 20 lbs/trip. Over the four-year period, the highest mean annual landing was recorded from Ngerchelong with 4,534 lbs/year, followed by Ngeremlengui with 3,936 lbs/year, Ngatpang with 3,333 lbs/year and Ngaraard with 3,263 lbs/year. Mean landings for other states during the period were less than 1,000 lbs/year.

Table 1.2.4: Mangrove crab fishing statistcis by state for the 1990-1993 period.

State	No. of fishermen	No. of trips	Landing (lbs)	Average (lbs/trip)	Productivity (lbs/km2 mangrove)
Aimeliik	Mangrove area: 2.8 km^2				
1990	12	29	617	21.3	220.36
1991	14	64	974	15.2	347.86
1992	20	64	882	13.8	315.00
1993	11	33	501	15.2	178.93
Mean	14.25	47.5	743.5	16.4	265.50
Kayangel	Mangrove area: 0.0				
1990	0	0	0	0.0	N/A
1991	0	0	0	0.0	N/A
1992	0	0	0	0.0	N/A
1993	2	2	45	22.5	N/A
Mean	0.5	0.5	11.3	5.6	
Koror	Mangrove area: 1.6 km^2				
1990	22	51	998	19.6	623.75
1991	12	26	762	29.3	476.25
1992	12	19	218	11.5	136.25
1993	26	31	544	17.5	340.00
Mean	18.0	31.8	630.5	19.5	394.10
Ngaraard	Mangrove area: 3.4 km^2				
1990	23	75	1,774	23.7	521.76
1991	18	60	985	16.4	289.71
1992	31	178	5,213	29.3	1,533.24
1993	24	143	5,082	35.5	1,494.71
Mean	24.0	114.0	3,263.5	26.2	959.90

State	No. of fishermen	No. of trips	Landing (lbs)	Average (lbs/trip)	Productivity (lbs/km2 mangrove)
Airai	Mangrove area: 7.9 km^2				
1990	12	38	643	16.9	81.39
1991	12	37	384	10.4	48.61
1992	16	33	605	18.3	76.58
1993	13	78	1,241	15.9	157.09
Mean	13.3	46.5	718.3	15.4	90.90
Angaur	Mangrove area: 0.0				
1990	0	0	0	0.0	N/A
1991	0	0	0	0.0	N/A
1992	0	0	0	0.0	N/A
1993	1	1	18	18.0	N/A
Mean	0.3	0.3	4.5	4.5	
Melekeok	Mangrove area: 1.7 km^2				
1990	6	9	142	15.8	83.53
1991	4	17	250	14.7	147.06
1992	8	31	779	25.1	458.24
1993	6	30	499	16.6	293.53
Mean	6.0	21.8	417.5	18.1	245.60
Ngardmau	Mangrove area: 7.2 km^2				
1990	3	16	365	22.8	50.69
1991	9	19	165	8.7	22.92
1992	3	4	34	8.5	4.72
1993	13	19	219	11.5	30.42
Mean	7.0	14.5	195.8	12.9	27.20

Table 1.2.4 continued.

State	No. of fishermen	No. of trips	Landing (lbs)	Average (lbs/trip)	Productivity (lbs/km2 mangrove)
Ngatpang	Mangrove area: 6.3 km^2				
1990	7	237	6,675	28.2	1,059.52
1991	15	64	999	15.6	158.57
1992	14	47	985	21.0	156.35
1993	13	155	4,675	30.2	742.06
Mean	12.3	125.8	3,333.5	23.8	529.1
Ngerchelong	Mangrove area: 2.1 km^2				
1990	13	38	1,212	31.9	577.14
1991	17	93	2,669	28.7	1,270.95
1992	40	189	6,442	34.1	3,067.62
1993	50	242	7,816	32.3	3,721.90
Mean	30.0	140.5	4,534.8	31.8	2,159.4
Ngiwal	Mangrove area: 1.3 km^2				
1990	10	22	628	28.5	483.08
1991	8	39	1,071	27.5	823.85
1992	8	4	1,021	255.3	785.38
1993	10	39	1,108	28.4	852.31
Mean	9.0	26.0	957.0	84.9	736.2
Unknown	Mangrove area: N/A				
1991	18	21	287	13.7	N/A
1992	19	19	304	16.0	N/A
1993	50	65	1,391	21.4	N/A

State	No. of fishermen	No. of trips	Landing (lbs)	Average (lbs/trip)	Productivity (lbs/km2 mangrove)
Ngchesar	Mangrove area: 1.8 km^2				
1990	11	18	313	17.4	173.89
1991	9	18	305	16.9	169.44
1992	13	26	350	13.5	194.44
1993	5	21	350	16.7	194.44
Mean	9.5	20.8	329.5	16.1	183.1
Ngeremlengui	Mangrove area: 4.0 km^2				
1990	16	46	1,458	31.7	364.50
1991	23	193	4,599	23.8	1,149.75
1992	23	230	6,063	26.4	1,515.75
1993	18	120	3,624	30.2	906.00
Mean	20.0	147.3	3,936.0	28.0	984.0
Peleliu	Mangrove area: 4.9 km^2				
1990	3	11	361	32.8	73.67
1991	3	4	40	10.0	8.16
1992	3	4	70	17.5	14.29
1993	8	28	1,127	40.3	230.00
Mean	4.3	11.8	399.5	25.2	81.5

Export of mangrove crabs as recorded in various references are given in Tables 1.2.5(a), (b), (c) and (d) for the 1990-1993 year period. These are summaries of air freight cargo on manifest forms for Continental Air Micronesia. Relative composition of mangrove crabs for each declared item is not known and impossible to estimate where mangrove crabs were shipped together with other foodstuffs. Mangrove crabs that were exported alone in 1990 amounted to 3,436 lbs. This weights however also include packaging. Packaging weight was estimated by Kitalong and Oiterong (1991) to be 35 per cent of the total weight.

Table 1.2.5 (a): Export of crabs in 1990, except September, as compiled from Continental Air Micronesia manifests. Weight (lbs) include those for packaging and "other" refers to agricultural food items and count is the number of containers sent. (Source: Kitalong and Oiterong, 1991).

Declared Item	Count	Wt. (lbs)
Crab	15	654
Mangrove crab	61	2,662
Live crab	2	76
Crabmeat	1	44
Bat and **crab**	6	864
Bat & **mangrove crab**	3	292
Bat, pigeon and **crab**	1	96
Coconut crab and **mangrove crab**	1	35
Crab & others	12	1,394
Crab, bat & others	2	187
Crab, seafood, and bat	1	240
Crab and fresh fish	2	1,311
Mangrove crab & others	4	237
Fresh fish & **crab**	15	5,670
Fresh fish & **mangrove crab**	2	1,041
Frozen fish, bat & **crab**	7	1,573
Frozen fish & **crab**	18	3,022
Frozen fish, **crabs**, others	12	2,569
Frozen fish, **crab**, bat & others	3	2,028

Declared Item	Count	Wt. (lbs)
Frozen fish, **crab**, bat & pigeon	1	114
Frozen fish, **crab**, and clam shell	1	77
Frozen fish & **mangrove crab**	2	139
Frozen fish, lobster & **mangrove crab**	1	157
Frozen fish, lobster & **crab**	1	1,096
Fish, coconut & **mangrove crabs** & others	1	132
Fish & **crab**	8	2,030
Fish, **crab** & others	18	3,620
Fish, **crab** & bat	7	1,579
Fish, **crab**, bat & others	1	347
Fish, **crab**, clam & others	1	121
Fish, **crab**, lobster & bat	2	293
Fish, **crab**, lobster & others	1	134
Fish and **mangrove crab**	1	102
Fish, **mangrove crab** and bat	1	50
Lobster, bat & **crab**	1	20
Live **crab** & others	1	149
Seafood, **crab** & others	1	31

Air cargo exports for January-November 1990, excluding September, as recorded by Continental Air Micronesia Airlines were 506 lbs (115 kg) crabs and 2,662 (1,198 kg) mangrove crabs. These weights include container and ice used in packing. In 1991, only 413 lbs of crabs (including packaging) were shipped alone and in 1992 only 102 lbs of crabs were shipped alone.

Table 1.2.5 (b): 1991 summary of air freight cargo declared on manifest forms for Continental Air Micronesia. (Source: Division of Marine Resources, Annual Report 1991).

Declared Item	Count	Wt (lbs)	Declared Item	Count	Wt (lbs)
Crab	6	295	Fish/crab/other	36	3,456
Live crab	3	77	Fish/lve crab	15	2,103
Mangrove crab	2	41	Fish/emang/land crab/clam	20	1,823
Crab/others	9	812	Fish/emang	10	1,561
Live crab/other	9	770	Fish/crab/clam/lobster/bats	10	894
Mangrove crab/landcrab/bats/others	4	156	Fish/crab/lobster	8	888
Crab/lobster/others	3	100	Fish/crab/seafood	9	880
Crab/clam/lobster/others	2	89	Fish/live emang	5	816
Crab/bats/others	1	57	Fish/live emang/other	7	762
Crab/lobster	1	45	Fish/emang/land crab	8	728
Crab/seafood/others	1	45	Fish/emang/bat	6	647
Crab/bats	1	34	Fish/crab/bat/others	7	629
Fresh fish/crab	4	753	Fish/emang/others	4	485
Fresh fish/crab/lobster	3	308	Fish/sardins/crab/clam	5	375
Fresh fish/crab/other	1	50	Fish/crab/clam	5	331
Fresh tuna/crab/others	1	115	Fish/crab/clam/lobster	2	212
Frozen fish/crab/others	43	3,795	Fish/crab/lobster/other	3	208
Frozen fish/crab	33	2,838	Fish/crab/seafood/other	2	156
Frozen fish/crab/bat/others	14	1,771	Fish/crab/lobster/bat	2	155
Frozen fish/emang/others	3	348	Fish/emang/bat others	3	102
Frozen fish /emang	3	154	Fish/crab	47	5,730
Frozen fish/crab/bat	1	100	Fish/crab/bat	35	3,720

Table 1.2.5 (c): Summary of air freight cargo on manifest forms for Continental Air Micronesia for items including crab in 1992.

Declared item	Count	Wt (lbs)	Declared Item	Count	Wt (lbs)
Crab (live)	2	66	Fish (frozen)/crab/other	38	3,005
Crab (stuffed)	1	36	Fish (smoked)/crab/clam/other	1	34
Crab (live mangrove, coconut)	1	12	Fish/crab	12	1,393
Crab (live)/bats	2	81	Fish/crab (live mangrove)/other	20	2,048
Crab (live)/other	2	76	Fish/crab (mangrove, coconut)/other	1	125
Crab (live)/sea cucumber	3	315	Fish/crab (mangrove, land, coconut)	5	440
Crab (live)/smoked fish	2	124	Fish/crab (stuffed)/lobster/other	4	205
Crab (mangrove, land)/bats/other	3	330	Fish/crab/bats	9	521
Crab (stuffed)/bats/other	3	308	Fish/crab/bats/other	3	467
Crab/bats	8	581	Fish/crab/clam	2	329
Crab/bats/other	2	201	Fish/crab/clam/bats	19	1,591
Crab/clam/other	3	263	Fish/crab/clam/other	1	181
Crab/clam/sea cucumber	1	45	Fish/crab/fish (smoked)/other	3	219
Crab/lobster	9	518	Fish/crab/lobster	3	298
Crab/lobster/other	2	130	Fish/crab/lobster/bats	1	109
Crab/sea cucumber/other	1	66	Fish/crab/lobster/clam	10	1,152
Crab/seafood/other	4	182	Fish/crab/lobster/other	12	1,074
Fish(fresh)/crab	9	744	Fish/crab/lobster/seafood	5	477
Fish (fresh)/crab/bats	3	245	Fish/crab/other	34	2,678
Fish (fresh)/crab/lobster	1	65	Fish/crab/seafood/other	1	106
Fish (fresh)/crab/lobster/other	1	76	Fish (frozen)/crab/bats/others	9	722
Fish (fresh)/crab/other	2	232	Fish (frozen)/crab/clam	1	31
Fish (frozen)/crab	54	6,028	Fish (frozen)/crab/lobster	21	1,612
Fish (frozen)/crab (mangrove, coconut)	5	640	Fish (frozen)/crab/lobster/bats	8	907
Fish (frozen)/crab/bats	3	339	Fish (frozen)/crab/lobster/other	23	1,950

The tables of exports, constructed using data collected from airline cargo manifests, clearly illustrate the need to design a better method of obtaining these data. Several options are possible which could be employed locally and include:

1. establishing an export permit system for marine products even if not for commercial purposes. Under the system, the exporter will be required to apply for a permit from DMR each time marine products will be exported. Upon application, details of products (e.g. organism specific name), weight and number of pieces, destination, purpose (commercial or home consumption) to be exported should be included.
2. developing a system requiring the exporter, when weighing in, to submit the detailed breakdown (as is in 1 above) of a container to the airline.
3. DMR to check contents of coolers containing fisheries products to be shipped out.

1.2.3 Stocks Status

There has not been any recent attempt to assess the status of the mangrove crab stocks in Palau. The estimate of a total of 6,100 mangrove crabs made by McHugh (1980) for Palau, and the subsequent adjustment to accomodate a better estimate of the mangrove area by DMR in 1990, giving a total of 7,400 crabs (15,186 lbs), are not consistent with the estimated landing figures after those years. Both estimates of commercial landings for 1992 (22,966 lbs) and 1993 (28,202 lbs) were about 1.5 times greater than the estimated total number of mangrove crabs in existence in Palau in 1990 (15,186 lbs). The high increase in landings in 1992 and 1993 resulted from increases in both the number of fishermen involved and/or fishing trips taken. This is particularly notable for Ngerchelong, Ngeremlengui, Melekeok, Ngaraard, Peleliu and Ngardmau (refer to Table 1.2.3).

Considering that the mangrove area is somewhat diminishing due to development, and in combination with the immense increase in fishing pressure especially in the commercial sector, the resource could be in real danger of crashing if concerted effort is not done now to manage its fishery. A monitoring program should be initiated to collect, from fishermen, accurate detailed catch and effort data, length frequencies etc for the mangrove crab fishery. The results could be used to confirm, modify or improve current management strategies. The example set by the State of Ngetpang in imposing a closed harvesting season during the breeding season should be followed and upheld by government. However, research will be required to establish the most beneficial closure period for the fishery.

1.2.4 Management

Current legislation/policy regarding exploitation: The State Government of Ngatpang bans the collection of mangrove crabs between April and August each year in order to protect spawning stocks (Ngatpang NSPL No. 13-85). Open season is from September until February. Hunters are required to purchase a $50 annual permit from the Office of the Governor of Ngatpang State. Net mesh size must not be less than 4 inches.

Section 4 (7) of the Marine Protection Act of 1994 prohibits the export of mangrove crab for commercial purposes except cultured species. Section 4 (10) of the same Act prohibits the buying and selling of mangrove crabs smaller than six inches in the greatest distance across the width of its carapace or a berried female of any size.

Recommended legislation/policy regarding exploitation: Research will be required to establish whether the minimum size limit currently applied is the appropriate width for the local mangrove crab stock. Application of a closed season nationally is a consideration. In Queensland, female mangrove crabs may not be taken by either commercial or recreational fishermen (Brown, 1993). Other management possibilities include limited entry by restricting the number of traps per fisherman, setting a quota per area etc. Perhaps one of the major considerations in the management of mangrove crab stocks concerns controlling developments that affect their habitat (i.e. mangroves).

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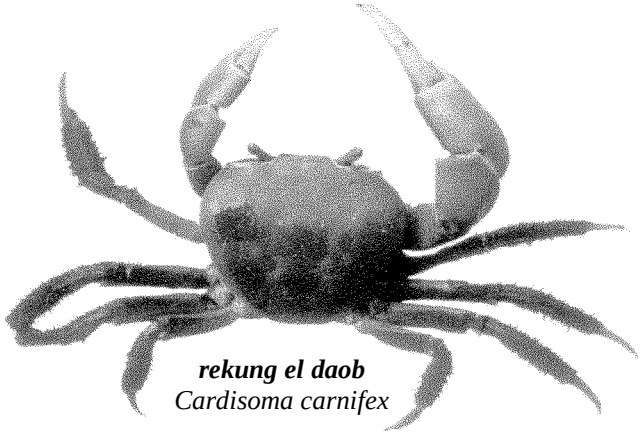
1.3 Land crabs - *rekung*

1.3.1 The Resource



rekung el daob
Cardisoma carnifex

Species present: The principal land crab species utilised in Palau for food are *Cardisoma hirtipes* (***rekung kakum*** or ***rekung el bead***) and *C. carnifex* (***rekung el daob***), with the former being the more important species.

Distribution: Land crabs are generally widespread in the forests of Palau. Land crabs are an important resource in Angaur and are abundant in the northwest portion of the island. They are an important and abundant resource around Kayangel. They are also an important resource in Melekeok, Ngchesar, Peleliu (Rochers and Matthews, 1992). Women from Airai and Koror collect land crabs from the Rock Islands while women in Ngaraard can collect them year round from the local forests (Matthews and Oiterong, 1991).

Biology and ecology: The adult, about the size of a fist, lives in the forest floor, and comes out at night to feed. This routine is interrupted several days before the full moon, especially during the months of the South-west monsoon (May-June). Egg bearing females leave their holes and undertake mass migrations to the sea. The crabs emerge at dusk, around 2 days before full moon and make their way to the waters edge. Eggs are carried underneath the abdomen and larvae are released from the eggs into the waves by vigorous flapping of the abdomen. Release of larvae at spring tides presumably maximises dispersal along the coast.

1.3.2 The Fishery

Utilisation: At the time of mass migrations to the sea, women and children collect the crabs by hand and place them in sacks, especially as they cross the roads on Angaur and Peleliu (Johannes, 1981). In Melekeok, land crabs is one of the resources that is harvested once per month. During a survey of seven states by Matthews and Oiterong (1991), land crab collection was one of the women's activities in three of the states (Aimeliik, Koror and Ngaraard) and land crabs were one of the invertebrate resources collected in greatest numbers in the same states. The crabs are caught when they are forced out of their burrows during long periods of heavy rain. "Since their eggs are a popular food, land crabs are also caught when they migrate to the sea to reproduce, several days before the full moon during the summer" (Matthews and Oiterong, 1991). Ngaraard is the primary source of land crabs for commerial where they can be collected year round from local forests. Rochers and Matthews (1992) noted that land crabs are collected daily in Angaur. In Kayangel, they are collected once a month from the islands and beaches during both the new and full moons (nomally up to 10 people go out together to collect crabs). It is an important resource in Melekeok where they are also collected about once per month. In Ngchesar , land crabs are collected during the full moon at Tab. Land crab is the most significant invertebrate species in Peleliu which is collected almost every day (Maragos, 1994). Peleliuans distinguish between the two species where *C. carnifex* is known as ***rekung el daob*** and *C. hirtipes* as ***rekung el bead***. *C. carnifex* is best collected during the new moon while *C. hirtipes* during full moon. Both species hide during the ***ongos*** months, (late October until April) when the prevailing winds are dry and from the east.

Land crabs are mostly utilised for subsistence but are an important limited commercial resource in places where they are abundant. Matthews and Oiterong (1991) estimated that of the land crabs collected by women in Airai, 10 per cent are sold, whereas all are used for subsistence in Koror. However, 64 per cent of the total land crab landings by women in Ngaraard were estimated to be for sale. Sometimes the crabs are kept in pens or large containers for a week or two until consumed. Crabs in these pens are "sweetened" on coconut or fattened with rice.

Production and marketing: The land crab resource is mostly a subsistence activity, but some land crabs may be sold in times of very high harvests. Oh's Market in Koror sometimes sells land crabs. No data on sale volumes are available but crab collecting is both widespread and very popular, as it offers an easy, free source of protein, with virtually no production costs. Simple boiling is the usual method of cooking for subsistence consumption. Alternatively the meat is extracted, cooked in coconut cream, put back into the shell and sold to local restaurants.

Perron *et al*. (1983) recorded commercial marine animals landed at PFFA for the 1976-1981 year period. Crabs were recorded in 1976 (907 lbs) and 1977 (47 lbs). Separate records were recorded for mangrove crab for these years which means that these weights could be for land crabs and/or reef crabs.

The survey conducted by Matthews and Oiterong (1991) in seven states in Palau indicated that 14 per cent of the women interviewed in Aimeliik were involved with land crab collection, while 17 per cent was recorded for Koror and 25 per cent for Ngaraard. Thirteen per cent in Airai indicated that of the invertebrates, land crabs were collected in greatest numbers. Eight per cent in Koror and 50 per cent in Ngaraard indicated the same. The same authors estimated average catches for each of the three states as 35 pieces in 2 hours of collection in Airai, 50 pieces in 4 hours in Koror and 58 pieces in 2 hours in Ngaraard. Collection was recorded as occuring twice per month in both Airai and Ngaraard

Rekung purchases in 1991 by commercial markets, as recorded by DMR, was 168 lbs valued at US$84. In 1992, 71 lbs (worth US$246) were recorded in the Melekeok Fisheries Cooperative purchases. This was listed separately from ***emang*** and is thus assumed to be land crabs.

Land crabs have been exported with other food items mostly to relatives in Guam and Saipan. These are shown as air freight cargo declared on manifest forms for Continental Air Micronesia. However, relative composition of each item is impossible to quantify. Records of coolers of food known to contain some land crabs are given in Table 1.3.1 for the 1990-1993 period. The weights (lbs) are gross weights which include packaging material (cooler & ice). Declared items containing crab, without specifying the type of crab, are presented in Appendix 1.3.1. "Crab" in these cases could be coconut crab, mangrove crab or land crab as all types are exported this way.

Table 1.3.1: Exports of land crabs as recorded on the Continental Air Micronesia manifests. (Sources: Kitalong *et al*., 1991; Division of Marine Resources Annual Reports for 1990, 1991, 1992; DMR Database).

Declared Item	1990		1991		1992	
	Count	Wt (lbs)	Count	Wt (lbs)	Count	Wt (lbs)
Land crab	3	94	4	212	0	0
Land crab/Others			3	257	6	684
Mangrove crab/**Land crab**/Bats/Others			4	156	3	330
Coconut crab/**Land crab**/bats	1	214				
Fish/**Land crab**			2	200		
Fish/Emang/**Land crab**			8	728		
Fish/emang/**Land crab**/Clam			20	1,823		
Fish/**Land crab**/Others			5	376	5	442
Fresh fish/**Land crab**/Other			2	209		

1.3.3 Stocks Status

No information is available on the status of land crab stocks in Palau, nor has there been an attempt to assess the stocks. Very little data exists on both the subsistence and commercial landing levels for the resource, and an estimate of production is impossible. The natural habitat of these crabs is very extensive in Palau.

1.3.4 Management

Current Legislation/Policy regarding exploitation: The species is not protected under the Palau National Code. The chiefs of Elab hamlet in Ngaraard State have banned the collection of land crabs during full-moon periods.

Recommended Legislation/Policy regarding exploitation: Even though there do not seem to be any obvious problems with the land crab resource in Palau, some management measures may be necessary for stocks in areas where this resource has been traditionally important both in the subsistence and commercial sectors. One consideration would be limiting collection during crab migration to spawn.

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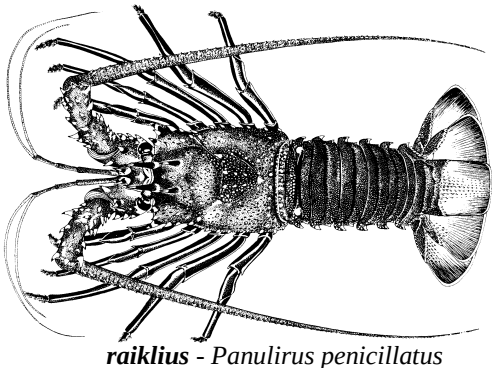
Appendix 1.3.1: Exports of crabs as recorded on the Continental Air Micronesia manifests. (Sources: Kitalong et al., 1991; Division of Marine Resources Annual Reports for 1990, 1991, 1992; DMR Database).

Declared Item	1990		1991		1992	
	Count	Wt (lbs)	Count	Wt (lbs)	Count	Wt (lbs)
Crab	15	654	6	295	13	538
Crab (live)	2	76	3	77	2	66
Crab (live)/Bats					2	81
Crab (live)/Other	1	149	9	770	2	76
Crab (live)/Sea cucumber					3	315
Crab (live)/Smoked fish					2	124
Crab (stuffed)					1	36
Crab (stuffed)/Bats/Others					3	308
Crab/Bat/Others	2	187	1	57	2	201
Crab/Bats			1	34	8	581
Crab/Clam/Other					3	263
Crab/Clam/Sea cucumber					1	45
Crab/Fresh fish	2	1,311				
Crab/Lobster			1	45	9	518
Crab/Lobster/Others			3	100	2	130
Crab/Others	12	1,394	9	812	0	0
Crab/Sea cucumber/Other					1	66
Crab/Seafood/Bat	1	240				
Crab/Seafood/Others			1	45		
Crabmeat	1	44				
Bat/pigeon/**Crab**	1	96				
Fish (fresh)/**Crab**	15	5,670	4	753	9	744
Fish (fresh)/**Crab**/Bat					3	245
Fish (fresh)/**Crab**/Lobster			3	308	1	65
Fish (fresh)/**Crab**/Lobster/Others					1	76
Fish (fresh)/**Crab**/Others			1	50	2	232
Fish (frozen)/Bat/**Crab**	7	1,573	1	100	3	339
Fish (frozen)/**Crab**	18	3,022	33	2,838	54	6,028
Fish (frozen)/**Crab**/Bat/Others	3	2,028	14	1,771	9	722
Fish (frozen)/**Crab**/Bat/Pigeon	1	114				
Fish (frozen)/**Crab**/Clam					1	31
Fish (frozen)/**Crab**/Clam shell	1	77				
Fish (frozen)/**Crab**/Lobster/Bats					8	907
Fish (frozen)/**Crab**/Lobster/Others					23	1,950
Fish (frozen)/**Crab**/Other	12	2,569	43	3,795	38	3,005
Fish (frozen)/**Crab**/Trochus meat					1	50
Fish (frozen)/Lobster/**Crab**	1	1,096	3	308	21	1,612
Fish (smoked)/**Crab**/Clam/Other					1	34
Fish/**Crab**	8	2,030	47	5,730	12	1,393
Fish/**Crab** (mangrove, land,coconut)					5	440
Fish/**Crab** (stuffed)/Lobster/Other					4	205
Fish/**Crab**/Bat	7	1,579	35	3,720	9	521
Fish/**Crab**/Bat/Others	1	347	7	629	3	467
Fish/**Crab**/Clam			5	331	2	329
Fish/**Crab**/Clam/Bats					19	1,591
Fish/**Crab**/Clam/Lobster			2	212	10	1,152
Fish/**Crab**/Clam/Lobster/Bats			10	894		
Fish/**Crab**/Clam/Others	1	121			1	181
Fish/**Crab**/Fish (smoked)/Other					3	219
Fish/**Crab**/Lobster			8	888	3	298
Fish/**Crab**/Lobster/Bat	1	121	2	155	1	109
Fish/**Crab**/Lobster/Others	1	134	3	208	12	1,074
Fish/**Crab**/Lobster/Seafood					5	477
Fish/**Crab**/Others	18	3,620	36	3,456	34	2,678
Fish/**Crab**/Seafood			9	880		
Fish/**Crab**/Seafood/Others			2	156	1	106
Fish/Live **Crab**			15	2,103		
Fish/Sardine/**Crab**/Clam			5	375		
Lobster/Bat/**Crab**	1	20				
Seafood **Crab**/Others	1	31				
Tuna (fresh)/**Crab**/Others			1	115		

1.4 Lobsters - *erabrukl*

1.4.1 The Resource



raiklius - *Panulirus penicillatus*

Species present: Lobster species found in Palau include: *Panulirus penicillatus* (the pronghorn spiny lobster - ***raiklius***), *P. versicolor* (the painted spiny lobster - ***bleyached***), *P. longipes femoristriga* (the longlegged spiny lobster - ***melech***) and *P. ornatus* (the ornate spiny lobster). The slipper lobster, *Scylarides neocaledonicus*, also occurs in Palau.

P. penicillatus and *P. versicolor* are the most important commercial lobster species in Palau accounting for over 98 per cent of commercial lobster landings. *P. longipes femoristriga* is of little economic importance, contributing less than 2 per cent of commercial landings and *P. ornatus* and the slipper lobster, *S. neocaledonicus* occur in very small numbers.

Distribution: Geographical distributions, keys to species identification as well as some biological information of all of the known marine lobster species is detailed in a recent FAO species catalogue (Holthuis, 1991). World wide distribution and biological information in this profile are derived directly from that source.

P. penicillatus - this is the most widespread species of spiny lobsters and is found in the Indo-West Pacific and Eastern Pacific regions, from the Red Sea, east and south east Africa to Japan, Hawaii, Samoa and the Tuamotu Archipelago and east to the islands off the west coast of America and in some localities near the continental coast of Mexico. It is found at depth from 1 to 4 m of rocky substrate in clear water not influenced by rivers. It is often found in surf zone and in surge channels and thus often near arid coasts and on small islands.

P. versicolor - this species is found in the Indo-West Pacific region from the entire Red Sea and east coast of Africa, southern Japan, Micronesia, Melanesia, northern Australia and Polynesia. This species is found in shallow waters from sublittoral down to 15 m depth in coral reef areas, often on seaward edges of the reef plateau. It is also found in clear water in surf areas.

P. longipes femoristriga - in the Indo-West Pacific, this subspecies (called eastern subspecies) inhabits waters of Japan, the Molluccas, Papua New Guinea, eastern Australia, New Caledonia and French Polynesia. It lives in clear or slightly turbid water at depths of 1 to 18 m in rocky areas and coral reefs.

P. ornatus - in the Indo-West Pacific region from the Red Sea and East Africa (south to Natal) to southern Japan, Solomon Islands, Papua New Guinea,S.W., W., N., N.E. and E. Australia, New Caledona and Fiji. This species is found in shallow and sometimes slightly turbid coastal waters from 1 to 8 m depth on sandy and muddy substrates, sometimes on rocky bottom often near the mouths of rivers but also on coral reefs.

Scyllarides neocaledonicus - this slipper lobster species is not listed in Holthuis (1991).

MacDonald (1971; 1979) and Kitalong and Oiterong (1991) present reults of comprehensive studies of the rock lobster species in Palau. "*P. penicillatus* is found within a narrow strip of habitat along the seaward margin of the reef wihtin 10 cm to 5 m of water. Most are caught within one and two meters depths where the waves break. This species is often found under branching coral, *Acropora* sp., at the northeastern exposure of the reef " (Kitalong and Oiterong, 1991). *P. versicolor* is generally more widespread and inhabits both exposed and sheltered reef areas, sometimes inside the lagoon, to depths

of 20-30 m. It is often associated with *Porites lutea* coral heads in calmer waters. *P. longipes femoristriga* is found in habitats overlapping both species mentioned above. It is found in small caves and the reef, especially on the west coast where they are most abundant. It occurs in a wide variety of habitats, ranging down to 30 m in both sheltered and exposed reef areas. The west coast of the Palau archipelago has large stocks of the species.

MacDonald (1979) reported lobster landings as mostly from northeastern reefs which was supported by high landings from Ngerchelong, Ngaraard and Ngiwal. High catches were also reported for the western reefs of Ngeremlengui and Koror. Over 1,500 sq.km. of lagoon and reef area has been estimated as suitable habitat for lobster in Palau.

Biology and ecology: Most of the following summary of the biology of the spiny lobsters is taken from Pitcher (1993). Spiny lobsters are considered opportunistic and omnivorous scavengers living mainly on gastropods, crustaceans, echinoderms, seagrass and algae (Phillips *et al*., 1980, quoted in Pitcher 1993). After mating, the female carries eggs under its tail for about 1 month before the tiny phyllosoma larvae are released (Pitcher, 1993). The larvae remain in the ocean for 4-12 months before moulting into the puerulus stage, about 50 mm long, which resembles a colourless miniature adult lobster. At this stage it "undertakes the transition from the oceanic to the benthic environment, where they settle in or near the adult habitat and quickly moult into pigmented juveniles" (Phillips and Sastry, 1980, quoted in Pitcher, 1993). *P. ornatus* is one of the largest *Panulirus* species and can attain a total body length of about 50 cm but is usually 30-35 cm. It has been reported as solitary or as living in pairs, but has also been found in larger concentrations (Holthuis, 1991). *P. penicilatus* has a maximum total body length of about 40 cm, averaging to about 30 cm with males usually much larger than females.It is not gregarious and is nocturnal, hiding during the daytime in crevices in the rocks and coral reefs (Holthuis, cited above). *P. versicolor* grows to a maximum total length of about 40 cm averaging less than 30 cm. It is nocturnal and not gregarious and hides in crevices and cavities of the rocks during daytime. *P. longipes femoristriga* grows to a maximum body length of 12 cm averaging 8-10 cm and is nocturnal and not gregarious.

In Palau, sexual dimorphism is apparent in *P. penicillatus*, with females tending to be somewhat smaller than males on average. MacDonald (1971) recorded mean carapace length of 7.9 cm for females and 11.3 cm for males. Males tend to be more common in commercial catches. MacDonald (1971) calculated carapace length at first spawning to be 10 cm (the smallest berried female sampled) for this species in Palau. Prescott (1988) states that for most localities in the Pacific, carapace length at first spawning for this species is around 7.5-8.0 cm. MacDonald (cited above) found this species to be gregarious (he found 18 specimens under one boulder).

Average carapace lengths for *P. versicolor* are similar for both sexes, 9.3 cm and 9.8 cm for females and males respectively with a sex ratio close to 1:1. MacDonald (1982) recorded the carapace length at first spawning for this species to be around 8.2 cm (the smallest berried female found). The species has been considered to be not gregarious (Kitalong and Oiterong, 1991).

The small average carapace length (around 7.0 cm for female and 7.5 cm for males) of *P. longipes femoristriga* detracts from the commercial value of this species. Carapace length at first spawning has been calculated at around 7 cm for the Palau stock. The species can be solitary or gregarious, and the smallest berried female was 7 cm (Kitalong and Oiterong, 1991).

Spawning appears to be continuous for *P. penicillatus* and *P. versicolor*, at the same level throughout the year. About 40 per cent of females of both species are ovigerous (bearing eggs) in any one month (MacDonald 1979). Fecundity in most tropical lobster species increases linearly with size. The larvae of tropical lobsters remain planktonic for many months, thus recruitment may occur from adult spawners many kilometers away. The natural mortality coefficient (M) has been calculated for a standing stock of 5,500 *P. penicillatus* at Enewetak Atoll, Marshall Islands as 0.284 $year^{-1}$ for males and 0.244 $year^{-1}$ for females, ie. around 25 percent natural mortality per year (Ebert and Ford, 1979).

1.4.2 The Fishery

Utilization: Lobster was not a traditionally preferred food and perceptions of its value and importance in Palau were introduced from other countries (Kitalong and Oiterong, 1991). It is now second to mangrove crabs in economic importance in the commercial crustacean fishery. In 1971, incentives were recommended to develop the then underexploited lobster fishery.

Spear fishing is the most common form of capturing lobsters in Palau, which often results in berried or undersized lobsters being taken. Fishermen use flashlights to catch *P. penicillatus* mostly at night when they move out of their holes and crevices to feed. Spearfishing by day is also common. Calm weather on a low tide is favoured by most lobster fishermen. *P. versicolor* are caught by spearfishing night and day in deeper waters.

MacDonald (1979) found that the north-eastern reefs produced a large proportion of the total landings in past years. Trap fishing was found to be unsuccessful due to the rough habitat in which *P. penicillatus* occurs, and the fact that *P. versicolor* does not appear to enter traps.

By 1991, lobster formed an incidental part of the catch of most fishermen, with an estimated 6-12 full-time lobster fishermen in Palau, some of whom could land up to 200 pounds (91 kg) of lobster in one trip (Kitalong and Oiterong (1991a). This was considered high, as the average landing was 16 lbs per trip. Most lobsters are, however, taken by spearfishing as an incidental catch. Lobsters are usually sold to existing fish markets for cash income, or consumed by local communities at the village level. The growing tourist industry and the increasing dollar value of lobster (in the past decade tourist numbers have increased four-fold and dollar value of landed lobster has increased three-fold) ensures that this fishery will continue to thrive, as long as stocks are not depleted.

Kitalong and Oiterong (1991) reported that rough weather prevents the collection of lobsters during six months of the year and collecting is thus restricted to calm weather months (May, June, July and August). Peak landings were during these months.

Production and marketing: There has been no estimate made of the level of lobster consumption and the extent of the fishery in the subsistence sector in Palau. In the commercial sector, the only data collected, though incomplete for most years, are those from the main markets and outlets, PFFA, PMCI and Oh's. These markets act as wholesale outlets to local restaurants, hoteliers and buyers from overseas. Average lobster values, estimated from market landings, increased from about $1.31/lb in 1980 to $3.38/lb in 1990, $3.91/lb in 1992 and $3.97 in 1993. Lobster species composition in the commercial landings was estimated by MacDonald (1979). Of the 2,006 individual lobsters he examined, approximately 63 per cent were *P. penicillatus*, 36 per cent *P. versicolor* and 1 per cent *P. longipes femoristriga*. Over 1,500 sq.km. of lagoon and reef area has been estimated as suitable habitat for lobster in Palau.

MacDonald (1982) states that commercial fishing for spiny lobsters began in 1966 in Palau. The fishery has gradually grown and by 1991, it has become second only to mangrove crabs in economic importance in the commercial crustacean fishery (Kitalong and Oiterong, 1991a). In terms of value, the 1993 data from the commercial markets indicate that lobsters were purchased at approximately the same average price (~$3.97/lb) as mangrove crabs.

Records of most of the annual lobster purchases at various commercial outlets as reported in some references for the period 1967-1993, are given in Table 1.4.1. Details of markets and period covered for each year is given under "Source and Notes" beneath the table. There was a general decrease in recorded landings from 1967 until 1985, when it gradually increased again with the highest recorded in

1993. Figure 1.4.2 shows that the trends, including volume landed, value and unit price for lobsters have continually increased since 1985.

Table 1.4.1: Records of lobster purchases at the commercial markets as recorded in various reference for Palau for most of the years between 1967 and1993.

	Weight		Value	Average
Year	lbs	kg	US$	price/lb
1967	7,000	3,182	n.a.	n.a.
1968	4,900	2,227	n.a.	n.a.
1969	3,000	1,364	n.a.	n.a.
1970	7,000	3,182	n.a.	n.a.
1976	512	233	545	1.06
1977	2,081	946	2,567	1.23
1978	1,483	674	847	0.57
1979	970	441	1,113	1.15
1980	1,414	643	1,857	1.31
1981	545	248	807	1.48
1983	750	341	1,190	1.59
1984	634	288	1,532	2.42
1985	1,788	813	4,177	2.34
1986	2,257	1,026	3,998	1.77
1987	1,622	737	2,864	1.77
1988	1,109	504	3,998	3.61
1989	1,983	901	6,363	3.21
1990	3,322	1,510	11,239	3.38
1991	7,153	3,251	27,971	3.91
1992	8,834	4,015	34,874	3.95
1993	11,327	5,149	44,920	3.97

Sources and Notes for Table 1.4.1.

Year	Data source	Reference
1967-1970	PFFA	MacDonald, 1971
1976-1981	PFFA	Perron *et. al.*, 1983
1985-1990	PFFA	MRD
1990	PFFA; Oh's	MRD
1991	PFFA; PMCI;Oh's (10 months)	MRD
1992	PFFA; PMCI (no May); Oh's (no Jan, Oct, Nov); Melekeok's Cooperative	MRD
1993	PFFA (Jan-Sep); PMCI (Jan-Sep); Oh's (Jan-Marc)	MRD

Table 1.4.2 records available data on annual commercial lobster landings, by state, from various outlets in Palau. It provides estimates of available lobster habitat by state, effort, landing, value and yield per sq.km. of lagoon/reef.

Table 1.4.2: Annual lobster fishery statistics by state in Palau for the period 1990-1993. (Sources: Nichols, 1991; DMR Annual Reports for 1991 and 1992; DMR data for 1993).

1990 State	Lagoon & reef area (km^2)	Fishermen (nos.)	Trips (nos.)	Landing (lbs)	Value (US$)	Average (lb/trip)	Average ($/trip)	Productivity (lbs/km^2)
Airai	56.7	3	6	62		10.3		1.1
Angaur	2.6	0	0	0		0.0		0.0
Ngardmau	47.3	6	7	44		6.3		0.9
Ngatpang	24.8	5	7	106		15.1		4.3
Peleliu	35.5	3	4	28		7.0		0.8
Ngeremlengui	34.8	15	45	441		9.8		12.7
Ngaraard	64.3	8	13	204		15.7		3.2
Aimeliik	90.2	4	5	57		11.4		0.6
Ngerchelong	497.0	16	29	972		33.5		2.0
Ngchesar	34.6	7	10	99		9.9		2.9
Melekeok	8.4	0	0	0		0.0		0.0
Koror	619.2	28	50	584		11.7		0.9
Ngiwal	17.9	4	7	529		75.6		29.6
TOTAL/MEAN	1,533.3	99	183	3,126		17.1		2.0

1991 State	Lagoon & reef area (km^2)	Fishermen (nos.)	Trips (nos.)	Landing (lbs)	Value (US$)	Average (lb/trip)	Average $/trip	Productivity (lbs/km^2)
Airai	56.7	14	29	373	1,433	12.9	49.4	6.6
Angaur	2.6	0	0	0	0	0.0	0.0	0.0
Ngardmau	47.3	11	28	380	1,482	13.6	52.9	8.0
Ngatpang	24.8	5	11	48	185	4.4	16.8	1.9
Peleliu	35.5	8	11	221	794	20.1	72.2	6.2
Ngeremlengui	34.8	28	61	496	2,020	8.1	33.1	14.3
Ngaraard	64.3	12	60	1,058	4,222	17.6	70.4	16.5
Aimeliik	90.2	2	4	109	433	27.3	108.3	1.2
Ngerchelong	497.0	16	43	1,026	3,591	23.9	83.5	2.1
Ngchesar	34.6	5	12	86	344	7.2	28.7	2.5
Melekeok	8.4	4	11	158	599	14.4	54.5	18.8

Koror	619.2	47	89	2,357	9,234	26.5	103.8	3.8
Ngiwal	17.9	3	13	1,162	4,573	89.4	351.8	64.9
Kayangel	19.2	6	19	203	810	10.7	42.6	10.6
Unknown		2	2	103	366	51.5	183.0	
TOTAL/MEAN	1,552.5	163	393	7,780	30,086	21.8	76.6	5.0

Table 1.4.2 continued

1992 State	Lagoon & reef area (km2)	Fishermen (nos.)	Trips (nos.)	Landing (lbs)	Value (US$)	Average (lb/trip)	Average ($/trip)	Productivity (lbs/km^2)
Airai	56.7	27	41	732	2,905	17.9	70.9	12.9
Angaur	2.6	2	2	23	92	11.5	46.0	8.8
Ngardmau	47.3	17	73	1,359	5,435	18.6	74.5	28.7
Ngatpang	24.8	2	2	14	58	7.0	29.0	0.6
Peleliu	35.5	1	1	15	52	15.0	52.0	0.4
Ngeremlengui	34.8	27	86	671	2,680	7.8	31.2	19.3
Ngaraard	64.3	17	94	1,525	6,078	16.2	64.7	23.7
Aimeliik	90.2	15	28	322	1,277	11.5	45.6	3.6
Ngerchelong	497.0	26	80	1,739	6,746	21.7	84.3	3.5
Ngchesar	34.6	6	15	172	722	11.5	48.1	5.0
Melekeok	8.4	20	54	258	899	4.8	16.6	30.7
Koror	619.2	46	103	1,307	5,243	12.7	50.9	2.1
Ngiwal	17.9	5	21	383	1,527	18.2	72.7	21.4
Kayangel	19.2	7	14	252	913	18.0	65.2	13.1
Unknown		7	8	61	243	7.6	30.4	
TOTAL/MEAN	1552.5	225	622	8,833	34,870	14.2	52.1	5.7

1993 State	Lagoon & reef area (km^2)	Fishermen (nos.)	Trips (nos.)	Landing (lbs)	Value (US$)	Average (lb/trip)	Average ($/trip)	Productivity (lbs/km^2)
Airai	56.7	3	4	112	445	28.0	111.3	2.0
Angaur	2.6	4	32	661	2,624	20.7	82.0	254.2
Ngardmau	47.3	17	89	1,757	6,954	19.7	78.1	37.1
Ngatpang	24.8	2	3	12	45	4.0	15.0	0.5
Peleliu	35.5	3	6	71	268	11.8	44.7	2.0
Ngeremlengui	34.8	20	43	624	2,479	14.5	57.7	17.9
Ngaraard	64.3	15	93	2,012	8,002	21.6	86.0	31.3
Aimeliik	90.2	10	42	331	1,297	7.9	30.9	3.7
Ngerchelong	497.0	39	119	1,724	6,851	14.5	57.6	3.5
Ngchesar	34.6	3	12	59	232	4.9	19.3	1.7
Melekeok	8.4	5	5	44	168	8.8	33.6	5.2
Koror	619.2	47	140	1,729	6,898	12.4	49.3	2.8
Ngiwal	17.9	4	11	296	1,184	26.9	107.6	16.5
Kayangel	19.2	12	48	1,694	6,675	35.3	139.1	88.2
Unknown		13	19	201	798	10.6	42.0	
TOTAL/MEAN	1,552.5	197	666	11,327	44,920	16.27	63.6	7.3

The overall number of fishermen recorded by the commercial markets as participating in the commercial lobster fishery for the 1990-1993 period increased from 99 in 1990 to 225 in 1992, but dropped to 197 for the nine months in 1993. However, the corresponding overall annual effort (number of trips) increased in each consecutive year with the highest in 1993, even though the number of fishermen was lower for that year than in 1992. The increase in effort in 1993 is about 3.6 times greater than that in 1990. The increase in the overall annual efforts in each consecutive year from 1990 to 1993 resulted in an increase in total annual lobster landings. An interesting feature is that the increased rate in effort between the years 1990 and 1993 corresponds to an equal rate of increase in the landings. The overall annual average catch per trip for the four years were within the 14-17 lbs/trip range except in 1991, where the overall average was 21.8 lbs/trip. Overall estimates of annual mean production using lagoon and reef areas increased from 2.0 lbs/km^2 in 1990 to 7.3 lbs/km^2 in 1993.

Commercial lobster landing details, sorted by state for the 1990-1993 period, are presented in Table 1.4.3. In terms of average lobster landing per trip from 1990 to 1993, increases were recorded from Airai, Anguar, Kayangel, Ngaraard, Ngardmau and Ngeremlengui. Decrease rates were recorded for Aimeliik, Melekeok, Ngatpang, Ngchesar, Ngerchelong and Ngiwal were noted to be decreasing for the period. Commercial catch rates for Koror seem to remain at about 12 lbs per trip except for the high rate, 26.5 lb/trip, recorded in 1991. The highest rate, 89.4 lbs per trip, was recordd from Ngiwal in 1991.

Table 1.4.3: Commercial lobster landing statistics for the period 1990-1994 broken down for each sate in Palau.

State	Fishers (nos.)	Trips (nos.)	Landing (lbs)	Average lb/trip)	Productivity (lbs/km2)
Aimeliik	Lagoon & Reef area = 90.2 km2				
1990	4	5	57	11.4	0.6
1991	2	4	109	27.3	1.2
1992	15	28	322	11.5	3.6
1993	10	42	331	7.9	3.7
Airai	Lagoon & reef area = 56.7 km2				
1990	3	6	62	10.3	1.1
1991	14	29	373	12.9	6.6
1992	27	41	732	17.9	12.9
1993	3	4	112	28	2
Angaur	Lagoon & reef area = 2.6 km2				
1990	0	0	0	0	0
1991	0	0	0	0	0
1992	2	2	23	11.5	8.8
1993	4	32	661	20.7	254.2
Kayangel	Lagoon & reef area = 19.2 km2				
1990	6	19	203	10.7	10.6
1991	7	14	252	18	13.1
1992	12	48	1,694	35.3	88.2
1993					
Koror	Lagoon & reef area = 619.2 km2				
1990	28	50	584	11.7	0.9
1991	47	89	2,357	26.5	3.8
1992	46	103	1,307	12.7	2.1
1993	47	140	1,729	12.4	2.8
Melekeok	Lagoon & reef area = 8.4 km2				
1990	0	0	0	0	0
1991	4	11	158	14.4	18.8
1992	20	54	258	4.8	30.7
1993	5	5	44	8.8	5.2
Ngaraard	Lagoon & reef area = 64.3 km2				
1990	8	13	204	15.7	3.2
1991	12	60	1,058	17.6	16.5
1992	17	94	1,525	16.2	23.7
1993	15	93	2,012	21.6	31.3

State	Fishers (nos.)	Trips (nos.)	Landing (lbs)	Average (lb/trip)	Produc-tivity (lbs/km2)
Ngardmau	Lagoon & reef area = 47.3 km2				
1990	6	7	44	6.3	0.9
1991	11	28	380	13.6	8
1992	17	73	1,359	18.6	28.7
1993	17	89	1,757	19.7	37.1
Ngatpang	Lagoon & reef area = 24.8 km2				
1990	5	7	106	15.1	4.3
1991	5	11	48	4.4	1.9
1992	2	2	14	7	0.6
1993	2	3	12	4	0.5
Ngchesar	Lagoon & reef area = 34.6 km2				
1990	7	10	99	9.9	2.9
1991	5	12	86	7.2	2.5
1992	6	15	172	11.5	5
1993	3	12	59	4.9	1.7
Ngerchelong	Lagoon & reef area = 497.0 km2				
1990	16	29	972	33.5	2
1991	16	43	1,026	23.9	2.1
1992	26	80	1,739	21.7	3.5
1993	39	119	1,724	14.5	3.5
Ngeremlengui	Lagoon & reef area = 34.8 km2				
1990	15	45	441	9.8	12.7
1991	28	61	496	8.1	14.3
1992	27	86	671	7.8	19.3
1993	20	43	624	14.5	17.9
Ngiwal	Lagoon & reef area = 17.9 km2				
1990	4	7	529	75.6	29.6
1991	3	13	1,162	89.4	64.9
1992	5	21	383	18.2	21.4
1993	4	11	296	26.9	16.5
Peleliu	Lagoon & reef area = 35.5 km2				
1990	3	4	28	7	0.8
1991	8	11	221	20.1	6.2
1992	1	1	15	15	0.4
1993	3	6	71	11.8	2
Unknown					
1991	2	2	103	51.5	
1992	7	8	61	7.6	
1993	13	19	201	10.6	

Monthly lobster landings at PFFA (1983-1992), Oh's market (1990) and PFFA, PMCI and Oh's (Jan-May) for 1993 are given in Table 1.4.4. It is indicated that harvesting of lobsters peak in the mid-year months, which are normally the calm months. This pattern is also shown in Figure 1.4.1. Kitalong and Oiterong (1991) also recorded that during these peak months, highest landings were recorded during new moon and during the first quarter.

Table 1.4.4: Monthly lobsters purchases by some of the commercial markets in Palau for the years1983-1993.

Year		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
1983	PFFA	0	0	0	20	27	204	208	106	126	26	36	4	757
1984	PFFA	21	-	52	73	20	35	317	40	18	21	14	23	634
1985	PFFA	32	24	8	65	179	47	387	463	87	164	227	96	1,779
1986	PFFA	0	11	51	96	328	354	554	65	471	266	46	18	2,260
1987	PFFA	67	114	239	196	288	350	33	177	158	-	-	-	1,622
1988	PFFA	3	0	61	39	76	141	222	214	256	52	5	40	1,109
1989	PFFA	25	73	77	94	73	530	425	442	172	36	24	14	1,985
1990	PFFA	5	62	24	40	90	71	13	268	6	68	0	9	656
	Oh's	-	-	-	-	970	381	689	24	261	404	250	143	3,122
1991	PFFA			15	47	7	21	439	177	54	55	144	61	1,020
1992	PFFA		1	68	181	196	4	31	21	114		21		637
	(Total* PFFA, PMCI, Oh's and Melekeok Coop)													(8,834)
1993	PFFA		18	7		111		76	188	14	40	13	31	498
	PMCI	421	485	504	1,267	1,770	926	1,378	1,168	1,325	1,097	472	386	11,199

	Oh's (Jan-May)	82	57	49	170	10								368

*PMCI (excluding May), Oh's (excluding Jan., Oct., and Nov.).

It has not been possible to quantify the amount of lobsters exported from Palau as they are normally shipped in coolers together with other foodstuff. Those exported with lobsters as recorded on Continental Air Micronesia freight cargo manifests are given in Tables 1.4.5 for each year from 1990 to 1993. Weights are gross weights which include packaging material and "other" which is mostly agricultural food such as taro, tapioca etc.

Table 1.4.5 : Export of lobsters as recorded on Continental Air Micronesia Manifests for 1990, 1991, 1992 and 1993.

Declared item	1990		1991		1992	
	Count	Gross Wt (lb)	Count	Gross Wt (lb)	Count	Gross Wt (lb)
Lobster	1	30	2	62	6	195
Lobsters					5	150
Crab/Clam/**Lobster**/Other			2	89		
Crab/**Lobster**			1	45	9	518
Crab/**Lobster**/Other			3	100	2	130
Fish (fresh)/Crab/**Lobster**			3	308	1	65
Fish (fresh)/Crab/**Lobster**/Other					1	76
Fish (fresh)/**Lobster**			19	1,667		
Fish (frozen)/Crab/**Lobster**/Bats					8	907
Fish (frozen)/Crab/**Lobster**/Other					23	1,950
Fish (frozen)/**Lobster**	7	515	19	1,936	26	2,055
Fish (frozen)/**Lobster**/Bat			5	302	1	72
Fish (frozen)/**Lobster**/Crab	1	1,096			21	1,612
Fish (frozen)/**Lobster**/Mangrove crab	1	157				
Fish (frozen)/**Lobster**/Other	1	77	6	526	18	1,194
Fish (frozen)/**Lobster**/Squid/Other					1	82
Fish (frozen)/**Lobster**/Trochus meat					1	84
Fish/Clam/Bat/**Lobster**			25	3,567		
Fish/Clam/**Lobster**/Other			6	747		
Fish/Crab (stuffed)/**Lobster**/Other					4	205
Fish/Crab/Clam/**Lobster**			2	212		
Fish/Crab/Clam/**Lobster**/Bats			10	894		
Fish/Crab/**Lobster**			8	888	3	298
Fish/Crab/**Lobster**/Bat	2	293	2	155	1	109
Fish/Crab/**Lobster**/Clam			2	212	10	1,152
Fish/Crab/**Lobster**/Other	1	134	3	208	12	1,074
Fish/Crab/**Lobster**/Seafood					5	477
Fish/**Lobster**	2	90	5	1,299	5	420
Fish/**Lobster**/Bat			3	315	1	44
Fish/**Lobster**/Bat/Other	1	225				
Fish/**Lobster**/Bat/Other			3	184		
Fish/**Lobster**/Other	2	463	14	1,469	17	2,015
Fish/**Lobster**/Trohus meat					1	103
Fish/Sardine/**Lobster**					2	262
Fish/Sardine/**Lobster**/Other					3	213
Lobster/Bat	1	23				
Lobster/Bat/Crab	1	20				
Lobster/Bat/Other	1	25	7	333	1	46
Lobster/Other			10	744		

1.4.3 Stocks Status

There may be little concern at present for management measures to conserve stocks, as mean size at maturity is less than the size at which they are recruited to the fishery and local extinctions are unlikely because recruits are supplied by distant populations and the individuals in isolated populations become very wary of fishermen and lights at night once the stock is substantially reduced. MacDonald (1982)

reports that the Palau stock of *P. versicolor* was lightly fished in the late 1970s-early 1980s, and much of the catch taken for subsistence. Lobster harvesting is made difficult for six months of the year because of rough weather (October-March). However, with increasing exploitation of the resource, collection of accurate and detailed data is important in order to monitor trends of the stocks. Birkeland and Richmond (1992) frequently observed *P. versicolor* during their surveys in 47 sites from Velasco Reef to Angaur.

1.4.4 Management

Several options for the management of reef lobsters have been proposed or implemented in other South Pacific countries. However, the decision on the strategy to adopt normally follows from results of specific research. Even though harvesting of lobsters is regulated, there is a need for research to form the background requirement for management strategies as well as to adjust or confirm existing laws. Pitcher (1993) notes that due to the wide dispersal of *P. penicillatus* phyllosoma larvae, and the existence of many unexploited reefs to provide recruitment to exploited reefs, this species is probably resilient to recruitment overfishing. Thus there is little need to protect berried females or introduce closed seasons especially when females tend to breed through out the year. He further notes that "the main biological concern of management is to maximize yield from the available stock by carrying out YPR research and setting appropriate minimum sizes. This requires reliable data on growth rates, fishing mortality rates and natural mortality rates, which should be determined for local populations rather than substituted from other fisheries or species".

Current legislation/policy regarding exploitation: Section 4 (5) of the Marine Protection Act of 1994 prohibits commercial use, selling or buying of rock lobsters, *P. penicillatus* and *P. versicolor* and *P. longipes femoristriga* smaller than six inches in total length of the carapace, as measured from the tip of the rostrum midway between the eyes to the end of the carapace. Under the same section of the Act, commercial use of berried females of any size is prohibited.

Section 4 (6) of the same Act prohibits the use of any form of underwater breathing apparatus, other than a snorkel, to fish.

Section 4 (7) of the same Act prohibits the export of rock lobster (*P. penicillatus*, *P. versicolor* and *P. longipes femoristriga*) for commercial purposes except cultured species.

Recommended legislation/policy regarding exploitation: Application of an appropriate minimum carapace length is a useful tool in the commercial exploitation of lobster. However, this must be formulated from research using local stocks rather than adapting lengths use elsewhere.

To avoid difficulty in enforcing the minimum size limit, especially where only lobster tails are required for a specific market, consideration may be taken to prohibit the selling/buying of lobster without the head (i.e. the form when selling or buying must be in whole).

Recent biological evidence tends to suggest that prohibiting the catch of berried female lobsters above the minimum size limit, does not seem to be of much value to the fishery, both in landing and recruitment.

One of the possible means of administrating minimum size limits is a change in fishing methods employed, e.g. catching by hand using gloves, traps and nets. Prohibiting the use of spears to catch lobsters would be a difficult option to enforce, but a possible means to administer the minimum size limits regulations.

The following management considerations have been recommended in several references, e.g. Kitalong and Oiterong (1991):

* presentation of available data be made to lobster fishermen;
* survey lobster fishing areas to estimate standing stocks;
* conduct a market survey for live and unspeared lobster, with presentation to fishermen of market and standing stock survey results;
* discuss appropriate lobster management and conservation strategies with all concerned in the fishery;
* if justified, include lobsters as a protected species in existing trochus sanctuaries.

Johannes (1991) strongly recommends banning spearfishing as a method to catch lobster, and banning the sale of speared lobsters at commercial markets. However, this would be difficult to enforce also because lobsters are difficult to catch any other way in Palau, as the nature of the reefs does not allow easy movement along the reef flats. A higher price paid at market for live, unspeared lobsters would probably help reduce spearing activity.

Johannes (1991) reports that many rural fishermen in Palau are supportive of size limits and closed seasons for lobster.

Prescott (1988) suggests there may be little requirement for management to conserve stocks because of the small size of maturity, large size at recruitment to the fishery and the fact that many adults are always inaccessible to fishermen due to the nature of the habitat which continue to produce recruits. However, management may be considered necessary in order to maximise returns to fishermen and to allow a profitable collection and marketing infrastructure. However there is no evidence at present to suggest that lobster stocks in Palau are unable to support existing levels of effort.

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Figure 1.4.1: Monthly lobster purchases made by PFFA for the years 1985, 1986, 1989, 1991 and 1992.

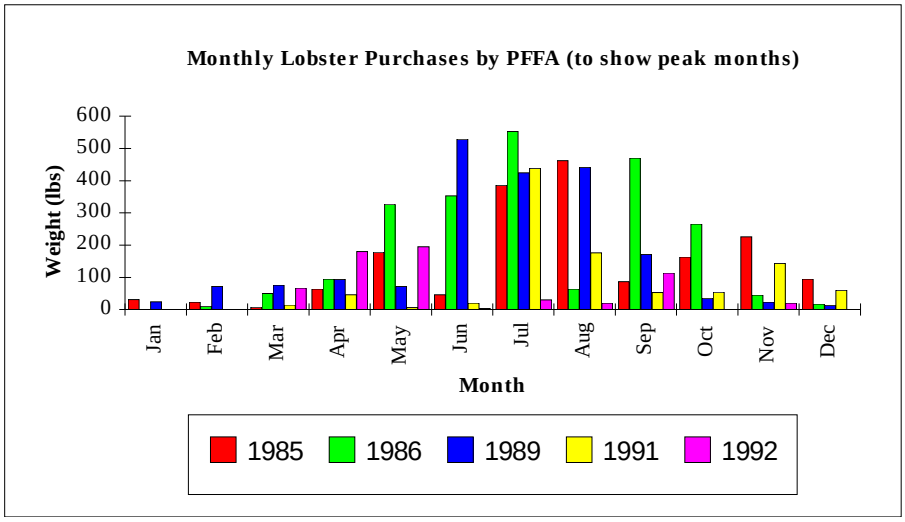
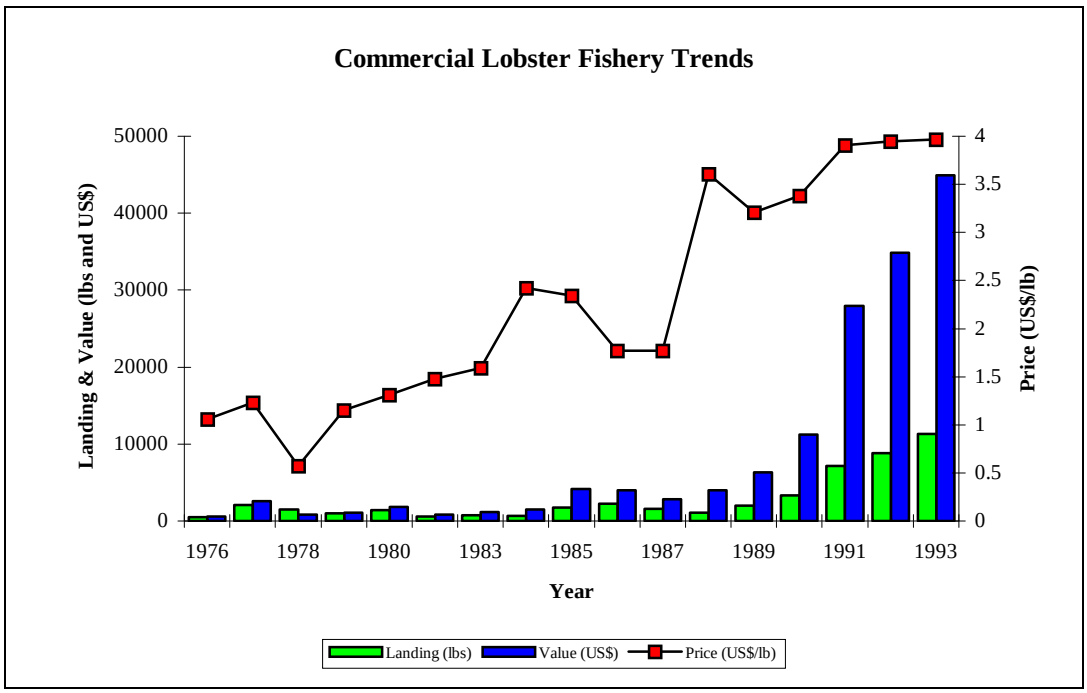
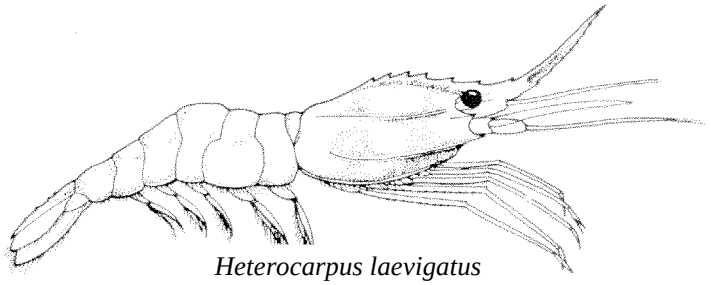


Figure 1.4.2: Lobster landings at the commercial markets in Palau showing trends in total landings, value and price (unit value).



1.5 Deep-water shrimps and crabs

1.5.1 The Resource



Heterocarpus laevigatus

Species present: Two species of caridean shrimp, *Heterocarpus ensifer* (armed nylon shrimp), and *H. laevigatus* (smooth nylon shrimp), and the deep-water crab, *Geryon granulatus*, are known to exist in Palauan waters in significant quantities. Other deep-water shrimp species recorded include, *H. gibbosus* (humpback nylon shrimp), *H. dorsalis*, *Plesionika ensis* (striped gladiator shrimp), and a deep-water penaeid, *Plesiopenaeus edwardienus.*

Distribution: The distribution of *Heterocarpus* species is at least in the Indo-Pacific and has been found in India and islands in the Indian Ocean as well as the Pacific Islands from Palau in the west to French Polynesia in the east (King, 1993). Deep-water shrimps inhabit the steep outer reef slopes of islands and the continental slopes of large land masses. Species occupy particular depths but with overlapping ranges with the smaller shrimps (*P. serratifrons* and *P. edwardsii*) being widely distributed in shallower waters (< 400 m). The medium-sized *Heterocarpus*, *H. sibogae* and *H. ensifer*, predominate catches over 400 m and *H. laevigatus*, one of the largest species, is common in depths of more than 500 m. Bottom type appears to be important, with hard bottoms generally producing higher yields than soft or muddy substrates.

Saunders and Hastie (1989) trapped significant quantities of deep-water shrimp and crab on the foreshore reefs at five sites in Palau: Mutremdiu Bay, Augulpelu Reef, Ngaremediu Reef, Aulong Bay, and Toagel Mlungui (Western passage) ie. generally around the main island archipelago. A total of 103 traps were set between 170m and 900m, and catches indicated significant stocks of deep water shrimp and crab exist in Palauan waters. *H. laevigatus* has a maximum abundance at depths of between 600-800 m, with a temperature preference of 6-7 Cº. Species depth distribution ranges in Palau were recorded by Saunders and Hastie (1989) as follows:

Species	Depth Range (m)	No. of animals
H. laevigatus	320-850	693
H. ensifer	170-480	163
H. gibbosus	208-380	15
H. dorsalis	560-850	24
P. ensis	200-480	67
Pl. dwardsianus	320-900	44
G. granulatus	300-900	184

Biology and ecology: Brood sizes may exceed 30,000 eggs carried on the underside of the tail of larger *Heterocarpus* species (King and Butler, 1985). Length at first spawning in *H. laevigatus* is reported to be 40-43 mm carapace length, at an age of 4-4.6 years (King, 1986).

Deep-water caridean shrimps have separate sexes (King, 1993). Biological parameters[2] for *H. laevigatus* in three countries are given in the same reference as presented in Table 1.5.1, including those for other species. Female sexual maturity in this species is attained between 4 to 4.6 years (40-43 mm carapace length) and spawning seems to be in winter. Growth parameters for some other species are also given and are reproduced below.

Table 1.5.1: Some biological parameters of a few deep-water shrimps (Source: King, 1993).

[2] L_∞ is the asymptotic carapace length,K is the growth coefficient, M is the natural mortality rate, L_m is the mean length at first reproduction and t_m is the relative age at first reproduction.

Species	Area	Sex	Growth		Mortality	Reproduction	
			L_∞ (mm)	K(yr^{-1})	M (yr^{-1})	L_m	t_m
H. laevigatus	Fiji	both	57.0	0.27	0.66	40.5	4.6
	Hawaii	male	57.9	0.35			
		female	62.5	0.25		40.0	4.0
	Marianas	both	55.2	0.30	0.75	42.7	4.5
P. edwardsii			29.5	0.66			
H. sibogae			41.0	0.38			
H. gibbosus			45.0	0.35			

H. ensifer is a medium sized shrimp, ranging from 20-45 g weight while *H. laevigatus* is larger and can exceed 90 g weight.

King (1993) notes that the "combination of slow growth rates with high natural mortality rates suggests that the biomass (weight) of shrimps from a given recruitment is maximized at an early age, after which the available biomass rapidly declines".

Saunders and Hastie (1989) recorded the following mean lengths and weights of the deep-water shrimp and crab specimens caught during their surveys in Palau:

	Carapace (mm)		Weight (g)	
Species	Average	Range	Average	Range
H. laevigatus	44.1	17.2 - 63.0	41	2 - 106
H. ensifer	25.3	6.5 - 35.9	9	2 - 22
H. gibbosus	38.9	33.6 - 44.9	34	24 - 42
H. dorsalis	25.6	16.0 - 43.6	10	2 - 32
P. ensis	18.2	11.7 - 23.7	4	2 - 8
Pl. dwardsianus	27.2	15.0 - 81.2	16	2 - 118
G. granulatus	150.4	114 - 179	1,115	500 - 2,020

1.5.2 The Fishery

Utilization: A few species of carid shrimps form the basis of commercial fisheries. For example, carid shrimps are commercially harvested in Alaska, North America and Chile (King, 1986) and also in Europe, Japan and Chile (Crossland, undated). No fishery currently exists, however Saunders and Hastie (1989) considered small-scale combined shrimp/crab fishing as being potentially profitable in Palau if operated as a secondary fishing activity. These researchers developed a combined crab/shrimp trap. Deep water shrimps and crabs may offer the potential for speciality food items in the restaurants and hotels of Koror.

In parts of the world where carid shrimps are commercially exploited, trawls of various types are the main method of harvesting. "This method is of little use to the South Pacific region as, apart from the Gulf of Papua in PNG, there are no areas of continental shelf. Most of the potential fishing grounds in the Pacific consists of uneven or sloping bottoms unsuitable for trawling, which can best be fished with traps" (Crossland, undated).

Production and marketing: No local fishery currently targets these resources. Saunders and Hastie (1989) reported soak times of 48-72 hours for a combined crab/shrimp trap were most productive, producing an average of 1.74 kg of shrimp and 6.1 kg of the large crab, *G. granulatus*. Most productive depths were 200-400 m for *H. ensifer* and 400-800 m for *H. laevigatus*, and 300-900m for *Geryon*, with yields for the latter increasing with depth. The yield rate for the crab in Palau was the highest recorded in the Pacific. Table 1.5.2 summarises the survey data obtained.

Table 1.5.2: Summary data on depth range, number of specimens, carapace size and weight range

for deep-water shrimps, prawns and crab. (Source: Saunders and Hastie, 1989).

Species	Depth Range (m)	No. of animals	Carapace (mm)		Weight (g)	
			Average	Range	Average	Range
H. laevigatus	320-850	693	44.1	17.2 - 63.0	41	2 - 106
H. ensifer	170-480	163	25.3	6.5 - 35.9	9	2 - 22
H. gibbosus	208-380	15	38.9	33.6 - 44.9	34	24 - 42
H. dorsalis	560-850	24	25.6	16.0 - 43.6	10	2 - 32
P. ensis	200-480	67	18.2	11.7 - 23.7	4	2 - 8
Pl. dwardsianus	320-900	44	27.2	15.0 - 81.2	16	2 - 118
G. granulatus	300-900	184	150.4	114 - 179	1,115	500 - 2,020

King (1993) produced a table comparing mean catch rates obtained from deep-water shrimp trapping surveys using small volume traps in Pacific Island as reproduced in Table 1.5.3.

Table 1.5.3: Deep-water shrimp mean catch rates obtained during trapping surveys using small volume traps in Pacific Islands. (Source: King, 1993).

Location	Depth (m)	Catch per Trap (kg)	Reference
Hawaii (north-west group)	500-800	0.9	Gooding, 1984
Guam (west coast)	440-680)	2.1	Wilder, 1977
Western Samoa (near Apia)	500-600	1.4	King, 1980; 1984
Tonga (near Nuku'alofa)	600-700	0.6	King, 1981; 1984
Fiji (near Suva)	450-650	1.2	King, 1984
Vanuatu (near Port Vila)	500-600	2.8	King, 1980; 1984
Vanuatu (north-west Efate)	450-500)	1.1	de Reviers *et al*., 1982
New Caledonia (Loyalty Is.)	800	2.0	Inte, 1978
New Caledonia (Mainland)	350-450	0.6	In: Crutz and Preston, 1987
Marianas	550-800	2.1	Moffitt and Polovina, 1987
Kiribati	400-500	1.0	In: Crutz and Preston, 1987
French Polynesia	550-650	0.3	Poupin *et al*., 1990
Palau	500-800	> 1	Saunders and Hastie (*in press*)

A market study of the catch taken during research surveys by Saunders and Hastie (1989) was carried out. A typical operation suggested involve 2-4 traps set for 24-48 hours at suitable sites. A conservative yield was estimated at 1 kg/trap for shrimps and 5 kg/trap for crabs. Local sales to restaurants and hotels should realise $17.00/kg for shrimps and $6.60/kg for crabs, generating a combined $50.00/trap yield. The possibility of marketing live *Geryon* crabs seems likely as a high priced ($20 each) speciality item.

1.5.3 Resource Status

The resource is not exploited and information on standing stocks is not known. More detailed assessment research is needed. Ralston (1986, quoted in King, 1993) reported a drastic decline in catch rates, from 3.3 to 1.8 kg per trap-night over a 16 day intensive trapping experiment for *H. laevigatus* in the Marianas. The decline in catch rates was attributed to the decline in shrimp numbers suggesting that the species may be vulnerable to even moderate trapping in that area (King, 1993).

Saunders and Hastie (1989) conclude that if a trap fishery were to develop, existing stocks could be depleted rapidly, due to the limited number of suitable sites for this activity. They recommend only 4 traps operating at each site per year, with close monitoring of yields. The potential for this fishery appears to be limited.

1.5.4 Management

A more comprehensive assessment on this particular potential resource is required to give some indications of stocks available for exploitation and its likely economic potential. Results of such research work will indicate strategies to be taken if exploitation is likely.

Current legislation/policy regarding exploitation: There is no curent legislation.

Recommended legislation/policy regarding exploitation: Not necessary until the resource stock is assessed and utilization initiated.

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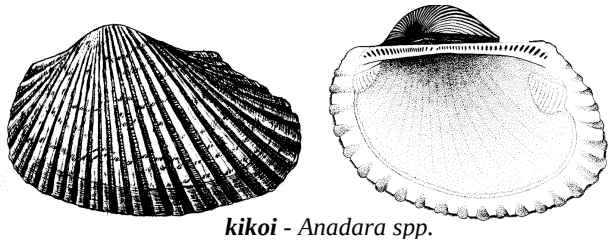
2. MOLLUSCS

2.1 Ark shell - *kikoi.*

2.1.1 The Resource

Species present: The two arkshell species of importance to the fishery in Palau are *Anadara* spp. and *Barbatia reeveana*. Both species are known locally as ***kikoi***.



kikoi *- Anadara spp.*

Distribution: In Palau, ark shells inhabit the area just under the sand, above the layer of mud close to mangrove areas (Matthews and Oiterong, 1991). The results of a survey conducted by the same authors on the role of women in fisheries in Palau indicated that of the seven states covered (Aimeliik, Airai, Koror, Ngaraard, Ngardmau, Ngatpang and Ngeremlengui), 40 per cent of those interviewed in Ngeremlengui and 17 per cent in Koror indicated ***kikoi*** as one of the invertebrates collected in greatest numbers. However, between 60 and 100 per cent of women interviewed in all the eight states listed ***kikoi*** as an invertebrate typically collected. Rochers and Matthews (1992) reported that ***kikoi*** was the only invertebrate of significance in Ngatpang mentioned during their interviews. The same authors mentioned collection of ***kikoi*** in Ngchesar and named it as an important invertebrate resource in Ngeremlengui.

Biology and ecology: Farmed cockles, *A. granosa*, are harvested in Thailand after 18 months when they reach about 4 cm in length and 24 g in weight (Tookwinas, 1983). In India the same species is found to spawn throughout the year and can have 2-4 reproductive cycles in a year. First maturity is attained at 20 and 24 mm for males and females respectively (Narasimham, 1988). In a study of the *Anadara* breeding season in Tonga, the following information was obtained in the first year as recorded in Sone (1993): *A. antiquata* - gonads are easy to identify as ovaries are reddish/orange in colour while testes are creamy white. Swift gonad deflation in April and the May-July period was shown as the inactive period for this species. The August-September period was found to be mostly inactive with only small amounts of gametes found in one specimen. Gonads rapidly develop during the October/November period. The majority of the sample were in fully ripe condition during the December sampling and that the January samples were mostly in spent stage. The majority of February and March samples were again in ripe condition with half in spent stage on 9 March, two days after full moon. The breeding season for this species in Tongatapu was then estimated to be from October to March. Sex differentiation and shell length relationship in *A. antiquata* is shown below for the specimens examined (the numbers are the numbers of individuals from the total number sampled). Females under 40 mm in shell length were difficult to find and it is assumed here that males reach sexual maturity at smaller sizes.

Shell length (mm)	Undetermined sex	Female	Male
20-	-	-	-
20-30	19	0	0
30-40	42	8	34
40-50	30	4	14
50-60	16	19	14
60-70	17	29	12
70-80	14	6	0
80-90	-	-	-
90+	2	0	0

A. maculosa - inactive period is the same as *A. antiquata,* but the breeding season was determined to be from November to March. Sex differentiation and shell length relationship for this species is presented in the following table.

Shell length (mm)	Undetermined sex	Female	Male

-20	-	-	-
10-30	12	0	4
30-40	7	1	16
40-50	4	3	27
50-60	0	16	22
60-70	0	19	12
70-80	0	23	13
80-90	1	7	4
90+	0	5	4

2.1.2 The Fishery

Utilization: Collection of ark shell involves mostly women who walk along the sand feeling for ***kikoi*** using their toes (Matthews and Oiterong, 1991). "Some women can spot the hole the clam's siphon makes in the sand and then collect the clam with their feet. Others stoop over and feel in the sand/mud with their hands".

The survey conducted in 1991 in seven states on the role of women in fisheries in Palau, indicated that ark shells are not collected as often as other molluscs except in Ngeremlengui (Matthews and Oiterong, 1991). Invertebrates typically collected by Palauan women were listed by the same authors and the molluscs category is reproduced in Table 2.1.1(a). Of the mollusc species, *Anadara* (***kikoi***) ranks first with *T. crocea* (***oruer***) in terms of responses of it being a species typically collected. Table 2.1.1(b) records molluscs collected in greatest numbers by Palauan women as produced by the same authors.

Table 2.1.1(a): Mollusc species typically collected by Palauan women. Numbsrs represent per cent of responses and "n" represent number of women interviewed. (Source: Matthews and Oiterong, 1991).

	Aimeliik	Airai	Koror	Ngaraard	Ngardmau	Ngatpang	Ngeremlengui	Total
	n=7	n=8	n=12	n=12	n=7	n=3	n=5	n=54
MOLLUSCS								
Ark shell	**71**	**88**	**83**	**92**	**86**	**100**	**60**	**83**
Tridacna crocea	100	100	92	67	71	67	80	83
Anodonita edulenta	100	88	50	83	71	33	80	78
Tridacna spp.	86	88	67	92	71	33	80	78
Cypaea tigris	57	100	67	67	43	67	40	65
Lambis lambis	57	100	67	67	43	67	40	65

Table 2.1.1(b): Mollusc species collected in greatest numbers by Palauan women. Numbers are per cent of responses and those in brackets represent per cent who collect for subsistence only. "n" is the number of women interviewed. (Source: Matthews and Oiterong, 1991).

	Aimeliik	Airai	Koror	Ngaraard	Ngardmau	Ngatpang	Ngeremlengui	Total
	n=7	n=8	n=12	n=12	n=7	n=3	n=5	n=54
Ark shell	**0**	**0**	**17 (100)**	**0**	**0**	**0**	**40**	**7 (50)**
Anodonita edulenta	86 (67)	88	50 (50)	83 (20)	86	100 (33)	100	80 (23)
Tridacna spp.	71 (60)	88	50 (33)	75 (22)	57 (25)	0	60 (33)	63 (26)
Tridacna crocea	86 (17)	88 (14)	92 (18)	0	14	33	60	54 (14)
Atactodea striata & A. striata f. glabrata	0	0	0	42 (100)	0	0	0	8 (100)
Nucula rugosa	0	0	0	25 (100)	0	0	0	6 (100)
Nerita maxima & N. undata	0	0	8 (100)	0	0	0	0	2 (100)

Ark shells are collected mostly for subsistence except in Ngeremlengui where a higher percentage of the catch is sold. In Koror, women collect ***kikoi*** solely for subsistence (Matthews and Oiterong,

1991). In terms of overall quantity collected in the seven states, ***kikoi*** ranks low with only some women in Koror and Ngeremlengui indicating it as a species collected in greatest numbers.

Production and marketing: No data has been collected on ***kikoi*** production/consumption both in the local subsistence and commercial levels in Palau. The 1991 survey by Matthews and Oiterong (1991) indicated that significant amounts of ***kikoi*** are collected only in two states, Koror and Ngeremlengui, of the seven surveyed. Women interviewed in other states indicated that they also collect ark shell but is not one of their important catch species.

Data obtained by Matthews and Oiterong during 1991 for the Koror and Ngeremlengui ark shell production by women, are reproduced in Table 2.1.2. These are the only states in which ***kikoi*** is collected in significant numbers. In Koror, collection of ark shell by women is all for subsistence while in Ngeremlengui, collection is mostly for sales in the market. Since an estimate of the number of fisherwomen was not given, it is not possible to estimate annual production of ***kikoi*** for the two states.

Table 2.1.2: Ark shell collected by women in Koror and Ngeremlengui. The figures are in number of pieces and represent state averages.

	Koror	Ngeremlengui	Average	Extrapolated catch per month per fisherwoman	
				Koror	Ngeremlengui
Good	25	550	288	50	5,500
Bad	13	375	194	26	3,750
Average	19	450	235	40	4,500
Time spent (hr)	2	5	3		
No. times per month	2	10	6		
Per cent sold	0	90	45		
Catch/unit effort (no./hr)	10	90	52		

None of the commercial markets (PFFA, PMCI and Oh's), from which DMR receive marine products data, recorded any ***kikoi*** purchases. Matthews and Oiterong (1991) listed several other markets and restaurants where women indicated as where they sell seafood and fish. Based on catches by three women, the same authors estimated value figures for ***kikoi*** in the commercial market as presented in Table 2.1.3. Figures for other marine products sold by women are included for comparison. In terms of number of pieces per unit size for sale, ***kikoi*** ranks as one of the highest. However, it is also one of the species with high income per sale.

Table 2.1.3: Comparative prices for seafood sold by women in Palau. (Source: Matthews and Oiterong, 1991)

Species	Unit size for sale (no. of pieces)	Price/unit (US$)	Average amount sold (no. of pieces)	Income per sale (US$)
Ark shell (*kikoi*)	**10**	**1.25**	**500**	**62.50**
Giant clam (***kim***)	3	1.00-1.50	20	7.00-11.00
T. crocea (***oruer***)	9	1.00-1.50	72	8.00-12.00
Sea cucumber (***cheremrum***)	10	1.00-1.25	80	8.00-10-00
Sea cucumber (***molech***)	10	1.00	100	10.00
Sea cucumber (***ngimes***)	20	1.00-1.50	200	10.00-15.00
Sea cucumber (***irimd***)	10	1.00-1.50	100	10.00-15.00
Sea cucumber (***sekesakel***)	1	0.25	75	18.75
Land crab (***rekung***)	lb	0.35-0.50	50 lbs	17.50-25.00
Mangrove clam (***ngduul***)	1	0.10-0.25	200	20.00-50.00
Coconut crab (***ketat***)	1	2.75	8	22.00
Mangrove crab (***chemang***)	lb	5.00	8	40.00
Urchin (***choalech***)	15	2.50	750	125.00
Fish	lb	0.85-1.10	50	42.50-55.00
Fish, smoked or fried	lb	2.25-2.50	40	90.00-100.00

2.1.3 Stocks Status

No information is available on ***kikoi*** stocks in Palau and there has not been an attempt to conduct specific research on any aspect of the animals's biology. Production statistics, both on the subsistence and commercial levels, do not exist.

2.1.4 Management

There appears to be no real concern on ***kikoi*** stocks in Palau as collection is very limited. A potential threat to the resource, however, is destruction of habitat especially mangroves.

Current legislation/policy regarding exploitation: There is no national legislation that specifically covers the exploitation of ***kikoi*** in Palau.

Recommended legislation/policy regarding exploitation: No legislation seems to be necessary. Regulations that are normally applied to the exploitation of bivalves include the application of a minimum size limit, quotas and establishment of reserves. These regulations are formed from specific research results.

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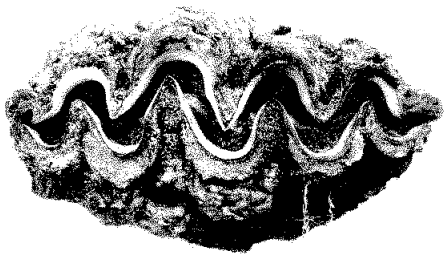
2.2 Giant clams - *kim*

2.2.1 The Resource



kism *- Tridacna maxima*

Species present: Of the nine surviving giant clam species found through-out the world (seven in the genus *Tridacna* and two in the genus *Hippopus*), seven are found in Palau, including:

Tridacna gigas (the Giant clam - ***otkang***);
T. derasa (the smooth giant clam - ***kism***);
T. squamosa (the fluted or scaley giant clam - ***ribkungel***);
T. maxima (the elongated or rugose giant clam - ***melibes***);
T. crocea (the boring or crocus giant clam - ***oruer***);
Hippopus hippopus (the horse's hoof, rolling, bear paw or strawberry giant clam - ***duadeb***);
H. porcelanus (China or porcelain clam).

A survey conducted by Matthews and Oiterong (1991) in seven states of Palau indicated that women normally use only two Palauan names for giant clams: ***kim***, as a general term for the free-diving giant clam species but usually *H. hippopus*; ***oruer***, for the smaller species, *T. crocea*.

Distribution: Giant clams, Tridacnids, are restricted to the Indo-Pacific region and are well adapted to tropical clear waters such as those which favour coral growth. Munro (1993) gives brief geographical distributions of each of the nine species currently known in the world. Due to over-exploitation or climatic changes the range of *T. gigas* has diminished a great deal. However, several of the species, especially, *T. gigas*, *T. derasa* and *H. hippopus* have been introduced to some countries outside of their natural ranges. For the two newly "discovered" giant clam species, *T. tevoroa* is limited to Fiji and Tonga while *T. rosewateri* is known only from the Saya de Malha Bank in the Indian Ocean.

T. gigas - this species has become extinct in some of its original range locations. Good populations still exist in Australia, Philippines, Solomon Islands, and possibly Burma, Kiribati, Marshall Islands, Palau, Papua New Guinea, and the west coast of Thailand. Extinctions have been reported in Fiji, Guam, New Caledonia, Northern Marianas, most of Japan, Federated States of Micronesia, Taiwan, Tuvalu, and Vanuatu. The species has been re-introduced to Fiji and introduced to Cook Islands, Tonga, American Samoa and Western Samoa.

T. derasa - this species occurs in 13 countries and territories with good standing stocks reported from Australia, Fiji, New Caledonia, Palau, northern Papua New Guinea, Solomon Islands and Tonga. It has become extinct in Guam and Northern Marianas. The species has been introduced to Cook Islands, FSM, American Samoa and Western Samoa.

T. squamosa - this species' range extends from the Red Sea and the East coast of Africa across the Indo-Pacific to the Pitcairn Islands and has been recorded in 41 countries. It could be extinct in Japan and Guam.

T. maxima - this species' range is about the same as that of *T. squamosa*. It is extinct in Hong Kong.

T. crocea - this species occurs in about 17 countries in the region extending from southern Japan to Australia in the south and Palau in the east.

H. hippopus - this species occurs in 19 countries in the region extending from Burma to Marshall Islands in the east and New Caledonia in the south. It has become extinct in American Samoa, Fiji, Tonga and Western Samoa but has been re-introduced to all of these localities.

H. porcellanus - this species has a very limited distribution and is found mainly in the Sulu and South China Seas in northern Indonesia and Philippines, and Palau.

There has not been a recent survey conducted in Palau for wild giant clam stocks and the distribution of native giant clam species is not accurately known. Several reports exists of surveys of wild giant

clam stocks conducted on the Northern reefs and Helen Reef to the South in mid-1970's: Hirschberger (1977); Bryan and McConnell (1976); Hester and Jones (1974); and at Aulong Channel on the West side of the main archipelago: Heslinga and Perron (1984). Heslinga and Peron (1984) cite instances throughout Palau where giant clam numbers have noticeably decreased over time. Past surveys indicated widespread distribution of most species. In a survey of 26 sites on coral reefs offshore from Ngeremeduu and Eastern Babeldoab and the Rock Islands, Birkeland (1991, cited in Maragos, 1992) recorded the occurrence of giant clams as follows:

Species	No. of sites in which species was observed
Hippopus hippopus	3
Tridacna crocea	12
T. derasa	6
T. gigas	6
T. maxima	13
T. squamosa	11

Birkeland and Richmond (1992) noted three species, *T. squamosa*, *T. maxima* and *T. gigas* were frequently observed during the 1992 Rapid Ecological Assessment during surveys in 47 sites from Velasco Reef to Anguar. Only large *T. gigas* (74-109 cm in shell length) were obseved, and empty shells were more common than live animals. The number of sites (out of 47) in which giant clam species were observed are as follows:

Species	No. of sites in which species was observed
Hippopus hippopus	6
Tridacna crocea	22
T. derasa	7
T. gigas	21
T. maxima	24
T. squamosa	36

Biology and ecology: The giant clam family, Tridacnidae, currently has nine living species in two genera, *Tridacna* (Bruguiere) and *Hippopus* (Lamarck) which includes the largest bivalve molluscs known. A unique characteristic of the giant clams is their symbiotic relationship with dinoflagellate algae, zooxanthellae, which live in the blood system of the giant clams, concentrating in the tissues of the brightly-coloured mantle that is exposed to light in the shallow sunlit waters of coral reefs (Munro, undated). Giant clams acquire the symbiotic algae at age 7-15 days. They receive photosynthetic sugars and oxygen from the algae while the algae receives waste carbon dioxide and nutrients from the clams. In addition, giant clams also filter-feed, as is typical of other bivalves, but all of its maintenance requirements can be derived from the symbiotic algae (Munro, 1993). The relationship with zooxanthellae restricts clams to shallow waters.

All species of giant clams mature initially as males (protandrous hermaphrodites) at the age of two or more years, depending on the species, and eventually become simultaneous hermaphrodites. Reproduction in the central tropics does not seem to show seasonality. However, seasonality is shown in gonad ripening at the northern and southern limits of distribution (Munro, 1993). Some degree of lunar periodicity has been observed. During spawning, sperm are normally released first followed by egg release after a short interval (generally ~30 minutes). Munro (cited above) reported that a 20 cm *T. maxima* specimen with ripe gonads would contain 20 million eggs. Specimens of 70-80 cm *T. gigas* were known to produce up to 240 million eggs. Fertilized eggs develop into swimming trochophores within 12 hours and shelled veligers within 36 hours. The larval phase lasts between 5 and 15 days after which it settles on the bottom. Soon after this it metamorphoses into a juvenile clam. Recruitment is low and erratic. Growth parameters for most of the giant clam species in several localities are given in Munro (1993). Overall, for the first few years, growth rates range between 3.5 to 10 cm per year depending on species. Natural mortality is low.

Munro (1993) quotes biological parameters for a few giant clam species in some countries, including Palau, as reported in several references. These are recorded in Table 2.2.1 for Palau and some selected locations for comparison.

Table 2.2.1: Biological parameters of some of the giant clam species. (Source: Munro, 1993).

Species/Locality	L_∞ (cm)	K	t_0	Age (Years) 1	2	4	6	8	10	15	20	Reference
				Shell length (cm)								
T. gigas												
Palau	100.0	0.136	0.64	4.80	16.91	36.69	51.77	63.26	72.01	85.82	92.82	Beckvar, 1981
PNG	100.0	0.087	0.43	4.80	12.73	26.67	38.38	48.22	56.49	71.84	81.77	Munro and Heslinga, 1983
Michaelmas Reef	88.7	0.07	0.03		11.4	21.50	30.28	37.91	44.55	57.58	66.77	Pearson and Munro, 1991
Orpheus Is., GBR				3-4	9-13							
T. derasa												
Palau	50.0	0.167	0.41	4.7	11.67	22.55	30.35	35.93	39.92	45.63	48.10	Beckvar, 1981
Palau				5.0	10.0	20.0	27.50					Watson and Heslinga, 1988
Tonga	50	0.132	0.25	4.7	10.30	19.51	26.59	32.02	36.19	42.86	46.31	McKoy, 1980
Michaelmas Reef	46.9	0.108	-0.20		9.87	17.06	22.86	27.55	31.31	37.81	41.60	Pearson and Munro,1991
Fiji	47.3	0.134	0.22	4.7	10.04	18.80	25.50	30.63	34.55	40.77	43.96	Watson and Heslinga, 1988
Philippines				5.0	8.5							
T. squamosa												
Palau	40.0	0.091		4.75	7.82	13.17	17.64					Beckvar, 1981
Tonga	40.0	0.187		4.75	10.76	19.89	26.16					McKoy, 1980
PNG	38.5	0.14		4.75	9.16	16.32	21.74					Munro and Heslinga, 1983
H. hippopus												
Palau	40.0	0.10		5.04	8.37	14.10	18.80					Beckvar, 1981
PNG	40.0	0.213		5.04	11.75	21.55	27.95					Munro and Heslinga, 1983
Orpheus Is., GBR	34.7	0.205		5.04	10.54	18.66	24.06					Shelley, 1988

2.2.2 The Fishery

Utilization: Tridacnid clams are an important traditional food source on Indo-Pacific reefs. Over-exploitation through commercial and subsistence fishing has lead to most species becoming uncommon throughout their range, with many cases of local extinctions. *T. gigas* and *T. derasa* are listed as vulnerable by the IUCN, and may become endangered if over-exploitation of wild stocks is not reduced, or numbers enhanced through reseeding with cultured material.

With the exception of the kidney, the meat of the whole clam is edible. The shell is valuable as a tourist curio, and in the customs and cultures of many Pacific Island countries. (Large scale) Commercial exploitation of wild stocks has been solely for the adductor muscle, which fetches high prices on markets in South-east Asia. The mantle can be made into clam chowder, and research into product development is continuing.

Reef gleaning is by far the most common form of fishing activity by Palauan women (Matthews and Oiterong, 1991). Women, and occasionally children, wade through the water at low tide and collect sea cucumbers, clams, crabs, urchins etc. During a survey conducted in 1991, 96 per cent of the women interviewed in seven states in Palau engage in some form of reef gleaning which is for selling in the local markets as well as for subsistence use. General gleaning activities by women in the seven states surveyed are as follows:

General gleaning	State Aimeliik	Airai	Koror	Ngaraard	Ngardmau	Ngatpang	Ngeremlengui	Total
Number interviewed	7	8	12	12	7	3	5	54
Per cent of responses	100	100	92	100	86	100	100	96

Table 2.2.2 records mollusc species typically collected and those collected in the greatest numbers by Palauan women as recorded in the 1991 survey in seven states in Palau by Matthews and Oiterong (1991).

Table 2.2.2: Mollusc species typically collected and those collected in greatest numbers by Palauan women. The figures in brackets represent per cent of those collected for subsistence purposes only. (Source: Matthews and Oiterong, 1991).

	Aimeliik	**Airai**	**Koror**	**Ngaraar**	**Ngardmau**	**Ngatpang**	**Ngeremlengui**	**Total**
	n=7	n=8	n=12	n=12	n=7	n=3	n=5	n=54
Mollusc species typically collected								
Tridacna crocea	**100**	**100**	**92**	**67**	**71**	**67**	**80**	**83**
***Tridacna* sp.**	**86**	**88**	**67**	**92**	**71**	**33**	**80**	**78**
Anadara sp. & *Barbatia reeveana*	71	88	83	92	86	100	60	83
Anodonita edulata	100	88	50	83	71	100	100	80
Cypraea tigris	57	100	67	67	43	67	40	65
Lambis lambis	57	100	67	67	43	67	40	65
Mollusc species collected in greatest numbers								
Anodonita edulenta	86 (67)	88	50 (50)	83 (20)	86	100 (33)	100	80 (23)
***Tridacna* sp.**	**71 (60)**	**88**	**50 (33)**	**75 (22)**	**57 (25)**	**0**	**60 (33)**	**63 (26)**
Tridacna crocea	**86 (17)**	**88 (14)**	**92 (18)**	**0**	**14**	**33**	**60**	**54 (14)**
Atactodea striata & *A. striata f. glabrata*	0	0	0	42 (100)	0	0	0	8 (100)
Anadara sp. & *Barbatia reeveana*	0	0	17 (100)	0	0	0	40	7 (50)
Nucula rugosa	0	0	0	25 (100)	0	0	0	6 (100)
Nerita maxima & *N. undata*	0	0	8 (100)	0	0	0	0	2 (100)

Both ***kim*** and ***oruer*** are collected for subsistence and commercial purposes. Rochers and Matthews (1992) reported the following results from interviews concerning the use of giant clams: in Melekeok, giant clam (***kim***) is an important invertebrate resource; it is one of the most important invertebrate resources in Ngarchelong collected by women and sold in Koror; ***oruer*** is an important resource both commercially and for subsistence purposes in Ngatpang; ***kim*** is an important resource in Ngchesar which the women collect; ***kim*** was indicated as an important invertebrate resource in Ngeremlengui where they are abundant inside the reef; ***kim*** is an important resource in Peleliu where it is collected about three times per month for food at customs; giant clams is one of the most important invertebrate species in Kayangel.

Commercial giant clam poaching is a widespread problem in Palau and many incidents have been reported. Clam meat continues to leave Palau for Taiwan, Guam and elsewhere (Maragos, 1994) even though export for commercial purposes has been prohibited.

Production and marketing: Production figures for exploitation of wild clams in Palau for domestic consumption are very patchy. Commercial export of clam meat is prohibited in Palau, thus all landings are supposedly for subsistence and the domestic commecial market. However, there are many exports to relatives. *T. crocea* in particular is targeted for commercial sales in the local markets. Giant clams are sold raw or with slices of lemon in local markets. The meat can also sold after dipping quickly in boiling water (***omur***). Occasionally the meat is marinated in coconut cream (Matthews and Oiterong, 1991).

Table 2.2.2 records giant clam estimated average catches by women for seven states in Palau in 1991.

Table 2.2.2: Estimated giant clam catches during collection expeditions by women in seven states in Palau. .Catch figures are in number of pieces and represent state averages. (Source: Matthews and Oiterong, 1991).

	Aimeliik	**Airai**	**Koror**	**Ngaraard**	**Ngardmau**	**Ngatpang**	**Ngeremlengui**	**Average**
Tridacna sp. & Hippopus sp. (kim)								
Good	44	78	54	20	47		77	53
Average	24	41	27	26	37		68	37
Time spent (hr)	2	2	3	3	2		4	3
No. times per month	1	3	3	3	2		6	3
Per cent sold	42	71	36	64	62		80	59
Catch/unit effort (nos./hr)	12	17	10	9	19		17	14
Tridacna crocea (*oruer*)					*	*		
Average catch	65	51	48		50	70	135	70
Time spent (hr)	3	3	3		2	4	4	3
No. times per month	2	3	3		1	6	7	4
Per cent sold	72	74	27		71	100	96	73
Catch/unit effort (nos./hr)	26	19	16		25	18	31	23

Note: * figures based on the catch of one women from each of these two states.

Perron *et al*. (1983) reported marine animal landings at PFFA between 1976 and 1981. The following purchases were recorded for giant clams (weights in lbs):

	1977		1978		1979		1980		1981	
	lbs	$	lbs	$	lbs	$	lbs	$	lbs	$
Clams	200	100	270	117						
Kim					527	200	1,195	478	252	286
Kism					157	63				
Total	**200**	**100**	**270**	**117**	**684**	**263**	**1,195**	**478**	**252**	**286**

The only other giant clam sales recorded from the commercial markets are those for 1992 and 1993 which are as follows:

	Weight (lbs)	Value (US$)
1992 - PFFA, Oh's, PMCI	91	158.00
1993 - Oh's (Jan-May)	124	62.00

Market prices, comparing different fisheries products sold by women as recorded in 1991, as reproduced from Matthews and Oiterong (1991), are given in Table 2.2.3.

Table 2.2.3: Fisheries products sold by Palauan women, comparing prices and average sales. (Source: Matthews and Oiterong, 1991).

Species	Price/unit	Average amount sold	Income per sale (US$)
Giant clam (***kim***)	$1.00-1.50/3 pieces	20 pieces	7.00-11.00[1]
Giant clam (***oruer***)	$1.00-1.50/9 pieces	72 pieces	8.00-12.00[2]
Sea cucumber (***cheremrum***)	1.00-1.25/10 pieces	80 pieces	8.00-10.00
Sea cucumber (***molech***)	1.00/10 pieces	100 pieces	10.00
Sea cucumber (***ngimes***)	1.00-1.50/20 pieces	200 pieces	10.00-15.00
Sea cucumber (***irimd***)	1.00-1.50/10	100 pieces	10.00-15.00
Sea cucumber (***sekesakel***)[3]	0.25 each	75 pieces	18.75
Land crab (***rekung***)	0.35-0.50/lb	50 lb	17.50-25.00
Mangrove clam (***ngduul***)	0.10-0.25 each	200 pieces	20.00-50.00
Coconur crab (***ketat***)	2.75 each	8 pieces	22.00
Mangrove crab (***chemang***)	5.00/lb	8 lbs	40.00
Ark shell (***kikoi***)[3]	1.25/10 pieces	500 pieces	62.50
Urchin (***choalech***)[3]	2.50/15 pieces	750 pieces	125.00

[1]One woman regularly sells $60 worth of this species.
[2]One woman regularly sells $108 worth of this species.

[3]Figures are based on catches of three separate women. All other women interviewed who collect these species collect them for subsistence only.

Actual figure for export of wild giant clams, presumably for relatives living overseas, is not possible to quantify from available information. They are exported together with other foodstuffs in the same containers (coolers). Table 2.2.4 records exports of foodstuff in which giant clam formed a portion, as recorded on Air Micronesia manifests. For items listed as "clam", is not clear whether it is giant clams or mangrove clams (but could be both).

Table 2.2.4: Export figures of foodstuff in which giant clam forms a portion as recorded on Air Micronesia manifests.

	1990		1991		1992	
	Count	Gross Wt (lbs)	Count	Gross Wt (lbs)	Count	Gross Wt (lbs)
Giant clam meat			2	111	14	593
Clam	3	261	2	166	10	390
Clam (live)			3	158	209	7,304
Giant Clam shell	4	1,006	27	3,129	5	496
Clam/Others	1	111			14	644
Clam/Fish (fresh)	1	174	3	644		
Fish (frozen)/Bat/Clam	1	59				
Fish (frozen)/Clam	5	675	3	196	5	530
Fish (frozen)/Clam/Others	1	45	5	225	5	325
Fish (frozen)/Crab/Clam shell	1	77				
Fish/Bat/Clam	1	188	4	731		
Fish/Clam	4	527	4	691	4	280
Fish/Clam/Others	1	119	15	1,752	17	1,752
Fish/Crab/Clam/Others	1	121			1	181
Giant clam shell/Black coral			1	82		
Crab/Clam/Lobster/Others			2	89		
Fish/Clam/Bats/Lobster			25	3,567		
Fish/Emang/Land crab/Clam			20	1,823		
Fish/Crab/Clam/Lobster/Bats			10	894		
Fish/Clam/Lobster/Others			6	747		
Fish/Sardines/Crab/Clam			5	375		
Fish/Crab/Clam			5	331	2	329
Fish/Clam shells/Others			6	240		
Fish/Crab/Clam/Lobster			2	212	10	1,152
Fish/Clam/Bats/Others			3	177		
Fish/Clam (live)			3	118	2	177
Fish/Clam/Pigeon			2	135		
Clam (dried)/Other					1	16
Clam/Bats					1	20
Clam/Bats/Others					2	80
Clam/Trochus meat					1	39
Crab/Clam/Others					3	263
Crab/Clam/Sea cucumber					1	45
Fish (frozen)/Crab/Clam					1	31
Fish/Clam/Seafood/Other					4	211
Tuna/Clam/Trochus meat/Bat					9	1,222

2.2.3 Aquaculture of giant clams in Palau.

A major aquaculture activity in Palau is the production of cultured clams at the Micronesian Mariculture Demonstration Centre (MMDC). The program was established in 1973 and the facility serves the Republic of Palau and the U.S.-affiliated Pacific islands by developing, demonstrating and promoting appropriate sea farming technology. MMDC also serves as a regional sea farming training centre, a marine science research laboratory and a popular tourist attraction. It has supplied supplied broodstock and/or juvenile giant clams for projects in American Samoa, Cook Islands, Marshall Islands and Western Samoa. The centre has been instrumental in the research and aquaculture programmes in several regional and international programmes and projects on the culture of giant clams. One such project as initiated by MMDC was the 3-Phase Regional Yield Trials for Commercially Valuable Giant Clam Species. Phase I of the project involved comparative culture of *T. gigas* and *T. derasa* in Palau, American Samoa, Saipan, Yap, Chuuk and Kosrae. Phase II involved the evaluation of the performance of *T. derasa* and *H. hippopus* in Palau, Saipan, Yap, Chuuk and Kosrae. The third phase compared

yields of *T. derasa* and *T. squamosa*. Details of the results of pahses I and II are documented in Heslinga (1993a and 1993b).

Using production costs in 1991 and 1992, Shang *et. al*. (1993) estimated that the cost of raising clams to one year of age in the land-based hatchery and nursery at MMDC is $0.82 per clam. The cost increases to $1.41 per clam if they are planted and grown in the ocean nursery for another year. MMDC's farm-gate prices for one and two years old clams are $1.00 and $3.00 respectively.

The summary of MMDC giant clam hatchery production and sales for the past eight years is given in Table 2.2.5.

Table 2.2.5: Summary of juvenile giant clam producton at MMDC and revenue from clam sales for the 1986-1993 period.

	1986	1987	1988	1989	1990	1991	1992	1993
No. of 5-ms. old seed clams produced	116,503	272,617	80,400	375,913	1,353,296			
No. of international shipments	14	14	21	45	199			
No. of local (Palau) shipments	8	1	0	7	29			
Revenues from clam hatchery sales ($)	2,325	20,560	49,958	60,170	122,097			96,224

Monthly giant clam production (5 months old seeds) at the MMDC hatchery for the period 1990 to 1994 is given in Table 2.2.6.

Table 2.2.6: Monthly 5-monh old giant clam seeds production at MMDC for the 1990-1994 period.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990 Species													
1991 Species													
1992 Species													
1993 Species	0	0	8,000 Tg	0	0	46,900 ??	6,615 Td	??	25,000 ??	0	??	0	
1994 Species	10,380 ??	8,500 Hh	149,300 Tc										

Monthly live giant clam sales from the MMDC hatchery for the period 1990-1994 are given in Table 2.2.7. The value figures have been rounded off to the nearest dollar.

Table 2.2.7: Summary of monthly live giant clam sales from MMDC with respective values during the 1990-1994 period..

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990													
Local (nos.)													
Local (value)													
Export (nos.)													
Export (value)													
1991													
Local (nos.)													
Local (value)													
Export (nos.)													
Export (value)													
1992													
Local (nos.)													
Local (value)													
Export (nos.)													
Export (value)													
1993													
Local (nos.)													
Local (value)	2,854	5,056	2,775	1,542	4,734	367	408	395	470	367	tot 2 >	1,649	20,617
Export (nos.)													
Export (value)	812	14,194	9,650	3,915	6,801	5,765	8,170	15,538	1,114	3,108	tot 2 >	6,540	75,60

													7
1994													
Local (nos.)													
Local (value)	4,930	2,934	3,137										
Export (nos.)													
Export (value)	1,672	4,906	4,827										

MMDC has been collaborating with each of the 14 coastal states of Palau in establishing small giant clam demonstration farms and sanctuaries. MMDC also makes seed clams available at low cost or no cost to individuals in the private sector in Palau for commercial farming. Hatchery sales reached a total of over $122,000 in the year ending September 30, 1990, more than twice the previous year's figure. The 1993 sales were $ 96,224.

Compliance with permitting requirements of the US Fish and Wildlife Service (which is responsible for enforcing CITES restrictions on trade in threatened and endangered species) is required before cultured clams can be exported from Palau. There is an urgent need to establish a locally-based wildlife inspector in the Republic of Palau, who should have the authority to inspect and certify Palau's wildlife export shipments covered by CITES agreement.

Export of giant clams by the private aquarium fish operator in Palau is recorded in Table 2.7.8. All were bought from MMDC.

Table 2.7.8: Export of cultured giant clams for the aquarium trade by the private company in Palau.

Year/Species	Description & size	# pieces	Price per piece	Total value	Reference
1992					
T. derasa	9 cm	1,325	1.50-12.00	6,19.50	DMR Annual Report
T. gigas	7 cm	326	4.25	1,384.00	
H. hippopus	9 cm	172	6.00	1,032.00	
Total		**1,823**		**2,441.5**	
1993*					
T. crocea	Blue SM. (4-5 cm.)	106	12.50	1,325.00	DMR data
T. derasa	14-16 cm.	57	14.50	826.50	
T. derasa	7 cm.	1,074	3.50	3,759.00	
T. derasa	9 cm.	139	7.00	973.00	
H. hippopus	15 cm.	19	24.00	456.00	
H. hippopus	5 cm.	10	3.00	30.00	
H. hippopus	7 cm.	6	4.40	26.40	
H. hippopus	9 cm.	36	8.80	316.80	
T. derasa	5 cm.	53	2.50	132.50	
Total		**1,500**		**7,845.20**	

*Palau Biotech exports (started in September, 1993).

2.2.4 Stocks Status

Stock status was estimated by Hirschberger (1977) in North Palau. By towing divers along transects, population estimates were obtained for wild clams on Ngaruangl, Kayangel, Ngerael (North-west) reefs and Ngebard reef. A total of 51,750 sq.m. was covered in this survey. Standing stocks estimated are given in Table 2.2.9. Hirschberger (1980) provides standing stock estimates for giant clams surveyed on the isolated Helen's Reef, in the South of the Palau archipelago (Table 2.2.10). *T. gigas* and *T. derasa* showed considerable decline in standing stock between surveys conducted in 1972 (Hester and Jones, 1974) for this area. *T. crocea* were reported to be present in large numbers on most transects but were not counted, while *T. squamosa* were not noticeable. Dead clam shells were seen on all reefs, their incidence reflecting different levels of fishing; the largest species being more affected. There was evidence that commercial clam poaching had occurred recently. Concern was expressed on the effects of commercial poaching and heavy subsistence exploitation by villagers.

Table 2.2.9: Giant clam population survey of four Northern reefs (from Hirschberger, 1977).

Species	Standing Stock by reef (x 1,000)			
	Ngaruangl	Kayangel	Ngerael	Ngebard
T. gigas	7.1	v. scarce	19.4	16.0
T. derasa	13.2	0.6	19.4	8.0
T. maxima	5.4	14.1	22.6	8.0
H. hippopus	26.9	1.1	12.1	16.8

Table 2.2.10: Giant clam population survey of Helen's Reef (after Hirschberger, 1980).

Species	Estimated standing stock		
	1972 estimate	1975 estimate	1976 estimate (range)
T. gigas	49.8 x 10 ^3	8.6 x 10 ^3	13.8 x 10^3 (4.7-22.9 x 10^3)
T. derasa	32.8 x 10 ^3	12.9 x 10 ^3	24.2 x 10^3 (8.1-40.3 x 10^3)
T. squamosa	1.2 x 10 ^3	4.3 x 10 ^3	10.4 x 10^3 (3.8-17.0 x 10^3)
H. hippopus	44.6 x 10 ^3	47.4 x 10 ^3	217.5 x 10^3 (89.1-345.9 x 10^3)
T. maxima	1.7 x 10 ^6	1.4 x 10 ^6	1.1 x 10^6 (0.7-1.4 x 10^6)
T. crocea	3.7 x 10 ^6	ubiquitous	ubiquitous

Many incidences of commercial poaching of clams in Palau have been reported. Two Taiwanese clam boats arrested in 1977 had a combined harvest of 11,500 pounds of clam meat, mostly muscle, representing 30,000 clams. Clam stocks on the remote Helen Reef were severely depleted by poaching in the 1970's (Bryan and McConnell, 1976). Prior to the activity of Taiwanese poachers, this reef supported abundant stocks of giant clams (Hester and Jones, 1974).

More recently, Heslinga and Perron (1984) surveyed 100 hectares of the reef north and south of Aulong Channel in the main barrier reef, an area known to support abundant numbers of giant clam which were exploited by small-scale commercial and subsistence fishermen. Standing stock estimates are given in Table 2.2.11.

Table 2.2.11: Giant clam population survey results of Aulong Channel, after Heslinga and Perron, 1983. Survey area: 10,000 sq.m.

Species	Standing stock	Mean no. live shells/hectare	Mean % dead shells/hectare
T. gigas	1,500	15	67
T. derasa	700	7	83
T. squamosa	1,200	12	43
H. hippopus	3,500	35	55

T. crocea was ubiquitous and *T. maxima* was common on seaward transects. These authors concluded that *T. derasa, T. gigas, T. squamosa* and *H. hippopus* were in a clear state of decline in the area, and that continued wild harvesting would threaten these species in the area. A ban on clam fishing was recommended, at least for this popular fishing area, where sustained exploitation was high.

No recent stock assessment surveys have been conducted for giant clams stocks in Palau. However, in a survey of 26 sites on coral reefs offshore from Ngeremeduu and Eastern Babeldoab and the Rock Islands, Birkeland (1991, cited in Maragos, 1992) recorded the occurrence of giant clams as follows which indicated *T. crocea, T. maxima* and *T. squamosa* as being observed in about half the sites:

Species	No. of sites in which species was observed
Hippopus hippopus	3
Tridacna crocea	12
T. derasa	6
T. gigas	6

T. maxima	13
T. squamosa	11

During the 1992 Rapid Ecological Assessment in 47 sites from Velasco Reef to Anguar, Birkeland and Richmond (1992) frequently observed three giant clam species, *T. squamosa, T. maxima* and *T. gigas*. Furthermore, only large *T. gigas* (74-109 cm in shell length) were observed, and empty shells were more common than live ones. The number of sites (out of 47) in which giant clam species were observed are as follows:

Species	No. of sites in which species was observed
Hippopus hippopus	6
Tridacna crocea	22
T. derasa	7
T. gigas	21
T. maxima	24
T. squamosa	36

T. squamosa had the widest distribution, occuring in 36 out of 47 sites, while *T. crocea, T. gigas,* and *T. maxima* were observed in about half the number of the sites surveyed.

Interviews with women in seven states during the 1991 survey by Matthews and Oiterong (1991) on the role of women in fisheries in Palau indicated the following (Table 2.2.12) with respect to finding giant clams during collection. The responses are for species women notice as harder to find and figures are per cent of responses.

Table 2.2.12: Mollusc species women notice are harder to find. Figures represent percentages of responses. (Source: Matthews and Oiterong, 1991).

Mollusc species	Aimeliik	Airai	Koror	Ngaraar	Ngardmau	Ngatpang	Ngeremlengui	Total
Tridacna spp (***kim***)	14	13	33	25	29	67	0	24
Tridacna crocea (***oruer***)	14	13	33	0	14	0	20	24
Anodonita edulenta (***ngduul***)	0	25	17	0	29	33	60	19
Conus sp. (***ototl***)	0	0	0	8	0	0	0	2

2.2.5 Management

Current legislation/policy regarding exploitation: The exploitation of wild giant clams is controlled under Title 24: Environmental Protection, Chapter 12: Protected Sea Life, subchapter VI of the Palau National Code, as follows:

- no commercial exporting of clam meat is permitted for the species *Tridacna gigas, T. squamosa, T. derasa, T. maxima, T. crocea* and *Hippopus hippopus*.
- violators face fines of between $500 - 2,000 and/or up to 12 months in jail.

Under section 1008 of the Endangered Species Act, an exemption is made for species for which ministerial permission to harvest is granted, and those raised in commercial quantities under controlled conditions of aquaculture, mariculture, etc. This important exemption facilitates the legal export of commercially cultured clams from Palau.

Section 4 (6) of the Marine Protection Act of 1994 prohibits fishing while using any form of underwater breathing apparatus other than a snorkel. Section 4 (11) of the same Act prohibits the commercial export of giant clam meat of *T.gigas, T. squamosa, T. derasa, T. maxima, T. crocea,* and *H. hippopus* or part thereof except cultured species.

Recommended Legislation/Policy regarding exploitation: Regulation of the subsistence fishery for giant clams would be very difficult to legislate and enforce, except through the system of traditional marine tenure. Where traditional ownership rights are still recognised and traditional conservation

regulations (or ***'buul'***) can be enforced, village chiefs can play an important role in conserving wild clam stocks.

Despite the above legislation, quantities of clam meat continue to be exported from Palau, especially to Taiwan. Such exports violate national law. Illegal exports of clam meat totalled around 2 tons in 1990, and 888 pounds during the first half of 1991. Better enforcement of existing law protecting wild clam stocks would help to deter such illegal activities. Clam meat is also sent to relations overseas, especially Guam, for home consumption.

Application of minimum size limits (different for each species) has been employed as a management tool for giant clam stocks in many countries. This is especially beneficial when giant clams have low natural mortality and thus "the largest yields will be obtained by taking giant clams at relatively large sizes" (Munro, 1993). Munro further noted that a combination of minimum size limits and the imposition of annual quotas to be harvested in a single short season, offer the best prospects. Even though the establishment of reserves has not been proven to increase recruitment in depleted areas, it would at least play a role in conserving the genetic pool of the remaining stocks.

Enforcement of the minimum size limits would be difficult in cases when only clam meat is sold. A consideration here is the banning of clam meat sales without the shells.

Other management options suggested by McKoy (1980) include; quotas on catches, closed areas and closed seasons.

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2.3 Mangrove clams - *ngduul*

2.3.1 The Resource

Species present: The main species of mangrove clams found and utilised for consumption in Palau are *Anodonita edulenta* (the thin-shelled mangrove clam - ***ngduul***) and *A. alba* (the large mangrove clam - ***delal a ngduul***). Other species include, *Polymededa luhuana* (***cheduid*** or ***debuongel***) and *Terebralia semestriata*.

Distribution: Mangrove clams are distributed throughout the mangrove areas of the Palau archipelago. *A. edulenta* is known to be particularly abundant in the mangroves around Babeldaob and Koror with Ngardmau and Ngeremlengui States producing the largest harvests.

Matthews and Oiterong (1991) describe mangrove clams as living a few feet deep in the mud in and around mangrove forests, submerged in the mud where water is about three feet deep. The best mangrove clam spots or gleaning areas (***ongduoll***) are considered to be small inlets in the mangroves (***dermetaoch***), edge of the mangroves (***lalou***) and pools by the mangroves (***uet***) in some areas near seagrass beds. All three types of gleaning areas are found in mangroves at Ngesaol in Koror but rare in other areas around Palau. Mangrove clams are collected most in Ngeremlengui, Ngardmau and Airai with fewer collected in Ngaraard and Ngatpang. ***Cheduid*** is an important invertebrate species in Ngeremlengui and Peleliu (Rochers and Matthews, 1992). Mangrove clam is one of the most important marine invertebrates for subsistence and commercial purposes in the northern barrier reef area, Ngatpang, Ngeremlengui and Peleliu (Maragos, 1994).

Biology and ecology: Biological information on these species are lacking.

2.3.2 The Fishery

Utilization: Matthews and Oiterong, (1991) gave the following description of the collection process of mangrove clams in Palau. The collection method is known locally as ***mengduul***. It is done by women who usually go out in groups of two to five, mostly during neap tides. At low tide, the women dig a pool within the mud allowing water to flow in the area making it more manageable as mud without water can be hard to dig. The women then wade inside the pool and start feeling for clams using their feet. Women always collect on one side of the spot, working their way out or in, depending on the tide. If the tide is coming in they would go all the way inside and collect as they move out. This is to leave the ungleaned area undisturbed. The next time they come to the previously worked area, they would collect from the undisturbed areas. A gleaned area can be known by (1) disturbed and uprooted mangrove roots, (2) bottom or mud is too soft, and (3) presence on fresh dead shells. The gleaners move to a different location if an area has these features. The gleaned area is left for about 3 to 6 months before gleaned again. (This is acknowledged as the time it takes for the clams to reach marketable size).

"Mangrove clams are a major local commercial species. All local markets, as well as several restaurants buy and sell them. Generally, clams bigger than 1.5 inches are sold to local fish and produce markets and restaurants; smaller clams are kept for family use" (Matthews and Oiterong, 1991). A survey conducted by the same authors in 1991 in 7 states in Palau recorded the invertebrate seafood collection methods used by Palauan women as reproduced in Table 2.3.1. Overall, it indicates mangrove clam collection as the third most practised invertebrate seafood method by women, after "general gleaning" and "sea cucumber collection (***olengimes***)".

Table 2.3.1: Seafood collection methods used by Palauan Women. Figures represent percentages of responses. (Source: Matthews and

Oiterong, 1991).

	Aimeliik	Airai	Koror	Ngaraard	Ngardmau	Ngatpang	Ngeremlengui	Average Total
	n=7	n=8	n=12	n=12	n=7	n=3	n=5	n=54
Mangrove clam collection (***mengduul***)	71	75	50	83	71	100	100	74
General gleaning	100	100	92	100	86	100	100	96
Sea cucumber collection (***olengimes***)	71	100	92	100	86	100	80	91
Sea cucumber collection (***omat a irimd***)	71	88	75	25	43	67	40	57
Collection at night (***meluich***)	57	50	42	58	14	0	60	44
Land crab collection	14	0	17	25	0	0	0	11
Coconut crab collection	0	13	0	0	0	0	0	2
Mangrove crab collection	0	13	0	0	0	0	0	2

Production and marketing: Production of clam chowder is the major use for mangrove clam. Production areas are generally in the less inhabited areas on Babeldaob Island and clams are brought by boat or car to markets in the main town of Koror. No figures are available on the subsistence production nor are there complete data on commercial sales of mangrove clams. Perron *et al*. (1983) recorded commercial marine animals purchased at PFFA for the 1976-1981 year period. In 1979, 5,676 lbs (valued $340) of ***ngduul***, comprising 1.2 per cent of the total marine food product landing for that year, was reported. Only 298 lbs (worth $15) was recorded in 1980. The only recent figure available from commercial markets is 50 lbs (worth $75.00) of ***ngduul*** from Ngaraard recorded in PFFA purchases data for August, 1993.

Landings of mangrove clams are mostly from Ngeremlengui, Ngardmau and Airai with a few from Ngaraard and Ngatpang. Molluscs typically collected, and those collected in greatest numbers by Palauan women, are presented in Table 2.3.2 as recorded in Matthews and Oiterong (1991) for seven states surveyed in 1991. The results indicate that mangrove clams are typically collected by most Palauan women and is the invertebrate seafood resource collected in greatest numbers in the seven states. All women who collect mangrove clams in Airai, Ngardmau and Ngeremlengui sell part of their catches. Only some women in Aimeliik, Koror, Ngaraard and Ngatpang collect solely for subsistence use.

Table 2.3.2: Invertebrate seafood resources typically and collected in greatest numbers by women in seven states in Palau. The figures represent percentages of responses and figures in brackets represent per cent of those collected for subsistence purposes only. (Source: Matthews and Oiterong, 1991).

	Aimeliik	Airai	Koror	Ngaraard	Ngardmau	Ngatpang	Ngeremlengui	Average Total
Mollusc species typically collected	n=7	n=8	n=12	n=12	n=7	n=3	n=5	n=54
Tridacna crocea	100	100	92	67	71	67	80	83
Anadara sp. & *Barbatia reeveana*	71	88	83	92	86	100	60	83
Anodonita edulata	100	88	50	83	71	100	100	80
Tridacna sp.	86	88	67	92	71	33	80	78
Cypraea tigris	57	100	67	67	43	67	40	65
Lambis lambis	57	100	67	67	43	67	40	65
Mollusc species collected in greatest numbers								
Anodonita edulenta	86 (67)	88	50 (50)	83 (20)	86	100 (33)	100	80 (23)
Tridacna sp.	71 (60)	88	50 (33)	75 (22)	57 (25)	0	60 (33)	63 (26)
Tridacna crocea	86 (17)	88 (14)	92 (18)	0	14	33	60	54 (14)
Atactodea striata & *A. striata f. glabrata*	0	0	0	42 (100)	0	0	0	8 (100)
Anadara sp. & *Barbatia reeveana*	0	0	17 (100)	0	0	0	40	7 (50)
Nucula rugosa	0	0	0	25 (100)	0	0	0	6 (100)
Nerita maxima & *N.*	0	0	8 (100)	0	0	0	0	2 (100)

undata								

Estimates of mangrove clams landed per trip by women in seven states in 1991 were made by Matthews and Oiterong (1991) and are reproduced in Table 2.3.3. The catch figures are in number of pieces and represent state averages. The catches (good, bad and average) are assumed here as catches per collector per trip. Extrapolations for the whole year have been conducted using average total figures and assuming that fishing is conducted four times in all 12 months of the year. Since the number of fisherwomen involved in this particular fishery was not given, it was not possible to make an attempt to estimate an annual production.

Table 2.3.3: Summary of estimates of mangrove clam (*A. edulenta*) collected per trip by women in seven states in Palau. (Source: Matthews and Oiterong,1991). Catch figures are in numbers of pieces and represent state averages.

	Aimeliik	Airai	Koror	Ngaraar	Ngardmau	Ngatpang	Ngeremlengui	Average Total	Total Extrapolations per collector per year
Good	167	274	175	180	308	170	320	228	10,944
Bad	22	51	50	52	137	40	94	64	3,072
Average	91	153	99	95	200	100	140	125	6,000
Time spent (hr)	5	5	4	6	7	6	5	5	240
No. times/month	1	4	3	3	5	2	9	4	
Per cent sold	43	78	50	77	100	78	66	70	
Catch/unit effort (nos./hr)	18	33	25	17	30	18	29	24	

Market price recorded in 1991 for mangrove clam was $0.10-0.25 a piece with average amount sold of 200 pieces per sale, earning an income of US$20.00-50.00 per sale.

2.3.3 Stocks Status

Stock status is presently unknown, but is believed to be considerable, given the relative importance of this fishery to the income earning potential of village women, and the large amount of mangrove habitat available. The use of low-technology, labour intensive collecting methods suggests that fishing pressure on stocks is probably light. However, there are indications that clams in some areas are not as abundant as they were 5 years ago. Habitat destruction due to increased development of coastal areas may be responsible.

During the 1991 survey, 19 per cent of all the women interviewed in the seven states said that mangrove clam is harder to find, especially in Ngaremlengui. The results (per cent of responses), indicating the species as harder to find, for each state were recorded as follows:

	Aimeliik	Airai	Koror	Ngaraard	Ngardmau	Ngatpang	Ngeremlengui	Average Total
	n=7	n=8	n=12	n=12	n=7	n=3	n=5	n=54
Ngduul	0	25	17	0	29	33	60	19

Changes which have been observed by women gleaners and which could have contributed to the declines of stocks, include: dead corals (35 per cent), pollution/trash (33 per cent), fewer species (19 per cent), effects of gravel or coral dredging (15 per cent), too many people collecting (11 per cent), algal fouling (7 per cent), siltation (7 per cent), cut/dead mangroves (2 per cent), outsiders using area (2 per cent), oil from boats (2 per cent) and lower water level (2 per cent).

2.3.4 Management

Matthews and Oiterong (1991) note that "for conservation reasons, the women will collect on one side of the spot (gleaning area) working their way out or in depending on the current. The next time they come to the previously worked area, they collect from undisturbed areas. Usually mangrove clams take a few months to reach the marketable size, so women wait three to six months before returning to an area". Even though a system seems to have traditionally been in existence amongst the women gleaners to sustain stocks of mangrove clams by rotation of area harvested, other factors, as listed under Stock Status, will affect sustainability of the resource.

Current Legislation/Policy regarding exploitation: No legislation exists at present. Traditional conservation guidelines may be in force at the state level in some areas. Women tend to collect clams only from around their home state. Other areas are not harvested, eg. those near industrial waste or sewerage outlets.

Recommended Legislation/Policy regarding exploitation: Basic information (including landing statistics and biological parameters) on the mangrove clam resource is a necessity prior to the formulation of any regulations. A regulation normally applied to control the exploitation of bivalves is the application of a minimum size limit.

Lewis (1988), summarising the existing subsistence fisheries for miscellaneous molluscs in the Pacific islands, notes that few data are available for these fisheries, but that they are often of considerable importance to rural communities; a fact that needs to be recognised in fisheries development and coastal management plans.

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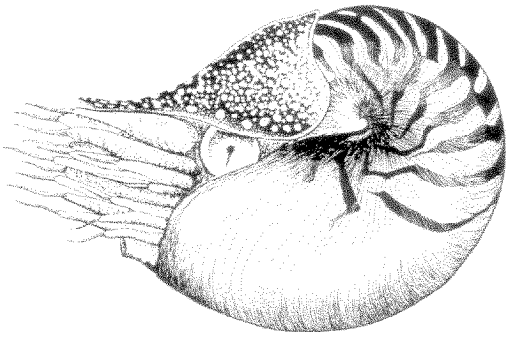
2.4 Nautilus

2.4.1 The Resource



Nautilus pompilius

Species present: The nautiloids *Nautilus belauensis* and *N. pompilius* are present in Palauan waters. Although these deep-water molluscs do not form the basis of any commercial or subsistence fishery, it is briefly mentioned here because a considerable amount of research into the biology and ecology of these poorly known animals has been conducted in Palau since 1977 by DMR staff in collaboration with research scientists from overseas, which has resulted in a significant contribution to the knowledge of this animal (Saunders, 1979).

Distribution: This species typically inhabits the relatively inaccessible deep fore-reef slopes of scattered Indo-Pacific island groups. Saunders *et al*. (draft, undated) recorded the most eastern occurrence of *Nautilus* in American Samoa. Nautilus has been best known from the Philippines, Palau, New Caledonia and Fiji (Saunders, 1978). Saunders (undated) presents the first direct study of *Nautilus* in its deep water habitat in Palau using time lapse photo sequences taken by remote cameras at baited sites. Surveys were carried out at Mutremediu Point at depths of 73-538 m. *Nautilus* appeared to be most abundant at depths of 150-300m, at ambient water temperatures of 17-19 degrees celsius. Water temperature appears to be an important factor in distribution and migrational movements.

Biology and ecology: The Palau studies showed for the first time that *Nautilus* is an active feeder both during the day as well as at night; it was previously believed that the species was nocturnal. Visual senses appear to be weak, with chemosensory ability of greater importance. The role of *Nautilus* in the marine ecosystem of Palau is that of a highly mobile, hovering, epibenthic scavenging generalist and opportunistic predator. Tagging studies have indicated that *Nautilus sp.* undertake considerable migratory movements of 150 km in 332 days, an average of 0.45 km/day (Saunders and Spinosa, 1979). Considerable sexual dimorphism exists in shell size and shape in Palauan nautiloids, with males tending towards larger sizes and broader apertures (Saunders and Spinosa, 1978).

From the work of Saunders (1979), data indicates a male dominated sex ratio, which is peculiar to Palau, Philippines and Fiji *Nautilus* populations. Saunders (1984), from mark and recapture study in Palau, recorded growth of *N. belauensis* as slow (0.1 mm of shell per day). Growth decreases as maturity is approached and individuals may live at least 4 years after maturity is reached. Maturity is attained at around 190-200 mm shell diameter. Saunders (1984) estimated that the life-span of Nautilus may exceed 20 years.

2.4.2 The Fishery

Utilization: *Nautilus* is not exploited in Palau on any level.

Production and marketing: *Nautilus* stocks in Palau are currently unexploited, except for occasional permitted collection for overseas aquariums.

2.4.3 Stock Status

Saunders (1979) points out that if substantial exploitation were to begin for either shells or export of live animals, depletion could proceed rapidly, as the population does not appear to be large, as indicated by the high rates of return for tagged animals. Monitoring of any trapping activities by DMR was stressed.

2.4.4 Management

Current legislation/policy regarding exploitation: There is currently no legislation or policy.

Recommended legislation/policy regarding exploitation: It might be worthwhile to legislate the collection/taking of live *Nautilus* specimens through a permittng system.

Reference

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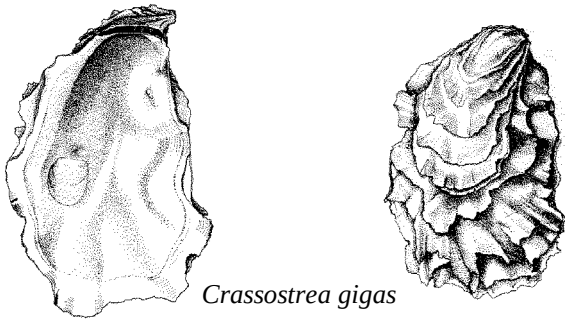
2.5 Oysters - *iiud*

2.5.1 The Resource


Crassostrea gigas

Species present: Oysters native to Palau include *Crassostrea echinata* (mangrove oyster - ***iiud***) and *Saccostrea glomerata* (rock oyster - ***iud***). These species grow to a sufficient size to be commercially valuable, but *C. glomerata* is not present in sufficient abundance to sustain a commercial yield (MMDC, 1975). *C. gigas* was introduced for aquaculture purposes in 1975. This species does not seem to have been able to establish in Palau. Two species of thorny oysters, *Spondylus barbatus* and *S. varius*, were reported from surveys on coral reefs offshore from Ngeremduu and several sites in Eastern Babeldaob and the Rock Islands and in sites from Velasco Reef to Anguar (Richmond, 1991 cited in Maragos, 1992; Birkeland and Richmond, 1992).

Distribution: With the exception of the Arctic and Antarctic regions, oysters are found in all the sea areas of the world. Species of oysters vary widely, from those living on the rocky reefs of outer ocean coasts with high salinity waters to those living in the inner recesses of bays with a high degree of fresh water flow. Among their species can be found a wide variety of life patterns as well. Approximately 200 species of oyster are known to exist in the world, and of these about 25 are believed to live in the waters of Japan (Yamaha, 1989).

Large oyster beds occur off the entrances to and within Ngeremeduu Bay (Maragos, 1994). It is not clear whether these were *Crassostrea* or thorny oysters *Spondylus*. Richmond (1991, cited in Maragos, 1992) recorded the thorny oyster species (*Spondylus*) observed in a survey of 26 sites on coral reefs offshore from Ngeremeduu and several sites in eastern Babeldaob and the Rock Islands as follows:

Species	No. of sites in which species was observed
Spondylus barbatus	3 out of 26
S. varius	10 out of 26

Birkeland and Richmond (1992) observed thorny oysters (*Spondylus*) in surveys of 47 sites from Velasco Reef to Anguar as follows:

Species	No. of sites in which species was observed
Spondylus varius	4 out of 47
Spondylus sp.	2 out of 47

Biology and ecology: Among the varieties of shellfish presently inhabiting the earth, the most prolific are the conch (Gastropoda) and bivalve (Pelecypoda) families. Of the conches, about 85,000 species exist while the Pelecypoda family has about 25,000 species. The conches actively search for food on the ocean floor with eyes and feelers, the bivalves such as scallops tend to bury themselves in the ocean floor or, in the case of oysters, attach themselves to rock outcroppings or reefs.

The soft body of the bivalves is fully enclosed in a shell and a mantle with which the shell is, so to speak, lined. There is also a gill between the mantle and internal organs. On the back edge of the body are a number of water pores through which water is drawn in to pass through the gill and thus constitute the breathing function. At the same time, the gill also functions to separate debris in the water from edible suspended matter such as plankton for the ingestive process. The volume of water thus processed by the gill in the case of "Magaki" (Pacific cupped oyster) is said to be about 10 litres per hour. Virginia oyster (American cupped oyster) filters about 5-25 litres/hour at a water temperature of 20 C°. This means that some oysters process more than 1000 times their body weight

(without shell) of water every hour (Yamaha, 1989). The amount of vegetable planktons consumed by an adult oyster in one day is thought to be between 1 and 5 grams.

Within the same species of oyster there are considerable differences in the shape of the shell and other biological characteristics depending on the environment conditions within they live.

The number of eggs produced by a single mature oyster ranges from 50 to 100 million (Yamaha, 1989). Fertilized eggs and larvae begin a random process of dispersion and reconcentration in accordance with the whims of forces like tides, wave motion and eddying currents. After two or three weeks in this drifting phase they enter the fixed stage of their life cycle in which they attach themselves to some stationary object.

Oysters feed primarily on vegetable planktons and detritus, but the amount of food consumed varies with species and also in accordance with the stage of growth and life environment conditions.

Shell growth is greatly influenced by such factors as water temperature and salinity, currents and gestation. It is generally most active in the spring and autumn, and tends to stagnate in the spawning season of summer and in winter.

Culture trials of imported *C. gigas*, in 1975, showed disappointing results. Using off-bottom techniques, 2 lots grown at Ngatpang Bay reached 61.5 and 50.8 mm shell length in 10 months, and those planted at a site off MMDC reached 53.3 mm. Oysters grown in Nestier trays at Ngetpang Bay reached 36.5 mm shell length.

Survival rates were poor. Culchless oyster seed in Nestier trays at MMDC farm site had no survival; culchless oysters glued to masonite plates had poor survival due to glue losses and drop-off. Culched oyster seed of two sizes had different mortality rates; 18 per cent for the larger spat and 18.2 percent for the smaller spat. Ngetpang Bay was considered to offer the best ecological conditions for culture of *C. gigas* using off-bottom techniques, but results of this experimental trial indicated culture to be not economically viable in Palau.

No commercial or small-scale fishery based on oysters currently exists, although the native species form a part of the subsistence diet in areas where they are prevalent.

2.5.2 The Fishery

Utilization: Oysters are of subsistence value to residents of Ngeremeduu and Ngeremlengui. Commercial ventures have not been favoured in these areas due to small populations (Maragos, 1994). “Native species of oysters are harvested for subsistence purposes, and may be marketed commercially, although exploitation is thought to be minimal” (Cassell *et al*., 1992). ***Chesiuch*** is one of the important invertebrates in Ngeremlengui with ***iiud*** being occasionally collected by women and children (Rochers and Matthews, 1992).

Production and marketing: No estimates have been made of subsistence level of utilization in areas where oysters are found and consumed. However, Perron *et al*. (1983) recorded marine animals of commercial value landed at PFFA during the 1976-1981 period. A total of 1,136 lbs (worth $1,136) and 200 lbs (worth $100) of ***iiud*** (*C. echinata*) were recorded in 1976 and 1977 respectively. No records were reported for the rest of the years in the period. It was not apparent whether the oysters purchased in 1976 and 1977 were from local stocks or imported.

2.5.3 Stocks Status

No information is available on oyster stocks in Palau. Maragos (1994) reports large oyster beds existing off the entrances to, and within, Ngeremenduu Bay. The author further noted that even though "oysters are of subsistence value to residents of Ngatpang and Ngeremlengui, commercial venture has not been favoured due to small population size". Richmond (1991) reported the occurrence of *S. barbatus* in 3 sites and *S. varius* in 10 sites, of the 47 sites surveyed on coral reefs offshore from Ngeremeduu and several sites in eastern Babeldaob and the Rock Islands. Birkeland and Richmond (1992) observed *S. varius* in 4 sites and *Spondylus* sp. in 2 sites, during surveys of 47 sites from Velasco Reef to Anguar.

2.5.4 Management

There is no commercial utilization of native stocks which seem to be able to support only subsistence consumption.

Current legislation/policy regarding exploitation: Apart from pearl oysters, there is no regulation that specifically deals with the exploitation of edible oysters included in this profile.

Recommended legislation/policy regarding exploitation: None seems necessary due to the low level of exploitation.

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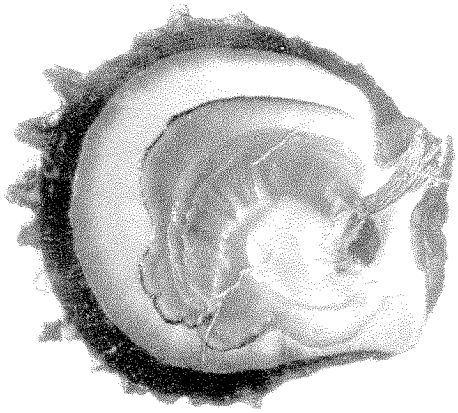
2.6 Pearl oysters

2.6.1 The Resource

Species present: *Pinctada margaritifera* (the black-lip pearl shell - ***esiuch***) occurs naturally in Palau. *Pteria penguin* (the brown-lip pearl shell or the winged Mabe pearl oyster - ***rudel***), is abundant and commonly associated with black coral on reef drop-offs and deep water lagoon areas. It is also abundant on the many ship wrecks in Palau, but it is apparently not collected. Maragos (1994) report that the brown-lip pearl shell is not collected locally. Birkeland and Richmond (1992) reported *Pt. brevialata* in surveys of 47 sites from Velasco Reef to Anguar. *P. maxima* (the gold-lip pearl oyster shell, commonly called the silver-lip pearl shell in Palau), is not a native species but was introduced for pearl mariculture (G. Heslinga, *pers. comm.*).



esiuch - *Pinctada magaritifera*

Distribution: Black-lip pearl oyster is widespread throughout Oceania. Gold-lip has a more restricted distribution, not being found in commercial quantities east of Solomon Islands.

P. margaritifera is found down to 40 m, but mostly just below low water mark. *P. maxima*, when it occurs naturally, is found on coral reefs down to a depth of 80 m with maximum abundance generally between 10 and 60 m.

In a survey of 26 sites on coral reefs offshore from Ngeremeduu and several sites in eastern Babeldaob and the Rock Islands, Richmond (1991, cited in Maragos, 1992), observed *Pt. penguin* in only 3 sites. During surveys in 47 sites from Velasco Reef to Anguar, Birkeland and Richmond (1992) reported the occurrence of the pearl oysters as follows:

Species	No. of sites where species was observed
Pinctada margaritifera	2 out of 47 sites
Pteria brevialata	3 out of 47 sites
Pt. penguin	1 out of 47 sites

The brown-lip pearl shell is abundant, and commonly associated with black coral, on reef drop-offs and deep water lagoon areas and on the many ship wrecks in Palau.

Biology and ecology: An excellent reference on the biology, culture and other aspects of pearl oyster species is Gervis and Sims (1992). The following information was extracted from that reference. *Pinctada* species are protandrous hermaphrodites, with ratios of males to females tending to be 1:1 with increasing age. Black-lip pearl oysters reach full maturity in the second year while *P. maxima* matures as a male at 110-120 mm during its first year of life, and it is possible for wild *P. fucata* to spawn twice in the first year. Spawning is often associated with temperature extremes or sudden changes in the environment, and that for tropical oysters is not limited to a single season. Fertilization takes place in the water after the release of both sperm and eggs, and the larval cycle ranges from 16 to 30 days depending on species, temperature, food and the availability of settlement substrates. Growth is affected by temperature and food availability. *P. margaritifera* reaches a shell diameter of 7 or 8 cm within one year and 11 cm by the second year while *P. maxima* averages 10-16 cm after two years. *P. fucata* reaches a maximum 9 cm (DVM, dorso-ventral measurement) within the first twelve months and has a lifespan of only four years. The von Bertalanffy growth parameters of wild stocks, in Cook Islands, of *P. margaritifera* were estimated by Sims (1990) to be; L_∞ = 79.31 mm, K=0.0756 and t_0=0.44 months. Predator fish, especially on the young oysters, include, *Balistes* sp.,

Tetradon sp. *Lethrinus* sp., *Serranus* sp., and various species of sharks and rays. Other predators include octopus, starfish, crabs and a variety of predator gastropods such as *Murex* and *Cymatium* sp.

Maximum sizes have been calculated for blacklip and goldlip as 14-17 cm and 20-25 cm diameter respectively. Like many bivalves, *Pinctada* species are hermaphrodites, reaching maturity in the second year of growth, but with uneven sex ratios until the fourth or fifth years, with greater numbers of males up to that time. Spawning is often not limited to distinct seasons, and a larval stage occurs lasting 2-4 weeks prior to settlement (Sims, 1988).

2.6.2 The Fishery

Utilization: It is thought that collection of pearl shell by free diving for export of the shell probably occurred intensively in Palau during the Japanese occupation before the war, resulting in severe depletion of wild stocks (G. Heslinga, *pers. comm.* to P. Nichols). There is no small-scale commercial fishery of pearl shell today, primarily because wild stocks are very small (G. Heslinga, *pers. comm.* to P. Nichols).

Pearl culture operations were established in Palau and Marshall Islands by the Japanese prior to the outbreak of the second world war. Experimental pearl farming in Palau commenced in 1935 off Koror using *Pinctada maxima*. Between 1937 and 1941, 8.23 lbs of pearls were produced (Anonymous, 1989).

Production and marketing: No export figures for past pearl shell production are available. Currently, no shell export is undertaken. Cultured pearls produced by a Japanese joint venture pearl culture facility are marketed through Japanese pearl buyers.

No shell production occurs today. Cultured pearl production figures are confidential.

An experimental pearl farming joint venture between a Japanese company, the Palau National and Koror State Governments was in operation, culturing pearls using *P. matencie fucata* and *P. maxima*. Due to the lack of wild shells available, *P. maxima* were imported from Japan and Indonesia for use in pearl culture in the mid-1980s. A total of 25,000 shells were imported in 1985, 150,000 in 1986 and 110,000 in 1987. Mortalities of these transplanted shells were reported to be high (Anonymous, 1989). Because of the lack of suitable wild shells, culture of parent stock with which to culture pearls has been a major developmental area. Since 1982, cultured shells have been used for pearl production by the company. Production of pearls for 1993 was forecast at 7,075 monme (= 933.9 ounces; 1 monme = 0.132 ounce), valued at 212.25 million yen.

MMDC plans to conduct research for the culture of pearl oysters involving spat collection but especially hatchery propagation of the black-lip pearl oyster, *P. margaritifera*. Broodstock will be collected from the wild for spawning purposes at BMDC (Heslinga, 1994, *pers. comm.*).

2.6.3 Stocks Status

No records are available of any attempt to conduct stock assessment work on the native pearl oysters in Palau. The resource is believed to have supported a pearl shell industry for export during the Japanese occupation of Palau which could have resulted in depletion of native stocks. The pearl farm ventures initiated on Palau have all depended on the importation of stocks due to the lack of locally available wild stocks. The planned MMDC efforts to propagate *P. margaritifera* collected locally will shed some light on the stocks available and areas where they still exist on Palau. Out of 26 sites surveyed by Richmond in 1991 on coral reefs offshore from Ngeremeduu and several sites in eastern Babeldaob and the Rock Islands, only *Pt. penguin* was observed in only 3 sites. Of the 47 sites

surveyed from Velasco Reef to Anguar by Birkeland and Richmond (1992), *P. margaritifera* was recorded in only 2 sites, *Pt. penguin* in 1 site, and *Pt. breviata* in 3 sites. No abundance figures were given for species observed.

No data are available at DMR concerning the history of *Pinctada* shell production.

2.6.4 Management

Current legislation/policy regarding exploitation: The harvesting of black-lip mother-of-pearl shell is controlled under Palau National Code, Title 24: Environmental Protection, Division 2: WildlifeProtection, Chapter 12: Protected Sea Life, Subchapter III: Mother-of-Pearl. Section 1221 lists these controls as:

a) no black-lip mother-of-pearl oyster shell (*Pinctada margaritifera*) shall be taken except whose shell ia at least four (4) inches in diameter as measured across the nacre;
b) no black-lip mother-of-pearl oyster shell of any size shall be taken from the first day of August to the thirty-first day of December inclusive;
c) notwithstanding any provisions of this section to the contrary, black-lip mother-of-pearl shells of any size may be taken at any time for scientific purposes when specifically authorised by the President;
d) a person violating any of the provisions of this section shall, upon conviction, be imprisoned for a period not exceeding 6 months, or fined not more than $100.00, or both.

No legislation exists for other species of pearl oyster species.

Recommended legislation/policy regarding exploitation: Without base line data on the wild stocks of black-lip and silver-lip in the country, it is hard to assess conservation requirements. As no fishery exists for the exploitation of wild shell, management measures are obviously not required at this time. Regulation of pearl culture is the subject of the existing joint venture arrangement. This activity may be assisting to enhance natural spat falls.

Sims (1988) provides a comprehensive review of culture and management issues relating to pearl shell in the Pacific.

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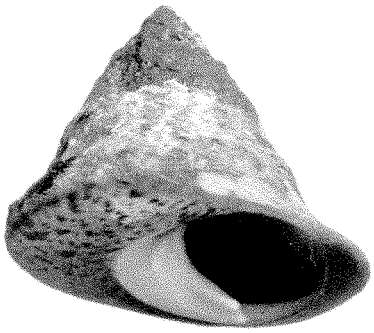
2.7 Trochus - *semum or ekoek*

2.7.1 The Resource



semum *- Trochus niloticus*

Species present: The top shell, *Trochus niloticus* (trochus - ***semum*** or ***ekoek***) is found in Palau.

Distribution: The natural distribution of trochus is dependent on the presence of coral reefs. It occurs in the intertropical belt between the Andaman Islands in the Indian Ocean and the islands of Fiji and Wallis in the Pacific (Bour, 1988). The edge of its natural habitat in the Western Pacific was marked by an oblique line running from Palau down to Wallis. However, with the many successful translocations and introductions, the area now inhabited by trochus extends more to the east. In the South Pacific, *T. niloticus* has been introduced to Cook Islands, Niue, Tokelau, Tonga, Tuvalu and Western Samoa.

In Palau, *T. niloticus* is generally spread throughout reefs with suitable habitats. According to Heslinga *et. al.* (1984), trochus distribution is dependent on reef orientation. South and south-east facing reefs generally support less shells than nearby east or north-east facing sections. Generally, trochus distribution in Palau is virtually restricted to hard substrates on seaward reefs. The species occurs from low water mark down to 14 fathoms (28 m) depth. The favoured depth in Palau is around 2-4 fathoms (4-8 m) (Asano, 1991). Ngiramolau *et. al*. (1991) noted that *T. niloticus* is a well known reef snail throughout Palau and their survey conducted on Koror and Babelthuap indicated that the reefs around Babelthuap have higher trochus densities than those around Koror. Richmond (1991, cited in Maragos, 1992), during surveys of 26 sites on coral reefs offshore from Ngeremeduu and several sites in eastern Babeldaob and the Rock Islands, observed *T. niloticus* in only one site. However, it should be noted that these surveys were rapid ecological surveys. Birkeland and Richmond (1992) observed *T. niloticus* in 14 sites out of 47 surveyed from Velasco Reef to Anguar.

Biology and ecology: *T. niloticus* (family Trochidae) has a large, thick, heavy, conical shell, pinkish in colour with dark, reddish brown blotches. It is the largest species in the genus, and may exceed 15 cm in basal length. Trochus inhabits shallow, sunlit waters rarely being found deeper than a few metres. The maximum densities of trochus suitable for harvesting are found on the first meters of the outer reef slope which is made up essentially of massive slabs of dead coral (Marchandise, undated). Trochus is primarily herbivorous, feeding on small algae, diatoms and foramaniferas on dead coral and rock surfaces. A trochus radula is estimated to comprise of about 150 teeth. This enables it to graze. In the stomach content of 20 specimens, ranging from 60 to 75 mm in diameter, Asano (1944) found Foramanifera, Cyanophyceae, and Phaeophyceae in large quantities and also a lesser proportion of other small red and green algae mixed with a large quantity of sand.

Trochus do not have secondary external sexual features by which the sexes can be distinguished. The only definite method to determine the trochus sex is to break the apex of the shell to reveal the gonad which, when mature, is a deep green colour in the female and milky white in the male. However, another method of determining the sex of an adult trochus without sacrificing it is to force the living trochus to retract far into its shell by pressing with one's thumb on the operculum. This will cause the animal to eject some water in the paleal cavity; if the water is examined under a microscope it will usually be found to contain some spermatozoa and sometimes some green ovocytes. This method is usually reliable during the spawning season when selecting genitors to obtain spawn for aquaculture.

Sexual maturity is reached in the second year (size 5-6 cm). Male and female gametes are released into the sea where fertilization takes place. The fertilized eggs are covered with a thick chorion which protects the embryo. After hatching, the trochophore develops a larval shell (the protoconch) and

swims towards the surface using the ciliated velum. At this stage it has become a lecithtrophic veliger. After a few days, the veliger settles on a substrate, sheds its velum and begins to crawl along on its single foot feeding on microscopic algae.

The number of eggs release by a female trochus depends on the size of the shell (basal length). Heslinga (1981) estimated that one female of 10 cm diameter can release up to 2 million ovocytes, while Nash (1985) stated that females in the 86-100 mm group can release an average of 1 million ovocytes. Bour (1990) sampled 596 mature females and found the following average fecundity per size class:

Average diameter (in cm)	70	80	90	100	110	120	130
Average fecundity (X 1000)	511	562	592	660	690	974	3,003

Trochus growth depends very greatly on environmental factors such as water temperature, quality of the substrate and available food.

In Palau, peak spawning occurs between June-December, when water temperature increases to 29°C, and a few days before new moon (Bour, 1990). Residual spawning occurs throughout the year. Fertilised eggs become planktonic larvae after 9-10 hours, and settle out as juveniles on the reef flat after 2-3 days. The short planktonic phase indicates that recruitment on the reef is dependent on the parental biomass of that reef, with little immigration from surrounding areas. Spawning is generally year-round and fecundity is very high, increasing with size. Trochus grows rapidly in the first 3-4 years, growth rates being strongly determined by environmental conditions.

The presence of well developed coral, good tidal flow, high dissolved oxygen levels and flourishing growths of filamentous algae are habitat requirements for good growth and reproduction. A principal component of the diet of the species are filamentous algal species such as are found on hard rocky substrates, in particular *Oscillatoria spp.* and *Sphacelaria spp.*

2.7.2 The Fishery

Utilization: *T. niloticus* is a major inshore fishery resource in Palau (Ngiramolau *et al*., 1991). Asano (1962) states that trochus harvesting began in Palau around 1899, under the German occupation. Trochus (*T. niloticus*) is a major inshore resource in Palau, generating considerable incomes for rural populations. The major use of the shell is in the production of buttons, shell jewellery and other artifacts. Exports of shell are mainly to Asia and to European producers of buttons and other artifacts.

Shells are collected by hand on the reef by rural fishermen diving with goggles or face masks from canoes. Meat is extracted either by par-boiling or through use of a steel hook (K. Kenichi, pers. comm.) and usually discarded, although smoking of trochus meat is becoming popular in Palau. Shells are stored in sacks and sold either to commercial buyers (Kitalong and Orak, 1989, cite nine trochus dealers) or exported by the fishermen directly. Prices paid for shell have ranged from $0.65 - $1.40 per pound, differing between states and shell size and condition. The effectiveness of enforcement of conservation laws, especially regarding size limits, has varied between states in the past (Orak and Naruo, 1988).

Matthews and Oiterong (1991) reported that trochus is collected for food and its pearly shell. Maragos (1994) report that smoked *T. niloticus* meat is popular in Palau although it is collected primarily for its shell and commercial value. Trochus meat has entered the local market on a small scale level.

Production and marketing: McGowan (1958) first described the development of a commercial fishery for trochus in Palau. Heslinga (1981) presents data indicating a commercial catch of around 325 short tons live weight in 1918 declining to around 55 short tons in 1979. Asano (1991) presents data of

Palau trochus production declining steadily from around 353 tonnes in 1923 to around 50 tonnes in 1939.

Commercial trochus purchases by PFFA for the 1976-1981 period is presented in Table 2.7.1 as extracted from Perron *et al*. (1983).

Table 2.7.1: Annual trochus (***semum***) purchases of trochus by PFFA for the 1976-1981 period. (Source: Perron *et al*., 1983).

Year	Weight (lbs)	Per cent of Total Yearly Reef Fish Weight Landing	Value (US$)	Percent of Total Yearly Reef Fish Value Landing
1976	-	-	-	-
1977	-	-	-	-
1978	25.0	0.01	3.75	negligible
1979	330.0	0.07	49.50	0.03
1980	557.0	0.12	111.40	0.05
1981	7,052.0	3.24	725.40	0.62

In recent years, trochus has become a major income earner for Palauan rural communities. Production figures are, however, not comprehensive: a moratorium on the harvesting of trochus for a period of three years from all states except Tobi State was imposed in 1989. Prior to this, annual exports of trochus shell over a 5-year period (1985-1989) averaged 130 tonnes. Palau's 1989 revenue from trochus of around US$676,400 makes it one of the most important revenue generating resources in the Republic. Table 2.7.2 summarises trochus production by year for the 1983-93 period. Historical production data is presented in Figure 2.7(a) (1915-1957).

In the years prior to 1981, trochus harvests were regulated by the national government and confined to June of each year. In 1981, responsibility for management and regulation of the trochus fishery was given to the states. During this period, it was difficult to obtain information concerning the total trochus harvest. Concerns about the ability of the resource to sustain itself arose as the fishing pressure increased throughout the 1980s, leading to the introduction of the moratorium.

Table 2.7.2: Trochus purchases (exports) by local buyers, by year from 1983-1993.

Year	Weight (mt)	Local Value ($)	Reference
1983	54.5	65,000	DMR unpublished data
1984	108.1	173,000	"
1985	104.0	-	DMR 1992 Annual Report
1986	32.0	-	DMR 1992 Annual Report
1987	87.0	-	DMR 1992 Annual Report
1988	168.0	-	DMR 1992 Annual Report
1989	257.0	676,487	DMR 1992 Annual Report
1990	moratorium		DMR 1992 Annual Report
1991	moratorium		DMR 1992 Annual Report
1992 Export	229.0	645,398	DMR 1992 Annual Report
(Export)	(251.9)	(1,100,000)	DMR data
(Local purchases)	(265.1)	(645,398)	DMR data
1993 Export	29.3		DMR data
(Local purchases)	(29.3)	(58,600)	

Commercial trochus shell landings by state in 1992 is given in Table 2.7.3 in descending order. Cleaned shell made up 24 per cent of the total landing while uncleaned shells comprise 76 per cent. Koror supplied about a fifth of the total trochus landing in 1992.

Table 2.7.3: Palau raw trochus shell landings in 1992 by state. (Source: Division

of Marine Resources, 1992 Annual Report)

State	No. of sales	No. of sellers	Weight (lbs)	Value (US$)
Koror	798	383	113,701	139,454
Kayangel	184	70	73,442	86,534
Ngardmau	256	114	51,299	61,680
Ngeremlengui	247	110	45,933	55,450
Peleliu	251	135	40,518	49,417
Ngerchelong	239	120	40,187	46,628
Airai	200	93	39,466	48,774
Ngaraard	194	107	37,566	44,943
Aimeliik	154	77	28,588	33,996
Ngatpang	93	38	16,628	19,898
Ngiwal	55	39	14,906	17,661
Ngchesar	73	35	13,957	17,151
Melekeok	40	29	10,620	12,633
Unknown	39	?	3,669	4,394
Angaur	11	10	2,721	3,264
Tobi*	5	3	2,240	3,447
Sonsorol	1	1	65	75
TOTAL	**2,943**	**1,438**	**535,506**	**645,398**

*may not reflect all of the trochus harvested since individual purchase receipts were not available.

From June 1-30, 1992, 64 tons of trochus were collected from Kayangel's reefs (Rochers and Matthews, 1992).

No estimates are available on the subsistence trochus meat consumption. Trochus meat landed at PFFA in 1992 was 309 lbs (but 323.5 lbs combined for PFFA, Oh's, PMCI or Melekeok Cooperative worth $323.50). Trochus meat purchased at PFFA (Jan-Sep), in 1993 amounted to 1,037 lbs valued at $1,037. All of the ***semum*** purchases at PFFA for 1993 were from Peleliu and were made during July-August. No purchases of ***semum*** were recorded at PMCI and Oh's markets in 1993. Mollusc purchases for 1993 at the three markets are recorded in Table 2.7.4. The table indicates that ***semum*** is by far the most important commercial mollusc (at least for these three markets).

Table 2.7.4: Purchases of molluscs at PFFA (Jan-Sep), PMCI (Jan-Sep) and Oh's (Jan-May) 1993. (Source: DMR data).

Mollusc	Weight (lbs)	Value (US$)
Trochus (*semum*) meat	**1,037**	**1,037**
Giant clam (***kim***)	124	62
Crab (***kmai***)	0	0
Octopus (***bukitang***)	12	13
Squid (***luut***)	29	36
Mangrove clam (***ngduul***)	50	75

The export of trochus meat in 1992 as recorded on Continental Air Micronesian manifests, together with other foodstuff, is given in Table 2.7.5. No records of declared items indicate any trochus export via this channel in 1990 and 1991. The exports of trochus meat are most probably for relatives in Guam and FSM.

Table 2.7.5: Exports of trochus meat with other foodstuff from Palau in 1992 as recorded on airline manifests as declared items. Gross weight include packaging (Source: DMR, 1992 Annual Report).

Declared item	Count	Gross weight (lbs)
Trochus meat	7	301
Trochus meat/Other	1	32
Trochus meat/Seacucumber	1	32
Clam/**Trochus meat**	1	39
Fish (frozen)/**Trochus meat**	18	1,352
Fish (smoked)/**Trochus meat**	1	65
Seacucumber (dried)/**Trochus meat** (dried)	2	10
Fish (frozen)/Crab/**Trochus meat**	1	50
Fish (frozen)/Lobster/**Trochus meat**	1	84
Fish/Lobster/**Trochus meat**	1	103
Lobster/**Trochus meat**/Other	1	66
Tuna/Clam/**Trochus meat**/Bats	7	1,312

2.7.3 Aquaculture of Trochus

The propagation of *T. niloticus* was initiated at MMDC around 1982. One of the important objectives of the Trochus Project was to determine the feasibility and cost-effectiveness of trochus mariculture as one of the several potential management options for the local trochus fishery (Division of Marine Resources, Annual Report for 1990). The original goal was to achieve reliable production from the hatchery, before assessing survival of hatchery-reared trochus seeds in the wild, to obtain economic analysis of this option. An expert was employed in 1989 for this particular project. Seed production for that year was over 30,000 trochus. The expert departed in mid-1990 leading to a decline in production of only 3,400 seeds for that same year (Annual Report, 1990). This number was considered insufficient for a meaningful seed release programme. In 1991, a substantial JICA grant was available for upgrading the trochus facility. In addition, a JICA mollusc expert was recruited for the project. Routine successful spawning on a monthly basis was achieved in 1991. Four-month old seed production was 5,156 for the year. By 1992, with the departure of the JICA expert, unacceptably low and inconsistent seed production led to the discontinuation of the trochus project at MMDC. Thus, the mariculture management option gave way to conventional management options such as size limits, closed seasons and sanctuaries (Division of Marine Resources, 1992 Annual Report). The conventional methods of management were considered more cost-effective in managing Palau's trochus fishery than artificial stock enhancement through mariculture.

2.7.4 Stocks Status

Trochus harvesting over the years has resulted in drastic declines of stocks in Palau. A three-year moratorium went into effect as of August 1989, which was due to be lifted in 1992. The enactment of this 3-year moratorium was due to over-exploitation from exploited and nonexploitated reefs (sanctuaries) (Ngiramolau *et al*., 1991).

Asano (1991) presents data from trochus population density studies in Palau carried out between 1936-1940. Densities varied between years, but west coast reefs had greater stock density than east reefs. Density was highest in water depths less than 6 feet (2 m) on west coast reefs, and in less than 4 fathoms on the east coast. Trochus in deeper waters tended to be bigger, especially on the west coast. Higher stock densities were found to have smaller individuals on average.

Monitoring trochus populations involves visual observation of the trochus on reefs that have been subjected to fishing, and keeping track of the level of annual export. Orak and Nauro (1990) surveyed

approximately 1,200 sq.m. of the western reef in Ngaraard State, an area considered to be an optimum habitat for trochus. Population density was calculated at 0.04 trochus per sq.m. Sizes ranged from 59-95 mm basal diameter (mean 77.8 mm). A recent survey (Ngiramolau *et. al.*, 1991) conducted on Koror and Babelthuap reefs indicated a mean population density of 155 live trochus per hectare (0.0155 m^2), with the reefs around Babelthuap having higher densities than those around Koror. The total trochus habitat was calculated at 40.9 sq. km. for both outer and inner reefs at the areas surveyed. The standing stock of *T. niloticus* in Palau was calculated at 160 tonnes, indicating a possible sustainable yield of 64 tonnes per year, if 40 percent of standing stock is considered sustainable. It is apparent that the production levels in recent years prior to the moratorium were not sustainable.

Anecdotal information from local fishermen indicates that trochus were harvested on reefs around Koror both day and night in 1989 and many shells were undersized. Cyclone Mike, which devastated Palau on November 11th, 1990, resulted in considerable damage to reefs, and may have further reduced juvenile trochus stocks.

The results of the survey conducted in 1991 (Ngiramolau *et al*. (1991) indicated that *T. niloticus* densities varied a lot in different reefs with reefs in Babeldaob (Airai, Aimeliik, Ngerchelong, Ngerenlengui, Ngatpang, Ngardmau and Ngaraard) having the highest densities. Reefs in Koror had the lowest densities (average 73 animals/hectare) as compared to 119 trochus/ha obtained by Heslinga *et al*. (1983). The variation in trochus densities was attributed to possible factors, as listed by Ngiramolau *et al*. (cited above) such as:

- harvest during the 1989 harvest season;
- typhoon “Mike” that hit Palau in November, 1990;
- other natural causes such as unsuitable habitat, predators and food limitation due to competitors.

During surveys in 1991 in 26 sites on coral reefs offshore from Ngeremeduu and several sites in eastern Babeldaob and the Rock Islands, Richmond (1991, cited in Maragos, 1992), observed *T. niloticus* in only one site. Birkeland and Richmond (1992) observed *T. niloticus* in 14 sites out of 47 surveyed from Velasco Reef to Anguar. However, it should be noted that these surveys were rapid ecological surveys and may not reflect actual occurrence of trochus in the areas surveyed. No trochus density information was given.

2.7.5 Management

An adequate management regime of the resource in Palau is necessary in view of its economic importance and the application of better fishing equipment and techniques for harvesting which has placed trochus populations under threat of over-exploitation (Heslinga and Hillmann, 1981).

Heslinga *et. al.* (1984) describe the establishment of seven trochus sanctuaries in Koror, the most populous state, as a result of recommendations by McGowan (1958). Sites were chosen by Palauan nationals with a good knowledge of the local environment. These were surveyed in 1982. Densities of *T. niloticus* ranged from 0-750 shells per hectare (0-0.075 m^2), with an overall mean of 119 (0.0119 m^2). Sanctuary sites were found to have lower densities than non-sanctuary sites, probably because the sanctuary sites offer sub-optimal habitat areas for trochus.

DMR plans to undertake satellite imagery along the same lines as that done in New Caledonia of reefs to refine trochus habitat values, and estimates of standing stock and sustainable yields. Further resource surveys on more sites are also planned.

DMR currently has one activity focusing on trochus, namely to assess the status of trochus stocks on the reefs and to monitor fisheries targeting them. Trochus was successfully introduced into Ulithi and Ngulu from Yap by the Japanese, but similar attempts on Woleai, Ifalick and Sorol have been unsuccessful.

The option of artificial stock enhancement through mariculture has been determined as not cost-effective and was thus abandoned in 1992.

Current legislation/policy regarding exploitation: Trochus is protected under the Palau National Code, Title 24: Environmental Protection, Chapter 12: Protected Sea Life, Subchapter V: Trochus. Section 1243 of the Title 24 was repealed by the Third Olbiil Era Kelulau (OEK) in 1989. Current legislation in force as at 2nd August, 1989 is summarised below:

* a moratorium on trochus harvesting throughout the Republic, except in the waters of Tobi State for 3 years;
* the OEK may by resolution designate and vary open and closed seasons and reef areas where trochus can be harvested (except Tobi State);
* State governments can impose closed seasons or areas for trochus harvesting regardless of national declarations;
* Palauan nationals may harvest trochus within state laws providing no trochus of less than 3 inches basal diameter is taken: violators face $100 fine for each undersized trochus taken;

The current 3-year moratorium is up until 1994.

New legislation under the Act covers commercial processing and storage of trochus, inspection of facilities by inspectors and requires that commercial processors first obtain a permit from the Sanitation Office of the Bureau of Health Services. Violators of these new rules face a fine of at least $5,000 and loss of licence for at least thirty days.

Ngaraard State Government has 3 designated trochus sanctuaries (NSPL No.2-27), in which no harvesting may take place at any time. Violators face fines of $50-200. This state has also declared its waters to constitute a marine life conservation area (NSPL No.3-4), empowering the Governor to make rules regarding commercial fishing within the State.

Koror State has 6 permanent trochus breeding sanctuaries in which collection of trochus is prohibited, unless specifically approved. Violators face a $25 fine and/or 30 days prison.

Recommended legislation/policy regarding exploitation: During the 1989 3-year moratorium period, DMR was to assess trochus stocks and re-evaluate existing laws with regards to conservation of trochus. Heslinga *et. al.* 1984 review past management practises and recommend their re-establishment including:

* a one-month harvest season (June);
* a size limit of 3 inches (7.62 cm) basal diameter be imposed;
* reef areas with good reef habitats and close enough to be easily monitored and policed be declared trochus sanctuaries, especially where customary resource management practises can be enforced by the people;
* voluntary moratoriums on shell collection for one or more years be initiated by individual states or villages

Further measures for consideration include:

* establishment of regulations ensuring that details of trochus purchases and exports are available to DMR;
* develop markets for trochus meat both locally and possibly for export.

In addition, a maximum size limit could be considered, in addition to the minimum size limit, in order to protect the older more fecund animals, which often have a lower commercial value anyway because of worm holes in the shell. Other Pacific Island countries have a minimum size limit of 8cms (3.15 inches) diameter and a maximum of 12 cm (4.72 inches) diameter (Bour, 1988; 1990). Curren (1988) suggests similar management options for trochus management in Pohnpei State, Federated States of Micronesia. Current size limits in force in the Pacific for trochus are summarised in Table 2.7.6.

Table 2.7.6: Summary of size limits for trochus currently in force in the Pacific.

Country	Minimum	Maximum	Comments
Marshall Islands	3 ins	5 ins	survey result recommendations (FFA Rep. 89/20)
Pohnpei	3 in	none	
Kosrae	3 in	4 in	
Palau	3 ins	none	
Solomon Islands	8 cm	none	
Western Australia, Queensland	6.5 cm	10 cm	
Australia	8 cm	12.5 cm	
Papua New Guinea	8 cm	13 cm	under consideration
Vanuatu	9 cm	none	
Fiji	3.5 ins	none	
Cook Islands	8 cm	11 cm	
French Polynesia	8 cm	11 cm	
Okinawa, Japan	6 cm	none	

Trochus exploitation is not covered under the Marine Protection Act of 1994.

Asano (1991) recommends a minimum size limit of 80 mm basal diameter, closed seasons timed to occur around the months of peak spawning, banning the use of SCUBA for harvesting and establishment of sanctuaries.

There are currently no plans to establish value-added processing of trochus (eg. button blank production, etc) in Palau.

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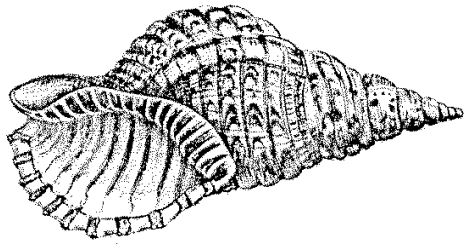
2.8 Other shellfish species

2.8.1 The Resource



debusech - *Charonia tritonis*

Species present: Various other shellfish species are collected in Palau for food, and include the following:

Gastropods
Cypraea tigris (tiger cowry- ***buich***);
Lambis lambis (spider shell - ***sang***);
Nerita maxima (snail - ***delsangel***), *N. undata* (***delsangel***);
Charonia tritonis (giant triton or Pacific trumpet shell - ***debusech***);
Conus spp. (cone - ***ototl***);
Cassis cornuta (horned helmet - ***omuu***);

Bivalves
Atactodea striata (nut clam - ***chesechol***), and *A. striata f. glabrata* (sand clam - ***chesechol***);
Nucula rugosa (***delebekai***)
Gafrarium tumidum? (venus shell - ***delebekai***);
Codakia interrupta (interrupted lucina - ***ilekum***);
Trachycardium flavum (clam - ***chesechur***);
Tapes literata (lettered venus - ***ebau***);
Pitar citrina (yellow pitar venus - ***edalngobel***).

Distribution: Most shellfish are habitat specific but are found in almost every type of marine habitat, from coral reefs and sand to silt and mud (Smith, 1992). They occur throughout the world but the centre of distribution and maximum diversity is generally considered to be the area of ocean bordered by Indonesia, Papua New Guinea and the Philippines.

Most of the species included here are harvested at low tide from the intertidal and subtidal zones in the tidal flats.

In Palau, Rochers and Matthews (1992) report ***ilekum*** as one of the important invertebrates in Kayangel and is one of the most important marine invertebrates north of Babeldaob (Maragos, 1994). The nut clam (***chesechol***) is also an important marine invertebrate resource in Melekeok, Ngarchelong, and ***delbekai*** is important in Ngchesar (Rochers and Matthews, 1992).

Matthews and Oiterong (1991) list habitats in Palau for the following shellfish species:

A. striata and *A. striata f. glabrata* (***chesechol***):- found in the surf zone along the shoreline. Rochers and Matthews (1992) noted that they are collected from sandy beaches;
Trachycardium flavum (?? - ***esechur***):- found between mangroves and reef in sandy areas where there is seagrass (*Enhalus* sp.) and is sometimes collected with *Anadara* sp.
C. tigris (***buich***):- live under rocks on barrier reef flat and fringing reef.
N. (*Amphinerita*) *maxima* and *N. undata* (***delsangel***):- collected from Rock Islands and Peleliu. They are found attached to rocks at low tide.
Conus sp. (cone shell - ***ototl***):- found in sandy areas.
L. lambis (spider shell - ***sang***):- often collected from sandy areas near rocks.

Biology and ecology: The *C. tritonis* shell can reach 40 cm or more in length and is usually found among corals on coral reefs. It feeds mainly on starfish, including *Culcita novaeguinea*, the blue starfish *Linckia laevigata* and the crown-of-thorns, *Acanthaster planci*, but also occasionally on holothurians (Wells *et al*., 1983). Maximum size is attained in up to six years. The female lays clumps of sausage-shaped egg capsules under protective rocks. Larvae are long-lived and have considerable dispersal abilities. Very little biological information is available on other species.

2.8.2 The Fishery

Utilization: During rough weather, lucina (***ilekum***) is collected from the beaches for subsistence use in Kayangel (Rochers and Matthews, 1992). In Melekeok, the nut clam (***chesechol***) are collected from sandy beaches about once every two months and is one of the important invertebrates there. It is one of the most important invertebrates reported in Ngarchelong. ***Delbekai*** is an important invertebrate in Ngchesar and is collected about once a month. ***Chesechol*** is collected from the beach in bad weather as needed source of protein when the sea is too rough to fish. It is sometimes sold by the bag of about 100 animals per bag and are usually cooked in their shells in soup (Matthews and Oiterong, 1991).

Mollucs typically collected and those collected in greatest numbers by Palauan women are presented in Table 2.8.1 as recorded in Matthews and Oiterong (1991) for seven states surveyed in 1991. Those covered under this particular profile are in bold. Overall, 65 per cent indicated that ***buich*** and ***sang*** are typically collected. Only women in Ngaraard identified ***chesechol*** (42 per cent) and ***delebekai*** (25 per cent) as species collected in greatest numbers, while only those in Koror (8 per cent) indicated ***delsangel*** as that collected in greatest numbers. All were for subsistence only.

Table 2.8.1: Molluscs typically collected and those collected in greatest numbers by Palauan women. Figures represent percentages of responses and those in brackets represent per cent of those collected for subsistence purposes only. (Source: Matthews and Oiterong, 1991).

	Aimeliik	Airai	Koror	Ngaraar	Ngardmau	Ngatpang	Ngeremlengui	Total
Mollusc species typically collected	n=7	n=8	n=12	n=12	n=7	n=3	n=5	n=54
Tridacna crocea	100	100	92	67	71	67	80	83
Anadara sp. & *Barbatia reeveana*	71	88	83	92	86	100	60	83
Anodonita edulata	100	88	50	83	71	100	100	80
Tridacna sp.	86	88	67	92	71	33	80	78
***Cypraea tigris* (*buich*)**	**57**	**100**	**67**	**67**	**43**	**67**	**40**	**65**
Lambis lambis (sang)	**57**	**100**	**67**	**67**	**43**	**67**	**40**	**65**
Mollusc species collected in greatest numbers								
Anodonita edulenta	86 (67)	88	50 (50)	83 (20)	86	100 (33)	100	80 (23)
Tridacna sp.	71 (60)	88	50 (33)	75 (22)	57 (25)	0	60 (33)	63 (26)
Tridacna crocea	86 (17)	88 (14)	92 (18)	0	14	33	60	54 (14)
Atactodea striata* & *A. striata f. glabrata (chesechol)	**0**	**0**	**0**	**42 (100)**	**0**	**0**	**0**	**8 (100)**
Anadara sp. & *Barbatia reeveana*	0	0	17 (100)	0	0	0	40	7 (50)
Nucula rugosa (delebekai)	**0**	**0**	**0**	**25 (100)**	**0**	**0**	**0**	**6 (100)**
***Nerita maxima* & *N. undata* (delsangel)**	**0**	**0**	**8 (100)**	**0**	**0**	**0**	**0**	**2 (100)**

Matthews and Oiterong (1991) listed cowrie (***buich***), spider shell (***sang***) and venus shell (***delebekai***) as species collected for subsistence use only.

Production and marketing: There is no data available on production of shellfish species included in this profile. This is mostly due to the nature of the fishery they are involved in, i.e. subsistence. The nut clam (***chesechol***) has been reported as sometimes sold by the bag of about 100 animals per bag (Matthews and Oiterong, 1991)

2.8.3 Stocks Status

Results from interviews in the 1991 Matthews/Oiterong survey indicated only women in Ngaraar (8 per cent in that state) notice that it was harder to find *Conus* spp. (***ototl***). No other information exists on stocks of shellfish species included in this profile for Palau.

2.8.4 Management

One of the important shellfish species included in this profile, concerning ecology on coral reefs, is the giant triton or Pacific trumpet shell, *C. tritonis* (***debusech***). It is a predator of the coral eating starfish, crown-of-thorns, *Acanthaster planci*. The species has been a target of the shell trade and is listed as threatened in the IUCN Red Data Book.

Current legislation/policy regarding exploitation: There are no regulations that specifically address the exploitation of shellfish included in this profile.

Recommended legislation/policy regarding exploitation: Due to the absence of commercial fishery that specifically targets these species, regulations do not seem to be necessary at this stage. However, a potential threat to these resources is the destruction of habitat from other activities, such as destructive fishing methods and land-based development.

In countries where shell trade (both local and export) takes place, a minimum size limit of 20 cm in length, when measured along the outside of the shell from one end to the other of the giant (trumpet) triton, *C. tritonis* (***debusech***), is applied for harvesting this species. The prohibition of the export of *C. tritonis* for commercial purposes has also been applied. Application of minimum size limits to other shellfish species, especially those in the artisanal fishery, is a possible management strategy. However, biological research into the appropriate areas concerning those species would be required first. In addition, minimum size limits seem to be only practical when applied to the selling and buying, but not on subsistence harvesting.

Regulations that have been suggested in other countries where shell trade of these species is important, include; restriction on harvesting areas and annual rotation together with the banning of the use of SCUBA or dredging in the collecting process. For the Federated States of Micronesia (FSM), Smith (1992) recommended prohibition of the collection of shells listed as threatened in the IUCN Red Data Book especially the giant triton, *C. tritonis*. This is presumably directed at the collection of shells for the shell trade, not including the subsistence fishery.

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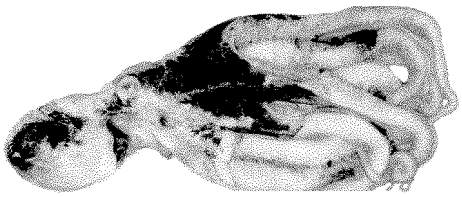
2.9 Octopus, squid and cuttlefish - *bukitang, luut* and *milengoll*

2.9.1 The Resource



bukitang - *Octopus* sp.

Species present: One species of each of octopus, squid and two cuttlefish species have been reported as occuring in Palau and contributing to the local small-scale commercial and subsistence fisheries. The species are:

Octopuses: *Octopus* sp. (***bukitang***);
Octopus cyanea (the big blue octopus) was reported by Birkeland and Richmond (1992) in two sites during surveys of 47 sites from Velasco Reef to Anguar;

Squids: *Loligo* sp. (squid - ***luut***);

Cuttlefishes: *Sepia latimanus* (the broadclub cuttlefish - ***milengoll***). Richmond (1991, cited in Maragos, 1992) reported *S. esculenta* (the golden cuttlefish) in one site in a survey on coral reefs offshore from Ngeremeduu and sites in eastern Babeldaob and the Rock Islands. However, the later could be a mis-identification as the known geographical distribution of *S. esculenta* is in the South China Sea (north of central Philippines) and East China Sea (Japan, excluding Hokkaido).

Roper *et al*. (1984) presented known geographical distributions of cephalopod species of the world giving some indication that the following species may occur in Palau waters:

Cuttlefishes: *Sepia pharaonis* (Pharaoh cuttlefish);

Squids: *Loligo duvauceli* (Indian squid); *Sepioteuthis lessoniana* (bigfin reef squid); *Onychoteuthis* (*Loligo*) *banksi* (common clubhook squid); *Ommastrephes* (*Loligo*) *bartrami* (neon flying squid); *Symplectoteuthis* (*Loligo*) *oualaniensis* (purpleback flying squid); *Thysanoteuthis rhombus* (*nuchalis*) (diamondback squid);

Octopuses: *Octopus cyaneus* (big blue octopus), *O. embranaceus* (webfoot octopus);

Argonaut (paper nautilus): *Argonauta argo* (greater argonaut).

Distribution: Geographical distribution of cuttlefishes of the family Sepiidae is restricted to the Old World, thus it is absent from the Americas (Roper *et al*., 1984). They are primarily demersal inhabitants of nearshore and continental shelf zones in warm and temperate waters. Their habitats range from rocky, sandy and muddy bottoms to grassflats, saweed beds and coral reefs. *S. latimanus* is distributed in the Indo-Pacific region from southern Mozambique, throughout the periphery of the Indian Ocean, Coral Sea, Melanesian Islands, South China Sea, Philippine Sea and East China Sea to southern Japan (Roper *et al*., 1984).

Squids of the family Loliginidae (inshore squids) inhabit all shelf and upper slope areas of the world's oceans except the polar seas and are demersal or semipelagic inhabitants of coastal and continental shelf areas to a maximum depth of about 400m (Roper *et al*., 1984). Some species are restricted to extremely shallow waters with some penetrating into brackish waters. They aggregate near the bottom during the day and disperse into the water column at night.

Roper *et al*. (1984) noted that most octopuses are benthic and representatives of the family are usually encountered throughout the world from the coast down to at least 1,000 m depth. "Many have

cryptic habits hiding in crevices, empty mollusc shells and seagrass beds during the day and hunting at night, while others occur over open trawlable bottoms". *O. cyaneus* occurs throughout the Indo-Pacific region, from East Africa to Hawaiian Islands in tropical and warm waters including the Red Sea, India and Australia. It is a benthic species occurring in shallow waters on coral reefs, and unlike other octopuses, it hunts during daylight hours (Roper *et al*., 1984).

Rochers and Matthews (1992) report that octopus (***bukitang***) is abundant and are most easily caught in May and June in Peleliu.

Biology and ecology: As in all cephalopods, sexes in octopuses are separate, exhibiting external sexual dimorphism, either in structure or size. Females are generally larger than males. Prior to mating there is often an elaborate mating ritual involving colour changes and touching of tentacles. One of the male's tentacles is modified to carry sperm to the mantle cavity of the female, and eggs are usually brooded while they develop directly into tiny adult form (Smith, 1992). They actively prey on crustaceans, fish and molluscs and are usually solitary (Roper *et al*., 1984). Octopuses are preyed upon by tunas, billfishes, sharks, rays and moray eels. *O. cyaneus* has a maximum total length of 120 cm and weight of 4 kg.

Most inshore squids have extended spawning season with peaks in spring or early summer and in fall. Eggs are encapsuled in gelatinous, fingerlike strings and are attached to various substrates. Hatchlings resemble adults (Roper *et al*., 1984). Inshore squids are short-lived, reaching maturity in about one year and having a life span ranging between 1 and 3 years. They predate on crustaceans and small and juvenile fishes.

In cuttlefishes, spawning takes place with an increase of water temperature. During mating, males use their modifid arm to transfer spermatophores to the females (Roper et al., cited above). Females spawn few but large eggs which they attach in grapelike clusters to plants, debris, gravel and other substrates. Sexual maturity is often reached within a few months after hatching and longevity rangs from between 1 and 3 years. Post-spawning mortality is usually high. Cuttlefishes are opportunistic, subdominant predators, preying on crabs, shrimps and small fishes.

2.9.2 The Fishery

Utilization: Octopus is one of the important reef invertebrate species in Peleliu (Maragos, 1994). A limited amount has been recorded in the local small scale commercial fishery. No data is available that suggests the level of utilization of these resources in the subsistence level. Limited amounts of octopus, cuttlefish and squid have been recorded in commercial purchases of fishery products at the local markets.

Production and marketing: There is no available data on the level of production (consumption) of octopus, squid and cuttlefish in the subsistence sector. Perron *et al*. (1983) recorded commercial marine animal landings at PFFA for the 1976-1981 year period and recorded only 15 lbs (worth $3) of ***bukitang*** in 1977. Data obtained from the commercial fish markets by DMR for the 1991-1993 period is given in Table 2.9.1.

Table 2.9.1: Invetebrates purchased at PFFA, Oh's, PMCI or Melekeok Cooperative from 1991 to 1993. (Source: 1991-DMR Data; 1992-DMR Annual Report for 1992;1993-DMR data).

Species	1991*[1]		1992*[2]		1993*[3]	
	Wt (lbs)	Value (US$)	Wt (lbs)	Value (US$)	Wt (lbs)	Value (US$)
Octopus (*bukitang*)	**141.50**	**176.88**	**274.00**	**341.00**	**12.00**	**12.5**
Cuttlefish (*milengoll*)	**85.00**	**107.75**	**149.00**	**187.00**	**0**	**0**
Squid (*luut*)	**47.00**	**58.75**	**122.00**	**153.00**	**28.80**	**35.94**
Crab (***kmai***)	3.25	13.00	14.00	28.00	0	0
Coconut crab (***ketat***)	138.25	623.63	75.00	305.00	11.00	44
Giant clams (***kim***)	178.50	89.25	91.00	158.00	124.00	62
Stingray (***rrull***)	874.00	719.23	670.00	517.00	93.00	74
Trochus meat (***semun***)	?	?	323.00	323.00	1,037.00	1,037

*[1] PFFA, PMCI, and Oh's (10 months);
*[2] PFFA, PMCI (excluding May) and Oh's (excluding January, October and November);
*[3] PFFA (January-September), PMCI (January-September) and Oh's (January-May).

Total commercial fisheries landings as reported in the UN Report, Agriculture, Marine Resources and Conservation/Entomology Divisions for the 1992 fiscal year (Oct 1, 1991-Sept. 30, 1992) is given in Table 2.9.2 for molluscs for the three major commercial outlets (PFFA, PMCI and Oh's market). There is a vast difference between these data and those recorded by DMR for the same year as presented in Table 2.9.1 above.

Table 2.9.2: Mollusc landings for three major outlets, PFFA, Oh's and PMCI for the 1992 fiscal year (Oct. 1, 1991 - Sept. 30,1992).

Mollusc species	Weight (lbs)	Value (US$)
Squids, Octopus and cuttlefish	**1,121**	**1,332**
Crab	20,387	81,214
Lobster	8,717	34,356
Shellfish	414	481
Stingray	798	626

Note: Oh's market data excludes Jan., 1992 and those from PMCI excludes May, 1992. (Source: UN Report. Agriculture, Marine Resources and Conservation/Entomology Divisions, October, 1992).

The only export figures of these resources are those recorded on Continental Air Micronesia manifests. However, these exports were made with other foodstuff and weights recorded included those of packaging (Source: DMR 1992 Annual Report and Kitalong and Oiterong, 1991):

Declared item	1990		1991		1992	
	Count	Gross wt (lbs)	Count	Gross wt (lbs)	Count	Gross wt (lbs)
Frozen squid	1	39				
Squid /Others	1	151				
Fish (frozen)/Octopus					1	111
Fish/Squid/Others			2	220	1	45
Octopus					1	42
Octopus/Bats					1	34
Squid/Other					1	90

2.9.3 Stocks Status

There is no information available on the stocks of octopuses, squids and cuttlefishes in Palau. In surveys of 26 sites on coral reefs offshore from Ngeremeduu, eastern Babeldaob and the Rocks Islands, Richmond (1991, quoted in Maragos, 1992) observed only *S. esculata* in only 1 site. Birkeland and Richmond (1992) observed only *O. cyanea* in only 2 sites of the 47 surveyed between Velasco Reef and Anguar.

2.9.4 Management

Current legislation/policy regarding exploitation: There is no existing legislation that deals with the exploitation of octopus, squid and cuttlefish resources in Palau.

Recommended legislation/policy regarding exploitation: Due to the apparent absence of a large scale or commercial fishery based on the cephalopod resource in Palau, no policy seems to be required. Their habitats are indirectly included in the consideration on habitat destruction from other activities and destructive fishing methods.

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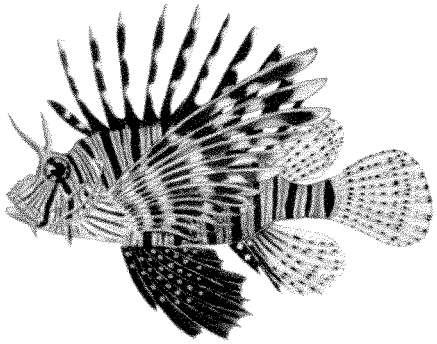
3. FIN-FISHES

3.1 Aquarium fish

3.1.1 The Resource



Pterois volitans

Species present: A comprehensive listing of individual species is given in Appendix 3.1. Species targeted for this enterprise involve those which are small in size and have bright or ornate colouration. Other important species' features that are considered include non-restrictive diets and overall adaptability to a captive environment (Pyle, 1993). Records of exports indicate that some of the species, sometimes at juvenile stage, are those that form a portion of the catch in the local artisanal and subsistence fisheries. Due to the numerous species involved, species collected for aquarium purposes can be categorized under their families. The more important ones included; Acanthuridae (surgeonfishes and tangs), Balistidae and Monacanthidae (triggerfishes and filefishes), Blenniidae and Gobiidae (blennies and gobies), Chaetodontidae (butterflyfishes), Cirrhidae (hawkfishes), Labridae (wrasses), Pomacanthidae (angelfishes), Pomacentridae (damselfishes) and Serranidae (groupers and basslets).

Export data avaiable also indicate that the non-finfish marine species (hard corals, soft corals, and shellfish) are important in this trade. In particular, increases in species composition have been noted for corals (including soft corals), giant clams and anemones. However, discussion in this section is limited to fin-fish, as the other organisms are treated separately in their respective profiles, except for a comparative composition made in the production section.

Donaldson (1992) notes that the Palauan fauna is certainly the most diverse in all of Micronesia but has the least number of endemic species compared to other Micronesian localities.

Distribution: Fish exploited for the aquarium trade in Palau, as is done in other South Pacific islands, are all wild-caught marine species mostly from the shallow-water coral reefs surrounding the islands. However, in some countries and for certain species, depths where collection take place can be very deep. For example, in Cook Islands, habitat depths for most of the commercially valuable aquarium fish species on Rarotongan reefs range from about 8 to 30 m (Richards, 1993).

Aquarium fish collecting operations occur mostly in shallow water, but specimens are collected from as deep as 120 feet (40 m) of water. Fish species collected from deeper waters include the Anthias and pygmy angel (*Centropyge flavicauda*).

It was not possible to obtain catch data from specific sites where collections have taken place in Palau. However, the company currently operating has licenses to collect from the States of Airai, Koror and Ngechesar. Licence fees have been US$500-750 (per annum or conditional).

Rochers and Matthews (1992) report aquarium fish were being collected off Melekeok’s shores.

Amesbury (1991) recorded 277 fish species from surveys in 26 sites in the Ngeremeduu study area. But it was noted that additional species occur within the bay but were not seen during the surveys. Large shoals of snappers (especially *Lutjanus gibbus*) and fusiliers (Caesionidae) were observed. The number

of species counted, as belonging to particular fish families, are as follows:

Family	No. of species	Family	No. of species	Family	No. of species
Acanthuridae	8	Lethrinidae	5	Pomacentridae	21
Blenniidae	4	Lutjanidae	3	Scaridae	9
Caesionidae	3	Microdesmidae	1	Serranidae	2
Chaetodontidae	12	Monacanthidae	1	Siganidae	3
Haemulidae	2	Mullidae	2	Synodontidae	1
Holocentridae	4	Nemipteridae	2	Tetraodontidae	1
Labridae	24	Pomacanthidae	5	Zanclidae	1

Donaldson (1992) reported results of the distribution patterns of the marine fishes in Palau during the the Rapid Ecological Assessment of 1992. The findings are summarised in Table 3.1.1. The highest number of species observed were recorded from Kossol, Kayangel and Peleliu-south/west.

Table 3.1.1: Distribution pattern of marine fishes in Palau. (Source: Donaldson, 1992).

Area	No. fish species observed	Per cent fish species known	Wide-ranging species observed
Kayangel	467	60.5	*Hippsocarus longiceps, Scarus sordidus, Ctenochaetus striatus, Cephalopholis, urodeta, Paracirrhites arcatus, Chromis margaritifer, Halichoeres hortulanus, Labroides dimidiatus and Balistapus undulatus.*
Kossol	495	64.1	*Zanclus cornutus, Pygoplites diacanthus, Scarus sordidus, Ctenochaetus striatus, Scarus schlegeli, Balistapus undulatus, Chaetodon trifasciatus, Centropyge bicolor, C. vrolicki, Chromis margaritifer, Pomacentrus vaiuli, Cheilinus undulatus, Halichoeres hortulanus, Thalassoma amblycephalum, Labroides dimidiatus and Acanthurus nigrofuscus*
Eastern Babeldoab	337	43.7	*Acanthurus nigrofuscus, Parupeneus barberinus, Labroides dimidiatus, Zanclus cornutus, Chaetodon vagabundus, Henichus chrysostomus, Halichoeres hortulanus and Thalassoma harwicki.*
Western Babeldoab	374	48.5	*Chaetodon ephippium, Hemigymnus melapterus, Labroides dimidiatus, Scarus sordidus and Zebrasoma scopas.*
Koror-Rock Islands	343	44.4	*Parapeneus barberinus, Chaetodon ephippium, Cheilinus fasciatus, Epibulus insidiator, Scarus dimidiatus, Acanthurus pyroferus, Zanclus cornutus and Balistapus undulatus.*
Peleliu-South/West	423	54.8	*Acanthurus nigrofuscus, Parapeneus bifasciatus, Chaetodon ephippium, C. kleini, C. trifasciatus, Chromis margaritifer, Pomacentrus vaiuli, Hippsoscarus longiceps, Ctenochaetus striatus, Naso lituratus, Balistapus undulatus and Sufflamen chrysoptera.*
Angaur	346	44.8	*Ctenochaetus striatus, Chaetodon citrinellus, Labroides dimidiatus, Acanthurus nigricans, A. olivaceus and A. pyroferus.*

Biology and ecology: Pyle (1993) gives the following table of some biological and ecological characteristics of the main fish families in the marine aquarium trade from the South Pacific:

Family	**Feeding Strategy**	**Reproductive Strategy**	**Habitat**
Angel fishes (Pomacanthidae)	herbivore/omnivore	harem-forming/pair-forming; some species protogynous; spawn at dusk; pelagic eggs	shallow to deep reef; rubble/coral
Butterfly fishes (Chaetodontidae)	omnivore/plantivore/ corrallivore	pair-forming/school-forming; pelagic eggs	shallow to deep reef; coral and ledges
Surgeonfishes and Tangs (Acanthuridae)	herbivore	school-forming; spawn at dusk in large groups; pelagic eggs	all habitats, depending on species
Wrasses (Labridae)	omnivore	harem-forming/school-forming; protogynous; spawn at all time of day (depending on species); pelagic eggs	all habitats, depending on species
Groupers and Basslets (Serranidae)	carnivore/herbivore/ planktivore	harem-forming/pair-forming/aggregate forming; protogynous; spawn at dusk; pelagic eggs	all habitats, depending on species; Anthiinae form aggregation
Damselfishes (Pomacentridae)	herbivore/plantivore/ omnivore	harem-forming/aggregate-forming; spawn in morning; demersal eggs	shallow reef coral/rubble; *Amphiprion* inhabit sea anemones
Triggerfishes and Filefishes (Balistidae and Monacanthidae)	omnivore	harem-forming/aggregate-forming; demersal sometimes pelagic eggs; some species build nests	all habitats, depending on species; refuge in holes on reef
Hawkfishes (Cirrhitidae)	carnivore	harem-forming; spawn at dusk; pelagic or demersal eggs	shallow reef often in association with coral
Blennies and Gobies (Blenniidae and Gobiidae)	omnivore	wide variety of reproductive strategies, depending on species	all habitats, depending on species

No specific study has been conducted in Palau on aspects of the fin-fish species exported in the aquarium fish trade.

3.1.2 The Fishery

Utilization: The Economic Development Plan (Fiscal Years 1995-1999, Volume 1) reports that export of ornamental aquarium organisms by the private sector began in 1991. Apart from exports of giant clams by MMDC, there has only been one private company exporting aquarium fish at any one time in Palau. Operation of the original company, Palau Aquatics, was taken over by Palau Biotech Inc., in September, 1993.

Rochers and Matthews (1992) report that people interviewed in Melekeok in 1992 claimed that a boat with about 20 men were collecting aquarium fish everyday from Melekeok waters. No indication on the types of fish and the amount collected were available.

The sole aquarium fish exporter from Palau has markets in both USA and Japan. About 85-90 per cent of the exports are to the US market. All coral exports were to the US market and not to Japan because of CITES regulations. Palau exports to the US were treated as shipments within the US.

The owner and president of Palau Biotech., Inc. is Palauan. He employs two expatriates as sales and operation managers, working under contracts. The company normally employs 6-8 divers during a normal collection operation with 2 using the hookah, 2 free divers and 1-2 invertebrate divers. In total, during normal operation, the whole setup employs about 20 people. In the past, the company used to contract about 6 outside collectors who collect and sell to the company.

The main method of collecting fish involves the use of barrier nets, which can be operated individually or by two divers. Fish are herded towards the net and are either hand-picked or scooped.

The land-based operation utilizes two water systems for holding marine animals. The open system is for corals in which the water is pumped directly from the sea and flows back to the sea. Seawater is not treated. The closed water system is used for holding finfish and is treated with nitrofurazone as an antibiotic (at 0.027 grams/gallon) and copper sulphate (level maintained at < 2 ppm) as a parasite treatment. The water is re-circulated and maintained at the specific gravity of 1.018-1.09. The closed system has three separate pumps which all feed through three separate biological filters and move approximately 12,000 gallons of water. Water in the closed system is normally changed about once a week. Water used for shipping animals is ultraviolet treated.

The company buys its giant clams from MMDC and exports them to their overseas markets.

Production and marketing: The first company, Palau Aquatic, started operation 3-4 years ago (1990). The current company, Palau Biotech Inc., took over in September, 1993 and is the only company in operation. The company management claimed that 30-40 per cent of their weekly requests for aquarium animals are turned down due to several factors. One of the problems currently faced is the competition with the tuna exporters for space on the commercial airline. There is only one airline (Continental Air Micronesia) serving the Republic of Palau. The 1993-94 levels of export were limited by space availability on the airline.

Mortality in the holding tanks is about 2-5 per cent. Any sick fish is put back to the sea. Mortality during shipment to the overseas market is also about 2-5 per cent. However, mortality to the Japanese market is almost nil.

Air cargo export for January-November 1990, excluding September, from Continental Air Micronesia manifests recorded only 202 lbs (91 kg) of live aquarium fish export for that year. This weight includes packaging material.

DMR 1991 Annual Report recorded the following as Continental Air Micronesia cargo in 1991:

Type	Count	Gross wt (lbs)	Destination
Aquarium fish	2,280	91,952	California
Aquarium fish/Inshore fish/ Crab/Lobster	27	2,001	Hawaii
Aquarium fish	371	15,466	Los Angeles
Aquarium fish	45	1,831	San Francisco
Aquarium fish/Swordfish	1,066	33,129	USA

Table 3.1.2 gives export records of aquarium products from air freight cargo declared on manifest for the Continental Air Micronesia, for 1991 and 1992.

Table 3.1.2: Export records of aquarium products as recorded on Continental Air Micronesia manifests for 1991 and 1992. (Source: DMR Annual Report for 1992).

	1990		1991		1992	
	Count	Gross wt (lbs)	Count	Gross wt (lbs)	Count	Gross wt (lbs)
Live fish	3	3,412				
Live clam			3	158	209	7,304
Live fish (aquarium)			3,894	147,408	5,738	230,328
Fish(live)/fish eggs					2	66
Fish/Clam (live)					2	177

Table 3.1.3 gives details of aquarium fish species exported in 1992 and 1993. Only one “normal” shipment was made in 1994 (April). Of the finfishes, chromis dominated exports during 1992, accounting for almost 70 per cent of the total number of fishes exported. Other fishfishes of importance in terms of numbers exported in the same year include, damselfishes, butterflyfishes, wrasses and surgeonfishes. In 1993, damselfishes dominated finfish exports accounting for almost 60 per cent of the number of pieces. Other important fishes exported during 1993 include, chromis, wrasses, butterflyfishes and triggerfishes. Mollusc exports for both years were dominated by giant clams both in numbers and value. Crustacean exports in 1992 were mostly hermit crabs but in 1993, there were more crabs exported. Exports of echinoderms in 1992 were dominated by sea urchins but in 1993, Sinularis dominated this category. Other important echinoderms include, soft and hard corals and starfish.

Table 3.1.3: Export of aquarium marine products during 1992 and 1993. The 1993 exports were only for the period September-December. (Source: DMR data).

	1992		1993	
	Nos.	US$	Nos.	US$
FINFISH				
Angelfish	721	1,167.25	969	2,787.20
Anglerfish	11	32.00		
Basslet	612	1,112.55	417	970.20
Batfish	4	3.20		
Blenny	401	401.00	454	544.80
Birdfish	173	503.00		
Boxfish	6	9.00	5	9.00
Butterfly	2,635	4,247.20	1,088	1,886.20
Cardinalfish	278	139.00	457	277.20
Catfish	290	43.50		
Chromis	32,264	8,146.65	6,039	1,690.92
Clownfish	358	482.25	230	210.30
Cowfish	1	1.00		
Damselfish	2,705	502.65	17,953	6,918.46
Dottyback	1	1.50	1	0.60
Dragonet	88	220.00		
Eel	7	35.00	9	22.60
Filefish	37	28.10	20	24.10
Flatfish			1	15.00
Flounder	2	6.00	1	3.60
Frogfish			4	9.60
Fussilier	75	150.00	14	33.60
Goatfish	23	20.70	27	20.15
Goby	716	622.00	73	112.20
Grouper	7	9.00	20	31.80
Hawkfish	136	92.80	26	24.70
Hogfish	47	94.00		
Lionfish	16	12.00		
Moorish Idol	157	188.40	89	129.05
Parrotfish	17	51.00	211	391.60
Pipefish	1	0.50	1	0.60
Pompano	6	18.00		
Puffer	74	96.30	66	95.60
Rabbitfish	8	16.00	60	405.20
Remora	2	3.00		
Sandperch	4	4.00	10	25.80
Scorpionfish	40	88.25	119	524.70
Shark	2	100.00	8	480.00
Snapper	10	42.00	4	7.20
Spinecheek	1	1.00		
Squirrelfish	14	14.00	10	12.00
Stingray	1	10.00		
Stonefish	8	4.80	11	7.70
Surgeonfish	1,296	3,421.50	346	908.50
Swallow	18	62.00		
Sweetlips	4	6.00	21	50.40
Trevally			1	3.60
Triggerfish	1,100	2,760.50	1,038	1,752.10
Trumpetfish	11	66.00		
Unicornfish	41	41.00	306	626.40
Wrasse	2,287	3,314.95	1,162	1,853.60
Finfish Total	**46,716**	**28,390.55**	**31,271**	**22,866.28**

	1992		1993	
	Nos.	US$	Nos.	US$
CRUSTACEANS				
Hermit crab	723	752.50	501	554.90
Crab	367	416.45	774	830.20
Shrimp	164	313.40	71	153.30
Crustacean Total	**1,254**	**1,482.35**	**1,346**	**1,538.40**
ECHINODERM				
Anemone	16	67.00	40	134.60
Coral			474	1,185.80
Polyrock			48	1,440.00
Sea cucumber	54	81.00	22	37.40
Sea squirts			10	6.00
Sinularis			1,114	8,247.00
Soft Coral			669	2,647.50
Starfish	253	268.85	702	850.40
Sea urchin	330	286.00	346	621.90
Worms	164	101.50	2	3.60
Echinoderm Total	**817**	**804.35**	**3,427**	**15,174.20**
MOLLUSC				
Abalone	206	309.00	135	243.00
Cowry			155	214.80
Cuttlefish	42	73.50	3	18.00
Giant clam	1,823	4,405.00	1,500	7,845.20
Nudibranch	62	89.50	98	200.10
Octopus			2	9.60
Scallop			6	15.60
Sea hare	173	259.50	33	79.80
Sea slug	211	283.30		
Sea snail	5	6.80		
Sea squirts	3	1.50		
Turbo	399	239.40	565	406.80
Mollusc Total	**2,924**	**5,667.50**	**2,497**	**9,032.90**
OTHER				
Algae			4	2.00
Jellyfish	125	125.00	8	9.60
Other Total	**125**	**125.00**	**12**	**11.60**

Species composition details are attached as Appendix 3.1.

According to the Economic Development Plan (Fiscal years 1995-1999 Volume 1) 38,553 live fish, worth US$48,600, were exported as ornamental aquarium organisms by the private sector in 1993 and that 220,000 organisms, mainly cultures clams, valued at $220,000, were shipped during 1992.

Attempts by the aquarium fish company and MMDC have been initiated in the propagation of corals (both hard and soft) by cutting and replanting method as described under the Corals Profiles.

3.1.3 Stocks Status

Fish fauna in Palau is the most diverse in all of Micronesia but has the least number of endemic species compared to other localities in Micronesia (Donaldson, 1992). Myers (1989) lists 892 species of Micronesian fishes found in Palau. Five inshore fish species were identified as endemic to Palau. A recent rapid survey resulted in the observation of at least 733 fish species from 61 families (out of 98 reported for Palau) on transects in the main Palau Islands, at Kayangel, Kossol, Eastern Babeldoab, Western Balbeldoab, Koror-Rock Islands, Peleliu-South/West and Angaur (Donaldson, 1992). Of these, approximately 136 were new records. "The ten most speciose in the main Palauan islands were the Gobiidae (95), Labridae (87), Pomacentridae (80), Serranidae (45), Acanthuridae (36), Scaridae (34 + 2 hybrids), Chaetodontidae (34), Blenniidae (28), Apogonidae (27), Lethrinidae (18) and Holocentridae (18). Kossol area was found to have the most diverse fish assemblage compared to other areas of the main Palau islands. Kayangel was found to have the second highest diversity followed by Angaur, Eastern Babeldoab, Peleliu-Southwest, Western Babeldoab and Koror-Rock Islands (Donaldson, cited above). However, these surveys did not record species densities.

Amesbury (1991) noted that fish diversity in Ngeremeduu Bay is quite high. Quantitative estimates of fish in two survey sites indicated fish densities ranging from 96 to 405.5 fish per 100 m^2. The wide range in densities was attributed to the patchiness and aggregating behaviour of some fish, e.g. huge schools of snappers and fusiliers were observed during these quantitative surveys.

Comparing fish populations in the main Palau islands and those of unfished populations of the south-west islands, Donaldson (1992) noted that commercial fishing in the main Palau islands has an impact on fish population there, where groupers, jacks, trevallies, snappers, emperors and parrotfish were either absent or present in very low numbers. Maragos (1994) presumed that this was also the case in isolated areas such as the northern and western lagoon where species richness and abundance were far below those of the average reefs in the south-west Palau islands.

3.1.4 Management

Pyle (1993) gives a comprehensive review of literature on the different views on the effects and management strategies of the aquarium fish trade undertakings in different countries. In small countries like those in the South Pacific, where in most cases, only one or two operators (exporters) are involved, exploitation guidelines seem to be sufficient. Apart from the removal of fishes, damage to habitats is perhaps a major concern. This can result from the breaking up of corals either incidentally in the process (anchorage, divers' fins or walking on them) or deliberately to extract a valuable fish specimen hidden in a coral-head. However, the greatest concern involves the use of destructive collecting methods such as sodium cyanide.

Current legislation/policy regarding exploitation: The *Marine Protection Act of 1994*:

Section 4 (1) prohibits commercial fishing for *Plectropomus areolatus, P. laevis, P. leopardus, Epinephelus microdon* and *E. fuscoguttatus* from April 1 to July 31.

Section 4 (2) prohibits commercial fishing for juvenile (less than 25 inches in length) parrotfish, *Bolbometopon muricatum* and juvenile wrasse, *Cheilinus undulatus.*

Section 4 (3) prohibits commercial export or fishing, selling or buying for commercial export of adult parrotfish (*B. muricatum*) and wrasse (*C. undulatus*).

Section 4 (4) prohibits the fishing for commercial purposes, sell or buy rabbitfish (*Siganus*

canaliculatus) from March 1 to May 31.

Section 4 (6) prohibits the use of any form of underwater breathing apparatus other than a snorkel to fish.

Section 4 (7) prohibits the commercial export of black teatfish (*Holothuria nobilis*), white teatfish (*H. fuscogilva*), prickly redfish (*Thelenota ananas*), surf redfish (*Actinopyga mauritiana*), sandfish (*H. scabra*), humphead parrotfish (*B. muricatum*), coconut crab, mangroce crab, rock lobster (*Panulirus longipes fermoristriga*, *P. versicolor*, *P. penicillatus*) and wrasse (*C. undulatus*), except cultured species thereof.

Section 4 (11) prohibits commercial export of giant clams or part thereof except cultured species.

Section 4 (13) prohibits fishing with a gill net or surround net having a mesh size of less than three inches measured diagonally.

Section 5 of the Act deals with permits and aquarium fish. The taking of fish for local aquarium use and for scientific research, mariculture research or medical research is allowed only with a valid and current permit from the Minister or his designee.

Section 6 enpowers the Minister to promulgate such regulations regarding as he deems necessary to protect the species identified in Section 4 from overharvesting, or to otherwise carry out the purposes of the Act.

Regulations on the Collection of Marine Resources for Aquaria and Research:-

Section 3 requires that any person taking or attempting to take more than five specimens or pieces of aquarium species, except cultured specimens, for aquarium purposes, local aquarium use, or for scientific, maricultural or medical research in a single day, must have an Aquarium Collecting Permit.

Section 4 limits the number of Aquarium Collecting Permits to twenty a year.

Section 5 makes only Palauan citizens eligible for Aquarium Collecting Permits starting January 1, 1997.

Section 9 prohibits the use of poisons to catch fish, and the use of any other collecting gear, except hand nets, barriers nets, drop nets, wads, and buckets is prohibited unless permitted by a Marine Research Permit.

Section 10 prohibits collection from an area off-limits to such collecting or fishing as stated in any National or State law or regulations or traditional ***bul***.

Section 11 prohibits the export of corals, marine rock, sponges and giant clams except cultured speciemens. Specimens of corals or marine rock taken incidentally in dredging can be exported.

Recommended legislation/policy regarding exploitation: Collection of accurate and consistent data is important. A consideration here is the inclusion of a regulation for anyone engaged in fishing, fish processing, fish marketing or the export of fish or fish products to provide to the Chief (DMR) such information relating to such fishing, processing, marketing or export activities and in such form as may be prescribed.

A policy statement could be developed giving guideline as to the harvesting of marine animals for aquarium purposes. Some areas that can be covered by such a statement include:

- submission of detailed catch statistics per site of collection prior to a shipment is made. Summary of species to be shipped (including numbers and estimated value) each time an application for export is made. For ease of databasing by DMR, recording of statistics by species on packing list forms should be made under separate headings such as, fin-fish, corals, soft corals, crustacean, bivalves, echinoderms etc. Fin-fish can be broken down to further subheadings to account for the different families.

- establishing means for ease identification and monitoring of collection vessels. Non-authorisation of shipments by the Bureau shall be the penalty for not complying.

- standing requirement for operator to notify DMR to inspect packaging of animals for each shipment to be made.

- requirement for operator to notify DMR of all collection expeditions before they take place detailing areas and dates so that if necessary, DMR staff will accompany such collecting expeditions.

- advocate increased Palauan participation and discourage factors that hinder the transfer of technology to Palauans. In order to increase the spread of the benefits to local people and improve the chance for local operators in this industry, a training component in all aspects of the industry would be necessary.

In the absence of biological information on which to base decision, it would be beneficial to limit the number of aquarium fish operators until proper assessment of the resource is completed.

Lewis (1985) listed Exploitation Guidelines used in Fiji for the aquarium fish trade as follows:

1. Operators exporting live fish should be licensed and limited to a single operator giving the sole operator a 12-month period of grace.

2. Future operators should be of a high international repute with a proven record in the trade.

3. Involvement of resource custodians in the collection process should be to the maximum extent practicable. There should be a training component in this process

4. The use of chemicals or poisons for collection to be prohibited.

5. Export permits required for each shipment, with quantities and species to be noted.

6. Conservation guidelines to be formulated by the Fisheries Division in consultation with the operator. A ceiling on the total number of fish exported per year to be set, taking into account the area to be fished.

7. Efforts should be made to ensure that collection activities do not conflict with other uses e.g. tourist diving, subsistence/artisanal fishing.

8. With a single moderate-level operator it is not necessary at this stage to consider reserves, closed-seasons and other conservation measures. The Fisheries Division should however closely monitor the development of this trade.

A sample form for the recording of fishing statistics by the operators is attached as Appendix 3.1.2.

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Appendix 3.1.2: Suggested form used for the collection of aquarium fish catch data.

AQUARIUM FISH CATCH DETAILS FOR EACH SITE	
Operator (company):	License number:
Collection (dive) date:	Number of collectors (divers):
Catching method used:	SCUBA used?:
	Hookah used?:
Area of collection (dive):	Specific area within site:
*[1]Time collection (dive) start:	*[1]Time collection (dive) finish:
Collection (dive) duration (in hours and minutes):	

CATCH DETAILS OF THE ABOVE OPERATION					
FIN-FISH		INVERTEBRATES		INVERTEBRATES	
Species	Total #	Species	Total #	Species	Total #

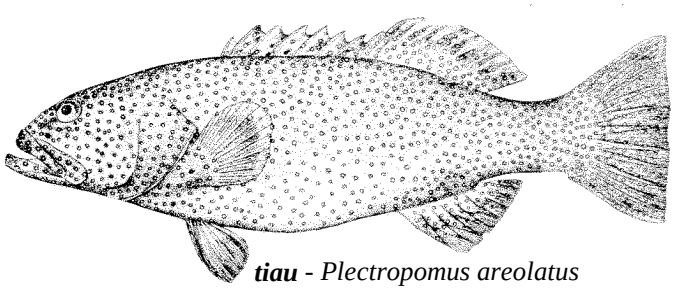
Name of person filling the form (signature and date):

Fisheries Officer receiving the form (signature and date):

*[1] =use separate forms for different dives, even if it is within the same area.

3.2 Groupers - *temekai* and *tiau*

3.2.1 The Resource



tiau - *Plectropomus areolatus*

Species present: The Division of Marine Resources, 1992 Annual Report lists grouper species in Palau as follows:

Temekai: *Epinephelus morrhua* (comet grouper), *E. septemfasciatus* (convict grouper), *E. chlorostigma* (brownspotted grouper), *E. fasciatus* (blacktip grouper), *E. macrospilos* (snubnose or bigspot grouper), *E. maculatus* (highfin grouper) and *Cephalopholis sonnerati* (tomato hind).

Ksau: *E. polyphekadion*, formerly *microdon* (camouflage grouper), *E. fuscus*, *miliaris*? (netfin or honeyfin grouper).

Remochel: *E. fuscoguttatus* (brown-marbled grouper).

or ***hludel***

Tiau: *Plectropomus areolatus* (squaretail coraltrout)

Katuu 'l tiau: *P. laevis* (blacksaddled coraltrout).

Mokas: *P. maculatus* (spotted coraltrout), *P. leopardus* (leopard coraltrout).

Baslokil: *Variola louti* (yellow-edged lyretail or moontail seabass).

Mengardechelucheb: *C. argus* (peacock hind).

All Serranids of value as food fish are members of the subfamily Epinephelinae, of which at least 33 species have been reported for Palau (Myers, 1991). During the rapid ecological assessment of 1992 where data were collected from 76 visual transects and supplemental observations made at Kayangel, Kossol, Eastern Babeldaob, Western Babeldaob, Koror-Rock Islands, Peleliu-South/West and Angaur, Donaldson (1992) recorded 45 species of Serranidae. Serranidae was the fourth most speciose, after Gobiidae, Labridae and Pomacentridae. Palau's grouper catch has been dominated by two genera, *Epinephelus* and *Plectropomus*. Palauans refer to most *Epinephelus* species as *temekai*, and to *Plectropomus* species as *tiau*. Although Palauans have one or more specific names for most species of these two genera, many people are not familiar with them and commercial catches are typically reported using the two generic Palauan names. Grouper landings have been dominated by *E. fuscoguttatus* (***remochel***), *E. polyphekadion*, formerly *E. microdon*, (***ksau***) and *P. areolatus* (***tiau***) (Kitalong and Dalzell, 1994). Other harvested species include, *E. morrhua, E. septemfasciatus, P. leopardus* (***mokas***), *P. laevis* (***katuu 'l tiau*** or ***mokas***), *P. maculatum* and *Variola louti* (***baslokil***).

Distribution: Geographical distribution of the grouper species are given in Heemstra and Randall (1993). Worldwide distributions of species important to Palau were taken directly from that reference, and are as follows:

E. morrhua: this species is distributed from the Red Sea and western Indian Ocean to the central Pacific Ocean (as far east as Cook Islands).

E. septemfasciatus: this species is closely related to *E. octofasciatus*. Thus most distribution records for *E. septemfasciatus* are probably based on *E. octofasciatus*. *E. septemfasciatus* is known with certainty only from Japan, Korea and China while reports of this species from other areas appear to be based on misidentifications of *S. octofasciatus*.

E. fuscoguttatus: this species is widely distributed in the Indo-Pacific region but is not known to occur in the Persian Gulf, Hawaii and French Polynesia. It probably occurs in all of the tropical islands of the Indian and west-central Pacific Oceans (east to Samoa and the Phoenix Islands) along the east coast of Africa to Mozambique, and has been reported from Madagascar, India, Thailand, Indonesia, tropical coast of Australia, Japan, Philippines, New Guinea and New Caledonia.

E. polyphekadion: this species is widely distributed in the tropical and subtropical Indo-West Pacific region from the Red Sea and east coast of Africa to French Polynesia in the east.

P. areolatus: this coral trout species occurs in the Indo-Pacific. With the exception of the Red Sea and Australia, records of this species are limited to insular localities which include; Chagos, Maldives, Cocos-Keeling Islands, Rowley Shoals (Western Australia), Indonesia, Philippines, Taiwan, Ryukyu Islands, Paracel Islands (South China Sea), Palau Islands, Great Barrier Reef, Caroline Islands, Marshall Islands, Samoa Islands and the Phoenix Islands.

P. leopardus: this species occurs in the Western Pacific, from southern Japan to Australia and eastward to the Caroline Islands and Fiji. It has also been confirmed to occur in Hong Kong, Viet Nam, Philippines, Indonesia, Palau, Papua New Guinea and New Caledonia.

P. laevis: this species occurs in the Indo-Pacific, from southern Mozambique to the Tuamotus, Austral Islands and Rapa but not in the Red Sea or Persian Gulf. It is known from most of the islands in the central and western Pacific between Japan and the southern Great Barrier Reef. It has not been recorded from the Asian coast or Indonesia.

Most grouper species inhabit coral rich areas and in Palau, the two dominant *Epinephelus* species are found on seaward reefs, in channels, and somewhat less on lagoon reefs. The three dominant *Plectropomus* species inhabit a variety of reef types, although *Plectropomus leopardus* appears to be largely confined to the lagoon while the other two appear to be more common on seaward reefs and in channels.

Although these species of grouper are found throughout the archipelago, many species experience dramatic changes in distribution by season and by lunar phase. Fishermen have long been aware of and taken advantage of the seasonal aggregations of *Epinephelus fuscoguttatus*, *E. polyphekadion*, and *Plectropomus areolatus* at several sites, particularly channels, including Ngerumekaol, Denges pass, Ngeremlengui channel, and Ebiil channel. Adults have traditionally been known to aggregate in channels around the full moon during May and June to spawn (Johannes, 1981). Figure 3.2 (a) shows areas with concentrations.

In a survey of marine fishes in 26 sites in the Ngermeduu Bay area, Amesbury (1991) recorded the following Serranidae species occurrences:

Species	No. of sites in which species was observed	Other information
C. argus	2 out of 26	
C. miniatus	3 out of 26	
C. sonnerati	1 out of 26	
C. urodeta	6 out of 26	
Epinephelus fuscoguttatus	6 out of 26	High abundance in one of the site
E. merra	3 out of 26	
E. microdon	2 out of 26	
Gracila albomarginata	1 out of 26	
Plectropomus areolatus	3 out of 26	High abundance in one of the sites
P. leopardus	11 out of 26	
Pseudanthias dispar	1 out of 26	
P. squammnipinnis	1 out of 26	
Variola louti	2 out of 26	

Groupers (***temekai***) and coral trout (***tiau***) are reported by Rochers and Matthews (1992) as spawning in the Ngarchelong channel in July. Several types of groupers have been reported to spawn in sites near Ngchesar. Groupers spawn in Ngetbaet, Idims and Ngetngod.

Maragos *et al*. (1994) reported groupers and coral trout spawning in the nearby channel, Ngamegai Passage, of Ngerchelong. The pass (Toachel Ngedbaet) near Melekeok is an important spawning ground. Several groupers spawn in Ngchesar, Idims and Ngetngod reefs. Spawning aggregations of groupers, parrotfish, coral trout, and humphead wrasse are found off Toachel Mlengui Pass, all of commercial significance.

Biology and ecology: Groupers are moderate to large sized fish which are predominantly shallow-water species, at or near the top of the food chain on tropical and sub-tropical marine habitats. All are carnivorous feeding mainly on fishes, larger crustacea and occasionally cephalopods. They are highly esteemed as food fishes (Randall, 1987). Groupers lead relatively sedentary lives and are strongly habitat-dependent with regards feeding, often feeding by ambush at all times of the day.

Some species, being protogynous hermaphrodites, undertake sex changes, resulting in adult populations generally containing a greater proportion of females. However, there is preliminary evidence that the sex ratio of at least one of Palau's aggregations of *P. areolatus* is weighted in favor of the larger proportion of males, possibly as a result of fishery targeting relatively small fishes (Johannes *et al*., 1994). Spawning is characteristically concentrated at particular times of the year over 1 or 2 months, often at sites used regularly each year, a fact used by fishermen to catch large quantities of grouper when they are very vulnerable to fishing. Size at maturity is around 250 mm total length in *E. fuscoguttatus*, 340 mm total length for *E. microdon*, and 300 mm total length for *P. leopardus*. Fecundity falls generally in the range of 100,000-5,000,000 eggs per female (Shapiro, 1987). The groupers are typically long-lived and slow growing, with maximum ages generally in excess of 10 years, and growth coefficients usually within the range 0.1-0.25/year (Manooch, 1987). Average weights of groupers caught in Ngerumekaol and Ebil Channel during the 1990-1991 period was recorded by Kitalong and Oiterong (1992), as extracted from FitzGerald et al. (1991), as follows:

Species	Area	Date	Numbers and sex	Average wt (kg)
E. microdin	Ngerumekaol	May 14, 1990	3 females	0.99
E. fuscoguttatus	Ngerumekaol	May 14, 1990	1 female	2.5
		June 5, 1991	2 females	7.3
		June 6, 1991	1 female	4.5
P. areolatus	Ebil Channel	May 1, 1991	18 females	2.3
		May 1, 1991	18 males	2.2
	Ngerumekaol	May 14 1990	2 males	2.2
		May 15, 1990	5 males	2.3
		May 13, 1991	7 females	1.5
		June, 5 1991	1 male	1.9

The strong ties of many groupers' spawning cycles to both the seasons and to the lunar cycle are readily observed in the dramatic aggregations of *Epinephelus* and *Polyphekadion* at several sites around Palau. Palau's aggregations of *Epinephelus fuscoguttatus, E. polyphekadion,* and *Plectropomus areolatus* are believed to typically occur during two or more lunar months between March and July, with peak numbers present just before the new moons, when they are believed to spawn. Catch records reflect the increased catchability of these species during their aggregations, with average monthly commercial landings from 1983 through 1990 of *Epinephelus* species peaking in June and July, and *Plectropomus* catches peaking from March through June (Kitalong and Oiterong, 1991).

Habitat and general biology of the following species were taken directly from Heemstra and Randall (1993):

E. morrhua: this species is a deep-water dweller and is usually found in depths of 80 to 370 m. Individuals can attain at least 61 cm standard length (73 cm total length) and weights of 5 kg. Fourmanoir and Laboute (1976, cited in Heemstra and Randall, 1993) estimated the maximum total length for this species to be 90 cm.

E. fuscoguttatus: this species is found in shallow coral reefs and rocky bottoms to depths of 60 m and feeds on fishes, crabs and cephalopods as indicated by stomach contents of specimen examined. Juveniles are normally found in seagrass areas. The maximum size that can be attained is at least 95 cm total length and a weight of 11 kg. Schroeder (1980, cited in Heemstra and Randall, 1993) reported the total length of this species to be 120 cm in the Philippines.

E. polyphekadion: this species is almost always found in clear water on coral reefs, either in lagoons or on the outer reef and is most abundant at islands, particularly atolls. It feeds mainly on cruataceans, especially portunid crabs and also some scyllarid and panularid lobsters, and fishes.

Gastropods and cephalopods are also eaten but to a lesser extent. Morgan (1959, cited in Heemstra and Randall, 1993) reported that in Kenya, females mature at 38 cm standard length while males mature at about 42 cm. Individuals can attain at least 61 cm standard length (75 cm total length) and weights of 4 kg. This grouper species is probably the least wary of divers thus uncommon at localities with heavy spearfishing.

P. areolatus: this species is found in lagoons and on the outer reef at depths of 2 to 20 m. It is shy and difficult for a diver to approach. In Palau, Myers (1989) reported that large numbers of this species gather in the seaward end of Ulong Channel for a few days before new moon in May to spawn. Recently, Johannes *et al*. (1994) reported that peak numbers during their observations were greater in June than in May. During this time males may display light bodies with about five irregular dark saddles and dark dorsal and anal fins. Attains at least 60 cm standard length (1 m according to Katayama, 1988, cited in Heemstra and Randall, 1993).

P. laevis: this species is conspicuous and quitecommon on coral reefs at depths of 4 to at least 90 m. The pale black-saddled form is usually smaller (8-57 cm standard length) than the dark reddish brown phase (15-100 cm standard length). Maturity seems to occur at 50-52 cm standard length (2.8-3.2 kg). It has been reported to feed exclusively on fishes with its prey comprising a variety of large reef fishes, including groupers. This diet of large fishes is responsible for the high concentrations of ciguatera toxins found in this species. Individuals attain 100 cm standard length (125 cm total length) and weights of 18 kg.

P. leopardus: this species occurs on coral reefs of the Indo-Pacific region at depths of 3-100m. Results of a study reported by Goeden (1978) in the Great Barrier Reef suggested that the largest fish (modal standard length of 50 cm) was 5 years old. The species was found to be a protogynous hermaphrodite with the smallest mature female measuring 21 cm standard length (age 2 years) with the largest 47 cm (age 4 years). The smallest mature male was 30 cm (3 years old) and the largest male was 54 cm. Spawning occurred in late November and early December. A 4-year old fish was estimated to contain 457,900 eggs. The study also found that this species feeds throughout the day with 96 per cent of the prey comprising of fish, primarily atherinids and scarids. It is inactive at night. Individuals attain a standard length of 57 cm (70 cm total length).

3.2.2 The Fishery

Utilization: At least since 1976, when records of commercial landings were first kept, groupers have been an important component of the commercial fisheries sector. While groupers are also caught for subsistence use, they probably do not make up as large a proportion of the subsistence catch as of the commercial catch, much of which is destined for overseas markets, particularly Guam and Saipan. Between 1976 and 1992, Serranids as a group comprised, on average, nine per cent of the reef fish landings at Palau Federation of Fishing Associations (PFFA), the only commercial buyer monitored regularly and probably the biggest single buyer during this period (MRD, no date). With the passage of the Marine Protection Act of 1994, which prohibits the commercial harvest of five of the most important species from April 1 through July 31, the proportion of groupers in the commercial catch is likely to decrease substantially (although their value per kilogram may consequently increase).

In addition to the subsistence catch and the commercial catch, Palau has exported a substantial amount of live grouper over the last decade to the Asian market, particularly between 1984 and 1988, when a Hong Kong-based company captured or purchased an estimated 54 tonnes of live grouper (Kitalong and Oiterong, 1991). Most of these fish were taken from known aggregation areas, including Denges pass, Ngeremlengui channel, and in the vicinity of Ngerumekaol. The company was eventually denied access to the reefs of individual states, and exports of live grouper are believed to have virtually ceased since then. In 1990, however, at least one foreign vessel was caught poaching live grouper in Palau's waters (Kitalong and Oiterong, 1991). As of mid-1994, at least one state was in the process of negotiating with a foreign company over access to its grouper resources.

Based on observations of landings in 1990 and 1991, the dominant groupers purchased by PFFA were reported to be *E. polyphekadion, E. fuscoguttatus*, and *P. areolatus* (Kitalong and Dalzell, 1993). The composition of the catch of the live fishery was probably dominated by the same three species, although the relatively large size of *Epinephelus fuscoguttatus* may make it less desirable for the live fishery. All three species will readily take a baited hook, although they are reported to stop biting shortly before the new moon while aggregating (Kitalong and Oiterong, 1991). Spearfishing is also a common method for capturing most species of grouper, especially for aggregating fishes, which tend to become less wary as the new moon approaches. Groupers (***temekai***) were noted as one of the species important in Kayangel (Rochers and Matthews (1992).

Production and marketing: Like other species of reef fish, groupers are distributed both domestically, through subsistence and commercial channels, and overseas, primarily for commercial purposes but also to families and friends. Excepting the live grouper fishery, no export figures for grouper are available. Estimates on the distribution of all reef fish, however, might be indicative for groupers. It was estimated that roughly 20 per cent of all harvested reef fish was exported in 1992, 60 per cent was for subsistence use, and about 20 per cent went through local commercial outlets and consumed in Palau (MRD, no date).

Several of the main commercial buyers are monitored regularly, and purchase data for PFFA have been collected since 1976. Because these data represent the purchases of only one buyer, year-to-year variations shown here should be interpreted very cautiously (live grouper catches, for example, which averaged about 11 mt from 1984 through 1988, are not shown).

Groupers landed at commercial centres are sold fresh on ice either to local restaurants, hotels etc., or exported on ice to Guam and South-east Asia destinations. Wholesale prices for *E. fuscoguttatus* and *P. areolatus* were around $0.67 and $0.87 per pound respectively in 1990. Prices average to almost a US$/lb in 1992-1993.

Export of live groupers commenced in 1984 through a joint local-Taiwanese commercail venture. During the operation from 1984 to 1988, over 54 mt of live groupers were exported (Kitalong and Oiterong, 1992). However, one dealer in Koror estimated that between 1986-88, between 10-15 tons of live grouper were exported every 3 months.

Table 3.2.1 gives detail commercial landings and value of catches at PFFA for the 1976-1993 period for *Epinephelus* spp. and *Plectropomus* spp. separately. There was a general increase in *Epinephelus* landings from 1976 until the peak around 20 mt in 1985 and start declining to around 4 mt a year in the 1991-1993 period. No similar significant trend is apparent for *Plectropomus* landings which generally increased from 1977 until 1981, and then decreased until 1986, followed by an increase to a maximum in 1991, and decrease again in the following years. The combined annual grouper landings at PFFA increased from about 1.5 mt in 1976 to a peak of almost 22 mt in 1985 and 21 mt in 1986. It then gradually decreased to about 10 mt in each of 1989,1990 and 1991, and continued decreasing to approximately 6 mt in 1992 and less than 5 mt in 1993.

Total ***temekai*** and ***tiau*** landings and effort information as recorded by Kitalong and Oiterong (1992) for the 1987-1992 period are given in Table 3.2.2. There was a general decrease in landings from 1987 to 1991 for ***temekai*** except that the 1992 landing was a little above the 1987-1989 average. The total grouper landing recorded at the commercial markets in 1993 totalled to only 14,061 lbs which is very low compared to the previous years.

Table 3.2.1: Total purchase landings data for *Epinephelus* spp. and *Plectropomus* spp. at PFFA for the 1976-1993 year period.

Year	*Epinephelus* sp.					*Plectropomus* sp.				Combined	
	Weigh t (lbs)	Weigh t (kg)	Unit price (US$/lb)	Value (US$)	Per cent of Total Annual Fish Landing	Weigh t (lbs)	Weigh t (kg)	Value ($)	Percentage of Total Annual Fish Landing	Total Wt (kg)	Total Value ($)
1976	1,899	860	0.30	581	0.8	1,402	635	412	0.6	1,495	993
1977	16,724	7,576	0.23	3,913	5.3	3,428	1,553	1,156	1.1	9,129	5,069
1978	14,453	6,547	0.26	3,686	4.8	866	392	185	0.3	6,939	3,871
1979	21,764	9,859	0.28	6,234	4.6	6,254	2,833	2,115	1.0	12,692	8,349
1980	18,261	8,272	0.29	5,370	4.0	9,272	4,200	3,673	2.1	12,472	9,043
1981	9,127	4,135	0.37	3,394	4.2	11,878	5,381	5,085	5.5	9,516	8,479
1982	-	-	-	-	-	-	-	-	-		
1983	27,674	12,536	0.38	10,739	-	5,982	2,710	2,800	-	15,246	13,539
1984	37,453	16,966	0.43	16,062	-	4,745	2,149	-	-	19,115	
1985	45,245	20,496	-	-	-	3,052	1,383	-	-	21,879	
1986	42,655	19,323	0.53	22,656	5.8	3,280	1,486	1,862	0.4	20,809	24,518
1987	27,951	12,662	0.61	17,070	5.9	8,400	3,805	5,463	-	16,467	22,533
1988	22,964	10,403	0.65	15,002	5.3	12,327	5,584	10,074	2.8	15,987	25,076
1989	9,452	4,282	1.00	9,452	2.2	13,045	5,909	11,742	2.7	10,191	21,194
1990	10,781	4,849	0.74	7,163	2.8	7,307 (6,986)	3,165	6,108	1.8	8,014	13,271
1991	3,857 (3,752)	1,753	0.91	3,510	1.4	21,551	9,796		7.9	11,549	
1992	4,263 (5,019)	1,938	0.96	4,093	1.6	9,324 (8,390)	4,238		3.5	6,176	
1993	5,355	2,434			1.8	7,048	2,304		2.4	4,738	

Figures in brackets are those as reported by Kitalong and Oiterong (1992).

Table 3.2.2: Details of temekai and tiau landings from 1987 to 1992. (Source: Kitalong and Oiterong, 1992).

	1987-1989 average	1990-1992 average	1990	1991	1992
Temekai					
Total landings (lbs)	20,152	14,591	13,468	8,426	21,878
Number of men selling	44	62	71	44	70
Number of sales	169	165	189	90	217
Average CPUE (lb/trip)	119	90	62	94	115
Tiau					
Total landings (lbs)	11,257	15,760	8,170	23,343	15,767
Number of men selling	33	39	42	33	41
Number of sales	122	108	95	139	90
Average CPUE (lb/sale)	114	135	86	168	151

Monthly landings (lbs) of groupers taken from purchase receipts at PFFA between 1983 and 1992 and at PFFA, PMCI and Oh's Market (Jan-May) in 1993, are given in Tables 3.2.3(a) and 3.2.3(b) for *Epinephelus* and *Plectropomus* respectively. (Source: DMR Annual Reports for 1991 and 1992, and DMR database). From mean monthly landing data, the highest landings for *Epinephelus* is during the March-August period peaking in July while that for *Plectropomus* seems to be between March and June with a peak in May.

Table 3.2.3(a): Monthly landings of *Epinephelus* spp. at PFFA, from 1983 to 1993. (na=not available).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1983	n.a.	n.a.	n.a.	1,185	3,754	3,331	6,994	3,326	2,581	2,316	2,193	1,994
1984	1,225	690	2,091	2,543	1,364	1,408	16,841	4,749	1,599	1,333	2,088	1,522
1985	1,971	1,564	2,652	3,932	4,594	4,458	11,675	3,105	1,908	3,667	4,226	1,355
1986	424	866	1,920	2,760	3,857	9,559	13,188	2,720	1,306	1,280	2,499	2,273
1987	1,900	130	127	174	0	15,404	8,122	1,051	1,043	n.a.	n.a.	n.a.
1988	249	492	1,096	1,395	1,044	7,598	10,473	348	196	0	66	51
1989	194	340	574	794	483	2,538	2,707	511	622	0	602	86
1990	79	29	331	393	596	3,808	3,016	305	878	950	215	103
1991		69	59		41	876	501	358	663	581	114	596
1992	150			159	134	1,146	2,205		317		80	

1993		168	225	224		15	265	3,185	566	64	155	468
Mean (PFFA)	774	483	1,008	1,375	1,346	4,681	6,899	1,815	910	984	1,116	807
(PMCI)						1,415	70					
(Oh's)	103											

Table 3.2.3(b): Monthly landings of *Plectropomus* spp. for Palau Federation of Fishing Associations, 1983 to 1993.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1983	n.a.	n.a.	n.a.	19	1,461	3,310	0	791	191	68	0	142
1984	0	59	732	1,431	765	727	14	99	64	41	313	500
1985	0	321	260	352	1,033	60	167	506	8	289	220	96
1986	0	78	298	617	477	31	227	96	406	380	665	0
1987	1,206	640	643	982	40	789	1,268	1,387	1,445	n.a.	n.a.	n.a.
1988	100	418	3,481	1,520	1,057	2,620	566	902	1,203	88	323	0
1989	506	458	3,468	2,533	1,524	453	65	189	303	921	1,586	1,035
1990	2,678	475	114	649	948	224	497	336	182	114	175	564
1991	789	362	488	931	7,194	2,758	1,898	753	3,061	1,593	1,101	622
1992	62	2,520	1,458	1,651	731	173	609		649		1,366	105
1993	249	1,526	858	810	258	631		853	435	354	886	188
Mean	799	686	1,180	1,045	1,408	1,071	590	591	722	428	737	407

Commercial monthly landings at main markets by major groups of groupers as is known in Palau are presented in Table 3.2.4 for the 1991-1993 period. PFFA data for the three years indicate that ***tiau*** dominates (more than 50 per cent) grouper landings, followed by ***temekai***. However, proportionally, ***tiau*** purchased at PFFA has decreased from about 85 per cent in 1991 to 56 per cent in 1993. In 1993, the ***temekai*** landing at PMCI was close to the ***tiau*** landing at PFFA.

Table 3.2.4: Comparative monthly landings of groupers, by Palauan group, as purchased at PFFA from 1991to 1993, and other commercial markets in 1993.

Year/ Group	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Group % of grouper landing
1991														
Plectropomus spp. (***tiau***)	789	362	488	931	7,194	2,758	1,898	753	3,061	1,593	1,101	622	21,550	84.8
Epinephelus spp. (***temekai***)		69	59		41	876	501	253	663	581	114	596	3,752	14.8
Epinephelus spp. (***ksau***)								105					105	0.4
TOTAL	**789**	**431**	**547**	**931**	**7,235**	**3,634**	**2,399**	**1,111**	**3,724**	**2,174**	**1,215**	**1218**	**25,408**	**100.0**
1992														
Plectropomus spp. (***tiau***)	62	2,520	1,458	1,651	731	173	609		649		1,366	105	9,324	68.6
Epinephelus spp. (***temekai***)	150			159	134	1,146	2,205		317		80		4,263	31.4
TOTAL	212	2,520	1,458	1,810	865	1,319	2,814		966		1,446		13,587	100.0
1993														
Plectropomus spp. (***tiau***) PFFA	249	1,526	858	810	258	631		853	435	354	795	188	6,957	49.7
Plectropomus spp. (***mokas***)											91		91	0.7
Epinephelus spp. (***temekai***) PFFA		168	225	244		15	265	3,185	566	64	155	468	5,355	38.3
PMCI						1,340	70						1,410	10.1
Oh's	103												103	0.7
Epinephelus spp. (***ksau***) PMCI						75							75	0.5
TOTAL	352	1,694	1,083	1,054	258	2,061	335	4,038	1,001	418	1,041	656	13,991	100.0

Table 3.2.5 gives relative composition of commercial fish landings, by family, at PFFA for the period 1976-1990 and individual years from 1990 to1993. Serranidae (groupers) showed a decrease in composition in the reef fish landings from about 9 per cent in the 1976-1990 period and in 1991, to 5.1 percent in 1992 and 4.3 per cent in 1993.

Of the most common fish families in the total reef fish landings in Palau between 1976 and 1990, Serranidae was ranked fifth (9 per cent) of all the total reef fish purchases at PFFA. Except for the increase to 9.3 per cent in 1991 from the 1976-1990 average, relative composition of Serranidae has been decreasing down to 4.1 per cent recorded in 1993. The per cent composition is even lower for 1992-1993 when combining data from other commercial markets as indicated in Table 3.2.6.

Table 3.2.5: Relative composition of reef finfish landed at PFFA Market for the 1976-1990 period and for 1990 to 1993. Percentage composition figures are shaded. (Source: DMR Annual Report 1990; DMR Database).

	% Wt		1990		1991		1992		1993			
	1976-1990		Weight (lbs)	% Wt	Weight (lbs)	% Wt	Weight (lbs)	% Wt	Weight (lbs)	Value (US$)	% Wt	% Value
Scaridae	17.88		53,186	16.98	13,368	4.90	21,380	8.04	56,710	65,944	19.8	19.6
Acanthuridae												
Surgeonfish									467	489	0.2	0.1
Unicornfish									46,777	55,965	16.3	16.7
Total	13.66		43,810	13.99	25,000	9.17	14,779	5.56	47,244	56,454	16.5	16.8
Assorted reef fish									4,074	5,412	1.4	1.6
Lethrinidae	13.52		57,099	18.23	25,939	9.52	22,357	8.41	30,795	34,192	10.7	10.2
Lutjanidae	11.99		29,123	9.30	74,405	27.30	56,456	21.23	47,676	54,823	16.6	16.3
Siganidae	10.35		69,331	22.13	37,814	13.87	33,599	12.63	29,560	37,181	10.3	11.1
Serranidae	**9.05**		**21,361**	**6.82**	**25,408**	**9.32**	**13,586**	**5.11**	**12,403**	**13,625**	**4.3**	**4.1**
Carangidae												
Trevally	3.57		11,711	3.74	3,801	1.39	12,861	4.84	10,063	10,564	3.5	3.1
Scad									5,834	7,332	2.0	2.2
Mullidae	1.09		5,746	1.83	875	0.32	1,436	0.54	3,900	4,489	1.4	1.3
Mugilidae	1.06		1,647	0.53	841	0.31	1,463	0.55	1,465	1,845	0.5	0.5
Labridae	0.92		1,397	0.45	608	0.22	928	0.35	1,462	1,615	0.5	0.5
Gerreidae	0.44		648	0.21	2,407	0.88	1,508	0.57	714	854	0.2	0.3
Holocentridae	0.21		280	0.09	343	0.13	454	0.17	73	99	0.0	0.0
Haemulidae	0.20						58	0.02	207	166	0.1	0.0
Kyphosidae									2,452	3,072	0.9	0.9
Sphyraenidae									2,963	2,877	1.0	0.9
Mackerel									14,525	17,544	5.1	5.2
Clupeidae									29	39	0.0	0.0
Chandidae									364	371	0.1	0.1
Scombridae												
R. kanagurta									14,525	17,544	5.1	5.2
Wahoo*									4,156	4,189		
Marlin*									1,056	840		
King mackerel*									2,770	3,050		
Tuna*									4,081	3,055		
Other oceanic pelagics*									456	185		
Others	16.05		17,904	5.72	61,733	22.65	85,078	31.99				
TOTAL			313,243		272,542		265,943		287,038	336,042		

*fish not counted as reef fish in the percentage calculations.

Table 3.2.6: Composition of commercial reef fish for all markets (PFFA, Oh's, PMCI and Melekeok Cooperative) during 1992 and PFFA, PMCI and Oh's Market (Jan-May) 1993. Percentage figures are shaded.

Finfish category	Common name	1992		1993			
		Total Wt (lb)	Percent Wt	Total Wt (lb)	Percent Wt	Total Value ($)	Percent Value
Acanthuridae	Surgeonfish			(467)	(0.06)	(489)	(0.06)
	Unicornfish			(51300)	(7.08)	(61566)	(7.18)
Acanthuridae Total		33,811	4.68	51,767	7.14	62,055	7.24
Assorted reef fish	Assorted reef fish			423,358	58.39	509,524	59.43
Carangidae	Trevally			(10063)	(1.39)	(10564)	(1.23)
	Herring			(927)	(0.13)	(622)	(0.07)
	Mackerel			(14525)	(2.00)	(17544)	(2.05)
	Scad			(5834)	(0.80)	(7332)	(0.86)
Carangidae Total		16,254	2.25	31,349	4.32	36,062	4.21
Clupeidae	Sardine			227	0.03	121	0.01
Chandidae	Milkfish			749	0.10	756	0.09
Gerridae	Silverfish	1,551	0.21	714	0.10	854	0.10
Haemulidae	Sweetlips	58	0.01	207	0.03	166	0.02
Holocentidae	Squirrelfish	514	0.07	73	0.01	99	0.01
Kyphosidae	Ruddefish			2,452	0.34	3,072	0.36
Labridae	Wrasses	2,712	0.38	1,504	0.21	1,668	0.19
Lethrinidae	Emperors	29,011	4.02	31,100	4.29	34,512	4.03
Lutjanidae	Snappers	71,032	9.83	48,371	6.67	55,604	6.49
Mugilidae	Mullet	2,003	0.28	1,613	0.22	2,008	0.23
Mullidae	Goatfish	2,788	0.39	4,094	0.56	4,676	0.55
Congridae	Moray eel			51	0.01	63	0.01
Rays	stingrays			93	0.01	74	0.01
Scaridae	Parrotfish	61,820	8.56	78,740	10.86	88,470	10.32
Serranidae	**Groupers**	**38,134**	**5.28**	**14,061**	**1.94**	**15,211**	**1.77**
Siganidae	Rabbitfish	44,542	6.16	31,589	4.36	39,468	4.60
Sphyreanidae	Barracuda			2,963	0.41	2,877	0.34
Others		418,301	57.89				
Total Reef Fish		**722,531**	**100.00**	**725,075**	**100.00**	**857,340**	**100.00**
Scombridae	King mackerel			2,850		3,138	
	Marlin			1,056		840	
	Tuna			4,081		3,055	

	Wahoo		4,516		4,588		
Other oceanic	Other oceanic pelagics		456		185		

Purchase records of groupers at the commercial markets in 1993 indicate that most of the ***tiau*** and ***temekai*** came from Koror and Ngerchelong. Purchases of ***tiau*** and ***temekai*** from these states account for more than 80 per cent and 60 per cent of these fish landings respectively.

Table 3.2.7: Monthly 1993 market purchases of groupers by State at PFFA, PMCI and Oh's (Jan-May). Weights are in pounds and value in US$.

Species	State		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total	Percent of Total
Tiau	Koror	Wt	319	308	567	202	76	631		162	413	2,678	47.1
		Value	396	400	765	263	84	694		197	507	3,306	46.4
	Ngaraard	Wt		161								161	2.8
		Value		209								209	2.9
	Ngerchelong	Wt		978	252	322				691		2,243	39.4
		Value		1,271	340	410				864		2,885	40.5
	Ngeremlengui	Wt		28	39	241					22	330	5.8
		Value		36	53	303					22	414	5.8
	Peleliu	Wt		51								51	0.9
		Value		66								66	0.9
	Ngchesar	Wt				45						45	0.8
		Value				50						50	0.7
	Kayangel	Wt					182					182	3.2
		Value					200					200	2.8
Ksau	Ngatpang	Wt						75				75	100
		Value						64				64	100
Temekai	Ngeremlengui	Wt	103						95	20	27	245	4.0
		Value	113						81	17	23	234	4.2
	Koror	Wt		86	61	117		345	170	99	308	1,186	19.2
		Value		104	71	129		297	130	84	262	1,077	19.2
	Peleliu	Wt		82	22					105	19	228	3.7
		Value		98	24					129	16	267	4.7
	Ngerchelong	Wt			142	51		255	70	2,215	212	2,945	47.6
		Value			156	56		289	88	1,883	180	2,652	47.2
	Ngchesar	Wt				76						76	1.2
		Value				84						84	1.5
	Angaur	Wt						40		619		659	10.7
		Value						34		526		560	10.0
	Ngatpang	Wt						715		127		842	13.6
		Value						641		108		749	13.3

The only export data on grouper are those recorded on Continental Air Micronesia cargo manifest for 1991, where grouper was reported on 6 counts with a combined (including other food and packaging) weight of 847 lbs.

3.2.3 Hatchery spawning and culture of groupers in Palau

Two species of groupers that were caught by hand-line were successfully induced to spawn at MMDC in 1991 using human chorionic gonadotropin (HCG). *P. areolatus* spawned on the week of May 6, 1991 and specimens of the same species and *E. fuscoguttatus* spawned on the week of June 3, 1991 (FitzGerald, 1991). Fertilized eggs were shipped to Guam Aquaculture Development and Training Center (GADTC), Guam for larval culture. Unfortunately, larval cultures were not successful. [A final report was written on the Preliminary Spawning and Larval Culture Trials for Groupers from Guam and Palau, July 2-24, and August 5-24, 1993. It was not possible to obtain a copy of this report and thus it was not possible to find out whether there were more and better results obtained in grouper culture.]

3.2.3 Stocks Status

Interviews with fishermen indicate concern over a decline in the abundance of groupers in recent years in Ngerumkaol Channel (Kitalong and Oiterong, 1991c). Landing data supports concern for the resource. As a result, DMR initiated in 1991 an underwater survey in the principal grouper areas, and

commenced the collection of grouper fishery statistics. Underwater visual assessments were also carried out on the main fishing grounds during 1990. Underwater visual survey data details for 1990 are presented in Table 3.2.8(a) as recorded by two divers swimming at a 15-35 m depth from the inner to outer end, toward the mouth of each channel during 45-minute dive. Encounter rates appear to be fairly high, but indicated a decline in numbers of groupers aggregating to spawn from numbers reported in the early 1980s by fishermen. Table 3.2.8(b) presents average counts for 1990-1992 period as recorded in Kitalong and Oiterong (1992).

Table 3.2.8(a): Summary of grouper survey results, May-June, 1990. Ngerumkaol Channel is a reserve, Denges Pass is a heavily fished area.

Area	Date	Time (mins)	Divers	Epin. fusco.	Plectr. areol.	Epin. microdon.
Ngerumkaol	May 22	45	1	19	26	5
Channel	May 22	15	1	20	54	0
	June 12	30	1	50	62	0
Total		90	3	89	142	5
Counts/diver/hr				19.8	31.6	1.1
Denges	June 12	15	2	1	1	0
Pass				1	2	0
	June 23	60	1	6	14	0
Total		75	3	8	17	0
Counts/diver/hr			2.0	4.5	0.0	

Table 3.2.8(b): Average counts by two divers during 45-minute dives at Ngerumekaol and Denges Passes. (Source: Kitalong and Oiterong, 1992).

Species	Site	Dates	1990	1991	1992
Tiau	**Ngerumekaol**	May, 22, 14, 28	73	21	104
		June 12, 09, 24	72	150	48
		July 10, (1)		115	(0)
	Average	May-July	72	95	83
	Denges	May 27			1
		June 12	14		
		July 11, 24	7		1
	Average		10		1
Temekai	**Ngerumekaol**	May 22, 14, 28	39	15	104
		June 12, 09, 24	50	150	46
		July 10 (1)		113	(10)
	Average		44	93	75
	Denges	May 27			4
		June 12	6		
		July 11, 24		5	4
	Average				
Ksau	**Ngerumekaol**	May			0
		June 09, 24		20	361
		July 10 (1)		55	(30)
	Average			38	196
	Denges	May 27			0
		June 12	0		
		July 11, 24		0	40

Preliminary length frequency analysis indicates that landed *E. fuscoguttatus* have a modal fork length of between 66-73 cm, and between 31-46 cm for *P. areolatus*, indicating ages of 2-5 years.

Kitalong and Oiterong (1992) recorded grouper catch and effort data as extracted from FitzGerald *et al*. (1991) as follows. Time used in CPUE calculations is actual time of fishing.

Area	1990 Date	1991 Date	1990 CPUE (lbs/hk/hr)	1991 CPUE (lbs/hk/hr)
Ngerumekaol	May 14	May 7	1.7	2.8
	May 15	May 8	2.4	3.4
		May 13		18.1
		June 5		13.6
		June 6		16.2
		June 7		16.6

Denges Pass	April 30	0.03
Ebil Pass	May 01	10.0

During the surveys of marine fishes in 26 sites in the Ngermeduu Bay area by Amesbury (1991), as reported under the "distribution" section of the profile, fish counts were made at 2 sites. *E. fuscoguttatus* was observed in the vicinity of one site and only one specimen of *E. merra* was observed in the other site.

During the 1992 Palau rapid ecological assessment, Donaldson (1992) notes that the surveys indicated the apparent effects of commercial fishing on populations of species in important families such as groupers (Serranidae), jacks and trevallys (Carangidae), snappers (Lutjanidae), emperors (Lethrinidae) and parrotfishes (Scaridae), in the main Palau islands. These fish groups were either absent from the stations or present in very low numbers. Furthermore, serranidae was one of the taxa with the most narrow-ranging species. It was found to be narrow-ranging in all areas surveyed, i.e. in Kayangel, Kossol, Eastern Babeldaob, Western Babeldaob, Koror-Rock Islands, Peleliu-South/West and Angaur.

Numbers of three grouper species monitored on the spawning grounds at Ngerumekaol between May 8 and June 10, 1994 by Johannes *et al*. (1994) are presented in Table 3.2.9. The numbers do not represent the whole population that aggregated to spawn.

Table 3.2.9: Three grouper species monitored on the spawning grounda at Ngerumekaol, May 8-June 10, 1994. (Sources: Johannes *et al*., 1994).

	P. areolatus		*E. fuscoguttatus*	*E. polyphekadion*
Date	Numbers	Sex ratio (M:F)	Numbers	Numbers
May 08	72			
May 09	119		50	16
May 10	120			
May 11	38			
May 15	8			
May 17	5			
May 20	0		6	0
May 23	17	16:1	45	11
May 24	33	14:1	44	15
May 25	36	no females	32	6
May 26	40	no females	44	4
May 27	53 (mean)	25:1	43	8
May 30	94	no females	24	33
June 02	108	25:1	44	56
June 03	125	18:1	89	77
June 05	195	10:1	74	78
June 07	177	7:1	65	66
June 08	154	9:1	73	72
June 09	65	12:1	104	56

PFFA's purchase records of grouper, which show landings generally decreasing since a peak in the mid-1980s, may not be indicative of the entire fishery. However, it is interesting that PFFA's purchases of *Plectropomus* species increased in the late 1980s while purchases of *Epinephelus* species decreased. This may suggest that stocks of *Epinephelus* have decreased relative to those of *Plectropomus*.

Kitalong and Oiterong (1991) reported that fishermen were concerned about dwindling numbers of groupers at Ngerumekaol. The aggregation of *P. areolatus* at Denges pass was described by Johannes (1991) as having been eliminated. Fishermen interviewed in the mid-1970s mentioned *Epinephelus* and *Plectropomus* species among nine species groups that had declined markedly (Johannes, 1981). In subsequent interviews in 1991, both groupers were reported again as having declined and were part of a group of fishes being of "greatest concern" to the fishermen (Johannes, 1991).

In 1994 the MRD commissioned a project aimed at developing a more rigorous underwater monitoring protocol, probably to be limited to two or three known aggregating sites (Johannes *et al*., 1994). Preliminary evidence from the 1994 data suggest that the sex ratio of at least one of Palau's aggregations of *P. areolatus* is weighted in favor of males, possibly as a result of fishery targeting relatively small fishes (Johannes *et al*., 1994). The lowest male to females ratio observed for *P. areolatus* at

Ngerumekaol during aggregations in May 8-June 10, 1994 was 7.4:1. Data collection initiated in 1994 will probably start to reveal seasonal and lunar phase variations, but any annual trends will not be known for several years.

3.2.4 Management

Current legislation/policy regarding exploitation: National law prohibits the taking of any fish from Ngerumekaol, a grouper aggregation area, from April 1 through July 31 (24 PNC 3101). Koror State, which has an active marine enforcement team, is considering extending the Ngerumekaol restriction to the entire year and expanding the size of the restricted area through either State legislation or a traditional *bul*. Koror State is also considering closing part of the Ngemelis area of the Rock Islands, Palau's the most popular diving area, to some or all types of fishing.

As a result of concern for grouper stocks, the Ngeremlengui State government, in its Fishing Conservation Act of 1987 (PL 13-87), prohibited commercial grouper fishing in the area known as Tewachel Mlengui between June 1 and August 31. Violators face fines of up to $150.00. Ollei State has also banned fishing on certain grouper aggregations, and has marked the areas with buoys.

The National government recently passed the Marine Protection Act of 1994, which places restrictions on the use of a variety of marine resources. Five species of grouper, *E. fuscoguttatus, E. polyphekadion*, *P. areolatus*, *P. laevis*, and *P. leopardus* may not be bought, sold, or captured for commercial purposes from April 1 through July 31. Another restriction that may affect groupers is the Act's prohibition on the use of SCUBA or "hookah.". The Act also gives to the Ministry of Resources and Development the authority to promulgate additional marine resource-related regulations.

While this list of grouper-related restrictions may appear formidable, there have been problems with enforcement. The Ngerumekaol area, for example, may be too small to enforce effectively. The Tewachel Mlengui restriction has had problems because the spawning ground is shared with a neighboring state (Johannes, 1991).

Recommended legislation/policy regarding exploitation: Grouper species in general are widely recognized as being particularly susceptible to overfishing and even local extinction, in part because of their vulnerability to capture while aggregating to spawn. Johannes *et al*. (1994) provide examples of grouper aggregations being overfished or disappearing in the Pacific and the Caribbean.

Previous recommendations have focussed on closing known grouper spawning sites to harvest during aggregation periods (e.g., Kitalong and Oiterong, 1991; Johannes, 1991), and indeed, this strategy has largely been realized in the recent passage of the Marine Protection Act of 1994. Kitalong and Oiterong (1991) further recommended that Denges pass, which was harvested so intensely in the 1980s, be closed year-round. These closures, if effectively enforced, will provide substantial protection to Palau's grouper stocks and help ensure that they persist. However, a real concern is the intensive fishing involved in the live-fish exploitation for export. This is particularly difficult to control on the national level with the authority given to states.

Kitalong and Oiterong (1991) suggest that the grouper fishery in Palau is in need of management, at least at existing commercial fishing sites. They recommend:

* Ulong, Denges and Ngeremlengui channels be made seasonal reserves, to protect groupers during the spawning season;
* fishing permits should be a requirement for future large scale export operations, and quotas should be set.

Application of minimum size limits is also a consideration for each species.

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Figure 3.2.1: Five of the well known grouper aggregating sites in Palau. (Source: Johannes *et al*., 1994).

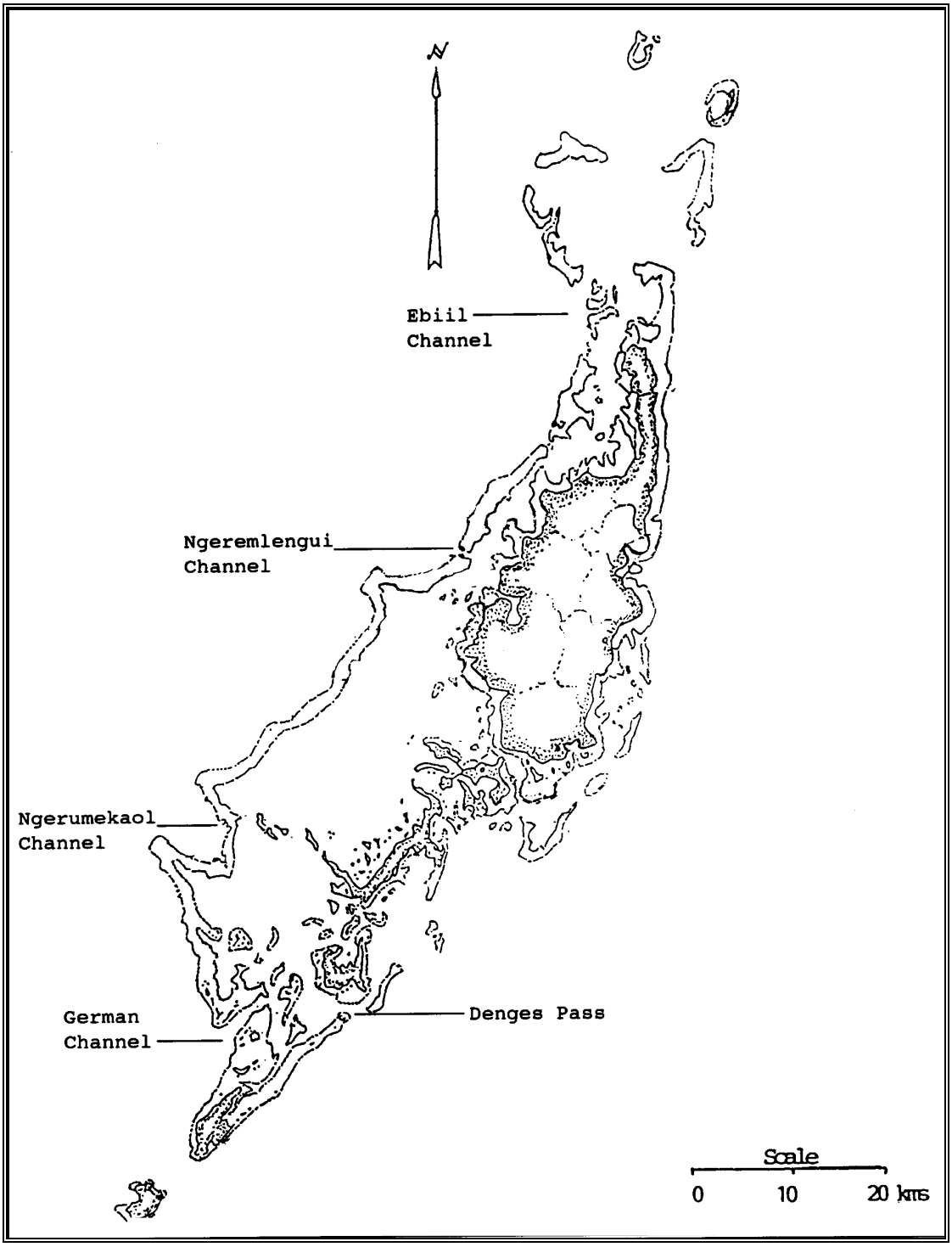


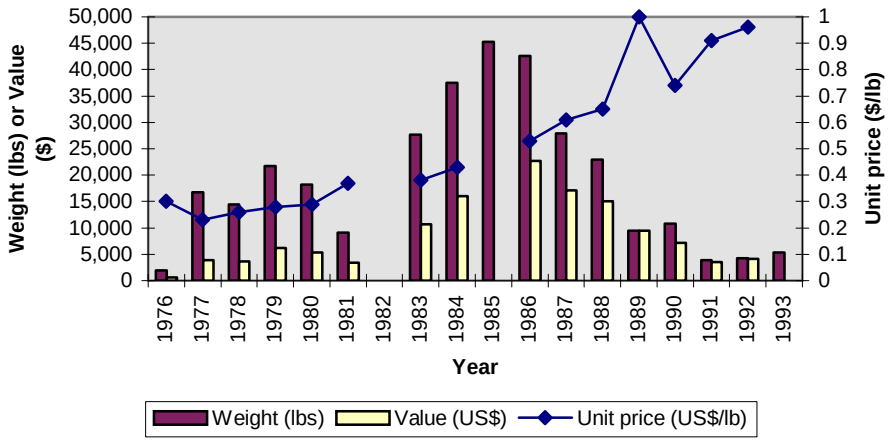
Table 3.2.11: Number of fishermen, trips and landings per trip of *Epinephelus* spp.from PFFA landings data (1984-1990). 1990 data also includes Oh's Market, Eptison Cold Storage and several restaurants.

Year	No. of boats	No. of trips	Landed (lbs)	Value ($)	Ave. lbs/trip	Ave. Kg/trip	Ave. $/trip
1984	n.a.	294	37,453	16,062	127	58	54.63
1985	n.a.	485	45,245	n.a.	93	42	n.a.
1986	50	328	42,655	22,656	130	59	69.07
1987	34	155	27,951	17,070	180	82	110.13
1988	55	203	22,964	15,002	113	51	73.90
1989	44	150	9,452	9,452	63	29	63.01
1990	40	142	10,704	7,163	75	34	50.44

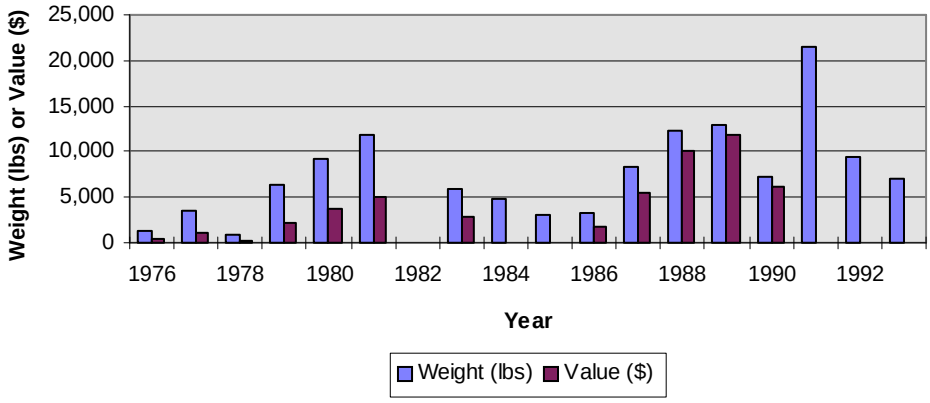
Table 3.2.12: Number of fishermen, trips and landings per trip of *Plectropomus* spp.from PFFA landings data (1984-1990). 1990 data also includes Oh's Market, Eptison Cold Storage and several restaurants.

Year	No. of boats	No. of trips	Landed (lbs)	Value (US$)	Ave. Wt. (lbs/trip)	Ave. wt (kg/trip)	Ave. (US$/trip)
1984	n.a.	49	4,745	n.a.	97	44	n.a.
1985	n.a.	51	3,052	n.a.	60	27	n.a.
1986	18	42	3,280	1,862	78	35	44.33
1987	21	46	8,400	5,463	183	83	118.76
1988	43	158	12,327	10,074	78	35	63.76
1989	36	162	13,045	11,742	81	36	72.48
1990	29	82	6,986	6,108	85	39	74.49

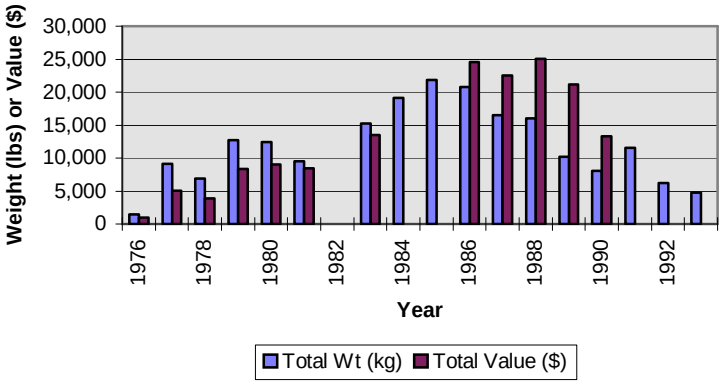
***Epinephelus* sp. commercial landing information at PFFA**

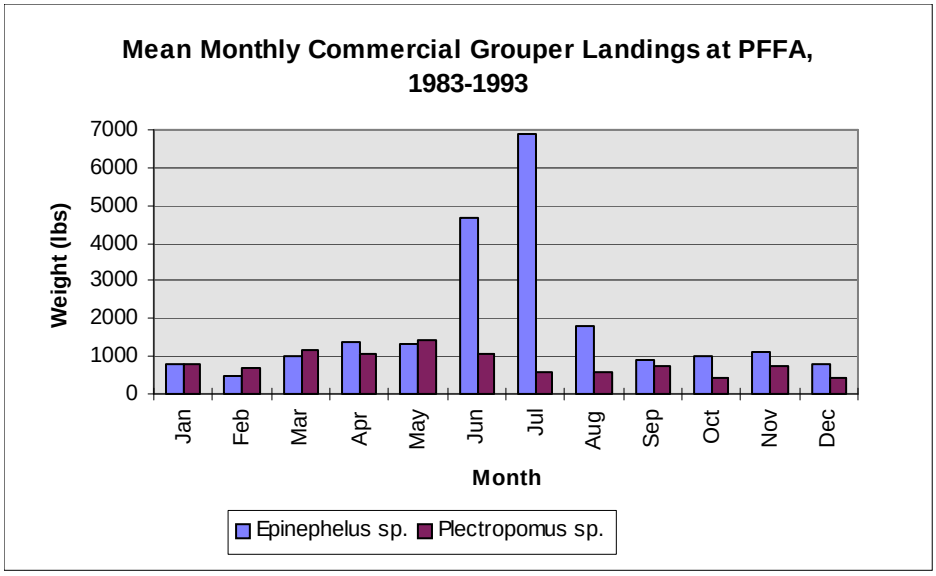


***Plectropomus* sp. commercial landings at PFFA**



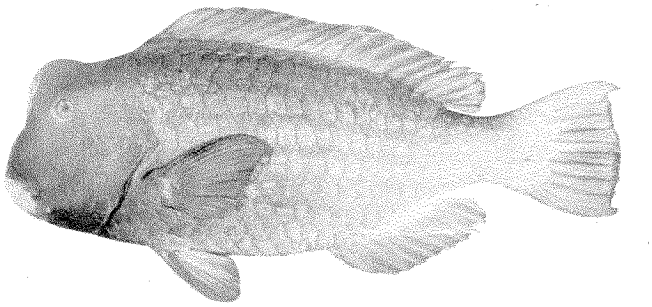
Combined *Epinephelus* sp. and *Plectropomus* sp. landings at PFFA




Mean Monthly Commercial Grouper Landings at PFFA, 1983-1993
Weight (lbs)
7000
6000
5000
4000
3000
2000
1000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Epinephelus sp.
Plectropomus sp.

3.3 Parrotfish

3.3.1 The Resource



kemedukl - *Bolbometopon muricatum*

Species present: A variety of parrot fish are taken in Palau, including:

Bolbometopon muricatum (humphead parrotfish - ***kemedukl*** for adult and ***berdebed*** for juvenile). This species is of major importance and is among the top ten reef fish landed for the past ten years at commercial fish markets;

Hipposcarus longiceps (Pacific longnose parrotfish - ***ngyaoch***);

Cetoscarus bicolor (bicolor parrotfish - ***beyadel*** for female and ***ngesngis*** for male);

Scarus oviceps (dark-capped parrotfish), *S. bleekeri* (Bleeker's parrotfish), *S. flaviplectoralia* (yelowfin parrotfish), *S. sordidas* (bullethead parrotfish) - ***mellemau***; *S. spinus* (pygmy parrotfish - ***butiliang***), *S. ghobban* (blue-barred parrotfish - ***elebdechukl***), *S. frontalis* (tan-faced parrotfish), *S. rubroviolaceus* (redlip parrotfish) - ***otord***, *S. gibbus* - ***udoudungelei***.

Distribution: Parrotfishes are generally widespread throughout the Pacific, favouring exposed and sheltered reefs with lush coral growth. Myers (1989) reported that ***kemedukl*** usually occur in schools in clear outer lagoons and on seaward reefs at depths of 1 to at least 30 m and may enter outer reef flats at low tides in unfished areas.

In surveys of marine fishes in 26 sites in the Ngermeduu Bay area in 1991, Amesbury (1991) reported the following scaridae species and the number of sites in which they were observed:

Species	No. of sites in which species was observed	Other information
B. muricatum	7	
C. bicolor	9	
H. longiceps	11	
S. bleekeri	8	
S. bowseri	2	
S. dimidiatus	9	
S. flavipectoralis	4	
S. ghobban	5	
S. gibbus	7	high abundance in two of these sites
S. globiceps	2	
S. niger	12	
S. oviceps	15	
S. psittacus	1	
S. prasiognathos	2	
S. pyrrhurus	1	
S. quoyi	1	
S. rubroviolaceus	8	
S. schlegeli	16	
S. sordidus	12	
S. spinus	6	

Rochers and Matthews (1992) reported spawning sites in Ngatpang for ***melemau***. Spawning aggregations are known to occur near the inner entrance of the barrier reef channel near Ngeremlengui starting on the eighth day of the lunar month. Recent interviews with fishermen substantiate these accounts (Johannes, 1981).

During the 1992 Rapid Ecological Assessment in Palau, Donaldson (1992) recorded parrotfish species that were observed as wide-ranging in areas surveyed as follows:

Site	Wide-ranging Scaridae Species
Kayangel	*Hippsoscarus longiceps*, *Scarus sordidus*
Kossol	*Scarus sordidus*, *Scarus schlegeli*
Eastern Babeldaob	*Scarus sordidus*
Koror-Rock Isands	*Scarus dimidiatus*
Peleliu-South/West	*Hippsoscarus longiceps*
Angaur	Scaridae reported as one of the most narrow-ranging families

Johannes *et al*. (1994) reported *S. schlegeli*, *S. oviceps*, *S. dimidiatus*, *S. sordidus*, *S. frenatus*, *S. microrhinos*, *S. bleekeri* and *Cetoscarus bicolor*, spawning at their grouper aggregating study site at Ngerumekaol.

Biology and ecology: Biological data on the species are given in Myers (1989) and Johannes (1981). In Palau, adults occur along steep outer reef slopes, channel slopes and occasionally on lagoon reefs at depths of 2 to at least 60 m. They feed mainly on coral (Myers 1989), but also apparently feed on young *Trochus* and *Turbo* shells. Anecdotal information indicates that large individuals were commonly fished by spear on the reef flat at night where they came to sleep in past years, but fishermen report that these fish now tend to sleep in deeper waters (Johannes 1981).

Palauan fishermen interviewed by Johannes (1981) report that females are full of ripe eggs from the first to the ninth day of the lunar month and appear to spawn on the eighth and ninth days, probably after sunset. Johannes *et al*. (1994) reported the following parrotfish species spawning at their study area at Ngerumekaol on May 27,1994, from 10:30 to 10:45 am: *S. schlegeli*, *S. oviceps*, *S. dimidiatus*, *S. sordidus*, *S. frenatus*, *S. microrhinos*, *S. bleekeri* and *Cetoscarus bicolor*.

The humphead parrotfish (***kemedukl***) is the second largest reef fish in Palau growing to 100 cm in length and weighing over 100 lbs (Kitalong and Oiterong, 1991). Kitalong and Dalzell (1994) listed growth and mortality parameters of ten reef species caught by commercial fishing in Palau. Two of the parrotfish species were included, for which the following parameters were estimated:

Species	L∞	K	Z	M	F	E
Bolbometopon muricatum	106.4	0.100	0.398	0.278	0.120	0.302
Hipposcarus longiceps	43.9	0.500	1.667	1.020	0.647	0.388

The optimum minimum first-capture lengths were also estimated from yield-per-recruit analysis for the same species and were as follows for parrotfishes:

Species	Optimum minimum first-capture length (cm)	Observed minimum first-capture length (cm)
B. muricatum	53.2	69.9
H. longiceps	26.3	25.5

3.3.2 The Fishery

Utilization: The large average size of the species make them to be popular for a range of fish dishes in local restaurants, or as a speciality dish for special occasions. The main gear type used is the speargun and hand held spear. Night time spearfishing with flashlights results in high catches, as parrotfish become torpid in crevices, enveloped in a mucous membrane secreted from the gills. They can be easily located and speared at such times.

Rochers and Matthews (1992) reported that the humphead parrotfish (***kemedukl***) and Pacific longnose parrotfish (***ngiaoch***) are important fish species in Kayangel and that the latter is important for use in custom in Melekeok. In Ngatpang, both these species are important with food prepared for special occasions and customs.

The highest production of ***kemedukl*** (humphead parrotfish) in Palau has been reported from Ngeremlengui.

In terms of volumes landed, the humphead parrotfish is one of the top ten commercial reef fishes in Palau. It is usually filletted and sold to the local restaurants (Kitalong and Oiterong, 1991).

Production and marketing: No estimate has been made on the level of consumption in the subsistence sector, and commercial landings are only recorded from the main markets. However, data from these sources are not complete. PFFA is one of the major commercial fish landing sites in Palau. Table 3.3.1 presents reef fish purchases, by family, at PFFA for the 1976-1993 period. The figures indicate that Scaridae comprised between 4.9 percent (lowest in 1984) and 26.9 per cent (highest in

1991) of the reef fish landing at this market. From 1991 to 1993, the Scaridae percentage increased from 4.9 to 21.0 per cent of the total reef fish landing there.

Table 3.3.1: Reef fish purchase at PFFA from 1976 to 1993, by family. Figures are in pounds.

Family	1976	1977	1978	1979	1980	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Acanthuridae	18,912	19,696	17,391	32,156	79,569	33,917	44,357	32,905	87,924	74,567	23,727	37,150	61,138	43,810	25,000	14,779	47,244
Assorted reef fish																	4,074
Carangidae	6,619	2,815	2,146	10,240	9,944	3,502	10,609	19,682	28,552	20,015	11,180	10,201	11,491	11,711	3,801	12,861	30,451
Gerridae	4,430	1,935	208	2,673	1,585	950	213	639	3,835	853	170	463	1,008	648	2,407	1,508	714
Haemulidae	0	95	335	903	1,307	325	1,224	1,214	3,236	132	0	0	0	0	0	58	207
Holocentridae	70	257	20	584	287	3,470	863	1,454	1,169	848	48	0	71	280	343	4,543	73
Labridae	1,255	918	957	3,836	3,366	2,578	4,645	3,712	7,604	6,048	1,742	1,994	910	1,397	608	928	1,462
Lethrinidae	25,005	13,461	4,104	37,569	72,886	23,817	42,259	56,669	94,491	61,859	19,070	44,895	48,091	57,099	25,939	22,357	30,795
Lutjanidae	18,327	10,044	3,898	18,830	40,840	18,321	41,446	41,960	98,951	82,479	15,570	62,682	50,810	29,123	74,405	56,456	47,676
Mugilidae	7,123	4,434	1,756	5,833	6,944	4,349	1,332	1,308	5,545	2,017	643	1,355	3,062	1,647	841	1,463	1,465
Mullidae	2,225	1,631	943	2,273	5,110	2,667	2,441	4,352	5,692	5,889	2,572	5,266	1,464	5,746	875	1,436	3,900
Scaridae	**25,095**	**25,667**	**12,070**	**54,117**	**68,600**	**46,510**	**47,977**	**92,426**	**95,942**	**113,549**	**55,718**	**42,137**	**62,127**	**53,186**	**13,368**	**21,380**	**56,710**
Serranidae	3,391	20,152	15,319	28,335	27,796	21,102	34,082	42,315	48,364	46,005	36,351	35,352	22,497	21,361	25,408	13,586	12,403
Siganidae	25,371	19,062	26,206	36,513	46,260	17,069	15,893	36,618	49,864	33,446	15,659	25,790	43,217	69,331	37,814	33,599	29,560
Sphyraenidae																	2,963
Others	65,288	137,441	50,114	30,842	12,327	1,370	14,359	8,071	100,417	17,933	188,013	36,173	33,145	17,904	61,733	85,078	
Total	203,111	257,608	135,467	264,704	376,821	179,947	261,700	343,325	631,586	465,640	370,463	303,458	339,031	313,243	272,542	270,032	269,697
% Scaridae	**12.4**	**10.0**	**8.9**	**20.4**	**18.2**	**25.8**	**18.3**	**26.9**	**15.2**	**24.4**	**15.0**	**13.9**	**18.3**	**17.0**	**4.9**	**7.9**	**21.0**

The breakdown of Scaridae (parrotfish) category by species per month as combined in Table 3.3.1 above, is given in Table 3.3.2 for the 1990-1993 PFFA and 1993 Oh's and PMCI reef fish purchases. Figures indicate that ***ngyaoch*** (Pacific longnose parrotfish, *H. longiceps*) has been the major parrotfish species, comprising more than 50 per cent of the Scaridae landings at PFFA in 1990 and 1993 and about 47 per cent in 1992. The next most important parrotfish species are ***kemedukl*** and ***mellemau***. ***Kemedukl*** dominates landings at PMCI and Oh's markets.

Table 3.3.2: Parrotfish (Scaridae) composition by Palauan name for 1990-1993 purchases at PFFA. 1993 purchases by PMCI and Oh's (Jan-May) are also given separately. Total values (US$) for each species are given for 1993 landings for the three markets.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (lbs)	Total ($)	Per cent Wt
1990															
Berdebed															
Kemedukl			196		1,319	4,392	303	836	1,408	802	1,693	166	11,115		31.6
Mellemau		231	217	407	794		392	1,704	884	519		151	5,299		15.1
Ngyaoch	256	1,067	889	6,038	2,912	1,865	1,194	1,725	1,013	494	1,141	134	18,728		53.3
Otord															
Total	**256**	**1,298**	**1,302**	**6,445**	**5,025**	**6,257**	**1,889**	**4,265**	**3,305**	**1,815**	**2,834**	**451**	**35,142**		**100.0**
1991															
Berdebed															
Kemedukl		107	1,131	165	738	637	192			115	49	315	3,449		25.8
Mellemau			1,336	864	304	179					1,869	1,106	5,658		42.3
Ngyaoch			645		30	468	957	366	424	352	448	571	4,261		31.9
Otord															
Total		**107**	**3,112**	**1,029**	**1,072**	**1,284**	**1,149**	**366**	**424**	**467**	**2,366**	**1,992**	**13,368**		**100.0**
1992															
Berdebed										14			14		0.1
Kemedukl	1,299	737	2,212	2,082	723		243	695	178			211	8,380		39.2
Mellemau		55		447	825	47	469	318	146		378	347	3,032		14.2
Ngyaoch	649	406	1,096	219	1,323		2,619	935	433		400	1,851	9,931		46.5
Otord															
Total	**1,948**	**1,198**	**3,308**	**2,748**	**2,871**	**47**	**3,331**	**1,948**	**757**	**14**	**778**	**2,409**	**21,357**		**100.0**
1993 PFFA															
Berdebed			35					201			9		245	249	0.4
Kemedukl		242	184	1,346	5,316	999	796	950	826	455	883	1,081	13,078	13,818	23.1
Mellemau	476	850	180	153	582	1,063	1,131	1,152	959	958	1,197	1,182	9,883	12,105	17.4
Ngyaoch	1,193	352	1,863	3,925	4,593	4,726	6,949	2,088	2,800	849	1,629	2,506	33,473	39,731	59.0
Otord			31										31	42	0.1
Total	**1,669**	**1,444**	**2,293**	**5,424**	**10,491**	**6,788**	**8,876**	**4,391**	**4,585**	**2,262**	**3,718**	**4,769**	**56,710**	**65,945**	**100.0**
1993 Oh's															
Kemedukl	40		10										50	44	5.7
Ngyaoch	152	260		421									833	979	94.3
Total	**193**	**260**	**10**	**421**									**883**	**1,023**	**100.0**
1993 PMCI															
Berdebed						1,308							1,308	1,308	6.2
Kemedukl	2,221	2,736	1,143	575		1,972	3,359	987	840	2,130	129	1,170	17,262	17,617	81.6
Mellemau					2,577								2,577	2,577	12.2
Total	**2,221**	**2,736**	**1,143**	**575**	**2,577**	**3,280**	**3,359**	**987**	**840**	**2,130**	**129**	**1,170**	**21,147**	**21,502**	**100.0**

Kemedukl landings from PFFA, Oh's Market, data from Perron *et. al*. (1983) and PMCI are presented in Table 3.3.3. Total landings for 1976-1989 represents only PFFA landings; no other records are available. The 1990 data set is the most complete, including Oh's market. Data for 1993 include PFFA, PMCI and Oh's (Jan-May only). Several restaurants are buying directly from fishermen but data on these receipts are not available. Unit price has gradually increased from $0.40 in 1976 to a little over $1.00 per pound recorded in 1993.

Table 3.3.3: Total landings of *B. muricatum* (***kemedukl***) at PFFA (1976-1981, compiled by Perron *et al*. 1983) and Oh's Market (1990) and PFFA (1983-1990) compiled by DMR staff. The 1983 data includes Apr.-Dec. only. The 1991-1992 data are from the 3 commercial markets while the 1993 are also from PFFA, PMCI and Oh's but Oh's data cover only Jan- May, 1993.

Year	Weight (lbs)	Value (US$)	Ave. Unit Price
1976	8,850	3,569	0.40
1977	20,738	7,734	0.37
1978	5,388	2,360	0.44
1979	33,335	14,444	0.43
1980	24,788	16,186	0.65
1981	23,699	15,719	0.66
1983	22,554	11,926	0.53
1984	74,026	35,494	0.48
1985	55,501	29,836	0.53
1986	63,642	36,592	0.57
1987	31,379	19,736	0.62
1988	12,260	8,204	0.67
1989	19,117	14,352	0.75
1990	15,262	12,752	0.82
1991	27,520	25,941	0.94
1992	34,915	35,585	1.02
1993	30,390	31,479	1.04

Table 3.3.4 shows effort for the ***kemedukl*** fishery (total number of fishermen and trips). Landings were highest during 1985 and 1986, however the average landing per trip is similar between 1985 and 1990.

Table 3.3.4. Number of fishermen, trips and landings per trip for *B. muricatum* from PFFA landings data (1985-1990). 1990 data also includes Oh's Market, Eptison Cold Storage and several restaurants.

Year	# fishermen	# of trips	Landed (lbs)	Value ($)	Ave. lbs/trip	Ave. kg/trip	Ave. $/trip
1984	n.a.	107	74,026	35,494	692	313	331.72
1985	15	173	55,501	29,836	321	145	172.46
1986	24	164	63,642	36,592	388	176	223.12
1987	19	58	31,379	19,736	541	245	340.28
1988	20	54	12,260	8,204	227	103	151.93
1989	25	67	19,117	14,352	285	129	214.21
1990	25	53	15,262	12,752	288	130	240.60

Source: fish market sales receipts.

Monthly landing data of ***kemedukl*** for the years 1985-1993 are presented in Table 3.3.5. There tends to be high landings in the first five months of the year peaking in April-May and then decreasing for the rest of the year.

Catch, effort and production figures on a state by state basis are given in Table 3.3.6 during 1990. The highest landing was recorded for Ngerchelong followed by Koror then Ngaraard and Ngeremlengui. In terms of production per unit area of lagoon and reef, Ngeremlengui has the highest followed by Ngaraard.

Table 3.3.5: Monthly landings of *B. muricatum* for PFFA from 1984 to 1990 and Oh's market (1990).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1983	n.a.	n.a.	n.a.	4,603	4,851	2,018	264	618	3,209	2,160	3,008	1,375
1984	17,321	10,275	7,629	9,096	10,109	4,351	1,205	158	7,837	1,750	759	3,536
1985	6,185	951	6,821	8,314	8,257	4,077	3,608	4,742	4,485	1,296	3,533	3,236
1986	55	2,214	1,770	8,610	1,328	7,148	2,193	3,819	5,138	11,900	3,705	3,804
1987	896	1,210	2,777	4,225	1,592	3,879	3,840	4,920	8,040	n.a.	n.a.	n.a.
1988	1,146	2,846	3,510	5,438	1,475	263	52	308	1,074	153	523	952
1989	198	3,652	1,705	2,811	854	2,206	993	310	4,022	954	898	732
1990	0	0	200	1,319	6,057	537	836	1,408	802	1,693	16	0
Mean	**3,686**	**3,021**	**3,487**	**5,552**	**4,315**	**3,060**	**1,623**	**2,035**	**4,326**	**2,844**	**1,777**	**1,948**
1991		107	1,131	165	738	637	192			115	49	315
1992	1,299	737	2,212	2,082	723		243	695	178			211
1993		242	184	1,346	5,316	999	796	950	826	455	883	1,081
PMCI	2,221	2,736	1,143	575		1,972	3,359	987	840	2,130	129	1,170
Mean	**1760**	**956**	**1168**	**1042**	**2259**	**1203**	**1148**	**877**	**615**	**900**	**354**	**694**

Table 3.3.6: The lagoon and reef area, fishermen, number of trips, total landings (lbs), average landings (lbs) and landings/sq km for each state during 1990.

State	Lagoon & reef (km^2)	Number of fishermen	Total number of trips	Total landing	Average landing	Production lbs/sq.km
Ngardmau	47.3	1	3	334	113	7.1
Pelelui	35.5	3	6	592	99	16.7
Ngeremlengui	34.8	6	6	1,794	299	51.6
Ngaraard	64.3	5	9	2,239	248	34.8
Aimeliik	90.2	1	1	96	96	1.1
Ngerchelong	497.0	2	11	4,058	369	8.2
Koror	619.2	7	10	2,626	263	4.2

Source: fish market sales receipts.

Commercial landings, by species and state, as given in Table 3.3.7, indicate that in 1993, the highest total landings of ***berdebed*** was from Kayangel; ***kemedukl*** from Ngaraard, Koror, Kayangel and Ngeremlengui; ***mellemau*** from Koror and Kayangel; and ***ngyaoch*** from Koror and Ngeremlengui. High catches were mainly around the first half of the year.

Table 3.3.7: Monthly parrotfish landings, by species and state, at the commercial markets (PFFA, PMCI and Oh's (Jan-May) in Palau during 1993.

Species	State	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Total
BERDEBED	Kayangel						1,308							1,308
	Ngaraard			35					60					95
	Peleliu								141					141
KEMEDUKL	Aimeliik						390							390
	Airai	40	35				85							160
	Angaur						352							352
	Kayangel		1,203	91	472	1,303	999	405	210					4,683
	Koror	181	351	184	105	3,695	754	696	365	388				6,719
	Ngaraard	1,848	969	1,052	103		391	2,803	912	780				8,858
	Ngardmau	72												72
	Ngchesar					119								119
	Ngerchelong							61		498				559
	Ngeremlengui				1,241	199		190	420					2,050
	Ngiwal	120	291											411
	Peleliu		129						30					159
MELLEMAU	Kayangel					1,651	189	541						2,381
	Koror	85	850		153	420	454	120	927	544				3,553
	Ngaraard					856								856
	Ngardmau					145								145
	Ngchesar			18		87	420	97						622
	Ngerchelong	391												391
	Ngeremlengui							373						373
	Peleliu			162					225	415				802

NGYAOCH	Aimeliik				505									505
	Airai	303		158	421									882
	Kayangel						79							79
	Koror		124	1,362	1,361	1,073	2,016	3,640	669	1,303				11,548
	Melekeok	52												52
	Ngatpang					174		95		68				337
	Ngchesar				271	585								856
	Ngerchelong	754			168		1,148	504		367				2,941
	Ngeremlengui		109		850	1,132	1,263	2,710	1,120	852				8,036
	Peleliu	439	76	343	770	1,629	220		299	210				3,986
	Unlisted States	100												100
OTORD	Koror			31										31

3.3.3 Stocks Status

The situation with parrotfish stocks remains the same as last reported, i.e. no assessment of stocks has been carried out. However, anecdotal evidence indicate that stocks may be declining in the face of increased fishing pressure. Field assessments in the major fishing areas appear to be urgently required. In addition, developing a system of obtaining accurate and detail time series data from fishermen will be an important component in efforts to assess trends in the fisheries.

Kitalong and Oiterong (June, 1991) noted that in the past, schools of up to one thousand ***kemedukl*** could be seen on the reefs. In 1990 DMR staff observed not more than 15 ***kemedukl*** in a school. Fishermen noted them to now be sleeping in deeper waters. Men interviewed by Rochers and Matthews (1992) in Kayangel in 1992 noted that it has become harder to find ***kemedukl*** (humphead parrotfish) in recent years. It is believed that the use of more sophisticated gear and spear fishermen who use SCUBA gear are the main causes of declines.

Quantitative marine fishes surveys conducted in 2 sites in the Ngereduu Bay area in 1992, Amesbury (1991) recorded the following for scaridae:

	Site 24					Site 25				
Species	50x2-m transect count	5-m point count	2-m point count	5-m point count	2-m point count	50x2-m transect count	5-m point count	2-m point count	5-m point count	2-m point count
Cetoscarus bicolor						x				
Scarus bowseri	x									
S. dimidiatus	x									
S. gibbus									2	
S. oviceps	x									
S. rubroviolaceus						x				
S. schlegeli	x									
S. sordidus	3	1								
S. spinus	x									
juvenile parrotfish	7			3						

(Note: x denotes that the species was observed in the vicinity but was not counted within the census areas).

During the 1992 REA in Palau, Scaridae was found to be one of the fish families having the most narrow-ranging species in Angaur. However, a few Scaridae species were found to be wide-ranging in other areas surveyed, as indicated in the following table, summarised from Donaldson (1992):

Site	Wide-ranging Scaridae Species
Kayangel	*Hippsoscarus longiceps, Scarus sordidus*
Kossol	*Scarus sordidus, Scarus schlegeli*
Eastern Babeldaob	*Scarus sordidus*
Koror-Rock Isands	*Scarus dimidiatus*
Peleliu-South/West	*Hippsoscarus longiceps*
Angaur	Scaridae reported as one of the most narrow-ranging families

Kemedukl landings at the commercial markets fluctuate from year to year, but without detailed and

accurate catch and effort data, analysis for the fishery trend is limited. Donaldson (1992) noted that a number of species in important families including groupers, jacks andtrevally, snappers, emperors and parrotfishes were either absent or present in very low numbers in stations surveyed. The situation was especially true in Kossol and Western Babeldoab which are seemingly isolated areas. This situation was attributed as apparent effects of commercial fishing.

3.3.4 Management

Current legislation/policy regarding exploitation: Section 4 (2) of the new Marine Protection Act of 1994 prohibits the fishing for commercial purposes, selling or buying of:

⇒ juvenile parrotfish of the species *Bolbometopon muricatum* (***berdebed***), i.e. a parrotfish less than 25 inches in length.

Section 4 (3) (a) of the same Act also prohibits commercial export, or fish for, sell, or buy for commercial purposes adult parrotfish, *B. muricatum* (***kemedukl***).

Section 4 (6) prohibits fishing while using any form of underwater breathing apparatus other than a snorkel.

Section 4 (7) prohibits the commercial export of the humphead parrotfish (*B. muricatum*).

Recommended legislation/policy regarding exploitation: Kitalong and Oiterong (1991) recommend the following additional management measures in light of reduced landings of this species:

- continued surveillance for illegal foreign fishing vessel on Palau's reef;
- document the timing and location of spawning schools;
- parrotfish should be included as protected species within state trochus sanctuaries.

Kitalong and Dalzell (1994) calculated the optimum minimum first capture length for *B. muricatum* to be 53.2 cm and 26.3 cm for *H. longiceps*. Predicted optimum net mesh size for each species were 10.0 and 4.7 inches respectively.

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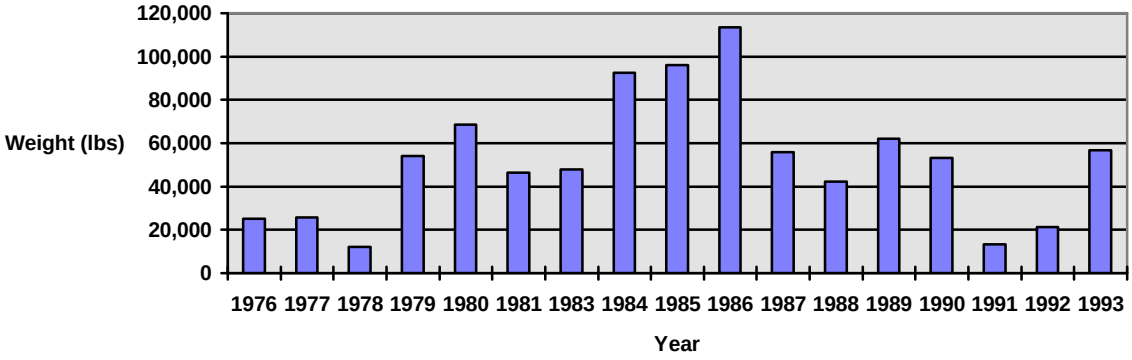
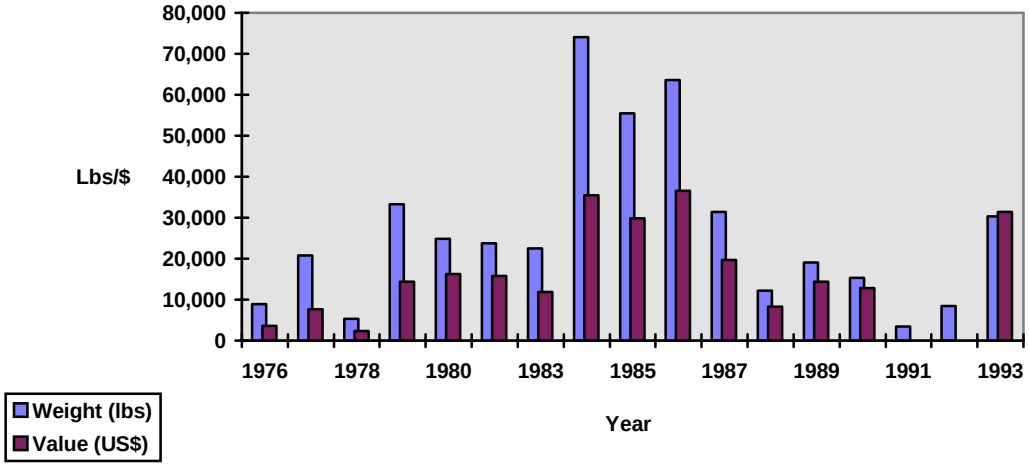
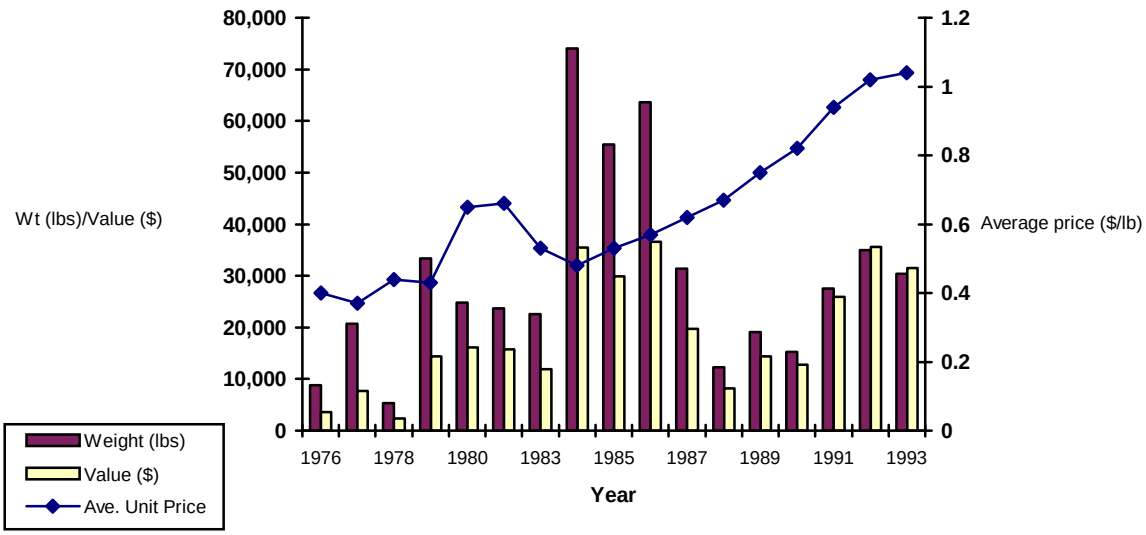
Scaridae Commercial Landings



Bolbometopon muricatum **Landings**

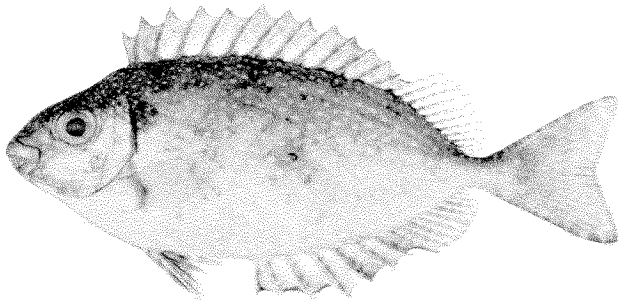


Kemedukl commercial landing and value



3.4 Rabbitfish - *meyas, klsebuul, beduut, reked*.

3.4.1 The Resource



meyas - *Siganus canaliculatus*

Species present: The Palauan rabbitfish fishery is based mainly on five species, namely: *Siganus canaliculatus* (seagrass rabbitfish - ***meyas***), *S. lineatus* (lined rabbitfish - ***klsebuul***), *S. argenteus* (forktail rabbitfish - ***beduut***), *S. punctatus* (peppered rabbitfish - ***bebael***), and *S. doliatus* (pencil-streaked rabbitfish - ***reked***), with ***meyas*** and ***klsebuul*** dominating landings. Commercial landings of these two species cause rabbitfish to be ranked among the top ten commercial reef fishes in Palau.

Distribution: Rabbitfish is found throughout Palau and is abundant in the west coast and southeast coast of Babeldaob and around Koror and Peleliu, where the mangroves and eelgrass beds are common. In Melekeok, the important finfish resources include three species of rabbitfish; seagrass, lined and blackspot rabbitfishes, which are found in shallow sandy lagoon areas or seagrass beds (Maragos, 1994). Spawning sites have been reported for three species of rabbitfish in Ngetpang with some spawning in the nearby Toachel Mlengui pass. Rabbitfish spawnings were also reported to occur in areas at Ngeremlengui, Ngerebokel, Usas, and Ngemolei. Lined rabbitfish is known to spawn at Omruchel in Peleliu. Both the lined and seagrass rabbitfishes were reported by Rochers and Matthews (1992) to spawn near Ngchesar. Johannes *et al*. (1994) observed *Siganus vulpinus* (***reked***) and *S. argenteus* (***beduut***) spawning in May, 1994 at their study site at Ngerumekaol.

In surveys of marine fishes in 26 sites in the Ngermeduu Bay area, Amesbury (1991) reported the occurrences of rabbitfish species, summarised as follows:

Species	No. of sites in which species was observed
Siganus argenteus	4 out of 21 sites
S. corallinus	12 out of 21 sites
S. doliatus	7 out of 21 sites
S. lineatus	1 out of 21 sites
S. puellus	16 out of 21 sites
S. punctatissimus	8 out of 21 sites
S. punctatus	1 out of 21 sites
S. vulpinus	14 out of 21 sites

The 1992 rapid ecological assessment surveys on distribution patterns of the marine fishes of Palau in Kayangel, Kossol, Eastern Babeldaob, Western Babeldaob, Koror-Rock Islands, Peleliu-South/West and Angaur, did not record any rabbitfish species.

Biology and ecology: Siganids are a schooling species usually found in and near the seagrass beds. *S. canaliculatus* and *S. lineatus* are usually observed in schools in inshore waters. Gravid individuals form large schools among the mangroves, then migrate seaward to the mouth of channels where they aggregate to spawn. Spawning occurs throughout the year with peaks from March to June and in November especially around Airai and Ngatpang (Myers, 1989). Adults migrate down the east and west coasts of Babelthuap Island and aggregate in schools of up to 500 fish at spawning grounds at Ngatpang, Aimeliik, Koror and Airai (Kitalong and Oiterong, 1991). Spawning sites are characterised by access to the open ocean via channels. Spawning occurs on the outer reef edge in the area of high wave activity, four or five days after the new moon (Hasse *et al.*, 1977). Johannes *et al*. (1994) observed the following rabbitfish

species spawning at their study site at Ngerumekaol:

Species	Spawning date	Time
Siganus vulpinus (***reked***)	May 11	17:45
S. argenteus (***beduut***)	May 17	17:50 - 18:05

S. canaliculatus length frequency data indicates size at first spawning at around 7-9 inches (18-23 cm), at an age of less than 1 year (Hasse, 1973). Schools of juveniles appear on reef flats 2-3 weeks after spawning. This species is believed to spawn several times a year. Longevity is thought to be around 2-3 years, with females living longer than males. Major food items are eelgrasses; schools of adults move onto the beds at high tide to graze and retreat to deeper water with the ebbing tide.

S. canaliculatus has a high growth rate and early age at maturation, indicating that large harvests are probably sustainable even with low spawning biomass. Pioneering work was conducted on the culture of rabbitfish during the mid-1980s at MMDC, but this work was not sustained.

Kitalong and Dalzell (1994) estimated growth parameters of ten reef fish species of commercial importance in Palau. Those estimated for rabbitfish species are as follows:

Rabbitfish species	L∞	K	Z	M	F	E
Siganus argenteus	31.0	0.750	3.077	1.466	1.611	0.524
S. canaliculatus	28.1	1.950	5.717	2.816	2.901	0.507
S. lineatus	33.6	0.600	2.739	1.239	1.500	0.548

Optimum and observed minimum first capture length were also given by the same authors for the same rabbitfish species as follows:

Rabbitfish species	Optimum minimum first capture length (cm)	Observed minimum first-capture length (cm)
S. argenteus	18.6	16.7
S. canaliculatus	21.8	24.1
S. lineatus	20.1	24.4

3.4.2 The Fishery

Utilization: The rabbitfishes, *S. canaliculatus* and *S. lineatus*, play a very important role on the Palauan diet. Traditionally, *S. canaliculatus* are prized for its eggs and are usually distributed among the Palauan communities in the villages during spring time. Rabbitfish form about 10 per cent of the reef fish species landed at the commercial markets. Palauan fishermen catch rabbitfish using cast nets, gill nets and set nets. It is also caught at night with spear and torch/flashlights at low spring tide during the spawning season. Lined and forktail rabbitfishes are two of the most important fishes in Peleliu (Maragos, 1994). In Ngchesar, ***klsebuul*** (lined rabbitfish) and ***meyas*** (seagrass rabbitfish) are considered important fish species with spawning sites for both species nearby.

Production and Marketing: The are no data available on the subsistence utilization level for rabbitfish in Palau. The only data available are fish purchase records by the commercial market operators. Purchase records from the commercial markets between 1990 and 1993 indicate that rabbitfish is the 3rd to 4th most important reef fish (in terms of quantity purchased). PFFA records shows rabbitfish as the most important reef fish species in 1990.

The major fishing area for *S. canaliculatus* was in Airai in the 1970s. Ngatpang is now the leading supplier of this species to Koror markets due to most trips taken. In Palau regular rabbitfish fishermen are well known from the state where rabbitfish runs occur. In recent years catches from Airai State have declined while those from Ngatpang and Koror lead due to increasing fishing efforts there.

Rabbitfish are sold directly to fish outlets throughout Koror and to some restaurants. Some are sold directly to buyers from Guam where rabbitfish is also a delicacy.

Table 3.4.1 records reef fish purchases at PFFA between 1976 and 1993. It indicates that rabbitfish constitutes about 10 per cent of all reef fish species purchased at that market annually. Figure 3.4.1 shows annual rabbitfish purchases at PFFA graphically, which seem to show a production cycle peaking every 4-5 years. The peaks between 1976 and 1993 were recorded in 1980, 1985 and 1990.

Table 3.4.1: Reef fish purchase at PFFA from 1976 to 1993, by family. Figures are in pounds.

Family	1976	1977	1978	1979	1980	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Acanthuridae	18,912	19,696	17,391	32,156	79,569	33,917	44,357	32,905	87,924	74,567	23,727	37,150	61,138	43,810	25,000	14,779	47,244
Assorted reef fish																	4,074
Carangidae	6,619	2,815	2,146	10,240	9,944	3,502	10,609	19,682	28,552	20,015	11,180	10,201	11,491	11,711	3,801	12,861	30,451
Gerridae	4,430	1,935	208	2,673	1,585	950	213	639	3,835	853	170	463	1,008	648	2,407	1,508	714
Haemulidae	0	95	335	903	1,307	325	1,224	1,214	3,236	132	0	0	0	0	0	58	207
Holocentridae	70	257	20	584	287	3,470	863	1,454	1,169	848	48	0	71	280	343	4,543	73
Labridae	1,255	918	957	3,836	3,366	2,578	4,645	3,712	7,604	6,048	1,742	1,994	910	1,397	608	928	1,462
Lethrinidae	25,005	13,461	4,104	37,569	72,886	23,817	42,259	56,669	94,491	61,859	19,070	44,895	48,091	57,099	25,939	22,357	30,795
Lutjanidae	18,327	10,044	3,898	18,830	40,840	18,321	41,446	41,960	98,951	82,479	15,570	62,682	50,810	29,123	74,405	56,456	47,676
Mugilidae	7,123	4,434	1,756	5,833	6,944	4,349	1,332	1,308	5,545	2,017	643	1,355	3,062	1,647	841	1,463	1,465
Mullidae	2,225	1,631	943	2,273	5,110	2,667	2,441	4,352	5,692	5,889	2,572	5,266	1,464	5,746	875	1,436	3,900
Scaridae	25,095	25,667	12,070	54,117	68,600	46,510	47,977	92,426	95,942	113,549	55,718	42,137	62,127	53,186	13,368	21,380	56,710
Serranidae	3,391	20,152	15,319	28,335	27,796	21,102	34,082	42,315	48,364	46,005	36,351	35,352	22,497	21,361	25,408	13,586	12,403
Siganidae	**25,371**	**19,062**	**26,206**	**36,513**	**46,260**	**17,069**	**15,893**	**36,618**	**49,864**	**33,446**	**15,659**	**25,790**	**43,217**	**69,331**	**37,814**	**33,599**	**29,560**
Sphyraenidae																	2,963
Others	65,288	137,441	50,114	30,842	12,327	1,370	14,359	8,071	100,417	17,933	188,013	36,173	33,145	17,904	61,733	85,078	
Total	203,111	257,608	135,467	264,704	376,821	179,947	261,700	343,325	631,586	465,640	370,463	303,458	339,031	313,243	272,542	270,032	269,697
% Siganidae	**12.5**	**7.4**	**19.3**	**13.8**	**12.3**	**9.5**	**6.1**	**10.7**	**7.9**	**7.2**	**4.2**	**8.5**	**12.7**	**22.1**	**13.9**	**12.4**	**11.0**

Table 3.4.2 presents commercial landings and value of rabbitfish recorded from forms supplied by MRD to PMCI, PFFA and Ohs for years 1991-1993. The figures indicate that ***meyas*** and ***klsebuul*** make up more than 90 per cent of the commercial rabbitfish landings at these markets with each species comprising about 50 per cent of that proportion.

Table 3.4.2: Number of fishermen, trips, landings and value for rabbitfish recorded from PFFA, PMCI and Ohs markets 1991-1993. (Oh's 1993 data covers only January to May). Ranking (in terms of quantity purchased) from the total commercial catch of reef fishes recorded is also given.

Year	Species	No. of fisherfolks	No. of trips	Weight (lbs)	Per cent Wt	Value US$	Per cent Value
1991	***Meyas***: *S. canaliculatus*	40	157	20,423	41.0	23,155	41.2
	Klsebuul: *S. lineatus*	31	165	25,698	51.5	29,057	51.7
	Beduut: *S. argenteus*	2	13	2,967	6.0	3,157	5.6
	Bebael: *S. punctatus*	8	10	774	1.6	875	1.6
Total		81	345	**49,862**	100.0	**56,244**	100.0
Rank					3		
1992	***Meyas***: *S. canaliculatus*	30	138	18,026	41.8	21,074	40.8
	Klsebuul: *S. lineatus*	39	160	21,347	49.5	25,939	50.3
	Beduut: *S. argenteus*	5	14	3,081	7.1	3,790	7.3
	Bebael: *S. punctatus*	8	13	548	1.3	615	1.2
	Reked: *S. doliatus*	2	2	165	0.4	182	0.4
Total		84	327	**43,167**	100.0	**51,600**	100.0
Rank					3		
1993	***Meyas***: *S. canaliculatus*	19	109	16,602	52.5	20,972	53.1
	Klsebuul: *S. lineatus*	22	112	13,776	43.6	17,094	43.3
	Beduut: *S. argenteus*	1	4	1,171	3.7	1,346	3.4
	Bebael: *S. punctatus*	2	3	80	0.3	106	0.3
Total		44	228	**31,629**	100.0	**39,518**	100.0
Rank					4		

Rabbitfish purchase records in 1993 at the three commercial markets, PFFA, PMCI and Oh's (Jan-May), as recorded in Table 3.4.3, indicate that even though fairly distributed throughout the year, the

overall commercial landing of rabbitfish is highest in January and February. High ***meyas*** landings are from January to April while those for ***klsebuul*** are from September to February.

Table 3.4.3: Monthly rabbitfish purchses at PFFA, PMCI and Oh's (Jan-May) during 1993.

Market	Palauan name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Wt	Value $
Ohs	***Klsebuul***	362		150	196	250								958	1,083
	Meyas			41	45									86	108
	Total	**362**	**0**	**191**	**241**	**250**								**1,044**	**1,191**
PFFA	***Bebael***	10		57									13.0	80	106
	Beduut				281			808			27.0		55.0	1,171	1,346
	Klsebuul	3,085	1,413	200	119		45	623	660	1,667	1,962.0	1,085.0	1,018.0	11,877	14,969
	Meyas	1,743	5,792	2,592	2,454	633	966	482	715	673	118.0	84.0	180.0	16,432	20,759
	Total	**4,838**	**7,205**	**2,849**	**2,854**	**633**	**1,011**	**1,913**	**1,375**	**2,340**	**2,107**	**1,169**	**1,266**	**29,560**	**37,181**
PMCI	***Klsebuul***										608.0	293.0		901	991
	Meyas		84											84	105
	Total	**0**	**84**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**608**	**293**	**0**	**985**	**1,096**
GRAND	**TOTAL**	**5,200**	**7,289**	**3,040**	**3,095**	**883**	**1,011**	**1,913**	**1,375**	**2,340**	**2,715**	**1,462**	**1,266**	**31,589**	**39,468**

Table 3.4.4(a) represents catch and effort, quantity landed and value for *S. canaliculatus* (***meyas***) by state. With the exception of Ngatpang, there is a general decrease in the number of trips taken leading to a decrease in landing for all states. Marked decreases are apparent for Koror, Ngchesar and Airai states. For the three years, Ngatpang supplied the most, with landings ranging from about 50 per cent of the total *S. canaliculatus* in 1991 and 1992 to more than 60 per cent in 1993.

Table 3.4.4(a): Rabbitfish, *S. canaliculatus* fishery information by state selling fish to PMCI, PFFA and Ohs in the 1991-1993 period.

State	1991			1992			1993		
	Trips	Weight	Value	Trips	Weight	Value	Trips	Weight	Value
Ngatpang	59	10,046	11,329	48	8,781	10,427	59	10,070	12,496
Koror	28	3,041	3,529	14	1,834	2,141	7	636	810
Ngchesar	21	2,764	2,985	13	2,066	2,454	10	1,112	1,578
Ngeremlengui	23	2,109	2,430	57	4,877	5,466	12	1,381	1,780
Airai	15	1,572	1,851	1	103	113	2	242	284
Peleliu	2	223	279	0	0	0	1	46	46
Ngerchelong	3	200	204	1	36	45	1	154	200
Melekeok	2	160	173	0	0	0	3	305	408
Ngardmau	1	146	183	0	0	0	0	0	0
Ngiwal	1	78	98	0	0	0	0	0	0
Aimeliik	1	53	66	0	0	0	12	2,470	3,250
Unknown	1	30	30	4	330	427	2	86	108
Total	157	20,422	23,157	138	18,027	21,073	109	15,091	18,991

3.4.3 Stocks Status

Rabbitfish have been subjected to constant heavy exploitation in Palau. Local fishermen interviewed have indicated a decline in rabbitfish populations. *S. canaliculatus* are particularly vulnerable to overfishing during February to June when they aggregate to spawn.

According to two surveys conducted by MRD in 1988 and 1990, almost all fisherfolks interviewed commented that ***meyas***, *S. canaliculatus*, has greatly decreased within the last five years. When asked what causes the decline they pointed out overfishing and infrastructure development as the leading factors.

In quantitative surveys of marine fishes in 2 sites in Ngermeduu Bay area, Amesbury (1991) reported three *S. punctatissimus* and two *S. vulpinus* during a 5-m point count survey in one of the sites. *S.*

vulpinus was also observed in the vicinity but not counted in the second site. *S. corallinus* was observed in the vicinity, but not counted, of one of the two sites.

The 1992 rapid ecological assessment surveys on distribution patterns of the marine fishes of Palau in Kayangel, Kossol, Eastern Babeldaob, Western Babeldaob, Koror-Rock Islands, Peleliu-South/West and Angaur, did not record any rabbitfish species (Donaldson, 1992).

3.4.4 Management

Current legislation/policy regarding exploitation: Airai State has a state ordinance to ban set nets during the spawning season. While this is not fully enforced, some elderly fishermen are banning fishermen from other states fishing on the ***meyas*** spawning ground during the season. Commercial fishing is prohibited.

Palau National Congress 4th OEK passed a bill (Marine Protection Act of 1994) on February 1994 banning fishing of *S. canaliculatus* for commercial purposes from March 1 to May 31. The bill also bans fishing with gill net and surround net having a mesh size of less than three inches diagonally, and set net or kesokes net with no bag portion or with the bag portion having a mesh size of less than three inches measured diagonally.

Recommended Legislation/Policy regarding exploitation: According to fishermen and field observations, ***meyas*** and ***klsebuul*** are overly exploited. Most fishermen interviewed are well aware of the decrease in the population of rabbitfshes but tend to fish for more. Traditional and national management regulations are required to protect this fish from extinction. Public education programmes will assist in this process.

Kitalong and Dalzell (1994) estimated optimum minimum first-capture length for *S. argenteus*, *S. canaliculatus* and *S. lineatus* to be 18.6, 21.8 and 20.1 cm respectively. The observed minimum first-capture length for *S. argenteus* (16.7 cm) was lower than the optimum first-capture length. The predicted optimum mesh sizes were estimated to be 3.7 cm, 3.9 cm and 3.6 cm for *C. argenteus*, *S. canaliculatus* and *S. lineatus* respectively. The minimum size mesh allowed in the Marine Protection Act of 1994 is 3 inches, which is smaller than all of the predicted optimum mesh size for the rabbitfish species.

Introduction of a minimum size limit of 7 inches (18 cm) for commercial sales of *S. canaliculatus* has been suggested. An additional consideration is increasing the mesh size for nets used in catching rabbitfish to accommodate optimum mesh sizes estimated for the rabbitfish species.

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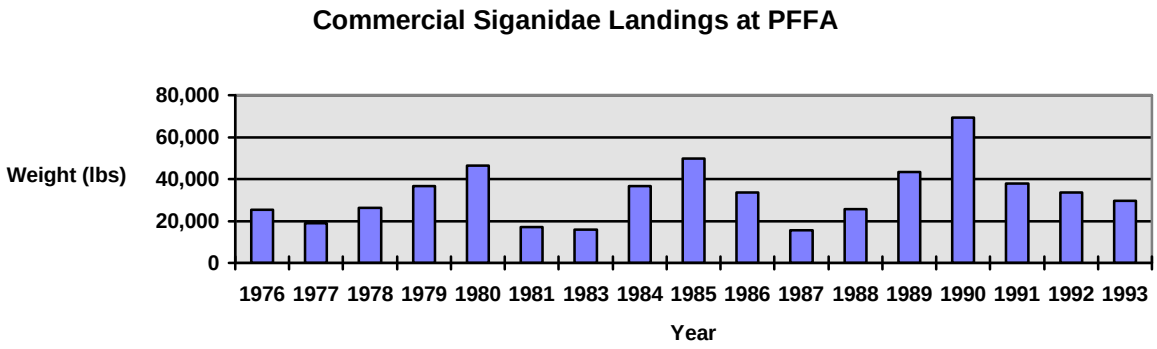
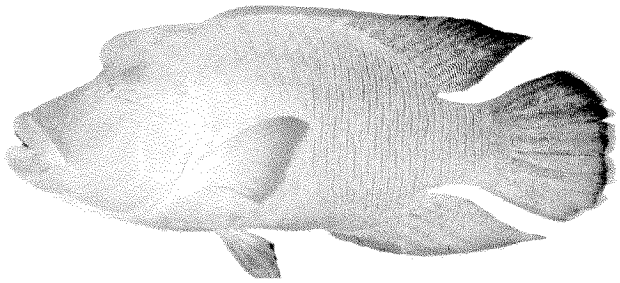
Figure 3.4.1: Siganidae commercial landings at PFFA from 1976 to 1993.



3.5 Wrasse - *maml* (adult), *mgimer* (juvenile)

3.5.1 The Resource



maml - *Chelinus undulatus*

Species present: The humphead or Napoleon wrasse, *Cheilinus undulatus* (***maml*** (adult), ***ngimer*** (juvenile), is regarded highly in the Palauan fishery, especially when in the adult stage, because of its large size and preference of taste. The other species of minor importance in the wrasse fishery is *Choerodon anchorago* (***budech***). In a rapid ecological assessment in 1992, Donaldson (1992) reported Labridae as one of the ten most speciose families in the main Palauan islands having 87 species after Gobiidae with 95 species. Amesbury (1991) recorded 39 wrasse species in 26 sites surveyed in the Ngermeduu Bay area.

Distribution: Adults occur along steep outer reef slopes, channel slopes, and occasionally on lagoon reef slopes, at depths of 2 to at least 60 cm. Juveniles occur in coral-rich areas of lagoon reefs, particularly among thickets of staghorn *Acropora* corals (Myers 1989). *C. undulatus* is found throughout Palau reefs in small numbers. It has been reported as abundant and of importance for special occasions in Ngatpang.

Amesbury (1991) recorded the occurrences of wrasse species in surveys of 26 sites within the Ngermeduu Bat area as follows:

Species	No. of sites in which species was observed	Species	No. of sites in which species was observed
Anampses meleagrides	3 out of 21 sites	*H. prosopeion*	7 out of 21 sites
A. twisti	3 out of 21 sites	*H. melanurus*	10 out of 21 sites
Bodianus axillaris	5 out of 21 sites	*H. richmondi*	3 out of 21 sites
B. diana	4 out of 21 sites	*H. trimaculatus*	4 out of 21 sites
B. mesothorax	5 out of 21 sites	*Hemigymnus fasciatus*	5 out of 21 sites
Cheilinus celebicus	5 out of 21 sites	*H. melapterus*	11 out of 21 sites
C. fasciatus	15 out of 21 sites	*Labrichthys unilineata*	6 out of 21 sites
C. trilobatus	1 out of 21 sites	*Labroides bicolor*	8 out of 21 sites
C. undulatus	12 out of 21 sites	*L. dimidiatus*	16 out of 21 sites
Cheilio inermis	1 out of 21 sites	*Macropharyngodon meleagris*	7 out of 21 sites
Choerodon anchorago	6 out of 21 sites	*Psedocheilinus hexataenia*	4 out of 21 sites
Cirrhilabrus cyanopleura	9 out of 21 sites	*Stethojulis bandanensis*	5 out of 21 sites
C. exquisitus	1 out of 21 sites	*S. strigiventor*	1 out of 21 sites
Coris gaimard	5 out of 21 sites	*Thalassoma amblycephala*	11 out of 21 sites
C. variegatus	11 out of 21 sites	*T. hardwicki*	12 out of 21 sites
Diproctacanthus xanthurus	4 out of 21 sites	*T. janseni*	1 out of 21 sites
Epibulus insidiator	11 out of 21 sites	*T. lunare*	6 out of 21 sites
Gomphosus varius	10 out of 21 sites	*T. lutescens*	5 out of 21 sites
Halichoeres chrysus	2 out of 21 sites	*T. quinquevittatum*	4 out of 21 sites
H. hortulanus	13 out of 21 sites	Juvenile wrasse	2 out of 21 sites

Labroides dimidiatus was found to be one of the wide ranging fish species during surveys at Kayangel, Eastern Babeldoad, Western Babeldoab, and Anguar (Donaldson, 1992). *C. undulatus* was found to be wide ranging in Kossol but narrow-ranging in Kayangel. With the exception of one species, Labridae in general were low-ranging in Kossol, Eastern Babeldoab, Western Babeldoab, Koror-Rock Islands, Peleliu-south/west and Anguar. Other Labridae species found as wide-ranging include *C. fasciatus* and *Epibulus insidiator* in Koror-Rock Islands.

Biology and ecology: Wrasses, family Labridae, comprise of fishes that vary enormously in size from the tiny *Pseudocheilinops ataenia*, a scant 5 cm long, to the giant humphead Maori wrasse (Randall *et al*., 1990). They also vary greatly in form and "juveniles are frequently of different colour than adults, and adult males and females are strikingly different". Many labrids undergo sex reversal

commencing their adult life as females and are able to alter their sex to females at which time they take on a different, often gaudier, colour patterns. Some species are both mature males and females in the initial phase and tend to spawn in aggregations, whereas terminal males reproduce with single females. Thus, both group spawning and pair spawning are possible within a single species (Randall *et. al*., cited above). All wrasses are carnivorous but food habits vary a great deal. *Cirrhilabrus* and some *Thalassoma* species often feed in aggregations mainly on zooplankton, Labroides and young of Labropsis and Bodianus feed mainly on the crustacean ectoparasites of other fishes. Adults of *Labropsis, Labrichthys* and *Diprotacanthus* feed on coral polyps. Most labrids feed on benthic hard-shelled invertebrates such as molluscs, sea urchins and crabs which they crush with their pharyngeal teeth. *C. undulatus* is among the largest of reef fishes and feeds on a variety of crustaceans, molluscs, fishes, sea urchins and other invertebrates. This species reaches immense size with the largest recorded at 229 cm, weighing 190.5 kg (Randall *et al*. cited above).

Johannes (1991) relates that the fishermen he interviewed have not witnessed spawning of ***maml*** in Palau. However, fishermen from Tuamotu have witnessed, in March, pairs of ***maml*** "swim" like fools and "play" and rise spirally from the depths to the surface (Ottino and Plessis 19??, quoted in Johannes, 1981).

Kitalong and Oiterong (1991) stated that divers have repeatedly observed "families" with two large ***mamls*** followed by two small ones at specific dive sites in Palau. One fishermen stated that at certain times of the year, schools of ***maml*** pass through certain channels and are easily caught by speargun.

Kitalong and Dalzell (1994) estimated growth and mortality parameters for ten reef fish species caught by commercial fishing in Palau. Only those for *C. undulatus* were calculated for wrasses and are as follows:

Species	L∞	K	Z	M	F	E
Cheilinus undulatus	137.5	0.100	0.479	0.259	0.220	0.459

The calculated optimum first-capture and observed minimum first-capture lengths were given for the same species as 68.8 and 48.9 cm respectively.

3.5.2 The Fishery

Utilization: ***Maml*** is the most highly regarded fish in Palau. The large size and distinguishable taste of this fish makes it very important in local customs and feasts. The large white meat is a delicacy among most restaurants, served as sashimi or fish steaks and other dishes. Maragos (1994) and Rochers and Matthews (1992) reported that humphead wrasse is one of the fish species that are especially important in customary uses in Ngchesar, Ngeremlengui, Peleliu, Kayangel, and Ngarchelong. It has been reported as abundant and of importance for special occasions in Ngatpang. ***Maml*** is an important fish species in the local commercial market.

Maml was also targeted for export during the 1985-86 peak of live grouper export from Palau.

A lot of the small wrasse species are exported in the aquarium fish trade and are discussed under that profile.

Production and marketing: Production at the subsistence level in Palau is not known and data available from commercial markets are often incomplete. ***Maml*** is often sold directly to markets, restaurants and individuals and that only data recorded are those from the three commercial markets (PFFA, PMCI and Oh's). Filleted ***maml*** is also being exported. In 1990, 1.5 tons of this species was confiscated from a foreign vessel operating at Helen's Reef. The smaller wrasse species are exported for

the aquarium fish trade. Aquarium finfish exports recorded in 1992 and 1993 indicated the following information
concerning wrasses:

	1992		1993	
	# pieces	value ($)	# pieces	value ($)
Finfish Total	46,716	28,390.55	31,271	22,866.28
Wrasse	2,287	3,314.95	1,162	1,853.60
% Wrasse	4.9	11.7	3.7	8.1

These indicate that in 1992, wrasse specimens made up 4.9 per cent (2,287 specimens worth $3,315) of the total number of finfishes (pieces) exported in the aquarium trade for that year, decreasing to 3.7 per cent (1,162 specimens worth $1,854) recorded in 1993. However, in terms of value, wrasses made up 11.7 per cent in 1992 and 8.1 per cent in 1993. Details are discussed under the "aquarium fish" profile.

Data collected from PFFA for the 1976-1993 period, as shown in Table 3.5.1, indicate that Labridae comprises between 0.2 and 1.8 per cent of all annual reef fish landed at that market. The highest landings of 7,604 and 6,049 lbs were recorded in 1985 and 1986 respectively.

Table 3.5.1: Reef fish purchase at PFFA from 1976 to 1993, by family. Figures are in pounds. (Source: DMR Annual Reports for 1991 and 1992 and DMR data).

Family	1976	1977	1978	1979	1980	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Acanthuridae	18,912	19,696	17,391	32,156	79,569	33,917	44,357	32,905	87,924	74,567	23,727	37,150	61,138	43,810	25,000	14,779	47,244
Assorted reef fish																	4,074
Carangidae	6,619	2,815	2,146	10,240	9,944	3,502	10,609	19,682	28,552	20,015	11,180	10,201	11,491	11,711	3,801	12,861	30,451
Gerridae	4,430	1,935	208	2,673	1,585	950	213	639	3,835	853	170	463	1,008	648	2,407	1,508	714
Haemulidae	0	95	335	903	1,307	325	1,224	1,214	3,236	132	0	0	0	0	0	58	207
Holocentridae	70	257	20	584	287	3,470	863	1,454	1,169	848	48	0	71	280	343	4,543	73
Labridae	**1,255**	**918**	**957**	**3,836**	**3,366**	**2,578**	**4,645**	**3,712**	**7,604**	**6,048**	**1,742**	**1,994**	**910**	**1,397**	**608**	**928**	**1,462**
Lethrinidae	25,005	13,461	4,104	37,569	72,886	23,817	42,259	56,669	94,491	61,859	19,070	44,895	48,091	57,099	25,939	22,357	30,795
Lutjanidae	18,327	10,044	3,898	18,830	40,840	18,321	41,446	41,960	98,951	82,479	15,570	62,682	50,810	29,123	74,405	56,456	47,676
Mugilidae	7,123	4,434	1,756	5,833	6,944	4,349	1,332	1,308	5,545	2,017	643	1,355	3,062	1,647	841	1,463	1,465
Mullidae	2,225	1,631	943	2,273	5,110	2,667	2,441	4,352	5,692	5,889	2,572	5,266	1,464	5,746	875	1,436	3,900
Scaridae	25,095	25,667	12,070	54,117	68,600	46,510	47,977	92,426	95,942	113,549	55,718	42,137	62,127	53,186	13,368	21,380	56,710
Serranidae	3,391	20,152	15,319	28,335	27,796	21,102	34,082	42,315	48,364	46,005	36,351	35,352	22,497	21,361	25,408	13,586	12,403
Siganidae	25,371	19,062	26,206	36,513	46,260	17,069	15,893	36,618	49,864	33,446	15,659	25,790	43,217	69,331	37,814	33,599	29,560
Sphyraenidae																	2,963
Others	65,288	137,441	50,114	30,842	12,327	1,370	14,359	8,071	100,417	17,933	188,013	36,173	33,145	17,904	61,733	85,078	
Total	203,111	257,608	135,467	264,704	376,821	179,947	261,700	343,325	631,586	465,640	370,463	303,458	339,031	313,243	272,542	270,032	269,697
% Labridae	**0.6**	**0.4**	**0.7**	**1.4**	**0.9**	**1.4**	**1.8**	**1.1**	**1.2**	**1.3**	**0.5**	**0.7**	**0.3**	**0.4**	**0.2**	**0.3**	**0.5**

Monthly *C. undulatus* landings, as recorded in Table 3.5.2, shows that on the average, this species is generally harvested throughout the year with peak landings between March and July. In terms of quantity landed, 1985/1986 showed the highest. A marked decrease from more than 6,000 pounds a year in the 1985/86 period to about 2,000 pounds a year in 1987/88. After a decline to 900 lbs in 1989, a marked increase to about 4,000 lbs was recorded in 1990, followed by a decrease in the following two years. Landings recorded at PFFA and PMCI in 1993 totalled only 1,400 lbs valued at USD1,500. Overall, a general decrease in landing has been observed from 1985/86.

Table 3.5.2: Seasonal landings of *Cheilinus undulatus.* Data from PFFA (1983-1990, 1991-1992), Oh's Market (1990), and PFFA and PMCI (1993). (Source: Kitalong and Oiterong, 1991; DMR Annual reports for 1991 and 1992; and DMR data).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Wt	Total Value
1983	na	na	na	92	606	586	52	320	396	537	0	338	2,927	
1984	177	86	476	299	255	200	303	228	691	330	131	444	3,620	
1985	463	434	750	1,592	1,229	631	0	459	25	326	593	68	6,570	
1986	0	0	391	978	829	910	945	168	302	648	583	294	6,048	
1987	102	0	199	237	0	337	38	63	760	0	0	0	1,736	
1988	329	201	622	282	0	26	123	226	108	76	0	0	1,993	
1989	38	27	62	278	0	169	0	314	0	0	0	22	910	
1990	86	58	127	194	66	31	3,058	0	157	77	0	108	3,962	
1991	61	0	43	0	0	0	35	0	215	95	0	112	561	
1992	15	41		58	0		143	83	80			74	494	
Ave:	141	94	334	401	299	321	470	186	273	232	145	146		
1993														
Maml		70	230	207	70	146	28	364	153	43	106		1,417	1,555
Ngimr			41								64		105	113
1993		70	271	207	70	146	28	364	153	43	170		1,522	1,668

Total														

The number of fishermen involved in the commercial harvesting of wrasses fluctuated between 7 and 24 per year as recorded at the commercial markets for the 1984-1993 period. However, there was a decline in the number of recorded trips taken which generally reflects the amount of fish landed. The average unit price has increased from US$0.64 in 1984 to US$1.14 in 1994. The average fish weight landed and value per trip have generally increased.

Table 3.5.3: Number of fishermen, trips and landings per trip from PFFA landings data (1985-1993). 1990 data also includes Oh's Market, Eptison Cold Storage and several restaurants while those for 1991 to 1993 include PMCI and Oh's (Jan-May of 1993).

Year	No. of fishermen	No. of trips	Landed (lbs)	Value ($)	Ave. price $/lb	Ave. lbs/trip	Ave. $/trip
1984	n.a.	n.a.	3,620	2,304	0.64	n.a.	n.a.
1985	15	127	7,501	5,231	0.70	59	41
1986	24	115	6,048	4,165	0.69	53	36
1987	14	17	1,742	1,101	0.63	102	65
1988	12	27	1,994	1,553	0.78	74	58
1989	14	17	910	845	0.93	54	50
1990	7	16	907	806	0.89	57	50
1991	11	14	961	1,054	1.08	69	75
1992	16	21	2,670	2,898	1.08	127	138
1993	12	17	1,504	1,667	1.14	88	98

Commercial landings of *C. undulatus* in Table 3.5.3 are given by state for the 1991-1993 period and presented in Table 3.5.4, indicating Koror, Ngerchelong, Ngchesar and Ngeremlengui as the main sources of *C. undulatus*. All of these states showed increases of *C. undulatus* landings from 1991 to 1992, but decreases from 1992 to 1993.

Table 3.5.4: Commercial *C. undulatus* landings by state for the 1991-1993 year period at PFFA, PMCI and Oh's market (January-May).

State	1991		1992		1993	
	Weight	Value	Weight	Value	Weight	Value
Ngerchelong	416	439	709	764	106	106
Ngaraard	217	257	0	0	0	0
Koror	146	157	717	785	552	655
Ngeremlengui	99	101	258	284	201	233
Ngchesar	68	85	632	695	61	67
Ngatpang	15	15	65	72	0	0
Airai	0	0	53	58	0	0
Angaur	0	0	56	60	224	227
Kayangel	0	0	80	80	192	211
Peleliu	0	0	0	0	168	168
Unlisted	0	0	100	100	0	0
Total	**961**	**1,054**	**2,670**	**2,898**	**1,504**	**1,667**

No accurate data is available on any exports of wrasses for food from Palau.

3.5.3 Stocks Status

There have not been any studies conducted in Palau specifically assessing the stocks of the wrasses and their fishery. According to data collected from 1976 to 1993, Labridae contribute a low proportion (about 1 per cent) of the total reef fish commercial catch recorded. Indications are that over the past few years the landings have steadily declined. According to some fishermen, *C. undulatus* is perhaps overfished due to some unregulated fishing. Some local fishermen claimed that a few ***maml*** fishers have been using SCUBA gear at nights for the last three years. In some states, the use of ***muud*** (damselfish) traditional fishing method has also diminished the population of wrasses by destroying its juvenile habitats of staghorn corals.

The value of this species as a live or chilled export has led to illegal fishing by foreign fishing and local fishing operations in partnership with foreign companies. These operations provide the most damaging impact on this fishery. Kitalong and Oiterong (1991) indicate that a combination of poisoning and excessive line fishing has resulted in localised extinctions in Palau, for example at Helen's Reef.

Anecdotal information from interviews with fishermen indicate that this species was commonly seen in groups of up to 75 individuals near channels around the barrier reef 5 years ago, especially around the time of full moon. Such large aggregations are reportedly not now seen.

Maml is a prized fish in Palau and is often not sold commercially but rather used for important customs. Fishermen are asked specifically to catch large individuals for special occasions. The traditional value of the species justifies better management. Immature wrasse (***ngimer***) are regularly sold at the markets and considered good eating, but these immature fish should be protected as a safeguard against growth overfishing.

Fishermen have indicated that at certain times of the year, schools of *C. undulatus* pass along certain channels in the reefs, presumably travelling to specific locations to spawn. When and where these schools pass should be documented and the schools protected. Fishermen have stated in interviews that the banning of SCUBA fishing would help protect the species in their "home" caves, as only very skilled spearfishermen can lure the fish out of its cave without the use of SCUBA gear.

Fish counts in two sites in Ngermeduu Bay is reported by Amesbury (1991) and those the labridae species are as follows:

	Site 24					Site 25				
Species	50x2-m transect count	5-m point count	2-m point count	5-m point count	2-m point count	50x2-m transect count	5-m point count	2-m point count	5-m point count	2-m point count
Anapmpses meleagrides	1									
A. twisti	1									
Bodianus axillaris	1			2		1				
Cheilinus celebicus	x									
C. fasciatus	1					2				
C. undulatus	x									
Coris gaimard						1				
C. variegata						7			2	
Epibulus insidiator		1								
Gomphosus varius	1									
Halichoeres chrysus							2			
H. hortulanus	1					4	1			
H. melanurus	1					5				
H. prosopeion				1						
Hemigymnus fasciatus	1									
H. melapterus	x					x				
Labroides bicolor				1						
L. dimidiatus	6			1		1	1			
Macropharyngodon meleagris	3									
Stehojulis bandanensis	1									
S. strigiventor						x				
Thalassoma amblycephela							5			
T. hardwicki						1				
T. lunare	1					2	1			
wrasse juveniles	2					10		4		

x denotes those observed in the vicinity of the survey but were not counted.

Almost all of these species are those utilized in the aquarium trade.

During the 1992 rapid ecological assessment in Palau, some wrasse species were found to be wide-ranging, within certain areas survey as presented in the following table:

Area	Wide-ranging Labridae species
Kayangel	*Labroides dimidiatus*
Kossol	*Cheilinus undulatus, Halichoeres hortulanus, Thalassoma amblycephalum, Labroides dimidiatus*
Eastern Babeldoab	*Labroides dimidiatus*
Western Babeldoab	*Labroides dimidiatus*
Koror-Rock Islands	*Cheilinus fasciiatus, Epibulus insidiator*

Peleliu-South/West	*Labridae* classified as one family most narrow-ranging in this area
Angaur	*Labridae* classified as one family most narrow-ranging in this area

3.5.4 Management

Current legislation/policy regarding exploitation: Some states in Palau issue permits in all type of fishery taking place in their territorial waters. In Ngeremlengui State, where schools of ***maml*** used to be seen in the channels as reported by some fishermen, fishing is limited to residents only. Permits from the state government have to be issued to outsiders.

The Fourth Olbiil Era Kelulau, Palau National Congress passed a bill in February 1994 (Marine Protection Act of 1994) banning the use of SCUBA in fishing. In addition, Section 4 (2) (b) prohibits the commercial harvesting of juvenile *C. undulatus* (***ngimer***) less than 25 inches in length. Section 4 (3) (b) prohibits the export of adult *C. undulatus*. Section 4(6) prohibits the use of any form of underwater breathing apparatus other than a snorkel. Section 4 (12) prohibits the use of gill net or surround net having a mesh size less than 3 inches or with a bag portion having a mesh size less than 3 inches.

Penalties for violation of these laws are as follows:

> upon the first conviction, a fine not less than $250; upon the second conviction, a fine not less than $500 and a sentence to serve up to thirty days in jail; upon the third conviction, a fine not less than $1,000 and a sentence to serve up to six months in jail; any conviction after the third is a fine of $5,000 and a sentence of up to one year in jail.

Regulations concerning the taking of aquarium fish is discussed under that particular profile.

Recommended legislation/policy regarding exploitation: Nichols (1991) recommends the following options:

⇒ existing trochus sanctuaries should include *C. undulatus* as a protected species;
⇒ closed seasons to be set up at known spawning sites during the peak spawning months: location and timing of spawning aggregations should be documented;
⇒ continue surveillance of foreign fishing vessels for illegal catches of the species; and
⇒ ban the sale of immature specimens at commercial markets

Kitalong and Dalzell (1994) estimated the optimum minimum first-capture length of *C. undulatus* to be 53.2 cm (20.9 inches). The predicted optimum mesh size was 13.5 inches. Appropriate research, involving detail and accurate time series data collection from fishermen are necessary to confirm introduced laws concerning the exploitation of *C. undulatus* and to assess its potential for development.

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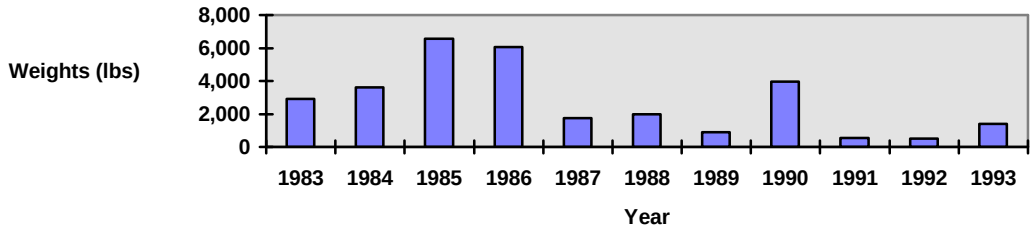
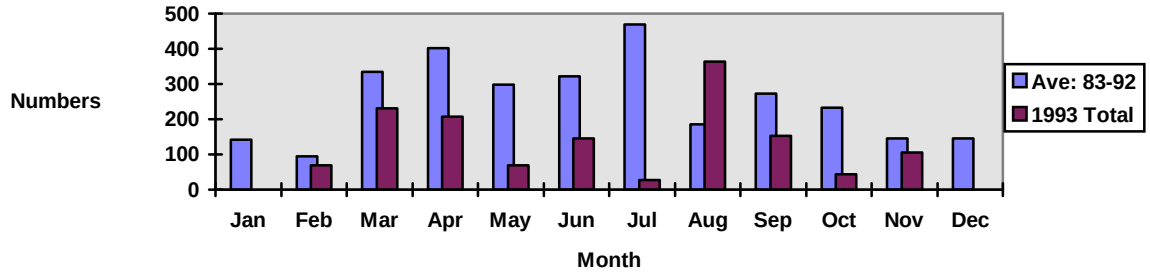
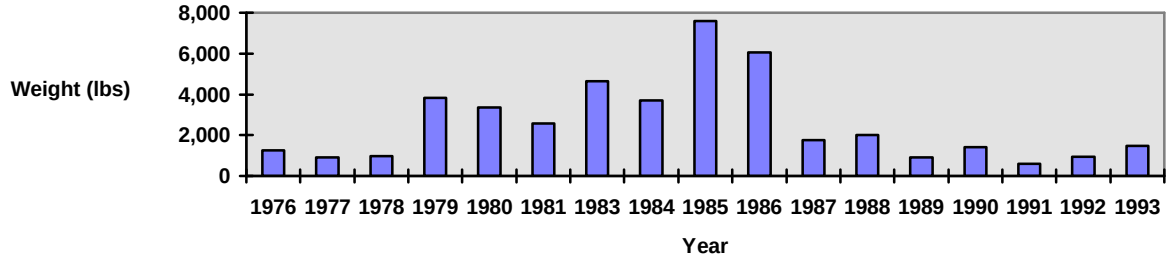
Cheilinus undulatus landings at commercial markets



Monthly _C. undulatus_ commercial landings



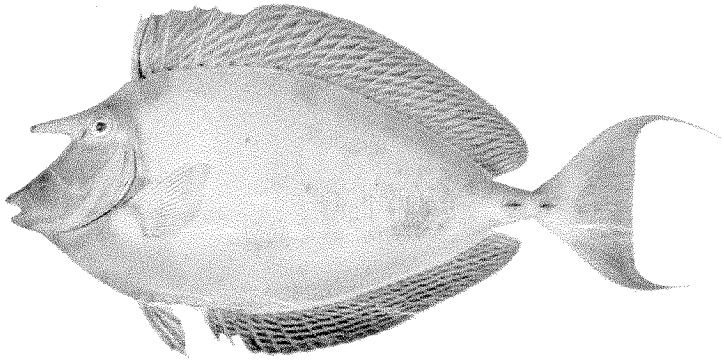
Labridae commercial landings at PFFA



3.6 Other shallow-water reef fish species

3.6.1 The Resource

Species present: Fish species listed in this profile include those of commercial value from shallow water reefs, mangroves and lagoons but exclude those, e.g. small pelagic fishes (small mackerels, scads, sardines), mullet, parrotfish, rabbitfish, groupers and wrasses, which are discussed under their respective profiles. Those discussed in this profile include:



um *- Naso unicornis*

Acanthuridae: surgeonfish species of importance in the commercial reef fish fishery in Palau include; *Naso unicornis* (bluespine unicornfish - ***um***), *N. lituratus* (orangespine unicornfish - ***erangel***), *Acanthurus xanthopterus* (yellowfin surgeonfish - ***mesekuuk***) and *A. olivaceus* and *A. thompsoni* (orangespine surgeonfish and Thompson's surgeonfish - ***esengel***). Other species of lesser importance are *A. lineatus* (bluebanded surgeonfish - ***belai***), *A. sandviscens* (***elas***), *A. nigrofuscus* (brown surgeonnfish - ***eremuuch***), *A. mata* (elongate surgeonfish - ***mesekuuk bad***), *N. vlamingii* (bignose or Vlaming's unicornfish - ***derbaksous***), *N. tuberosus* (humpnose unicornfish - ***ongchutel***), and *N. annulatus* (whitemargin unicornfish - ***sechou***)

Carangidae: trevallies and jacks [excluding scads, which is discussed under "small pelagics" profile, and rainbow runner and amberjack, discussed under "oceanic pelagics"] of importance include: *Caranx ignobilis* (giant trevally - ***eropk***), *C. sexfasciatus* (bigeye trevally - ***esuch***), *C. lugubris* (black jack - ***omektutau***), *C. melampygus* (bluefin trevally - ***orwidel***), *Carangoides fulvoguttatus* (yellow-dotted trevally - ***yab***), *Gnathanodon speciosus* (golden trevally - ***wii***) and *Trachinotus blochi* (snub-nosed dart - ***iliuchbuil***).

Lethrinidae: emperor species of importance in the commercial reef fish fishery include; *Lethrinus ramak* (yellowstripe emperor - ***udech***), *L. obsoletus* (orange-striped emperor - ***udech***), *L. elongatus* (longnose emperor - ***melangmud***), *L. haematopterus* (***metengui***), *L. mahsenoides* (yellowbrow emperor - ***metengui***), *L. harak* (blackspot or thumpprint emperor - ***itotech***), *L. kallopterus* (orangefin emperor - ***menges***), *L. amboinensis* (ambon emperor - ***rekruk***), *L. xanthochilus* (yellowlip emperor - ***mechur***), and *Monotaxis grandoculus* (bigeye emperor - ***besechamel***).

Kyphosidae: rudderfish (sometimes called drummers or sea chubs) species of importance are: *Kyphosus cinerascens* (highfin rudderfish or topsail drummer - ***komud***) and *K. vaigiensis* (longfin rudderfish or drummer - ***komud***).

Gerreidae: silverfish (more commonly known as silver biddes or mojarras) species of importance include; *Gerres filamentosus* (filamentous mojarra - ***kotikou***), *G. oyena* (oyena mojarra or oceanic silver biddy - ***esall***), and *G. abbreviatus* (deep-bodied mojarra - ***edoched***).

Mullidae: goatfish species of importance include: *Mulloides flavolineatus* (yellowstripe goatfish - ***dech***), *Parupeneus barberinus* (dash-dot goatfish - ***bang***), *P. indicus* (Indian goatfish - ***eldebsungel***) and *Mulloides vanicolensis* (yellowfin goatfish - ***emisech***).

Haemulidae: sweetlip and grunt species of importance include: *Plectorhinchus obscurus* (giant sweetlips - ***bikl***), *P. flavomaculatus* (netted sweetlips - ***debeliich***), *P. celebecus* (Celebes sweetlips - ***merar***) and *P. goldmani* (Goldman's sweetlips - ***yaus***).

Holocentridae - soldierfish and squirrelfish species include: *Myripristis berndti* (bigscale soldierfish - ***bsukel***), *M. melanostictus* (***bsukl***), *Sargocentron caudimaculatum* (tailspot squirrelfish - ***desachel***), *S. spiniferum* (long-jawed squirrelfish - ***desachel***), *S. tiere* (blue-lined squirrelfish - ***desachel***) and *Neoniphon sammara* (bloodspot squirrelfish - ***kedaol***).

Chanidae: *Chanos chanos* (milkfish - ***mesekelat***).

Distribution: Shallow-water coral reefs, lagoons and mangrove areas are the main habitats for the fish species discussed in this section. As such, fishing activities for these fishes are normally confined within or near these habitats. Palau's reefs generally possess abundant and diverse reef fish communities, upon which considerable small-scale commercial and subsistence fisheries have developed. Most species live on relatively shallow-water reefs. Donaldson (1992) noted that the Palau Islands are a remarkable assemblage of tropical high islands, low coral islands, atolls and submerged offshore reefs which support a highly diverse fish fauna and easily the richest in all of Micronesia. Most of the islands are surrounded by a complex of fringing and barrier reefs with species diversity recorded as highest in the lagoon environments of the main Palau islands. Survey results of marine fish species occurrences in the Ngermeduu Bay is reported in Amesbury (1991). Distribution patterns of the marine fishes as recorded during 76 visual transects and supplemental observations made at Kayangel, Kossol, Eastern Babeldaob, Western Babeldaob, Koror-Rock Islands, Peleliu-South/West and Angaur, are reported in Donaldson (1993).

Johannes *et al*. (1994) observed spawing of *Naso unicornis*, *N. literatus*, *Acanthurus xanthopterus*, *A. nigricauda*, *Ctenochaetus striatus*, and *Parupeneus multifasciatus* at their Ngerumekaol study site.

Biology and ecology: Sexes are separate in most shallow-water reef-associated fishes including holocentrids, mugilids, mullids, gerrids, siganids, carangids (Wright, 1993). Protogynous (change from female to male) fishes include serranids, lethrinids, nemipterids and labrids while platycephalids, sparids, gobiids and muraenids change sex from male to female (protandrous). Most species produce pelagic eggs except for the majority of siganids, tetradontids and balistids which nest. Spawning migration, to a reef location contiguous to oceanic water, vertically in the water column or inshore, is common (Wright, 1993).

Acanthuridae: Ecological characteristics of Acanthuridae are given in Pyle (1993) as follows:

Family	Feeding Strategy	Reproductive Strategy	Habitat
Acanthuridae (surgeonfishes and tangs)	herbivorous	school-forming; spawn at dusk in large groups; pelagic eggs	all habitats depending on species

Most of the surgeonfishes graze on benthic algae but four species of the Acanthurus and many of Naso feed mainly on zooplankton while those of the genus *Ctenochaetus* are detritus-feeders (Randall *et al*., 1990). They sleep at night in small caves or crevices in the reef. The acanthurids typically have a long life larval lifespan and settle out at a large size resulting in widespread distribution for most species. They are among the most conspicuous and abundant inhabitants of shallow coral reefs (Myers, 1989). Some reproduction activities occur throughout the year but typically takes place on a lunar cycle with peak activity during winter or early spring. Johannes *et al*. (1994) recorded the following information concerning surgeonfish spawning observed at Ngerumekaol in 1994:

Species	Date of spawning	Time spawning took place
Naso unicornis	June 6, 1994	18:20
N. literatus	May 8 to 11	17:45 to 18:20
Acanthurus xanthopterus	May 9 and 11	18:00 to 18:10
A. nigricauda	May 9, 10	18:00 to 18:10
Ctenochaetus striatus	May 9	17:55

Kitalong and Dalzell (1994) calculated growth and mortality parameters for ten reef fish species caught

by commercial fishing in Palau which included two *Naso* spp. as follows:

Species	L∞	K	Z	M	F	E
Naso lituratus	35.1	0.350	1.683	0.860	0.823	0.489
N. unicornis	57.0	0.140	0.683	0.413	0.270	0.395

The same authors calculated the optimum minimum first-capture length for both species in Palau to be 19.0 and 19.3 cm for *N. lituratus* and *N. unicornis* respectively.

Carangidae: species in the family Carangidae exhibit a wide size range from scads that attain 30 cm to the great trevally that grows to 170 cm and may weigh over 35 kg (Randall, *et al*., 1990). "They are voracious predators that feed on a variety of fishes, with some species such as *G. speciosus* feeding mainly on molluscs and crustaceans while scads feed mainly on palnktonic invertebrates. Trevallies are pelagic spawners that release large numbers of of tiny, buoyant eggs, and larvae may lead a pelagic existence for extended periods. Juveniles of several species, e.g. *C. sexfasciatus*, are often found in brackish estuaries or in fresh water". They frequently occur in large schools and are common on edges of reefs especially along steep outer reef dropoffs.

Lethrinidae: most species of emperors occur on the sandy fringe of reefs where they actively forage on sand-dwelling invertebrates such as gastropods, polychaetes, crabs, prawns and chitons with larger species being fish predators also (Randall *et al*., 1990). Most species feed primarily at night. Sex reversal from female to male (protogynous hermaphroditism) has been demonstrated in several species (Myers, 1989). Kitalong and Dalzell (1994) estimated growth and mortality parameters for one emperor species as follows:

Species	L∞	K	Z	M	F	E
L. ramak	34.5	0.380	1.486	0.912	0.574	0.386

Kyphosidae: rudderfishes (drummers or sea chubs) are omnivores but feed mainly on benthic algae. They sometimes occur in small aggregations (Randall *et al*., 1990). Juveniles often occur far out at sea beneath floating debris (Myers, 1989).

Gerreidae: Silver biddies occur on sand or mud bottoms, frequently in brackish environments (Randall *et al*., 1990). They feed on small benthic invertebrates, including polychaete worms and small crustaceans for which they root in the sand (Myers, 1989; Randall *et al*., 1989).

Mullidae: goatfishes are characterised by the pair of long barbels under the chin which are used to probe the sand, mud or holes in the reef for food. Some goatfish species are active primarily at night while others are most active by day, or active by day or night (Myers, 1989). All goatfishes are carnivores feeding mainly on worms, crustaceans, brittle stars, small mollusks and heart urchins that live in sediment, while some species feed in part on small fishes (Randall *et al*., 1990). Johannes *et al*. (1994) observed *Parupeneus multifasciatus* spawning at Ngerumekaol on May 20 at 17:30 hour.

3.6.2 The Fishery

Utilization: The shallow-water reefs and lagoons surrounding the islands have always been an integral part of the Palauan way of life. The resources from these areas have been a vital source of protein at the subsistence level, and with the change from a barter to a cash economy, these resources have become important in the artisanal, and recently the commercial fisheries. Smaller specimens and juveniles of some of the species included here are also utilized in the aquarium fish trade. Details on these are discussed under the "aquarium fish" profile.

Most reef fishing is carried out around Koror, as this is the most populous state, and activity is generally concentrated between the barrier reef and the islands of Babelthuap and Koror. Reef systems around Peleliu, the islands to the North-west and around Angaur also support rich reef fish stocks.

The fishery is conducted with multi-gear types, including dropline, trolling, hand spears, spear guns, gill nets, set nets (kesokes), portable fish traps, cast nets and to a lesser extent custom methods (Johannes, 1981). Illegal methods such as dynamite and industrial poisons (bleach) have caused concerns in some areas (Johannes, 1991). Most fishing is done from boats of 5-8 m length, powered by 50-120 hp outboards. GRP or wooden inboard powered vessels of 12-70 hp are also important. The introduction of spearguns in the 1940s has changed traditional spearng methods (Donaldson, 1992). Most of the traditional fishing methods have been replaced by modern gear of catching fish. The use of SCUBA has enabled fishermen to exploit habitats and harvests species that were previously underutilised. Even the traditional poisons, made from leaves and roots (fruit?) of *Barringtonia asiatica* and the roots of *Derris elliptica* have been replaced with liquid bleach, gasoline and dynamite (Donaldson, cited above). Over 20 types of traditional nets, which require highly developed and specialised skills to operate, have been replaced by monfilament cast nets (***bidekill***), stationary barrier nets (***kesokes***) and surround nets.

Year-round trolling tends to be for strongly reef-associated species (trevallies, dogtooth tuna, barracuda, etc.).

Production and marketing: Species included in this profile are important fish species in the subsistence fishery and now, due to the change of economy base, they have become targets of increasing pressure for the commercial fishery mainly for food. A limited amount is exported for the aquarium fish trade.

The 1992-1993 exports of finfish via the aquarium trade is summarised in the following table for fish included in this profile (details are discussed under the “aquarium fish” profile”). Only surgeonfishes of those species in this profile contribute a significant number to the trade.

	1992		1993	
Aquarium fish	Nos.	US$	Nos.	US$
This profile species				
Goatfish	23	20.70	27	20.15
Squirrelfish	14	14.00	10	12.00
Surgeonfish	1,296	3,421.50	346	908.50
Sweetlips	4	6.00	21	50.40
Trevally			1	3.60
Unicornfish	41	41.00	306	626.40
All Finfish Total	**46,716**	**28,390.55**	**31,271**	**22,866.28**

Rochers and Matthews (1992) reported that portions of almost all commercial fish catches are kept for family use. However, fishing for subsistence is an every day activity in most communities. From household surveys conducted in 1975, Perron *et al*. (1983) estimated that the annual per capita fish consumption in Palau was 141 kg. Using this figure, total fish production was estimated to be 2,015 t/year in 1990. Kitalong and Dalzell (1994) suggested that the subsistence fisheries production for Palau may lie between 500 and 1,100 t/year, which include tuna and other pelagic fish species.

An estimated 305,447 pounds (138.5 mt) of reef fish were landed in Koror for 1990. Shimada (1987) estimated total annual reef fish production at 2,000 tons for the coastal fisheries in Palau, 300-400 tons were estimated to be marketed through domestic outlets and exports, and 1,200-1,300 mt. consumed by the fishermen and villagers for subsistence. If these figures are correct, then a significant proportion of fish is marketed through avenues other than markets such as PFFA.

Annual reef fish landings at PFFA between 1976 and 1993, by family, are given in Table 3.6.1(a). Table 3.6.1(b) is the same but figures are converted to percentages of the total reef fish landing for each particular year. Figures show that two of the fish families discussed in this particular profile,

Acanthuridae and Lethrinidae, contribute significantly to the reef fish landings at PFFA. Each contribute between 10 and 20 per cent of the total reef fish landing each year. Fish in this particular profile are in bold. A substantial amount has been recorded as "other" and in 1993, this category was called "assorted fish".

Table 3.6.1(a): Reef fish purchase at PFFA from 1976 to 1993, by family. Figures are in pounds and those for species included in this particular profile are in bold.
(Source: DMR Annual Reports for 1991 and 1992 and DMR data).

Family	1976	1977	1978	1979	1980	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Acanthuridae	**18,912**	**19,696**	**17,391**	**32,156**	**79,569**	**33,917**	**44,357**	**32,905**	**87,924**	**74,567**	**23,727**	**37,150**	**61,138**	**43,810**	**25,000**	**14,779**	**47,244**
Assorted reef fish																	**4,074**
Carangidae	**6,619**	**2,815**	**2,146**	**10,240**	**9,944**	**3,502**	**10,609**	**19,682**	**28,552**	**20,015**	**11,180**	**10,201**	**11,491**	**11,711**	**3,801**	**12,861**	**30,451**
Gerridae	**4,430**	**1,935**	**208**	**2,673**	**1,585**	**950**	**213**	**639**	**3,835**	**853**	**170**	**463**	**1,008**	**648**	**2,407**	**1,508**	**714**
Haemulidae	**0**	**95**	**335**	**903**	**1,307**	**325**	**1,224**	**1,214**	**3,236**	**132**	**0**	**0**	**0**	**0**	**0**	**58**	**207**
Holocentridae	**70**	**257**	**20**	**584**	**287**	**3,470**	**863**	**1,454**	**1,169**	**848**	**48**	**0**	**71**	**280**	**343**	**4,543**	**73**
Lethrinidae	**25,005**	**13,461**	**4,104**	**37,569**	**72,886**	**23,817**	**42,259**	**56,669**	**94,491**	**61,859**	**19,070**	**44,895**	**48,091**	**57,099**	**25,939**	**22,357**	**30,795**
Mullidae	**2,225**	**1,631**	**943**	**2,273**	**5,110**	**2,667**	**2,441**	**4,352**	**5,692**	**5,889**	**2,572**	**5,266**	**1,464**	**5,746**	**875**	**1,436**	**3,900**
Sphyraenidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**2,963**
Others	**65,288**	**137,441**	**50,114**	**30,842**	**12,327**	**1,370**	**14,359**	**8,071**	**100,417**	**17,933**	**188,013**	**36,173**	**33,145**	**17,904**	**61,733**	**85,078**	
Labridae	1,255	918	957	3,836	3,366	2,578	4,645	3,712	7,604	6,048	1,742	1,994	910	1,397	608	928	1,462
Lutjanidae	18,327	10,044	3,898	18,830	40,840	18,321	41,446	41,960	98,951	82,479	15,570	62,682	50,810	29,123	74,405	56,456	47,676
Mugilidae	7,123	4,434	1,756	5,833	6,944	4,349	1,332	1,308	5,545	2,017	643	1,355	3,062	1,647	841	1,463	1,465
Scaridae	25,095	25,667	12,070	54,117	68,600	46,510	47,977	92,426	95,942	113,549	55,718	42,137	62,127	53,186	13,368	21,380	56,710
Serranidae	3,391	20,152	15,319	28,335	27,796	21,102	34,082	42,315	48,364	46,005	36,351	35,352	22,497	21,361	25,408	13,586	12,403
Siganidae	25,371	19,062	26,206	36,513	46,260	17,069	15,893	36,618	49,864	33,446	15,659	25,790	43,217	69,331	37,814	33,599	29,560
Total	**203,111**	**257,608**	**135,467**	**264,704**	**376,821**	**179,947**	**261,700**	**343,325**	**631,586**	**465,640**	**370,463**	**303,458**	**339,031**	**313,243**	**272,542**	**270,032**	**269,697**

Table 3.6.1(b): Reef fish purchase at PFFA from 1976 to 1993, by family. Figures are in percentages and those for species included in this particular profile are in bold. (Source: DMR Annual Reports for 1991 and 1992 and DMR data).

Family	1976	1977	1978	1979	1980	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Acanthuridae	**9.3**	**7.6**	**12.8**	**12.1**	**21.1**	**18.8**	**16.9**	**9.6**	**13.9**	**16.0**	**6.4**	**12.2**	**18.0**	**14.0**	**9.2**	**5.5**	**17.5**
Assorted reef fish	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.5**
Carangidae	**3.3**	**1.1**	**1.6**	**3.9**	**2.6**	**1.9**	**4.1**	**5.7**	**4.5**	**4.3**	**3.0**	**3.4**	**3.4**	**3.7**	**1.4**	**4.8**	**11.3**
Gerridae	**2.2**	**0.8**	**0.2**	**1.0**	**0.4**	**0.5**	**0.1**	**0.2**	**0.6**	**0.2**	**0.0**	**0.2**	**0.3**	**0.2**	**0.9**	**0.6**	**0.3**
Haemulidae	**0.0**	**0.0**	**0.2**	**0.3**	**0.3**	**0.2**	**0.5**	**0.4**	**0.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**
Holocentridae	**0.0**	**0.1**	**0.0**	**0.2**	**0.1**	**1.9**	**0.3**	**0.4**	**0.2**	**0.2**	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	**1.7**	**0.0**
Lethrinidae	**12.3**	**5.2**	**3.0**	**14.2**	**19.3**	**13.2**	**16.1**	**16.5**	**15.0**	**13.3**	**5.1**	**14.8**	**14.2**	**18.2**	**9.5**	**8.3**	**11.4**
Mullidae	**1.1**	**0.6**	**0.7**	**0.9**	**1.4**	**1.5**	**0.9**	**1.3**	**0.9**	**1.3**	**0.7**	**1.7**	**0.4**	**1.8**	**0.3**	**0.5**	**1.4**
Sphyraenidae	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.1**
Others	**32.1**	**53.4**	**37.0**	**11.7**	**3.3**	**0.8**	**5.5**	**2.4**	**15.9**	**3.9**	**50.8**	**11.9**	**9.8**	**5.7**	**22.7**	**31.5**	**0.0**
Labridae	0.6	0.4	0.7	1.4	0.9	1.4	1.8	1.1	1.2	1.3	0.5	0.7	0.3	0.4	0.2	0.3	0.5
Lutjanidae	9.0	3.9	2.9	7.1	10.8	10.2	15.8	12.2	15.7	17.7	4.2	20.7	15.0	9.3	27.3	20.9	17.7
Mugilidae	3.5	1.7	1.3	2.2	1.8	2.4	0.5	0.4	0.9	0.4	0.2	0.4	0.9	0.5	0.3	0.5	0.5
Scaridae	12.4	10.0	8.9	20.4	18.2	25.8	18.3	26.9	15.2	24.4	15.0	13.9	18.3	17.0	4.9	7.9	21.0
Serranidae	1.7	7.8	11.3	10.7	7.4	11.7	13.0	12.3	7.7	9.9	9.8	11.6	6.6	6.8	9.3	5.0	4.6
Siganidae	12.5	7.4	19.3	13.8	12.3	9.5	6.1	10.7	7.9	7.2	4.2	8.5	12.7	22.1	13.9	12.4	11.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Annual monthly reef fish family landing composition by species at PFFA for those included in this profile, for the 1990-1993 period, is presented in Table 3.6.2. With the exception of 1990, the Acanthuridae commercial landings at PFFA for the last four years have been predominantly ***um***, making up more than 60 per cent. Of the Carangidae purchases, ***orwidel*** have consistently made up more than 50 per cent of the trevally and jacks landings. ***Mechur***, ***melangmud***, ***udech*** and ***metengui*** have contributed the most significant portions, of varying degree, to the annual emperor landings. However, ***metengui*** data could include those for *Pristipomoides* as some *Lethrinus* and *Pristipomoides* spp. have only one Palauan word, ***metengui***. Of the four leading emperor species, ***mechur***, ***udech*** and ***metengui*** show decreases in purchases at PFFA by about 50 per cent from 1990 to 1993. However, ***melangmud*** purchases have increased about ten times for the same period. ***Aii*** has been the main barracuda species except that in 1993, almost about the same amount of ***lolou*** was purchased at PFFA.

Table 3.6.2: Annual reef fish landing at PFFA (weights in lbs) by species (of those included in this profile) after their corresponding families. [Source: DMR Annual Reports for 1990,1991 and 1992; DMR Data].

Family	Species	1990	1991	1992	1993
Acanthuridae	***Um***	15,352	22,026	13,412	40,490
	Erangel	15,566	2,788	1,097	6,287
	Mesekuuk		186	270	467
Carangidae	***Oruidel***	2,620	3,076	3,256	9,211
	Omektutau		369	307	
	Esuch			239	
	Eropk		356	359	852
Gerridae	***Kotigo?***		756	1,508	714
Haemulidae	***Yaus***			58	207
Holocentridae	***Desachel***				73
	Bsukl			454	
Lethrinidae	***Besechamel***		23	100	28
	Itotech		993	434	568
	Mechur	9,439	3,187	1,793	3,318
	Melangmud	1,817	6,743	9,599	11,795
	Menges				14
	Metengui	9,212	11,928	5,756	5,728
	Rekruk		180	1,246	667
	Udech	20,177	14,836	9,215	8,677
Mullidae	***Bang***		376	1,153	1,967
	Dech		499	284	1,933
Sphyraenidae	***Aii***		1,008	1,413	1,496
	Lolou		865	340	1,208
	Meai		135	113	259
Others or Assorted Reef Fish			4,376	11,870	4,074

Table 3.6.3 presents the 1993 fish purchases, both weight and value, at PFFA (Jan-Sept.), PMCI (Jan.-Sept.) and Oh's (Jan.-May) by fish family and state. Koror and Peleliu seem to be the main sources of surgeonfishes. The high value for "assorted reef fish" is due to data collected from PMCI and Oh's markets which tend to classify more fish under this category. Koror is again the main source of fish in this category, with substantial contributions from Aimeliik, Anguar, Kayangel, Ngaraard, Ngardmau, Ngarchelong and Ngaremlengui. Barracuda are landed mainly from Peleliu, Ngaremlengui and Koror while trevallies and jacks landings are made up mainly of catches from Koror, Ngaremlengui and Peleliu. Most of the rudderfish landings originate from Peleliu while emperors are landed mainly from Koror, Ngarchelong, and Ngaremlengui with fair portions from Peleliu and Ngchesar. Koror and Peleliu are the main sources of goatfishes.

Table 3.6.3: Reef fish purchases at the commercial markets, Jan-Sep 1993 [PFFA, PMCI, Oh's (Jan-May)] byfish family and state.

Fish family	State	Wt (lbs)	Value (US$)
Acanthuridae	Aimeliik	97.00	121.25
	Angaur	2,880.00	3,408.15
	Kayangel	1,013.00	1,114.30
	Koror	22,699.00	27,597.70
	Ngatpang	794.00	886.95
	Ngchesar	191.00	210.10
	Ngerchelong	956.00	1,240.85
	Ngeremlengui	526.00	572.80
	Peleliu	14,362.00	17,654.55
	Unlisted States	869.00	1,086.25
Assorted reef fish	Aimeliik	11,871.50	14,523.28
	Airai	9,299.20	11,294.84
	Angaur	16,700.00	20,845.50
	Kayangel	23,009.00	28,498.25
	Koror	99,735.75	123,903.06
	Melekeok	3,505.00	4,257.95
	Ngaraard	36,922.75	45,959.69
	Ngardmau	24,151.00	30,105.55
	Ngatpang	6,280.00	7,827.50
	Ngchesar	2,543.00	3,162.85
	Ngerchelong	56,983.00	70,975.25
	Ngeremlengui	10,066.25	11,886.01
	Ngiwal	2,135.00	2,668.75
	Peleliu	3,248.50	4,041.35
	Unlisted States	8,174.75	10,071.44
Carangidae	Aimeliik	118.00	129.80
	Airai	57.00	61.30
	Angaur	189.00	207.90
	Koror	3,356.00	3,656.70
	Melekeok	8.00	8.80
	Ngaraard	42.00	46.20
	Ngatpang	597.00	640.60
	Ngchesar	411.00	452.10
	Ngerchelong	12.00	13.20
	Ngeremlengui	2,252.00	2,417.10
	Peleliu	1,141.00	1,191.40

Fish family	State	Wt (lbs)	Value (US$)
Barracuda	Angaur	21.00	23.10
	Koror	112.00	117.60
	Ngchesar	57.00	62.70
	Ngerchelong	60.00	66.00
	Ngeremlengui	167.00	177.60
	Peleliu	184.00	202.40
Gymnophorax	Aimeliik	50.50	63.13
Gerridae	Koror	190.00	190.00
	Peleliu	524.00	663.85
Haemulidae	Koror	207.00	165.60
Holocentridae	Koror	73.00	98.55
Kyphosidae	Koror	184.00	241.00
	Peleliu	1,129.00	1,390.05
Lethrinidae	Aimeliik	591.00	694.70
	Airai	103.00	134.50
	Angaur	89.00	96.60
	Koror	4,387.00	4,766.95
	Ngaraard	344.00	377.30
	Ngatpang	851.00	932.70
	Ngchesar	1,411.00	1,702.55
	Ngerchelong	4,551.00	5,011.55
	Ngeremlengui	4,951.00	5,871.00
	Peleliu	2,929.00	3,081.72
Mullidae	Koror	1,003.00	1,194.00
	Ngatpang	232.00	258.20
	Peleliu	1,832.00	2,052.35

Some fishes are exported together with other food items in coolers as recorded on Continental Air Micronesia manifests. However, species could not be differentiated.

3.6.3 Stocks Status

Donaldson (1993) reported that commercial fishing in the main Palau islands is having an impact on fish populations compared to unfished populations of the South West islands. In particular, groupers, jacks, trevallies, snappers, emperors and parrotfish were either absent, or present in very low numbers in the main islands compared to South West islands. He suggested overfishing of some species was occurring in the main islands because of the very low species richness and abundance levels there, as compared to those of the average reefs in the SW Palau islands.

Quantitative surveys of marine fishes in two sites within the Ngermeduu Bay area, Amesbury reported the

following for species discussed in this profile:

	Site 24					Site 25				
Species	50x2-m transect count	5-m point count	2-m point count	5-m point count	2-m point count	50x2-m transect count	5-m point count	2-m point count	5-m point count	2-m point count
Acanthuridae										
A.canthurus nigricans	1									
A. nigrofuscus	1					x				
A. pyroferus		1		2						
A. thompsoni		5		1						
A. xanthopterus									6	
Ctenochaetus striatus	10	3		4		17	9		4	
Zebrasoma scopas	6	3								
Z. veliferum										
Haemulidae										
Plectorhynchus chaetodonoides				3						
P. qaterinoides		1	4							
Holocentridae										
Myripristis adusta		1								
M. murdjan	6					x				
M. violacea		1		2						
Neoniphon sammara	1									
Mullidae										
Parupeneus barberinus						1				
P. cyclostomus						x				

Donaldson (1993) reported the results of the Palau Islands rapid ecological assessment in 1992. Species included in this profile that were recorded as wide ranging within some areas visited include:

Kayangel	: *Ctenochaetus striatus*;
Kosol	: *C. striatus, Acanthurus nigrofuscus*;
Eastern Babeldoab	: *A. nigrofuscus, Parupeneus barberinus*;
Western Babeldoab	: *Zebrasoma scopas*;
Rock Islands	: *P. barberinus, A. pyroferus*;
Peleliu-South/West	: *A. nigrofuscans, P. bifasciatus, C. striatus, Naso lituratus*;
Angaur	: *C. striatus, A. nigricans, A. olivaceus* and *A. pyroferus*.

In Palau's multi-species, multi-gear fishery, different species are being exploited at different levels. Given the varying biological characteristics of the many species involved, it is possible that some species are being overexploited (Preston, 1989). Rochers and Matthews (1992) reported that interviews with fishermen from certain villages indicate that the use of modern sophisticated fishing methods is one of the main causes of the declines in fish populations. In addition, decrease in fish sizes has also been noticed. DMR staff are attempting to assess the current levels of exploitation of marine inshore resources in Palau. This is being achieved through close liaison with PFFA and major local markets to monitor landings and to estimate the current catch of all marine resources harvested. Until catch levels are more accurately known, it is not possible to manage the fishery to achieve biological or economic optimum yields.

The data presently available for the fishery is limited. Some landing and biological data for a range of species has been collected from PFFA by DMR. Unfortunately records maintained by PFFA for the last decade are not adequate to document developments that have taken place in Palauan reef fisheries throughout that period. Even though fish purchase statistics from the commercial markets indicate fluctuations in landings of certain species, it would be inaccurate to use these to assess the status of stocks. This is due to several factors, such as lack of accuracy of data, absence of vital information, incomplete recording, and changes in marketing strategies by the fishermen.

3.6.4 Management

Current legislation/policy regarding exploitation: Ngeremlengui State, in its Fishing Conservation Act of 1987 (Public Law No.13-87), prohibits fishing of any kind all year round in the inner reef area known as Usas, and the outer reef area known as Mecherong. Violators face fines of up to $150.00. Ngatpang State requires fishermen to obtain an annual $30 fishing license from the Governor (NSC Bill No. 03-87). Ngardmau State Preservation Act of 1985 requires fishermen to obtain an annual commercial fishing licence ($100) from the State Treasury Office (NSL No. 1-008, KN Bill No.1-0011). Only residents of the state are entitled to apply for a fishing license. Koror State is also reported to require a fishing licence for fishermen exploiting the reef fishery.

Palau National Code, Title 24, Division 2, Chapter 13, subchapter I, § 1302 prohibits the use of dynamite, poisons or chemicals to catch fish. However, §1303 of the same law lists exceptions to the prohibitions as where:

- the President has granted a written permission;
- the President has determined that the purpose of obtaining the fish or other marine life is to avoid the waste or loss of such fish or marine life; and that the consumption or sale of fish or other marine life caught by any means the use of which is prohibited,is not harmful or hazardous to health and human life.

§ 1304 permit the use of local roots, nuts and plants, which have have the effect of stupefying but not killing fish, to catch fish.

Section 4 (6) of the Marine Protection Act of 1994 prohibits fishing while using any form of underwater breathing apparatus other than a snorkel. Section 4 (12) prohibits fishing using a gill net or surround net having a mesh size of less than three inches.

Recommended Legislation/Policy regarding exploitation: Baseline data for the reef fishery are lacking. Data collection needs to be improved, and basic biological parameters collected for the dominant species (say, the top 20). Ianelli (1987) and Preston (1990) provide guidelines for monitoring the fishery and providing data on which management decisions can be based. Restrictions on the export of reef fish could be considered in view of the paucity of information regarding the status of reef fish stocks and the importance of the fishery to both subsistence needs and in-country demand from commercial retailers and restaurants. Kitalong and Dalzell (1994) observed minimum first-captured length, estimated the optimum minimum first-capture length and predicted optimum net mesh size for the following species in this profile:

	Observed minimum first-capture length (cm)	Optimumu minimum first-capture length (cm)	Predicted optimum mesh size (inches)
Lethrinus ramak	17.3	18.3	3.3
Naso lituratus	21.3	19.3	3.9
Naso unicornis	42.3	28.5	5.0

The application of minimum size limits for the sales of certain fish species is a mechanism for the management of resources. However, it would require basic research to ascertain these parameters. Enforcement of existing laws that directly involve the exploitation of the reef fish resoures, especially fishing methods, is of utmost importance. Some consideration might be given to prohibit fishing using “local poisons” as their effects on marine life are not limited to the target species. They are lethal to corals, fish and other marine organism larvae as well as marine life in general. An additional consideration is the total banning of the use of explosives, poisons and chemicals to catch fish, without any exceptions, for the same reasons as given to prohibit “local poisons”.

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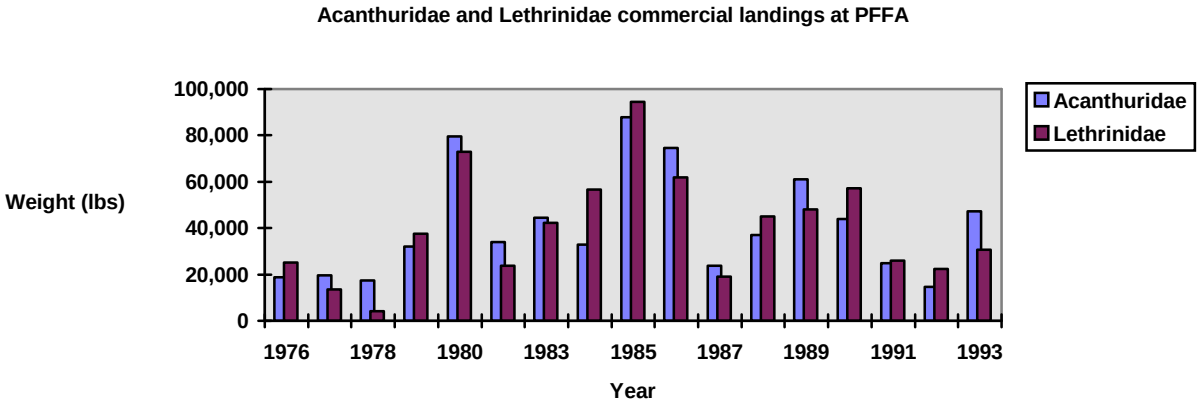
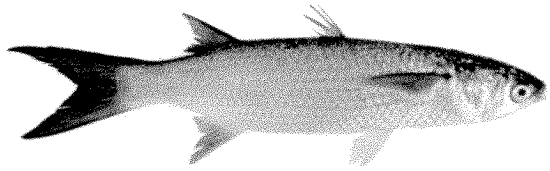

Acanthuridae and Lethrinidae commercial landings at PFFA
Weight (lbs)
100,000
80,000
60,000
40,000
20,000
0
1976
1978
1980
1983
1985
1987
1989
1991
1993
Year
Acanthuridae
Lethrinidae

3.7 Mullet - *kelat, uluu*

3.7.1 The Resource



kelat - *Crenimugil crenilabis*

Species present: *Crenimugil crenilabis* (warty lipped or fringelip mullet - ***kelat***) is well-known among most Palauan fishermen due to its aggression and strength. Because of this aggressive behavior, fishermen require special skill to spear it, and only skilled and experienced fishermen catch large numbers. A smaller species, *Liza vaigiensis* (yellowtail, squaretail or diamond-scale mullet - ***uluu***), is commonly seen in the mullet fishery.

Distribution: *C. crenilabis* occurs in the Indo-Pacific from the Red Sea to the Line and Tuamotu Islands, north to south of Japan, south to Lord Howe Islands; Ifaluk, Marianas and Marshall Islands in Micronesia (Myers, 1989). It is commonly found in sandy lagoons and on shallow seaward reef flats (Randall *et al*., 1990).

L. vaigiensis occurs in East Africa to the Tuamotus, north to south Japan, south to the south Great Barrier Reef and New Caledonia. It is found throughout Micronesia in lagoons and on reef flats where it is most common along protected sandy shorelines (Myers, 1989). This species forms large schools frequently in mangrove areas (Randall *et al*., 1990).

Sea mullet, *M. cephalus*, inhabits coastal waters and estuaries in tropical and temperate waters of all seas of the world, and are distributed mainly between the latitudes 42° N and 42° S. It has a strong tendency to school as juveniles, and during the spawning season, as adults. Juvenile schools commonly disperse over sand and mud flats of estuaries when feeding during high tide, but re-form on the ebb tide (Kailola *et al*., 1993). Myers (1989) reported that even though *M. cephalus* has been mentioned in reports, no verifiable literature reccords the presence of this species in Micronesia.

Mullet is found all around the waters of Palau, over sand flats inside lagoons and near the mangrove line during hightides. Peliliu State produce most mullets to the fishery landings. Rochers and Matthews (1992) reported spawning site for ***kelat*** near Ngchesar and Johannes (1981) reported that this species gather in schools near Peleliu before undergoing their spawning migration.

Biology and Ecology: Mullet feed on detritus, diatoms, algae and microscopic invertebrates in estuarine waters, which they filter from mud and sand through their mouth and gills (Kailola *et al*., 1993). Fish eggs may also be consumed (Randall *et al*., 1990). Most mullet species can tolerate a wide range of salinities, with some ranging into purely fresh-water, and are important in aquaculture. A few species are most at home on coral reefs (Myers, 1991).

Johannes (1981) reported that ripe ***kelat*** individuals gather in schools near Peleliu over sand flats in the lagoon, then migrate out to the edge of the western fringing reef using pathways well known to fishermen, who intercept them with nets. This spawning migration usually begins three days before the full moon. Spawning takes place at the surface over the outer reef slope and begins in the evening. Seasonal clockwise migrations of schools of this species are also widely known in Palau. Schools of ***kelat*** move from the reef flats north of Peleliu northward up the west coast of Babeldaob. The first schools arrive at Ngermlengui usually in November. Schools continue to move past Ngeremlengui travelling north for about six months. When the fish reach the northern tip of Babeldaob they turn and move southward down the east coast. Today the schools are said to be much smaller and fewer than there were ten years ago because of net and dynamite fishing. The best fishing for this species (with nets) is during the spawning migration.

3.7.2 The Fishery

Utilisation: ***Kelat*** is favoured among Palauans for its white soft meat and easy cooking. It is often smoked or cooked as fish soup. A favourite mullet fish soup is when it is cooked with ***titiml*** leaves (amra tree, *Spondias pinnata*).

Traditionally, only skilled and experienced fishermen catch good numbers of mullet. A communal traditional method that was usually used to catch mullet is called ***mettilab***. This involved setting up a fence, where upon a group of people make splashing and dashing noises on the water driving fish into the corner end where they are trapped. Some men stand behind the fence, equipped with wooden clubs or sticks ready to strike any fish that attempts to escape by jumping over the fence.

Rochers and Matthews (1992) reported that mullet are important to resource users in Melekeok and Ngchesar. Mullet has been important in the subsistence fishery and forms a relatively small percentage of the local commercial landings.

Production and Marketing: As is the case for other fisheries, there are no figures available on the subsistence utilisation of mullet in Palau. Today, ***kelat***, is ranked amongst fishes with the lowest catches and sales. This is due to the declining population. During the 1960s and the 1970s, dynamite was widely used to catch mullet.

Large set-nets have also been utilised and their wide use is believed to have contributed greatly to the decline of ***kelat*** populations around Palau. Greater demands in the local commercial markets, and the export of mullet to other parts of Micronesia, have accelerated the declining trend in mullet numbers in Palau.

Table 3.7.1 presents reef fish purchases by PFFA from 1976 to 1993 by main fish family. It indicates that mullet landings form a minor portion (0.2 to 3.5 per cent) of the catches landed there. A steady decline in composition is noticed between 1976 to 1987 from 3.5 to 0.2 per cent. For the last six years (1988 to 1993), mullet per cent composition seems to have stabalised around 0.5 per cent. The percentage trend is also generally reflective of the quantity landed and for the last six years, mullet landing seems to stand around 1,400 lbs. The highest mullet landing (7,123 lbs) at PFFA for the period was recorded in 1976. High landings were also recorded in 1977 (4,434 lbs), 1979 (5,833 lbs), 1980 (6,944 lbs) and 1985 (5,545) with the lowest (643 lbs) recorded in 1987. Generally, mullet landings at PFFA have been declining since 1976.

Table 3.7.1: Reef fish purchase at PFFA from 1976 to 1993, by family. Figures are in pounds and those for species included in this particular profile are in bold.

(Source: DMR Annual Reports for 1991 and 1992 and DMR data).

Family	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Acanthuridae	18,912	19,696	17,391	32,156	79,569	33,917	44,357	32,905	87,924	74,567	23,727	37,150	61,138	43,810	25,000	14,779	47,244
Assorted reef fish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,074
Carangidae	6,619	2,815	2,146	10,240	9,944	3,502	10,609	19,682	28,552	20,015	11,180	10,201	11,491	11,711	3,801	12,861	30,451
Gerridae	4,430	1,935	208	2,673	1,585	950	213	639	3,835	853	170	463	1,008	648	2,407	1,508	714
Haemulidae	0	95	335	903	1,307	325	1,224	1,214	3,236	132	0	0	0	0	0	58	207
Holocentridae	70	257	20	584	287	3,470	863	1,454	1,169	848	48	0	71	280	343	4,543	73
Lethrinidae	25,005	13,461	4,104	37,569	72,886	23,817	42,259	56,669	94,491	61,859	19,070	44,895	48,091	57,099	25,939	22,357	30,795
Mullidae	2,225	1,631	943	2,273	5,110	2,667	2,441	4,352	5,692	5,889	2,572	5,266	1,464	5,746	875	1,436	3,900
Sphyraenidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,963
Others	65,288	137,441	50,114	30,842	12,327	1,370	14,359	8,071	100,417	17,933	188,013	36,173	33,145	17,904	61,733	85,078	-
Labridae	1,255	918	957	3,836	3,366	2,578	4,645	3,712	7,604	6,048	1,742	1,994	910	1,397	608	928	1,462
Lutjanidae	18,327	10,044	3,898	18,830	40,840	18,321	41,446	41,960	98,951	82,479	15,570	62,682	50,810	29,123	74,405	56,456	47,676
Mugilidae	**7,123**	**4,434**	**1,756**	**5,833**	**6,944**	**4,349**	**1,332**	**1,308**	**5,545**	**2,017**	**643**	**1,355**	**3,062**	**1,647**	**841**	**1,463**	**1,465**
Scaridae	25,095	25,667	12,070	54,117	68,600	46,510	47,977	92,426	95,942	113,549	55,718	42,137	62,127	53,186	13,368	21,380	56,710
Serranidae	3,391	20,152	15,319	28,335	27,796	21,102	34,082	42,315	48,364	46,005	36,351	35,352	22,497	21,361	25,408	13,586	12,403
Siganidae	25,371	19,062	26,206	36,513	46,260	17,069	15,893	36,618	49,864	33,446	15,659	25,790	43,217	69,331	37,814	33,599	29,560
Total	**203,111**	**257,608**	**135,467**	**264,704**	**376,821**	**179,947**	**261,700**	**343,325**	**631,586**	**465,640**	**370,463**	**303,458**	**339,031**	**313,243**	**272,542**	**270,032**	**269,697**
Per cent mullet	**3.5**	**1.7**	**1.3**	**2.2**	**1.8**	**2.4**	**0.5**	**0.4**	**0.9**	**0.4**	**0.2**	**0.4**	**0.9**	**0.5**	**0.3**	**0.5**	**0.5**

Some indications of catch and effort statistics on the mullet fishery, involving the two main species, *C. crenilabis* and *L. vaigiensis*, are given in Table 3.7.2 as recorded at the main commercial markets.

The landings seem to be closely distributed between the two species during the three-year period with no significant variation except for the approximately doubling in *L. vaigiensis* landings from 1991 to 1992. Unit price has increased from an average of $1.10/lb in 1991 to $1.25/lb in 1993.

Table 3.7.2: Mullet, *Crenimugil crenilabis* and *Liza vaigensis*, catch and effort statistics as recorded by the commercial markets.

Year	Species	No. of fisherfolks	No. of trips	Weight (lbs)	Catch rate (lbs/trip)	Value ($)	Avg. unit price ($/lb)
1991	*C. crenilabis*	4	5	848	169.6	945	1.07
	L. vaigensis	3	5	463	92.6	521	1.13
	Total	7	10	1,311		1466	
1992	*C. crenilabis*	7	8	638	79.8	770	1.53
	L.vaigensis	7	9	1,327	147.4	1,644	1.22
	Total	14	17	1,965		2,414	
1993	*C. crenilabis*	8	11	879	79.9	1,092	1.25
	L. vaigiensis	5	6	734	122.3	916	1.25
	Total	13	17	1,613		2,008	

Commerial mullet landing distribution by state for the 1991-1993 period is given in Table 7.2.3. Peleliu is clearly the main and consistent supplier of mullet and having annual landings showing an increase for consecutive years during this period.

Table 7.2.3: Mullet purchases at the commercial markets in Palau, by state for the 1991-1993 period.

State	1991		1992		1993	
	Weight	Value	Weight	Value	Weight	Value
Peleliu	545	611	661	826	867	1,062
Ngaraard	355	444	112	123	0	0
Ngerchelong	296	296	0	0	289	390
Airai	0	0	364	476	0	0
Aimeliik	0	0	265	353	285	342
Koror	0	0	656	799	134	164
Ngchesar	0	0	0	0	38	49
Total	**1,196**	**1,351**	**2,058**	**2,577**	**1,613**	**2,007**

3.7.3 Stocks Status

All fishermen in Palau share similar views regarding rapid decline in numbers and sizes of mullet in Palau. Fifty to sixty years ago, mullet was considered abundant throughout the entire Palau waters. Today, their diminishing average sizes and numbers should be a cause of concern, otherwise, they may be overfished to extinction. Possible local extinctions of mullet species in other areas in the Pacific have been documented, e.g. Bell *et al*. (1994) reported possible extinction of *M. cephalus* in Tonga.

3.7.4 Management

Current Legislation/Policy Regarding Exploitation: There is currently no national or state law that specifically deals with the exploitation of mullet in Palau.

The Palau National Code, Title 24, Division 2, Chapter 13, subchapter I, § 1302 prohibits the use of dynamite, poisons or chemicals to catch fish. However, §1303 of the same law lists exceptions to the prohibitions as where:

- the President has granted a written permission;
- the President has determined that the purpose of obtaining the fish or other marine life is to avoid the waste or loss of such fish or marine life; and that the consumption or sale of fish or other marine life caught by any means the use of which is prohibited,is not harmful or hazardous to health and human life.

§ 1304 permits the use of local roots, nuts and plants, which have have the effect of stupefying but not killing fish, to catch fish.

Section 4 (12) of the Marine Protection Act of 1994 prohibits fishing using a gill net or surround net having a mesh size of less than 3 inches measured diagonally. Section 4 (13) prohibits fishing with a ***kesokes*** net with no bag portion or with a bag portion having a mesh size of less than 3 inches, one year after the Act's effective date. Section 6 of the same Act authorises the Minister to promulgate regulations to protect species from overharvesting etc.

Recommended Legislation/Policy Regarding Exploitation: The same prohibition that protects the rabbit fish fishery from being overfished should be applied to ***kelat*** fishery as well, e.g. banning commercial fishing for, selling and buying mullet during spawning season. This fish has been part of Palauan's diet for many years, and it would be a great loss if it is not protected immediately.

Rigorous enforcement of the existing laws, (e.g. dynamite fishing), is necessary. Additional considerations could include:

⇒ banning or licensing of the use of fish fences as a fishing method;
⇒ imposing a minimum size limit for mullet offered for sale;
⇒ controlling the use of cast nets, by limiting numbers;
⇒ prohibiting commercial fishing in Marine Reserves;
⇒ banning or limiting fishing during spawning season or during migration to spawn;
⇒ prohibiting fishing using "local poisons" as their effects on marine life are not limited to the target species. They are lethal to corals, fish and other marine organism larvae as well as marine life in general;
⇒ total banning of the use of explosives, poisons and chemicals to catch fish, without any exceptions, for the same reasons as given to prohibit "local poisons".

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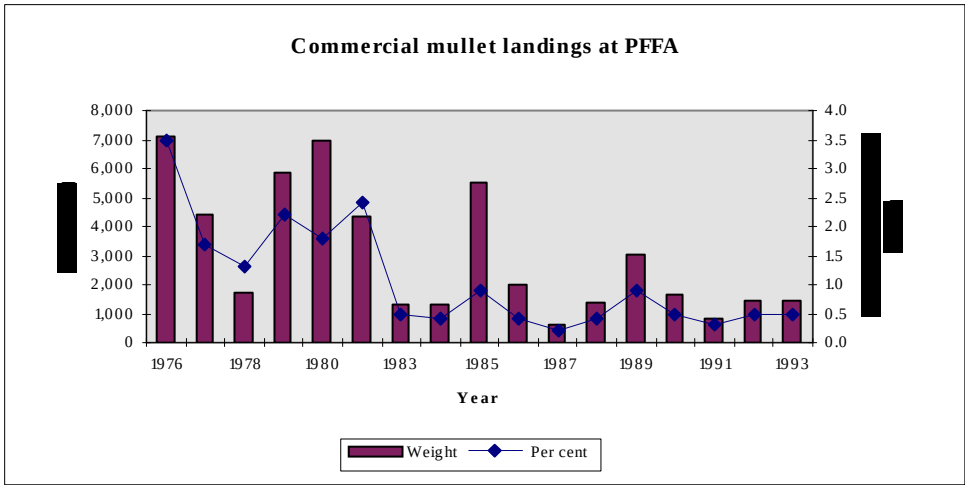
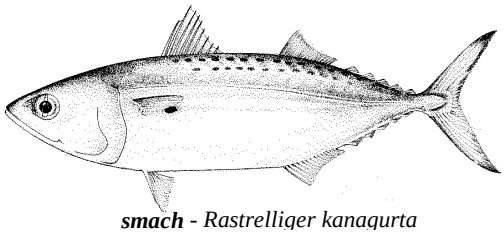

Commercial mullet landings at PFFA
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1976
1978
1980
1983
1985
1987
1989
1991
1993
Year
Weight
Per cent

3.8 Small pelagics (baitfish)

3.8.1 The Resource



smach *- Rastrelliger kanagurta*

Species present: Small pelagic species of commercial importance include *Selar crumenophthalmus* (big eye scad - ***terekrik*** or ***mams*** for juvenile), *S. boops* (yellowband scad - ***terekrik***), *Rastrelliger kanagurta* (striped mackerel - ***smach***), *Herklotsichthys quadrimaculatus* (gold spot herring - ***mekebud***), *Hemiramphus far* (spotted halfbeak - ***bolobel***), *Tylosurus crododilus crododilus* (crocodile needlefish - ***sekos***), and a *Decapterus* spp. (scad - ***agie***). The ten most common baitfish species caught with bouki-ami gear in Palau during the 1978-1980 SPC skipjack and baitfish assessment project in Micronesia include, in decreasing order of quantity landed: *Stolephorus heterolobus* (blue anchovy), *Spratelloides delicatulus* (blue sprat), *Hypoatherina temmincki* (silverside), *Dussumieria* sp. (sharp-nosed sprat), *Apogon (Rhabdamia) cypselurus* (luminous cardinalfish), *Spratelloides gracilis* (silver sprat), *Leiognatus bindus* (slipmouth), *H. quadrimaculatus*, *Spratelloides* sp. and *Sardinella clupeoides*.

Distribution: Dalzell (1993) gives some details of the distribution of the small pelagics in the South Pacific. The smaller gracile stolephorid anchovies, particularly *E. heteroloba* and *E. devisi* and the sprats, *S. gracilis* and *S. delicatulus* (and *S. lewisi* in the waters of PNG and Solomon Islands) are found in the coastal lagoons of the coralline areas. The larger anchovies, including *Thryssa balaema*, *T. setirostris* and the larger stolephorids such as *S. indicus* and *S. waitei*, are often found in lagoons and passages that are bordered by mangroves. The fusiliers' (*Caesio* and related genera) distribution is determined largely by the extent of coral cover, which is associated with shallow coastal water (<30 m depth). The mackerels (*Rastrelliger* spp) occur further offshore whereas the roundscads (*Decapterus* spp.) are found between the neritic and oceanic areas, with flying fishes inhabiting both inshore waters and open ocean (Dalzell and Lewis, 1989). Kovalevskaya (1982, quoted in Gillett and Ianelli, 1993) notes that flyingfish species common in the tropical Pacific have limits of distribution bounded by 40° S and 40° N. Gillett and Ianelli (1993) note that depth at which flyingfish occurs affect the catchability in night surface fisheries. During the night, flyingfish is distributed as deep as 18 m with about 86 per cent found in the first 0-2 m layer (Nesterov and Bazanov, 1986, quoted in Gillet and Ianelli, 1993).

During the 1978-1980 skipjack and baitfish resources assessment project in Northern Marianas, Guam, Palau, Federated States of Micronesia and Marshall Islands, baitfish species caught in specified areas in Palauan waters are presented in Table 3.8.1 as given in Tuna Programme (1984).

Table 3.8.1: Baitfish species caught during the 1978-1980 skipjact and baitfish resources assessment survey conducted by the SPC Tuna Popgramme in four locations in Palau. (Source: Tuna Programme, 1984).

Locality	Dominant Species	Other Common Species
Rock Islands	*Stolephorus heterolobus* *Archamia lineolata* *Spratelloides delicatulus*	*Selar crumenophthalmus* *Rsatrelliger brachysoma* *Herklotsichthys quadrimaculatus*
Malakai Hbr	*Stolephorus heterolobus* *Spratelloides delicatulus* *Hypoatherina temmincki*	*Leiognathus bindus* *Herklotsichthys quadrimaculatus* *Apogon (Rhabdamia) cypselurus*
Malakai Hbr	*Stolephorus heterolobus* *Hypoatherina temmincki* *Spratelloides delicatulus*	*Herklotsichthys quadrimaculatus* *Atherinomorous lacunosa* *Leiognathus bindus*
Helen Reef	*Dussumieria sp.* *Spratelloides delicatulus* *Apogon (Rhabdamia) cypselurus*	*Spratelloides gracilis* *Hypoatherina temmincki* *Archamia lineolata*
Helen Reef	*Spratelloides delicatulus* *Dussumieria sp.* *Hypoatherina temmincki*	*Spratelloides gracilis* *Apogon (Rhabdamia) cypselurus* *Spratelloides sp.*
Urukthapel Hbr	*Stolephorus heterolobus* *Sardinell clupeoides* *Hypoatherina temmincki*	*Spratelloides delicatulus* *Leiognathus bindus* *Rastrelliger kanagurta*
Urukthapel Hbr	*Stolephorus heterolobus* *Herklotsichthys quadrimaculatus* *Mullidae sp.*	*Selar crumenophthalmus* *Hypoatherina temmincki* *Spratelloides delicatulus*
Helen Reef	*Spratelloides delicatulus* *Hypoatherina temmincki* *Spratelloides gracilis*	*Archamia zosterophora* *Apogonidae sp.* *Synodontidae sp.*
Helen Reef	*Spratelloides delicatulus* *Hypoatherina temmincki* *Spratelloides sp.*	*Apogon (Rhabdamia) cypselurus* *Spratelloides gracilis* *Crustacea sp.*

In surveys of marine fishes in 26 sites in the Ngermeduu Bay area, Amesbury (1991) observed *R.*

kanagurta in one site and S. japonicus? in two. Johannes *et al*. (1994) reported observing spawning of a *Decapterus* sp. (***agie***?) at their study site at Ngerumekaol.

Rochers and Matthews (1992) reported from interviews with fishermen of Kayangel that thousands of fry of ***mekebud*** (gold-spot herring), ***teber*** (hardyhead) and ***merau*** (sardine) have been seen there but did not know where actual spawning occurs.

Biology and ecology: Most studies on the small pelagic fishes in the Pacific have concentrated on the species that are important to the pole-and-line fishery, which include anchovies, sprats and clupeids. However, "the biology of the small mackerels, flying fishes, scads and halfbeaks has tended to be neglected in the region" (Dalzell, 1993). But one important study was conducted by Conand (1986) on the biology and ecology of the larger small pelagic fishes and the smaller clupeoid species in the lagoon of New Caledonia (quoted in Dalzell, 1993). Based on their life history parameters, Conand (1986), Lewis (1990) and Dalzell (1993) separated the tropical small pelagic fishes into three groups as follows:

Group	Life cycle	Size	Growth	Age sexual Maturity	Spawning period	Batch fecundity
1	< 1 year	7-10 cm max	rapid	3-4 months	extended period	500-1500 oocytes/grm of fish
Species: Stolephorid anchovies (*E. heteroloba, E. devisis, E. punctifer*), Sprats (*S. gracilis, S. delicatulus, S. lewisi*) and Silverside (*Hypoatherina ovalau*)						
2	1 to 2 years	10-24 cm max	-	towards end first year	restricted seasonal	300-500 oocytes/grm of fish
Species: Herring and sardines (*Herklotsichthys* spp., *Amblygster* spp., *Sardinella* spp.), Larger anchovies (*Thrissina* spp.,*Stolephorus*spp), Sharp nosed sprats (*Dussumieris* spp.).						
3	2-5 years	20-35 cm max	-	-	restricted seasonal	400-600 oocytes/grm of fish (50-100 for flying fish)
Species: Round scads (*Decapterus* spp), Big eye scads (*Selar* spp), Small mackerels (*Rastrelliger* spp), Flying fish (Exocoetidae), Half beaks (Hemiramphidae).						

Tropical flyingfishes grow rapidly with many species spawning several times per year. Small species spawn between 400 and 1,100 eggs at a time, with the larger forms in certain species in the genera *Cheilopogon*, *Cyselurus*, and *Hirundichthys*, having fecundity ranging between 16,000 and 24,000 eggs (Gillett and Ianelli, 1993; Kovalevskaya, 1982, quoted in Gillett and Ianelli, 1993).

Dalzell (1993) gave a summary table for the growth, mortality and maturity parameters for a number of small pelagic fish species in the South Pacific, and is reproduced in Table 3.8.2.

Table 3.8.2: Biological parameters for some small pelagic fish species in the South Pacific.

Species	Location	L∞ (cm)	K (yr^{-1})	M (yr^{-1})	t_{max} (year)	Lm (cm)	$L_m/L\infty$	Ref
Encrasicholina heteroloba	PNG	7.9	2.6	4.9	1.0	5.1	0.65	Dalzell (1984)
Stolephorus waitei	PNG	10.9	1.7	3.4	1.5	7.3	0.67	Dalzell (1987, 1989)
Spratelloies delicatulus	Fiji	7.3	4.6	6.9	0.4	4.0	0.55	Dalzell *et al* (1987)
Atherinomorus lacunosus	New Caledonia	11.4	2.5	4.1	1.2	8.5	0.75	Conand (1988)
Herklotsichthys sp.	Vava'u, Tonga	14.7	1.30	2.0		16.0		King *et al*. (1994)
H. quadrimaculatus	Fiji	12.6	2.0	3.5	1.6	9.5	0.75	Dalzell *et al* (1987)
Amblygaster sirm	New Caledonia	22.9	1.5	2.4	2.0	15.0	0.66	Conand (1988)
	Vava'u, Tonga	23.2	0.97	1.5		270		King *et al*. (1994)
Decapterus russelli	New Caledonia	24.9	1.3	2.1	3.0	18.0	0.72	Conand (1988)
Selar crumenophthalmus	Hawaii	27.0	2.57	3.4	2.0	23.0	0.85	Kawamoto (1973)
Rastrelliger kanagurta	New Caledonia	23.7	3.0	3.7	1.0	20.0	0.87	Conand (1988)

Gillett and Ianelli (1993) note that flyingfish in the tropics generally live to about 2 years of age and are mature after 10-14 months. In addition, many of the commercially important flyingfish species from the genera *Hirundichthys*, *Cypselurus*, and *Cheilopogon* grow to about 20-25 cm and attain weights of 300-450 g.

Muller (1976, cited in Dalzell, 1993) presented the spawning season for one of the baitfish species in Palau, as follows (+ = month when spawning observed, X peak spawning):

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Encrasicholina heteroloba	+	+	X	X	+	X	X	+	+	+	+	+

Most of the small pelagics are considered planktivorous, though scads, mackerel and the larger anchovies feed on small fishes. For flyingfishes, their food consists mainly of large zooplankton and small fish (Gillett and Ianelli, 1993). Flyingfish fall prey to skipjack tuna and large pelagics in the Pacific islands as well as yellowfin tuna as recorded in the eastern Pacific (South Pacific Commission, 1980-1985 and Olson and Boggs, 1986, quoted in Gillett and Ianelli, cited above).

3.8.2 The Fishery

Utilization: Species included in this profile as small pelagic fish species do seem to be an important resource both on the subsistence and artisanal levels. However the level of utilisation in the subsistence is not known. Scads (*terekrik*) have been reported as one of the most important fish species in Ngatpang, along with humpback snappers, emperors and rabbitfish (Maragos, 1994). In Melekeok, mangroves support schools of sardines. ***Smach*** and ***terekrik*** form fair portions of the commercial reef fish landings.

Rochers and Matthews (1992) note that fish species most often caught by spearing, are sardines, jacks, sharks and rays. (Spears traditionally consist of a long bamboo shaft with either a single hardwood point or several barbed points clustered together).

Crocodile needle fish is often sold cooked in one of the food places in Koror.

Johannes (1981) reported that scoop nets are used to capture flying fish which are attracted by a kerosene pressure lamp mounted on a canoe in moonless nights. Cast nets are used to capture *H. quadrimaculatus* when they aggregate to spawn while the big eye scads are caught by gill nets.

Production and marketing: There is no available information on the level of utilization of small pelagic species in the subsistence level.

The baitfish resource in Palau was able to support a large commercial fishery from the 1930s. Between 1964 and 1972 (Muller, 1977 cited in Tuna Programme, 1984) estimated that the Palau fleet of about 12 pole-and-line vessels caught and average of 94 kg of bait per vessel per night which was dominated by the anchovy, *S. heterolobus*. This species was estimated to sustain an annual harvest of about 160 tonnes in Palau waters, but occasionally bait catch exceeded 200 tonnes. The baitfishery operation for pole-and-line ceased in 1982 but it was not due to the lack of bait (Tuna Programme, 1984).

Perron *et al*. (1983) recorded commercial marine animals landed at PFFA from 1976 to 1981. Landing data for small pelagics are recorded in Table 3.8.3 as recorded for that period. ***Terekrik*** and ***mekebud*** dominate small pelagic landings for this period.

Table 3.8.3: Small pelagic fish species purchases at PFFA between 1976 and 1981.
(Source: Perron *et al*., 1983).

Year		***Terekrik***	***Mekebud***	***Smach***	**Total**
1976	Weight (lbs)	2,609		805	3,414
	% wt of total reef fish	1.16		0.36	1.52
	Value ($)	633.82		233.25	867.07
1977	Weight (lbs)	1,414	585	31	2,030
	% wt of total reef fish	0.45	0.18	0.01	0.64
	Value ($)	454.90	204.75	7.75	667.4
1978	Weight (lbs)	215	1,164		1,379
	% wt of total reef fish	0.07	0.39		0.46
	Value ($)	49.75	407.40		457.15
1979	Weight (lbs)	1,834	3,155		4,989
	% wt of total reef fish	0.39	0.66		1.05
	Value ($)	642.65	993.14		1,635.79
1980	Weight (lbs)	958	1,815	583	3,356
	% wt of total reef fish	0.21	0.40	0.13	0.74
	Value ($)	381.95	502.23	262.35	1,146.53
1981	Weight (lbs)	678		91	769
	% wt of total reef fish	0.31		0.04	0.35
	Value ($)	305.10		36.40	341.5
Mean % wt of total reef fish		0.43	0.41	0.14	0.79
Mean annual wt (lbs): 1976-1981		1,285	1,120	252	2,656

The SPC skipjack and baitfish resources assessment work conducted during the 1978-1980 period in Northern Mariana Islands, Guam, Palau, FSM and Marshall Islands recorded the following bouki-ami gear catch details of operations in Palau, for the ten most common baitfish species, listed in decreasing order (Tuna Programme, 1984):

Species	Total (kg)	Kg per haul	Per cent per haul
Stolephorus heterolobus	1,807	53	55
Spratelloides delicatulus	682	20	21
Hypoatherina temmincki	244	7	7
Dussumieria sp.	241	7	7
Apogon cypselurus	68	2	2
Spratelloides gracilis	55	2	2
Leiognathus bindus	48	1	1
Herklotsichthys quadrimaculatus	36	1	1
Spratelloides sp.	32	1	1
Sardinella clupeoides	4	<1	<1
Total caught	3,310	97	97
Hauls	34		
Nights	18		
Total catch per night	184		

The SPC project concluded that the size of the Palau Islands lagoon, the availability of good baitfish habitat and the presence of stolephorid anchovies confirmed that Palau Islands have a substantial baitfish resource (Tuna Programme, 1984). In 1990, Masanori Kuniyoshi's pole and line vessel reported monthly catches of small pelagic species as follows for that year:

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Agie		1,400	1,400	700	200	400	900	0	900	400	400	700	7,400
Terekrik		200											200

Reef fish species landings at PFFA for the 1990-1993 period is recorded in Table 3.8.4. Small pelagic species as included in this profile comprise between 5 and 10 per cent of the total reef fish landings at PFFA during the 1991-1993 year period. The highest landing (and percentage of reef fish landing) was in 1992. Species composition of the 1993 small pelagic landing at PFFA is presented in Table 3.8.5 which clearly shows that ***smach*** is the main small pelagic species sold, making up more than 70 per cent of the total small pelagics for all the three years.

Table 3.8.4: Reef fish landings at PFFA during the 1990-1993 year period. Figures are in lbs.

Family	**1990**	**1991**	**1992**	**1993**
Acanthuridae	43,810	25,000	14,779	47,244
Assorted reef fish				4,074
Carangidae	11,711	3,801	12,861	10,063
Chanidae				364
Gerridae	648	2,407	1,508	714
Haemulidae	0	0	58	207
Holocentridae	280	343	4,543	73
Kyphosidae				2,452
Lethrinidae	57,099	25,939	22,357	30,795
Mullidae	5,746	875	1,436	3,900
Sphyraenidae				2,963
Others	17,904	61,733	85,078	0
Labridae	1,397	608	928	1,462
Lutjanidae	29,123	74,405	56,456	47,676
Mugilidae	1,647	841	1,463	1,465
Scaridae	53,186	13,368	21,380	56,710
Serranidae	21,361	25,408	13,586	12,403
Siganidae	69,331	37,814	33,599	29,560
Small pelagics		**14,944**	**29,541**	**20,388**
Total Reef Fish	**313,243**	**287,486**	**299,573**	**272,513**
Percentage Small Pelagics		**5.2**	**9.9**	**7.5**

Table 3.8.5: Species composition of the small pelagic fishes landed at PFFA during the 1991-1993 period.

		1991		1992		1993	
Category	Species	Wt (lbs)	Per cent	Wt (lbs)	Per cent	Wt (lbs)	Per cent
Small Pelagic Fish Species	***Smach***	12,738	85.2	22,489	76.1	14,525	71.3
	Terekrik	2,206	14.8	7,052	23.9	5,834	28.6
	Mekebud					29	0.1
	Total	14,944	100	29,541	100	20,388	100

Monthly small pelagic landings at PFFA for the 1991-1993 period is presented in Table 3.8.6. Monthly totals indicate that these species are generally landed throughout the year with peaks between December and April. Means of species monthly landing for the three-year period indicate that ***smach*** is landed throughout the year but highest in December, with relatively high landings also from October to March. ***Terekrik*** is also landed throughout the year with the highest catch also recorded in December. High catches were also recorded from March to May, and August. ***Mekebud*** was only recorded in December.

Table 3.8.6: Monthly landings of small pelagic species at PFFA. Figures in lbs.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1991													
S. crumenophthalmus (***terekrik***)				237	925	257	230	91	149	42	275		2,206
R. ganagurta (***smach***)	1,559	592	523		297			1,306	513	1,738	1,892	4,318	12,738
Total	**1,559**	**592**	**523**	**237**	**1,222**	**257**	**230**	**1,397**	**662**	**1,780**	**2,167**	**4,318**	**14,944**
1992													
S. crumenophthalmus (***terekrik***)	342	528	239	418	1,127	312	305	437	286	352		2,706	7,052
R. ganagurta (***smach***)	1,646	2,609	2,146	721	518	851	1,519	1,886	2,036	2,270	1,221	5,066	22,489
Total	**1,988**	**3,137**	**2,385**	**1,139**	**1,645**	**1,163**	**1,824**	**2,323**	**2,322**	**2,622**	**1,221**	**7,772**	**29,541**
1993													
H. quadrimaculatus (***mekebud***))												29	29
R. ganagurta (***smach***)	3,111	3,502	2,084	2,152	1,195	984	392	849	195			61	14,525
S. crumenophthalmus (***terekrik***)	429	523	1,713	1,134	125	100		1,551	56			203	5,834
Total	**3,540**	**4,025**	**3,797**	**3,286**	**1,320**	**1,084**	**392**	**2,400**	**251**	**0**	**0**	**293**	**20,388**
Means													
terekrik	257	350.3	650.7	596.3	725.7	223	178.3	693	163.7	131.3	91.67	969.7	

smach	2,105	2,234	1,584	958	670	612	637	1,347	915	1,336	1,038	3,148	
mekebud	0	0	0	0	0	0	0	0	0	0	0	29	

The following table records estimated landings of small pelagics with their respective value at the commercial markets (PMCI, PFFA and Oh's) during the 1992-1993 period as recorded in the DMR "species 91-93" database. The 1993 data from Oh's market covers only January-May.

	1991		1992		1993	
Species	Wt (lbs)	Value (US$)	Wt (lbs)	Value (US$)	Wt (lbs)	Value (US$)
Mekebud			1,041	558	927	622
Sardines	669	398	403	202	227	121
Smach	12,738	14,198	22,842	28,057	13,899	17,231
Terekrik	3,299	3,572	7,120	8,690	5,834	7,332
Total	**16,706**	**18,168**	**31,406**	**37,507**	**20,887**	**25,306**

Table 3.8.7 records monthly small pelagic species, by state, landed at PFFA and PMCI from January to September, and Oh's (Jan-May) 1993. Koror is the main source of these species, especially ***smach***. Koror and Ngeremlengui supplied about the same quantity of ***terekrik*** during the year.

Table 3.8.7: Small pelagic species landings, by state, at PFFA and PMCI (Jan.-Sept.) and Oh's (Jan-May) in 1993. States were not specified for landings during Oct.- Dec.

Species	State	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mekebud	Aimeliik			129										129
	Airai	182												182
	Kayangel	78												78
	Koror	79	106											185
	Ngeremlengui	86												86
	Unlisted	58				180								238
	Total	**483**	**106**	**129**	**0**	**180**	**0**	**0**	**0**	**0**				**898**
Sardine	Airai	22	153											175
	Unlisted	52												52
	Total	**74**	**153**	**0**	**0**	**0**	**0**	**0**	**0**	**0**				**227**
Smach	Aimeliik			225										225
	Anguar	115												115
	Koror	2,996	3,502	1,859	2,025	1,195	984	392	884	160				13,997
	Ngatpang				127									127
	Total	**3,111**	**3,502**	**2,084**	**2,152**	**1,195**	**984**	**392**	**884**	**160**				**14,464**
Terekrik	Koror	351	102	769	333		100		1,001	56				2,712
	Ngatpang				103									103
	Ngeremlengui	78	421	944	698	125			550					2,816
	Total	**429**	**523**	**1,713**	**1,134**	**125**	**100**	**0**	**1,551**	**56**				**5,631**
TOTAL		**4,097**	**4,284**	**3,926**	**3,286**	**1,500**	**1,084**	**392**	**2,435**	**216**				**21,220**

3.8.3 Stocks Status

Tuna Programme (1984) estimated that the baitfish resource (for pole-and-line) in Palau, is substantial considering the size of the Palau Islands lagoon, availability of good baitfish habitat and the presence of stolephorid anchovies No recent informatin exists on the status of the resource especially for those species which are important to the domestic commercial market and subsistence. Johannes (1981) reported that *H. quadrimaculatus* (***mekebud***) stocks in Palau have been reduced through a combination of legal fishing and illegal dynamite fishing. However, Dalzell (1993) noted that although evidence for this decline is convincing, it is based on subjective reports of declines in seasonal abundance rather than accurate time series of catch and fishing effort records and supporting biological data. Small pelagic species landed at PFFA during the 1976-1981 year period was dominated by ***terekrik*** and ***mekebud*** averaging 1,285 and 1,120 lb per year respectively for the 6-year period. There were no ***mekebud*** landings at PFFA in 1991 and 1992, and only 29 lbs were recorded in 1993. However, about 1,000 lbs per year of the species were landed at other markets for 1992 and 1993. The 1991-1993 PFFA data indicate that ***smach*** commercial landing has increased tremendously from an annual average of about 1,500 lbs per year in the late 1970s/early 1980s to about 13,000 lbs in 1991, 22,000 lbs in 1992, and about 15,000 lbs in 1993. It currently dominates the small pelagic

local commercial fishery. ***Terekrik*** has also shown an increase in annual commercial landings at PFFA, from about 1,200 lbs per year in the 1976-1981 period, to 2,200 lbs in 1991, 7,000 lbs in 1992 and 5,800 lbs in 1993.

3.8.4 Management

Current legislation/policy regarding exploitation: There is currently no legislation that is specifically directed at managing the small pelagic resources.

Palau National Code, Title 24, Division 2, Chapter 13, subchapter I, § 1302 prohibits the use of dynamite, poisons or chemicals to catch fish. However, §1303 of the same law lists exceptions to the prohibitions as where:

- the President has granted a written permission;
- the President has determined that the purpose of obtaining the fish or other marine life is to avoid the waste or loss of such fish or marine life; and that the consumption or sale of fish or other marine life caught by any means the use of which is prohibited,is not harmful or hazardous to health and human life.

§ 1304 permit the use of local roots, nuts and plants, which have have the effect of stupefying but not killing fish, to catch fish.

Section 4 (6) of the Marine Protection Act of 1994 prohibits fishing while using any form of underwater breathing apparatus other than a snorkel. Section 4 (12) prohibits fishing using a gill net or surround net having a mesh size of less than three inches.

Recommended legislation/policy regarding exploitation: Managing this resource seems best addressed through controlling the fishing methods used to catch them, such as minimum net mesh size and prohibiting destructive fishing methods such as explosives. Rigorous enforcement of existing legislation is necessary.

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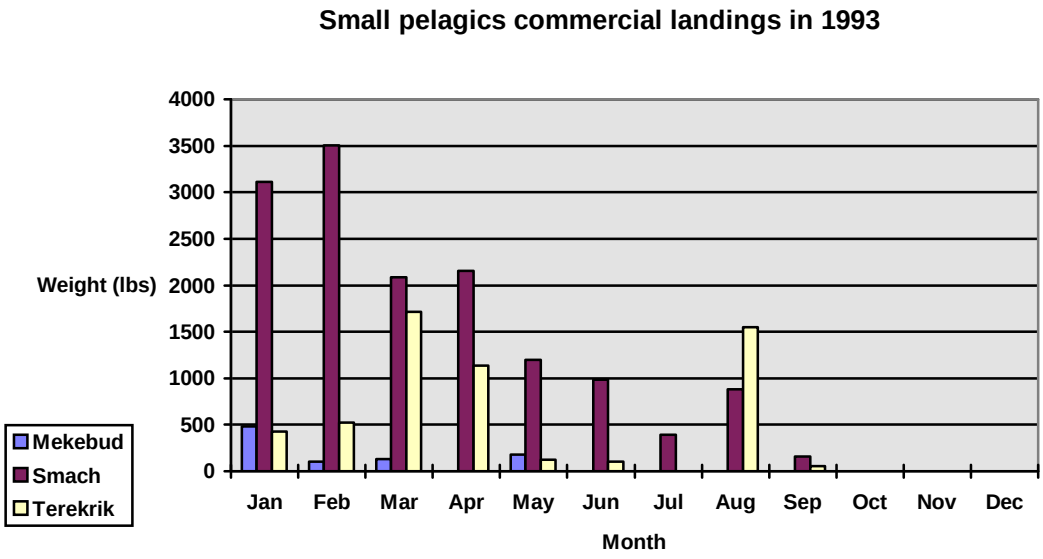
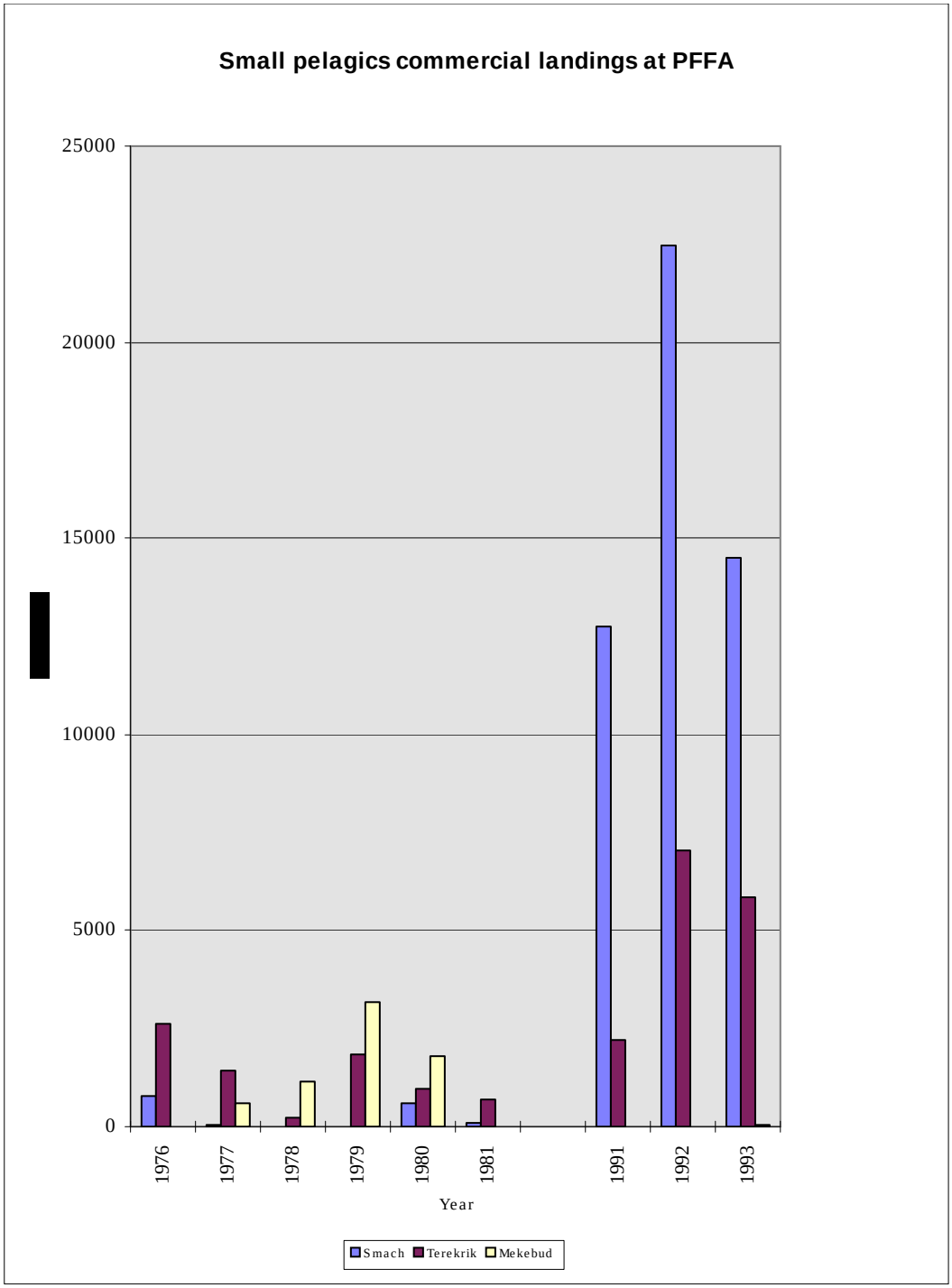
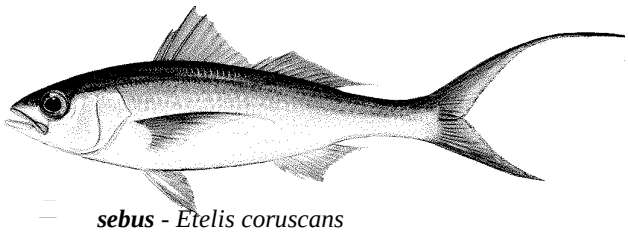

Small pelagics commercial landings in 1993
Weight (lbs)
4000
3500
3000
2500
2000
1500
1000
500
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Mekebud
Smach
Terekrik


Small pelagics commercial landings at PFFA
25000
20000
15000
10000
5000
0
1976
1977
1978
1979
1980
1981
1991
1992
1993
Year
Smach
Terekrik
Mekebud

3.9 Bottomfish[3] (deep-water snappers and groupers)



sebus - *Etelis coruscans*

3.9.1 The Resource

Species present: The bottomfish (deep-water) resource in Palau is dominated by snappers (f. Lutjanidae), emperors (f. Lethrinidae) and groupers (f. Serranidae). Dominant species in the bottomfish catch include:

Lutjanus gibbus (paddle-tail or humpback snapper - ***keremlal***), *L. bohar* (red bass (snapper) - ***kedesau***), *L. kasmira* (blue-lined snapper);

Pristipomoides flavipinnis (pink opakapaka - ***metengui***), *P. filamentosus* (crimson jobfish - ***metengui***), *P. filamentosus* (crimson jobfish - ***metengui***), *P. argyrogrammicus* (ornate jobfish - ***dudul***), *P. auricilla* (goldflag jobfish - ***dudul***), *P. sieboldii* (lavender jobfish - ***metengui***), *P. zonatus* (oblique-banded snapper);

Aphareus furcatus (*A. rutilans* (rusty jobfish - ***metengui ra tmolech***);

Etelis carbunculus (ruby snapper - ***sebus***), *E. coruscans* (longtail snapper - ***sebus***);

Lethrinus miniatus (*elongatus*) (longnose emperor - ***melangmud***), *L. variegatus*, *L. kalopterus* (orangefin emperor - ***menges***), *L. reticulatus*, *Wattsia mossambicus* (large-eyebream);

Aprion virescens (green jobfish - ***udel***);

Epinephelus miliaris (honeycomb grouper), *E. morrhua* (curve-banded grouper - ***temekai***), *E. fasciatus* (red-banded grouper - ***temekai***), *Variola louti* (lunar-tailed cod - ***baslokil***);

Promethichthys prometheus (snake mackerel);

Ruvettus pretiosus (oil fish);

Caranx lugubris (black trevally - ***omektutau***), *Seriola rivoliana* (amberjack - ***mekeem***).

A total of 102 deep-water reef fish species have been recorded from dropline catches in Palau (Dalzell and Preston, 1992). Comparison of the number of deep reef fish species recorded from dropline catches and lengths of the 100-fm isobath in different locations in the South Pacific, is given in the same reference as summarised in Table 3.9.1. Even though Palau has a relative short 100-fm isobath, it has the second highest deep reef fish diversity, after Fiji.

Table 3.9.1: Number of deep reef fish species recorded from dropline catches and 100-fm isobath. (Source: Dalzell and Preston, 1992).

Counrty/Territory	Land Area (km^2)	Linear distance east from Palau (km)	Isobath length (n.mi.)	No. of deep reef slope species
Palau	**460.0**	**0**	**232.0**	**102**
Yap	100.2	500		69
Truk	99.9	2,000		88
Papua New Guinea	462,243.0	2,250	7,305.0	94
Kosrae	109.6	3,250		63
Solomon Islands	27,556.0	3,375	2,444.3	23
Marshall Islands		4,000	1,420.0	44
Kiribati		4,500	708.7	78
Vanuatu	11,880.0	4,500	1,400.0	51
New Caledonia	19,103.0	4,750	1,556.0	65
Tuvalu		5,250	128.2	51
Fiji	18,272.0	5,625	3,000.0	107
Wallis and Futuna	265.0	5,875	69.9	61
Tokelau		6,250	56.4	49
Western Samoa	2,482.0	6,250	307.8	45
Tonga	646.0	6,375	893.0	68
American Samoa	200.0	6,500	143.3	41
Niue	259.0	6,750	53.1	42
Kiritimati	363.4	7,655		26
Penrhyn	1.0	7,900		37

[3] All landings (weights) for species in this profile are also included in family categories (e.g. Lutjanidae, Lethrinidae) under "Other Reef Fish" profile.

Rarotonga	64.0	8,170		29
French Polynesia		9,655	2,970.9	47

Distribution: Deep water species are distributed throughout the tropical Indo-Pacific. Throughout the South Pacific, the most important fish catch components of the deep-water fishery, in terms of total landing and value, comprise snappers and groupers. Most of the species in these two families are "widely distributed throughout the central, western and South Pacific although species richness tends to decline with distance from the Indo-Pacific faunal centre, leaving areas like Hawaii with somewhat fewer species" (Moffitt, 1993). Allen (1985) gives an overall general distribution pattern by subfamilies in the family Lutjanidae as well as the known distribution and identification of individual species. He also writes that "the family is divisible into four discrete geographical faunas: eastern Pacific, Indo-West Pacific, eastern Atlantic and western Atlantic" with no species found in more than a single region. Furthermore, "many species, particularly members of *Aphareus, Aprion, Etelis, Lutjanus, Macolor, Paracaesio, Pinjalo* and *Pristipomoides* have broad distributions encompassing wide areas of the Indo-West Pacific region. Some of these species such as *Lutjanus bohar, L. gibbus, L. kasmira, L. monostigma,* and *L. rivulatus*, as well as species of *Etelis*, *Paracaesio* and *Pristipomoides* are frequently associated with oceanic insular localities. Relatively few species have greatly restricted distribution and some of these may be more widespread, but because of their relatively deep habitat, they are seldom collected".

Moffitt (1993) notes that even though most of these species are wide ranging, their relative composition in catches varies considerably with location.

“The 100-fm (or 200-m) isobath in Palau extends for 232 n.mi., although there seems to be two sea-mounts within Palau’s EEZ where bottom fishing has yet to be carried out” (Dalzell and Preston, 1992). Palau has a number of areas of suitable habitat and sea-mounts for deep water fishing, with 75 percent of the 250 m depth contour lying within 70 m of the barrier reef (Taumaia and Crossland, 1980). Best areas lie off the north, north-east and south-west reefs. Details of species abundance in different areas are not available. Deep water snappers are generally found between 80-400 m depth in waters adjacent to the reef edge or on sea mounts and deep water plateaus. Taumaia and Cusack (1989) reported good catches of the valuable deep-water snapper, *E. carbunculus*, in depths as shallow as 150 m (80 fathoms).

Surveys in 26 sites in the Ngrmeduu Bay area, Amesbury (1991) reported the occurrences of some of the species included in this profiles as follows:

Species	No. of sites in which species was observed	Other information
Aphareus furcatus	11 out of 21 sites	notably high abundance in 1 of the sites
Aprion virescens	3 out of 21 sites	
Lutjanus bohar	11 out of 21 sites	notably high abundance in 1 of the sites
L. gibbus	14 out of 21 sites	notably high abundance in 6 of the sites
L. kasmira	1 out of the 21 sites	
L. monostigma	8 out of the 21 sites	
Macolor niger	12 out of the 21 sites	notably high abundance in 1 of the sites

Johannes *et al*. (1994) reported *L. bohar* spawning at their Ngerumekaol study site.

Biology and ecology: For most deep-water species, growth tends to be slow, and recruitment may be low, resulting in most stocks being highly susceptible to overfishing if high fishing pressure is sustained. All species are top level carnivores, usually weighing 1-5 kg, although some species of serranid (groupers) reach 30-40 kg.

It has been established that benthic fish and crustaceans form an important dietary component for deep-water snappers and groupers, and that pelagic urochordates are important prey items for many *Pristipomoides* species (Moffitt, 1993). Deep-water snappers are serial spawners, able to spawn several times over a prolonged breeding season. Reproduction takes place in the summer, May to September in the North Pacific and November to May in the South Pacific. In Palau, Johannes *et al*.

(1994) observed *L. bohar* spawning at Ngerumekaol on May 15 between the 17:50 and 18:25 hour. Fecundity increases with size and for some species it has been estimated to be between 300,000 and 2,000,000 eggs. Groupers on the other hand are protogynous hermaphrodites with an abbreviated breeding season peaking for 1-2 months. Groupers aggregate in large numbers during spawning and they usually become susceptible to fishing during this period. Fecundity has not been determined. Both snappers and groupers are long lived and slow growing. For natural mortality (M), Ralston (quoted in Moffitt, 1993) found the relationship M=0.0189+2.06K for snappers and groupers.

Kitalong and Dalzell (1994) estimated growth and mortality parameters for *L. gibbus* in Palau as follows:

Species	L∞	K	Z	M	F	E
L. gibbus	39.8	0.400	1.144	0.906	0.238	0.208

3.9.2 The Fishery

Utilization: During the 1980s, Palauan fishermen active in the bottomfish fishery generally fished in depths of less than 80 m, using weighted monofilament handlines of 45-80 lbs (20-36 kg) breaking strain wound on pieces of bamboo for storage, with wire traces and a single hook as terminal gear (Taumaia and Crossland, 1981). A number of 10.6 m (35 ft) fibreglass displacement hull diesel vessels, donated under Japanese grant-aid, operated by fishing co-operatives and managed by PFFA, are active in this fishery. Many of the private and PFFA-run boats, landing their catches at PFFA and at other markets in Koror, utilise hydraulic or hand operated drop-line gear. However, species composition of the catch landings at PFFA indicates that these vessels tend to target shallower water reef fish (Annex 2). The extent of the deep water fishery in Palau today is unclear from available data, but species composition of the landed catch indicates that little effort is specifically directed at the deep water fish resource.

Production and marketing: Deep-water species, when caught, are stored, transported and marketed in much the same way as reef fish. PFFA paid an average price of $1.65 per kg for deep water species during 1991.

Production figures for deep-water fishes are scarce. Available commercial landings data at PFFA indicate few true deep-water species are landed. Export figures are not broken down to species or species groupings, and therefore it is not clear if these snappers are exported via another market.

Catch details, including weights by species, during the SPC dropline fishing assessment in Palau between 1979 and 1987 are given in Dalzell and Preston (1992). The overall results are summarised in Table 3.9.2 as given by the same authors.

Table 3.9.2: Summaries of catches by the SPC deep-water fishing assessment in Palau between 1979 and 1988. (Source: Dalzell and Preston, 1992).

Area	Date	# trips	Total reel-hours	Total D-B catch (kg)	Total catch without sharks (kg)	Average per trip	Average per reel-hour
Nothern and central Palau	13 Nov 79-21 Jan 80	11	660	2,136.0	1,972.0	179.0	3.0
Ngardmau, Koror, Peleliu, Kayangel, Melekeok, Ngchesar, Ngiwal, Ngaraard, Angaur, Ngecherlong	17 May 83-20 Oct 83	42	1,500	8,560.0	6,937.0	165.2	4.6
Koror	14 Oct 87-27 Apr 88	13	287	565.8	500.8	38.5	1.7
Southern area	14 Oct 87-27 Apr 88	3	76	225.3	225.3	75.1	3.0
Northen area	14 Oct 87-27 Apr 88	7	164	512.9	471.4	67.3	2.9

Perron *et al*. (1983) compiled commercial marine animals purchased at PFFA for the 1976-1981 period. The major bottomfish species recorded are given in Table 3.9.3 with corresponding weights and value. The data shows vast increases in catches during the 1979-1981 period. This is probably due to the SPC bottomfish assessment project. ***Keremlal*** dominated landings for all the years. Species

breakdown was not possible on 1983-1989 catch data.

Table 3.9.3: Bottomfish landings recorded at PFFA for the 1976-1981 period. (Source: Perron *et al*., 1983).

Species		1976	1977	1978	1979	1980	1981
Keremlal	Weight (lbs)	15,574	7,043	2,801	15,169	28,504	23,699
	Value ($)	4,684	2,465	1,133	6,839	16,773	15,719
Kedesau	Weight (lbs)	2,071	2,760	992	2,702	5,148	4,112
	Value ($)	593	953	217	744	1,563	1,515
Metengui	Weight (lbs)	535	35	165	2,972	21,799	3,044
	Value ($)	136	12	58	1,402	10,687	1,499
Dudul	Weight (lbs)				443	884	
	Value ($)				214	514	
Sebus	Weight (lbs)	682	190	105	341	5,523	263
	Value ($)	212	67	47	133	3,056	124
Melangmud	Weight (lbs)	2,713	148	35	4,873	3,908	5,135
	Value ($)	872	51.8	12	2,065	2,190	3,065
Menges	Weight (lbs)				34	126	14
	Value ($)				13	63	8
Udel	Weight (lbs)				502		487
	Value ($)				235		292

DMR Annual Report for 1990 lists the 22 most important commercial finfish landed at PFFA during 1990 on a monthly basis. Those listed and which have been classified as bottomfishes are presented in Table 3.9.4. Fish species have been categorised according to estimated fishery. Of these, ***keremlal***, dominates the fishery, followed by ***metengui***.

Table 3.9.4: Monthly estimates of commercial bottomfish landing at PFFA during 1990. Figures are in lbs. (***Keremlal*** was reported as being caught both by speargun and handline).

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Lutjanus gibbus (***keremlal***)	596	904	284	280	1,722	2,038	725	2,280	1,437	2,511	109	902	13,788
L. bohar (***kedesau***)	62		21	122	194	103	6	229	609	536		51	1,933
Pristipomoides sp. (***metengui***)	126	497			98	96	421	1,379	2,`26	2,452	108	1,909	9,212
Lethrinus elongatus (***melangmud***)		261		22	554	199	127					654	1,817

Landings at PFFA for 1991, 1992 and 1993 of species classified here as bottomfishes are given in Table 3.9.5. The 1993 landings at PMCI and Oh's (Jan-May) are added separately. Of the species considered here as bottomfish, ***keremlal*** (*L. gibbus*) forms about 50 per cent of the annual landing each year.

Table 3.9.5: Bottomfish commercial landings at PFFA for 1991 and 1992, and PFFA, PMCI and Oh's (Jan-May) during 1993. Figures in lbs. (Source: DMR Annual Report for 1992 and database).

		1991	**1992**	**1993**		
Palauan	**Species**	**PFFA**	**PFFA**	**PFFA**	**PMCI**	**OH's**
Keremlal	*Lutjanus gibbus*	48,061	39,420	36,118	1,760	584
Metengui*	*Pristipomoides* sp. & *Lethrinus* sp.	11,928	5,756	5,728		180
Kedesau	*Lutjanus bohar*	10,658	8,107	7,574		
Melangmud	*Lethrinus elongatus*	6,743	9,599	11,795		62
Sebus	*Etelis* sp. & some *Lutjanus* spp.	2,474	1,544	2,155		
Dudul	*Pristipomoides argyrogrammicus* & *P. auricila.*	1,136	828	1,322		
Besechamel	*Monotaxis grandoculis*	23	100	28		
Udel	*Aprion virescens*	486	682	349		
Total		**81,509**	**66,036**	**65,069**	**1,760**	**826**

* *Lethrinus haematopterus, L. mahsenoides, Gymonocranius japonicus, Pristipomoides sieboldii* and *P. filamentosus roseus*.

The 1993 total monthly landings at PFFA for species selected as bottomfish is given in Table 3.9.6 with their respective values. All of the species are sold at more than $1/lb. One of the species included in this profile, namely *L. gibbus* (***keremlal***) forms a major component in the commercial landings of finfish in the whole Palau fisheries. It was estimated to make up 10 per cent of the ten most common species in the commercial reef fish landings in Palau between 1976 and 1990 (DMR Annual Report for 1992). The 1993 bottomfish landings at PFFA indicate that ***keremlal*** make up about 57 per cent of the bottomfish catch, followed by ***melangmud*** (19 per cent) and ***kedesau*** (12 per cent). The fishery is generally spread throughout the year with higher catches in the earlier months peaking around March/April, as indicated by the 1993 data, especially ***keremlal***.

Table 3.9.6: Monthly PFFA 1993 Market Landings of bottomfish species.

	Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	% Wt	% $
Besechamel	lbs								28					**28**	0.0	
	$								28					**28**		0.0
Melangmud	lbs	261	1,252	1,978	397	623	282	1,554	1,982	1,707	502	368	889	**11,795**	18.5	
	$	287	1,364	2,158	437	685	310	1,678	1,982	1,707	437	313	756	**12,113**		16.7
Metengui	lbs	99	148	729	65			406	192	1,163	227	2,467	232	**5,728**	9.0	
	$	112	192	984	75			464	240	1,454	284	3,067	307	**7,179**		9.9
Udel	lbs			13					28		145	113	50	**349**	0.5	
	$			14					28		129	96	43	**309**		0.4
Dudul	lbs	182		123	147	870								**1,322**	2.1	
	$	237		151	162	957								**1,506**		2.1
Edui	lbs											158		**158**	0.2	
	$											134		**134**		0.2
Kedesau	lbs	365	754	1,603	1,609			159	632	203	433	1,296	520	**7,574**	11.9	
	$	384	859	1,763	1,770			159	632	203	363	1,110	442	**7,685**		10.6
Keremlal	lbs	1,766	2,961	6,442	6,090	2,213	2,150	1,160	4,102	3,258	1,184	2,753	2,039	**36,118**	56.5	
	$	2,075	3,849	8,697	7,727	2,434	2,365	1,319	5,128	3,269	1,184	2,742	1,758	**42,546**		58.6
Sebus	lbs			112	90		457	19		424	889	164		**2,155**	3.4	
	$			151	122		503	21		530	1,111	205		**2,643**		3.6
Total (lbs)		**2,501**	**5,125**	**10,887**	**8,261**	**2,846**	**2,899**	**3,308**	**6,974**	**6,765**	**3,390**	**7,329**	**3,740**	**63,915**	100.0	
Total ($)		**2,868**	**6,274**	**13,777**	**10,141**	**3,129**	**3,188**	**3,651**	**8,048**	**7,173**	**3,518**	**7,677**	**3,316**	**72,647**		100.0

Bottomfish species landings by state at PFFA during the first nine months of 1993 are presented in Table 3.9.7. ***Kedesau***, ***keremlal*** and ***melangmud*** involve eight or more states with ***keremlal*** having the highest number of states. During the nine months, the highest quantity of ***keremlal*** was landed from Ngeremlengui and Ngerlong followed by Koror. For ***kedesau***, the highest amount was landed from Koror followed by Ngerchelong and Ngeremlengui. Ngerchelong and Ngeremlengui landed the highest amount of ***melangmud*** followed by Koror and Peliliu while Anguar landed the most ***dudul***, ***metengui*** and ***sebus***.

Table 3.9.7: Bottomfish landings at PFFA in 1993 by state.

Species	State	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Dudul	Angaur	182		61	147	870					1,260
	Peleliu			62							62
Kedesau	Aimeliik		17								17
	Airai		27								27
	Angaur		10	96							106
	Koror	333	387	430	674			159	485	83	2,551
	Ngaraard				18						18
	Ngerchelong	32	115	459	309				257		1,172
	Ngeremlengui		178	508	608					120	1,414
	Peleliu		20	110					67		197
Keremlal	Airai		30								30
	Angaur	106	267	276	41	77	117			259	1,143
	Kayangel						920	82			1,002
	Koror	1,139	1,008	1416	486	58		929	802	888	6,726
	Melekeok					133					133
	Ngaraard	189	335	116	60				20		720
	Ngardmau						35				35
	Ngatpang	227	94					58			379
	Ngerchelong	159	710	1,628	1,800	293		91	3,052	1,882	9,615
	Ngeremlengui	97	775	2,508	3,517	1,785	1078		212	20	9,992
	Peleliu	153		498	186				16	209	1,062
Melangmud	Aimeliik				41						41
	Angaur		45	31							76
	Koror	62	326	159	39			423	331	488	1,828
	Ngaraard		32	5					52	15	104
	Ngatpang	28					77		67		172
	Ngchesar				120		36				156
	Ngerchelong	153	512	915		301	99		1,340	386	3,706
	Ngeremlengui	40	144	195	105	322	70	1,131	45	84	2,136
	Peleliu	40	193	673	92				147	734	1,879
Metengui	Angaur		55	56				202		819	1,132
	Koror	99	31	243	65			106	192	67	803
	Ngaraard		28	41				98		53	220
	Ngchesar	158									158
	Ngerchelong		34	22						224	280
	Ngeremlengui		22	267							289
Sebus	Angaur			60			218	19		424	721
	Koror						100				100
	Ngerchelong						69				69
	Peleliu			52	90		70				212
Udel	Angaur			13							13
	Koror								28		28

3.9.3 Stocks Status

Taumaia and Crossland (1980) undertook a survey of deep snapper fishing potential on reefs around Babelthuap Island, using deep-water Samoan-type hand-reels with standard 3 hook terminal gear. Eleven trips resulted in 2,210 kg fish consisting of 50 species representing 9 families. 16 species of snapper (Lutjanidae) made up 53 per cent of the catch, with serranids (13.6 percent) and carangids (13.1 percent). Catch rates were considered poor, and poor fish prices at that time made the development of the fishery not economic. In contrast, Taumaia and Cusack (1989), following on from Taumaia and Crossland's (1980) earlier visit, conclude that "extensive deep-bottom grounds holding substantial stocks of valuable species of snapper" exist in Palau which, in 1983, were "unexploited or under-exploited". These authors state that the existence of well organised fishermen's co-operatives, adequately equipped catching platforms, shore facilities and a large local market indicate viable development of fishing for deep-water snappers.

The most recent bottomfish assessment is a six months survey conducted by the SPC's Deep Sea Fisheries Development Project in 1987-88 (Chapman, 1988). Droplining was conducted on seamounts and deep hard-bottom up to 200 m deep. The average catch rate obtained was 1.84 kg/reel hour for droplining (2.0 kg/reel hour for trolling), as compared to 3.0-4.5 kg/reel hour on previous visits. The best catch rates were obtained in the north and south areas of the barrier reef, with poorest catches around Koror. Again, these rates were considered low, and it was concluded that the deep-water snapper

resources of Palau are limited. One significant finding was that deep-water species were caught in much shallower depths (down to 180 m) than is generally the case elsewhere in the Pacific. This could be due to bottom definition or temperature profiles, which have been assumed to limit the available habitat for deep-water species in Palau. The catch of *Etelis* spp. was far less off the east coast compared with those in the west. A sunken reef between Angaur and Peleliu yielded the highest catch rate of 2.94 kg/reel hour and offers good potential, but currents in the area are strong. Overall, the survey assessed the deep-water snapper resources to be habitat-limited, and therefore of low development potential. Deep water fishing using droplining and vertical longline was not considered economic in Palau by the Project.

Amesbury (1991) reported the results of quantitative surveys in two sites in the Ngermeduu Bay area as follows, for species discussed in this profile:

	Site 24					Site 25				
Species	50x2-m transect count	5-m point count	2-m point count	5-m point count	2-m point count	50x2-m transect count	5-m point count	2-m point count	5-m point count	2-m point count
L. gibbus		100		200						
Macolor niger		3		3						

Dalzell and Preston (1992) noted that the MSY for bottomfish in Palau would be expected to lie between 16.2 and 48.7 t/yr and estimated that the fishery was approaching MSY by 1988.

Apart from the visits of the SPC Deep Sea Fisheries Development Project, which have helped identify fishing grounds, demonstrate techniques to local fishermen, identified species composition of the resource and tested market acceptability of the saleable species, no formal assessments of the sustainability of deep-water resources have been undertaken.

3.9.4 Management

Current legislation/policy regarding exploitation: There is no existing legislation that specifically adresses the management of the deep-water bottom fishery. Current government policy to increase off-shore fishing in order to reduce pressure on near-shore, shallow water stocks may increase pressure in future, resulting in necessary management inputs.

Recommended Legislation/Policy regarding exploitation: None appears to be required at present. An initial assessment of available fishing area, and potential yield using length frequency and catch-per-unit-effort data to estimate fishery parameters, allowing calculation of equilibrium yields from total biomass models, such as those proposed by Polovina (1987) would be useful in planning for the exploitation of this resource.

Chapman (1988) recommends further fishing surveys to determine deep-water snapper fishing potential in Palau.

Efforts should be invested to separate data for landings at the commercial markets according to their specific fishery, e.g. bottomfish, shallow-water reef fish etc. Because of the problem of having more than one species with the same Palauan name, either common English names or scientific names (genus or even species in most cases) should be used in data recording. These two factors made the current estimation of the landings from this particular fishery very difficult.

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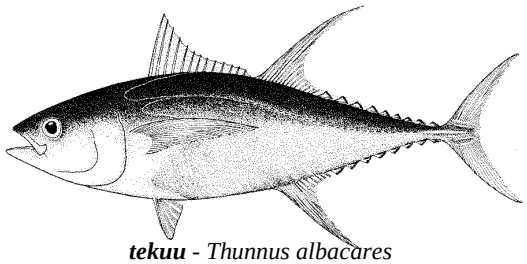
3.10 Tuna

3.10.1 The Resource



tekuu *- Thunnus albacares*

Species present: Commercially important species of tuna that occur in the Palau EEZ include: *Thunnus albacares* (yellowfin tuna - ***tekuu***), *T. obesus* (bigeye tuna), *T. thynnus* (Northern bluefin tuna), *T. alalunga* (albacore), *Katsuwonus pelamis* (skipjack - ***katsuo***), *Gymnosarda unicolor* (dogtooth tuna), *Euthynnus affinis* (kawakawa - ***soda***).

Williams (1991) reports that ninety five per cent of the airfreight tuna for the sashimi market in Japan from Palau is made up of *T. albacares* and *T. obesus*.

Distribution: Tuna and billfishes inhabit surface oceanic tropical and temperate waters of the Atlantic Pacific and Indian Oceans (Joseph *et al.*, 1988). Taxonomically, 61 species are grouped together in the sub-order Scombroidei, which is commonly recognised to comprise three families: the Scombridae (true tunas, bonitos, seerfishes and mackerels), Istiophoridae (spearfish, sailfish and marlins) and Xiphiidae (swordfish). These families contain species which support some of the most important commercial fisheries for food and sportfishing in the world. Tuna resources are undoubtedly the single most important renewable resource available to the island nations of the Forum Fisheries Agency for commercial exploitation.

Many species undertake extensive migrations during their life cycle, presenting particular problems for effective management of the resource. International cooperation and harmonisation of management regimes is essential for effective management of most stocks.

Collette and Nauen (1983) give the general geographical distribution of the scombrids including the tunas. They provide the following geographical distribution information concerning the tuna species, for those which have been recorded in Palau waters. Additional and more specific information from Hampton (1993) is also included:

Skipjack tuna - cosmopolitan in tropical and warm-temperate waters but absent in the Black Sea. "Skipjack are highly mobile and are capable of unrestricted movement throughout the Pacific Ocean. Most spawning seems to occur in the western Pacific where most of the catch is also taken. Tagging results show substantial mixing of skipjack from Philippines and eastern Indonesia to at least 150° W. However movement, at least of adult skipjack, between the central and eastern Pacific appears more limited".

Yellowfin tuna - worldwide in tropical and subtropical seas of the Pacific Ocean, without any obvious barriers to movement, but absent from the Mediterranean Sea. "There is some evidence from fisheries, tagging and biological data that interchange between the eastern and western Pacific (divided at 150° W) is limited".

Mackerel tuna - throughout the warm waters of the Indo-West Pacific including oceanic islands and archipelagos. A few stray specimens have been collected in the eastern tropical Pacific.

Dogtooth tuna - tropical Indo-West Pacific from the Red Sea and East Africa east to Japan, the Philippines, PNG, and Australia and out into the islands of Oceania.

Albacore - cosmopolitan in tropical and temperate waters of all oceans, including the Mediterranean Sea, extending north to 45 to 50° and south to 30 to 40° but not at the surface between 10°N and 10° S. "Fishery data and tag returns suggest that albacore in the North and South Pacific constitute

separate stocks. These data, along with gene frequency data, further suggest that albacore throughout the South Pacific should be considered as a single stock".

Bigeye tuna - worldwide in tropical and subtropical waters of the Atlantic, Indian and Pacific oceans, but absent from the Mediterranean. There are currently limited data to test stock structure hypotheses.

Frigate tuna - probably cosmopolitan in warm waters but there are only a few documented occurrences in the Atlantic Ocean.

Southern bluefin tuna - probably found throughout the Southern Ocean south of 30° S.

Northern bluefin tuna - at least two subspecies with one in the Atlantic and the other in the Pacific. The Pacific subspecies occurs in the Gulf of Alaska to southern California and Baja California in the eastern Pacific, and in the western Pacific it is known from Sakhalin Island in the southern Sea of Okhotsk south to the northern Philippines.

Biology and ecology: All species produce buoyant eggs, containing an oil droplet. Tuna eggs are around 0.04 mm diameter (billfish eggs tend to be rather larger). Larvae at hatching are around 2.5 mm long, and grow at a rapid rate. All species are highly fecund, producing around 100,000 eggs per kilogram of body weight. All tunas and tuna-like species are apex predators of fish, squid and crustacea. The smallest species, the bullet and frigate tunas, rarely exceed 3 kg weight (6.6 pounds), whereas the Northern bluefin can exceed 700 kg (1,500 pounds). Yellowfin attain 2.4 kg in 1 year, 15 kg at 2 years, 43 kg at 3 years and around 80 kg at 4 years. Detailed information on growth rate, longevity and biology of most tuna species is poor (Joseph *et al.*, 1988).

Smith (1992) notes that even though the tunas form the basis of one of the world's largest fisheries[4], many of the parameters regarding their life history are still unknown. 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, 1989).

3.10.2 The Fishery

Utilization: Most commercial tuna production in Palau is currently exported, primarily for the Japanese sashimi market. There are no plans to establish value added processing (eg. canning) at present. A single domestic pole-and-line vessel operated by a local company provides fresh tuna to the domestic market. This vessel limits effort according to local demand. A review of the longline trans-shipment activities in Palau is provided by Williams (1991). Fifty Japanese longliners and thirty purse seiners were licensed by PMA to fish in Palau's EEZ. Three companies have access agreements: 1) Palau Marine Industries Corp. (PMIC) has an access agreement for maximum of 120 vessels, but only 93 were active in 1993; 2) Palau International Traders Inc. (PITI) has an access agreement for a maximum of 250 longliners but only 145 were active in 1993; 3) Kuniyoshi Fishing Company (KFC) has an agreement for a maximum of 70 vessels with only 11 in operation in 1993, (Economic Development Plan, Vol. 1, 1994). All PITI fishing vessels are Mainland Chinese while PMIC operated 52 Chinese and 41 Taiwanese vessels.

[4]Stamatopoulus (1993) ranks the production, in the Pacific Ocean, of tunas, bonitos and billfishes fourth on the list of ISSCAAP species groups for diadromous and marine fish and crustaceans and molluscs for 1990, after 1). herrings, sardines, anchovies 2). cods, hakes, haddocks and 3). misc. fish species

Palau signed the Multilateral Treaty on Fisheries Between the Governments of Certain Pacific Islands States and the Government of the United States of America on 16 October, 1987. The treaty allows US purse seiners to fish in EEZs of those Pacific Island States that sign the treaty for a set fee.

Production and marketing: Vessels operating under access arrangements do not land their catches in Palau. The three commercial companies based on Koror export catches by air freight for the fresh sashimi market in Japan, and also by reefer vessels. The single domestic pole-and-liner produced 87 mt of fresh tuna in 1990, all sold on the local market.

Commercial fishing for skipjack did not start in Palau until the Japanese gained control of the territory at the beginning of World War I, when live bait and pole-and-line fisheries were developed in Saipan, then Mariana Islands and then Palau. Catches increased rapidly throughout the 1930s in Micronesia, reaching 33,000 mt per year in 1937, over 75 per cent of which came from Palau and Truck (now the State of Chuuk) (Rothschild and Uchida, 1968).

Exploitation ceased during World War II. From 1964 the Van Camp Seafood Company of the United States operated a live bait fishery for surface tunas in Palau, taking around 6,600 mt of skipjack annually between 1978-1981 with 8-15 locally based pole-and-line vessels manned mainly by foreign crews. It ceased in 1982 as a result of depressed tuna markets, increased fuel costs and growth in purse-seine fishing.

Catch statistics derived from published records of Japanese and Taiwanese longliners catches within the estimated EEZs of the South Pacific Commission area between 1962 and 1977 are summarized in Table 3.10.1(a) for Palau as reported in Skipjack Programme (1981). Catches are in numbers of fish and effort in 1,000 hooks and includes other catches such as billfishes, marlins and sailfishes, which are discussed under the "Other Pelagics" profile in this document. Klawe (1978) converted the numbers of fish to weights but unfortunately, those for Guam, FSM, Northern Marianas and Palau were pooled together. Skipjack Programme (1980) reported Japanese skipjack fishing effort and catch within the estimated EEZ's of the SPC area for the 1972-1978 period. Table 3.10.1(b) records the estimated landings by the Japanese pole-and-line fleet in Palau waters for this period.

Table 3.10.1(a) : Longliners catch in Palau waters from 1962 to 1977. Catches are in numbers of fish. (Source: Skipjack Programme , 1981).

Year	Country	Hks/1000	B/fin	Alba	B/eye	Y/fin	Broadbill	Str. mar	Blu. mar	Bla. mar	Sailfish	S/jack	Small tuna
1962	Japan	2,718	2	220	10,217	46,948	299	185	2,807	270	1,968	33	0
1963	Japan	1,182	0	1,126	4,917	23,295	297	59	715	219	665	1	0
1964	Japan	1151	14	749	3,466	21,007	177	88	1,443	121	817	90	0
1965	Japan	4,796	61	12,626	13,673	74,169	968	743	3,198	501	2,387	489	0
1966	Japan	2,634	23	4,516	9,502	38,492	416	111	1,923	263	991	88	0
1967	Japan	1,849	38	532	6,733	23,425	348	59	1,031	253	688	94	0
	Taiwan	2	0	5	6	39	0	0	2	1	0	0	0
1968	Japan	2,358	21	570	10,746	29,979	541	64	1,404	270	353	325	0
	Taiwan	17	0	1	124	630	2	0	8	0	0	0	4
1969	Japan	1,258	2	1,051	3,943	19,084	176	43	588	87	161	111	0
1970	Japan	1,099	2	1,083	3,776	15,214	110	11	1,091	77	190	112	0
1971	Japan	934	0	732	3,252	14,152	149	21	646	104	59	12	0
	Taiwan	10	0	0	19	113	0	0	9	1	1	0	0
1972	Japan	855	3	643	4,615	8,726	311	41	664	49	36	14	0
	Taiwan	73	0	10	619	1,551	0	0	8	0	0	0	0
1973	Japan	2,007	2	1,002	7,836	37,186	271	97	2,108	199	796	186	0
	Taiwan	98	0	0	242	2,782	7	6	39	1	0	0	0
1974	Japan	4,067	7	1,908	15,621	79,271	466	122	2,581	255	397	350	0
	Taiwan	283	0	66	417	8,892	12	0	127	8	31	0	0
1975	Japan	2,995	5	1,249	9,429	50,041	374	33	1,798	161	128	58	0
	Taiwan	94	0	3	229	1,788	15	0	4	0	0	0	0
1976	Japan	3,441	0	753	12,270	61,146	513	117	1,195	195	357	44	0
1977	Japan	1,542	1	255	9,105	25,202	196	14	584	44	92	25	0

Table 3.10.1(b) : Estimated pole-and-line catches by the Japanese fleet within Palau waters, 1972-1978. Catches in tonnes. (Source: Skipjack Programme, 1980).

Year	Boat days	S/jack	Alba.	Y/fin	B/fin	B/eye	Frig. tuna	Other
1972	396	1,446	0	16	0	4	0	5
1973	982	5,542	0	89	0	8	0	16
1974	599	3,255	7	9	50	2	0	1
1975	216	768	0	51	0	7	0	4
1976	654	1,849	0	13	0	0	0	4
1977	341	1,351	0	10	0	0	0	6
1978	308	1,356	1	20	0	1	0	10

Perron *et al*. (1983) recorded the following tuna species purchases by PFFA for the 1976-1981 period:

Species	Item	1976	1977	1978	1979	1980	1981
Katsuo	Wt (lbs)	1,585	25,770	70,666	133,771	24,280	4,320
	Value ($)	253	3,966	11,014	26,535	4,447	433
Karengab	Wt (lbs)	75				1304	287
	Value ($)	26				569	154
Tekuu	Wt (lbs)	4,235	3,447	13,556	5,605	6,588	7,709
	Value ($)	1061	457	3,797	1,205	2,962	4,360
Katsuo-soda	Wt (lbs)		6,431	3,290	7,072	6,654	1,660
	Value ($)		546	305	786	1,088	184

At the request of the Division of Marine Resources, Palau, a project was conducted by SPC from November, 1991 to October, 1992 to assess tuna vertical dropline in the Republic. The trials were unsuccessful for catching the target species, *T. albacares* and *T. obesus* (Watt, 1992).

Basic production figures are available for foreign access fisheries. Data for domestic joint venture companies and the one private pole-and-line vessel are incomplete, primarily because neither DMR or PMA have the technical staff to collect and analyse data available, and lack of reliable data supplied by these companies.

The total annual landings by the Japanese longliners between 1985 and 1990 in Palau's EEZ are presented in Table 3.10.2. The catches were dominated by yellowfin and bigeye.

Table 3.10.2: Total landings (mt) by Japanese longliners operating under foreign access arrangements, 1985-1990.

Year	Alba-core	Bigeye	Yellow-fin	Bluefin	Strp marl	Blue marl	Black marl	Sword-fish	Sailfish	Others	Total
1985	1.67	270.02	559.09		2.53	32.66	3.94	17.6	0.10	57.43	945.04
1986	0.69	54.84	92.49		1.37	4.33	0.84	2.71	0.08	0.00	157.35
1987	0.05	27.31	25.94		0.04	0.77	0.16	0.73	0.06	0.00	55.06
1988	5.39	19.82	46.96		0.04	1.81	0.09	0.68	0.00	0.03	74.82
1989	5.24	772.86	547.89		1.00	41.70	2.38	13.22	0.25	1.70	1,386.24
1990	1.16	580.49	660.90		0.30	31.00	2.57	17.66	0.23	2.44	1,296.75

Fishery parameters for Japanese access longliners for 1985-1990 period in Palau's waters are as follows:

Year	No. vessels	Logsheet days	EEZ days	Fishing days
1985	51	1,450	1,450	1,220
1986	20	291	291	230
1987	4	98	98	84
1988	8	145	145	115
1989	54	1,879	1,879	1,524
1990	47	1,609	1,609	1,308

Annual longline catches in Palau's Exclusive Economic Zone for the 1990-1993 year period are presented in Table 3.10.3, by flag. The combined catches for the period indicated that bigeye and

yellowfin consistently dominated the landings. Specieswise, bigeye catches predominate although yellowfin catches are very close.

Table 3.10.3: Longline catches in Palau waters, by flag. Figures are in kg. (Source: FFA database).

Flag	Logsht. Days	Albcore	Yellowfin	Bigeye	Bluefin	Stripe marlin	Black marlin	Blue marlin	Sword-fish	Sailfish	Shark	Other
1990												
China	1,540	3,267	90,054	162,816	540	0	70	0	15,576	29,941	23,007	5,612
Japan	2,013	6,177	749,952	747,085	0	534	3,222	34,032	20,760	226	0	3,439
Taiwan	5,143	3,800	331,941	309,634	1,385	1,726	35,372	4,612	38,214	22,347	73,759	60
Total	**8,696**	**13,244**	**1,171,947**	**1,219,535**	**1,925**	**2,260**	**38,664**	**38,644**	**74,550**	**52,514**	**96,766**	**9,111**
1991												
China	3,481	0	330,439	367,963	562	0	0	0	36,378	62,090	21,124	39,498
Japan	1,169	580	341,660	492,031	0	1,156	2,642	22,375	10,382	435	0	1,877
Taiwan	1,708	0	149,246	165,661	0	185	579	142	179	614	18,108	13,719
US	7	0	525	250	0	0	0	0	0	0	0	0
TOTAL	**6,365**	**580**	**821,870**	**1,025,905**	**562**	**1,341**	**3,221**	**22,517**	**46,939**	**63,139**	**39,232**	**55,094**
1992												
China	6,942	0	851,157	916,982	0	0	11,515	931	13,834	8,941	11,036	35,245
FSM	6	0	250	360	0	0	0	0	0	0	0	0
Japan	780	300	144,418	187,828	160	200	463	6,259	1,883	0	0	62
Taiwan	3,103	1,370	379,219	524,331	440	259	2,536	9,431	2,786	187	3,259	10,913
TOTAL	**10,831**	**1,670**	**1,375,044**	**1,629,501**	**600**	**459**	**14,514**	**16,621**	**18,503**	**9,128**	**14,295**	**46,220**
1993												
China	2,956	110	133,878	218,207	60	427	16,653	1,911	16,240	1,808	9,572	3,272
Japan	61	0	12,119	21,280	150	0	0	1,795	209	0	0	0
Taiwan	216	488	291,851	322,121	827	4,031	6,595	40,239	21,207	3,754	46,177	615
TOTAL	**3,233**	**598**	**437,848**	**561,608**	**1,037**	**4,458**	**23,248**	**43,945**	**37,656**	**5,562**	**55,749**	**3,887**

Table 3.10.4 presents total annual catches made in Palau's EEZ for the 1985-1993 year period by the Japanese purse-seiners together with fishery parameters.

Table 3.10.4(a): Total landings (mt) by Japanese purse-seiners operating under foreign access arrangements, 1985-1990.

Year	Skipjack	Yellowfin	Bigeye	Total	No. vessels	Logsheet days	EEZ days	Fishing days
1985	5,777.00	3,136.00	42.00	8,955.00	27		277	277
1986	1,402.00	428.00	11.00	1,841.00	14		78	78
1987	1,985.00	979.00	0.00	2,964.00	17		161	161
1988	3,247.00	809.00	9.00	4,065.00	14		141	141
1989	10,204.00	3,104.00	50.00	13,358.00	28		600	600
1990	746.00	1,058.00	6.00	1,810.00	12		75	75

Table 3.10.5 presents monthly purse seine catches in Palau waters by various fleets for the 1989-1993 year period. With the exception of 1989, catches seem to indicate that purse seine operations concentrate in Palau waters during the first half of the year. In 1989, skipjack made up about two-thirds of the catch with yellowfin making up one-third. Bigeye made up a small portion of the total annual catches. However, catches in 1990 was made up mainly of yellowfin. In 1991, skipjack again dominated purse seine catches, making up about three-fifths of the total. Not much purse seine fishing operations were recorded in 1992 and 1993. However, the 1992 catch was dominated by yellowfin making up more than 50 per cent of the toatl catch.

Table 3.10.5 : Monthly purse-seine catches in Palau waters. Catches in mt. (Source: FFA database). Blank spaces do not mean absence of fishing boats.

Year/ species	Flag	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1989														
Skipjack	Japan	413.0	156.0	1,326.0	3,364.0	3,916.0	581.0	235.0	2.0	189.0	20.0	17.0		10,219.0
	USA						258.5			342.0				600.5
Total		**413.0**	**156.0**	**1,326.0**	**3,364.0**	**3,916.0**	**839.5**	**235.0**	**2.0**	**531.0**	**20.0**	**17.0**	**0.0**	**10,819.5**
Yellowfin	Japan	274.0	32.0	206.0	612.0	1,041.0	269.0	247.0	30.0	331.0	5.0	48.0		3,095.0
	USA						47.2			977.3				1,024.5
Total		**274.0**	**32.0**	**206.0**	**612.0**	**1,041.0**	**316.2**	**247.0**	**30.0**	**1,308.3**	**5.0**	**48.0**	**0.0**	**4,119.5**
Bigeye	Japan	**0.0**	**0.0**	**1.0**	**10.0**	**19.0**	**10.0**	**7.0**	**3.0**	**0.0**	**0.0**	**0.0**		**50.0**
1990														
Skipjack	Japan	68.0	334.0	14.0	120.0	55.0	155.0							746.0
	Taiwan	0.0		6.0						15.0				21.0
Total		**68.0**	**334.0**	**20.0**	**120.0**	**55.0**	**155.0**			**15.0**				**767.0**
Yellowfin	Japan	7.0	385.0	6.0	455.0	165.0	60.0							1,078.0
	Taiwan			2.0										2.0
Total		**7.0**	**385.0**	**8.0**	**455.0**	**165.0**	**60.0**							**1,080.0**
Bigeye	**Japan**	**0.0**	**6.0**	**0.0**	**0.0**	**0.0**	**0.0**							**6.0**
1991														
Skipjack	Japan				3,639.0	2,056.0	854.0	55.0						6,604.0
	Korea					20.0								20.0
	Taiwan					28.0	27.0							55.0
	USA					8,678.5	170.7							8,849.2
Total					**3,639.0**	**10,782.5**	**1,051.7**	**55.0**						**15,528.2**
Yellowfin	Japan				3,909.0	2,492.0	156.0	25.0						6,582.0
	Taiwan				10.0	6.0	5.0							21.0
	USA				0.0	3,684.9	157.0							3,841.9
Total					**3,919.0**	**6,182.9**	**318.0**	**25.0**						**10,444.9**
Bigeye	Japan				5.0	2.0								7.0
	USA				0.0	13.6								13.6
Total					**5.0**	**15.6**		**0.00**						**20.6**
1992														
Skipjack	Japan	1,293.0	40.0	53.0										1,386.0
	Taiwan	287.0	61.0	6.0										354.0
Total		**1,580.0**	**101.0**	**59.0**										**1,740.0**
Yellowfin	Japan	2,280.0	195.0	687.0		0.0								3,162.0
	Taiwan	28.0	0.0	4.0		54.0								86.0
Total		**2,308.0**	**195.0**	**691.0**		**54.0**								**3,248.0**
Other	Japan	**2.0**	**0.0**	**0.0**		**0.0**								**2.0**
1993														
Skipjack	Japan					**194.0**	**58.0**							**252.0**
Yellowfin	Japan					**36.0**	**12.0**							**48.0**

Available data on the landings for PITI for 1987-1992 are presented in Table 3.10.5(a) and for PMIC for 1989-1992 are presented in Table 3.10.5(b).

Table 3.10.5(a): Total landings by PITI longliners, 1987-1990. Value in mt.

Year	BE	YF	BUM	BLM	BBS	SWF	SLF	SHK	OTH	Total
1987	99.60	39.40	2.50	2.50	0.00	15.00	0.50	16.00	0.00	175.50
1988	590.60	659.70	5.70	19.10	0.00	9.70	0.00	0.00	0.00	1,284.80
1989	48.50	42.00	0.00	1.50	0.00	2.30	2.30	27.00	0.00	123.60
1990*	1,671.00	65.70	0.00	0.00	23.10	18.40	0.00	0.80	0.00	1,779.00
1992**	757.80	723.7	2.50	0.0	0.0	0.4	0.0	0.0	0.0	1,484.4

*1990 data January-June only; ** data represents only those that were exported for sashimi.

Table 3.10.5(b) : Total landings by PMIC longliners, 1989-1990. Value in mt.

Year	No. vessels	No. trips	Unit	BE	YF	Others	Total
1989	5	9	pieces	400	307	735	1,442
			mt	14.29	10.92	25.11	50.32
1990*	18	3	pieces	1,034	2,510	1,830	5,374
			mt	42.57	86.80	76.25	205.62
1991	n/a						
1992**			pieces	10,251	13,745	44	24,040
			mt	566.68	529.39	3.23	1,099.2

Kunioyoshi Fishing Co. landed about 4 mt bigeye tuna and 5 mt yellowfin tuna in the 1993-94 licensing period.

Williams (1991) estimates production by locally-based longliners at around 3,000 mt per year. PMIC and PITI operate vessels from Taiwan and mainland China, mostly in the 25-49 GRT category. Yellowfin and bigeye contribute over 95 per cent of tuna air freighted to Japan, with billfish making up less than 4 per cent of the total. In 1990, Williams (1991) estimated that around 2,500 mt of fish was trans-shipped on Palau and airfreighted fresh to Japan for sale on the sashimi market. Trans-shipments for air freighting in the first half of 1991 was approximately 1,400-1,500 mt. Reject tuna and lesser species are frozen and stockpiled in Palau prior to shipment to Taiwan where it is canned, but amounts utilised in this way are not accurately known; a realistic figure would appear to be 0.5-1.0 mt per vessel departure.

Export of tuna in 1990 (Jan-Nov, excluding Sept) as recorded on Continental Air Micronesia manifests totaled to 1,894,008 lbs (818,630 kg) in 182 shipments (Kitalong and Oiterong, March 1991). Since this figure included packaging material, which was estimated to be 9 per cent, the actual tuna weight exported would be 1,723,547 lbs or 744,953 kg (~745 mt). Most of the tuna exported during the year was to Japan with some to Los Angeles. Tuna exports via Continental Air Micronesia air freight cargo during 1991 and 1992 are recorded in Table 3.10.6. Those exported together with other foodstuff are mostly to relatives. DMR (1992 Annual Report) estimated tuna export to Japan for sashimi via air freight cargo to be 626,174 lbs and 773,629 lbs in 1991 and 1992 respectively. Since these figures include 9 per cent packaging, then tuna actual volumes would be 569818 lbs (~259,008 kg) and 704,002 lbs (~320,000 kg). [Note: “count” is the number of shipments and “weight” is in lbs and includes packaging]

Table 3.10.6: Exports of tuna in 1991 and 1992 as recorded on Continental Air Micronesia manifests. Weights are in lbs and include packaging (9 per cent). (Source: DMR Annual Report 1992).

	1991		1992	
Tuna Category	Count	Weight	Count	Weight
Tuna	0	0	620	134,590
Tuna (fresh fillet)	55	3,203	0	0
Tuna (fresh)	2,769	615,252	3,733	872,572
Tuna (soda fresh)	0	0	8	929
Tuna (frozen)	40	7,511	71	8,011
Tuna (yellowfin frozen)	1	90	0	0
Tuna (soda frozen)	0	0	11	2,566
Tuna (fresh)/Other	0	0	43	4,004
Tuna/Bats	1	23	0	0
Tuna/Other	0	0	9	1,222
Tuna (frozen)/Other	0	0	8	1,390
Tuna (soda)/Other	0	0	2	377
Tuna (fresh)/Crab/Other	1	115	0	0
Tuna/Bats/Other	0	0	11	626
Tuna/Clam/Trochus meat/bats	0	0	7	1,312

Tables 3.10.7(a) and (b) present a summary of export data for PITI and PMIC. Information on shipments

of other low grade tuna is not available at this time. Tuna export for sashimi were 1,500 mt in 1990. Williams (1991) estimates the level of longline production from PITI and PMIC to be around 3,000 mt per year, worth around US$25 million once trans-shipped to Japan. Table 3.10.7(b) shows that 3,000 mt of sashimi fish (mostly tuna) were exported in 1991 and 3,400 mt in 1992 by the two companies. Figures for 1993 were not available yet.

Table 3.10.7(a): Tuna exports to Japanese sashimi market by PITI and PMIC, 1990. Value in mt.

Month	PITI	PMIC	Total
January	15.311		15.31
February	20.400		20.40
March	23.449		23.45
April	80.286	11.615	91.90
May	186.413	46.852	233.27
June	399.912	38.087	438.00
July	323.586	79.482	403.07
August	177.260		177.26
September			226.00
October			89.90
November			71.60
December			26.20
Total			**1816.36**

Table 3.10.7(b): Export of fish for sashimi for the 1991-1993 period. Figures are in mt. (Source: Maritime Authority data).

	Bigeye Tuna		**Yellowfin Tuna**		**Blue Marlin**		**Swordfish**		**Bluefin Tuna**		
	PITI	**PMIC**	**PITI**	**PMIC**	**PITI**	**PMCI**	**PITI**	**PMCI**	**PITI**	**PMCI**	**Total**
1991											
Jan	12.97	1.04	10.79	0.16	0.00	0.00	0.00	0.00	0.00	0.00	**24.96**
Feb	0.00	1.06	0.00	3.74	0.00	0.00	0.00	0.00	0.00	0.00	**4.80**
Mar	1.17	1.78	21.23	17.69	0.00	0.32	0.00	0.00	0.00	0.00	**42.19**
Apr	46.93	44.85	110.16	45.74	3.22	3.28	0.12	0.00	0.00	0.00	**254.30**
May	688.17	80.34	195.47	103.48	8.89	2.49	0.52	0.00	0.00	0.00	**1,079.36**
Jun	74.41	10.96	60.33	16.29	1.53	0.45	??	0.00	??	0.00	**163.97**
Jul	139.38	27.30	195.30	18.00	1.63	0.12	0.57	0.58	2.65	0.59	**386.12**
Aug	94.22	30.62	106.19	42.94	0.42	1.53	0.00	0.00	0.00	0.00	**275.92**
Sep	160.73	18.44	134.01	12.21	0.19	0.00	0.00	0.00	0.00	0.00	**325.58**
Oct	62.06	9.88	58.64	25.42	0.00	2.78	0.00	0.00	0.00	0.00	**158.78**
Nov	43.50	22.68	38.25	12.10	0.00	0.10	0.00	0.00	0.00	0.00	**116.63**
Dec	51.16		45.00		0.00		0.00		0.00		**96.16**
Total	**1374.7**	**248.95**	**975.37**	**297.77**	**15.88**	**11.07**	**1.21**	**0.58**	**2.65**	**0.59**	**2,928.77**
1992											
Jan	**4.68**	**3.85**	**5.54**	**5.51**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**19.58**
Feb	**24.92**	**5.37**	**3.61**	**2.32**	**0.16**	**0.28**	**0.10**	**0.00**	**0.00**	**0.00**	**36.76**
Mar	**23.00**	**5.04**	**6.43**	**2.62**	**0.21**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**37.3**
Apr	**26.82**	**25.17**	**16.32**	**20.26**	**0.00**	**0.54**	**0.00**	**0.00**	**0.00**	**0.00**	**89.11**
May	**71.30**	**76.00**	**69.71**	**50.34**	**0.80**	**1.12**	**0.00**	**0.22**	**0.00**	**0.00**	**269.49**
Jun	**95.73**	**88.90**	**105.81**	**69.41**	**0.00**	**0.51**	**0.00**	**0.00**	**0.00**	**0.00**	**360.36**
Jul	**87.10**	**81.55**	**35.00**	**67.03**	**0.40**	**0.48**	**0.00**	**0.00**	**0.00**	**0.00**	**271.56**
Aug	**51.14**	**112.35**	**51.14**	**96.21**	**0.00**	**0.46**	**0.00**	**0.00**	**0.00**	**0.00**	**311.30**
Sep	**151.99**	**161.62**	**187.40**	**157.35**	**0.28**	**0.59**	**0.29**	**0.00**	**0.00**	**0.00**	**659.52**
Oct	**119.07**	**165.08**	**136.81**	**188.76**	**0.00**	**0.26**	**0.00**	**0.00**	**0.00**	**0.00**	**609.98**
Nov	**93.80**	**220.08**	**89.60**	**199.57**	**0.40**	**0.47**	**0.00**	**0.00**	**0.00**	**0.00**	**603.92**
Dec	**8.26**	**64.75**	**16.29**	**60.01**	**0.25**	**0.34**	**0.00**	**0.00**	**0.00**	**0.00**	**149.9**
Total	**757.81**	**1,009.76**	**723.66**	**919.39**	**2.50**	**5.05**	**0.39**	**0.22**	**0.00**	**0.00**	**3,418.78**

For the domestic commercial markets, Masanori Kuniyoshi's local pole-and-line vessel landed the following tuna in 1990 (weights in lbs) of which 13 per cent was sold to PFFA (DMR Annual Report

for 1990):

Tuna species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
Soda	1,500	1,600	1,700	2,700	1,300	3,000	600	400	2,000	7,200	5,000	1,000	**28,000**
Tekuu		0	0	0	0	0	0	0	0	2,000	2,500	1,000	**5,500**
Katsuo		3,900	4,800	15,200	13,100	16,200	22,500	21,200	15,100	12,100	7,500	18,00	**131,618**
Total	**1,500**	**5,500**	**6,500**	**17,900**	**14,400**	**19,200**	**23,100**	**21,600**	**17,100**	**21,300**	**15,000**	**2,018**	**165,118**

Tuna purchases at the domestic market, PFFA, are presented in Table 3.10.8. No tuna purchases were shown in fish purchase records for PMCI and Oh's in 1993. The "tuna" category in the 1993 landing is probably all skipjack.

Table 3.10.8:Tuna purchases in the domestic commerial markets (PFFA, PMCI and Oh;s) during the 1991-1993 period. Figures are in lbs. (Source: DMR Annual Reports for 1990, 1991 and 1992 and DMR database).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Total**
1991													
Y/fin	2,092	671	647	3,469	30	207	1,133	2,344	2,955	1,906	1,283		**16,737**
Soda	500	207	1,206	119				2,412	1,552	46	1,972	2,666	**10,680**
Katsuo		335		612	3,319	1,047	2,585	493	493				**8,883**
Total	**2,592**	**1,213**	**1,853**	**4,200**	**3,349**	**1,254**	**3,718**	**5,249**	**5,000**	**1,952**	**3,255**	**2,666**	**36,300**
1992													
Y/fin	1,266							539			80		**1,884**
Soda			200		2,261			1,319				1,469	**5,249**
Kerengab	35		768					81					**884**
Katsuo	4,417	447	3,821	1,208	928	4,241	2,682	2,524	547		2,310	35	**23,160**
Total													**31,177**
1993													
Soda (Value)													**626 (313)**
Y/fin (Value)			87		175					299.2	884.0	43.0	**1,488 (1,396)**
Tuna (Value)	208	1,104	125		47					1,108.8			**2,593 (1,659)**
Total Wt Value													**4,707 3,367**

The 1993 tuna landing for the first nine months (January-September) at PFFA by state is as follows:

Tuna	State	Weight (lbs)	Value ($)
Yellowfin	Peleliu	87	44
	Koror	175	126
Sub-total		262	170
Tuna	Koror	1,359	507
	Peleliu	125	44
Sub-total		1,484	551

3.10.3 Stocks Status

Tuna Programme (1984) provides details of the only stock assessment carried out so far of the potential sustainable yield of Palau's skipjack tuna resources. Surveys conducted in October 1978 and August 1980 indicated a throughput of 14,000 mt/month. The general conclusion was formed that Palau has large skipjack resources that constitute the single most important renewable resource in the country. Stock assessments are lacking for all other species, but indications of catches by existing commercial operations is that they too are substantial. Based on returns from October 1978 tag releases, it was estimated that skipjack fom Palau have contributed about 9 per cent to throughput in FSM and about 2

per cent to throughput in Marshall Islands. Tagged skipjack released in Palau were captured in Philippines, Indonesia, PNG, Solomon Islands, Northern Marianas, FSM, Marshall Islands and Kiribati. From interaction analysis,Tuna Programme (1984) suggested that migrants from the Palau area contributed most recruits to fisheries in FSM and Marshall Islands. It was also suggested that purse-seiners operating in PNG waters north of Bismarck Sea, southern waters of FSM, and in international waters between these countries could be harvesting a large fraction of the skipjack migrants from Palau.

Due to their migratory behaviour beyond any country's EEZ, stocks of tunas are always considered on a regional basis rather than in a single EEZ. As such, catch per unit effort (CPUE) on a local level may not be reflective of the status of the tuna resources and may be useful only in assessing economic viability of a particular fishery type (eg. pole-and-line) in a local situation.

On the status of tuna stocks in the SPC Area, Hampton (1993) provides the following conclusions concerning those in the western Pacific (west of 150° W):

Yellowfin tuna - catches have doubled in the past decade with recent annual level being of the order of 370,000 mt. However, CPUE in the purse seine fishery, which is responsible for half of the total catch, has not declined. Longline CPUE has shown a declining trend since the late 1970s, when CPUE was at all time high, but the current level of CPUE is about the same as it was in the mid-1970s. Analysis of tagging results indicate that the impact of fishing on the yellowfin stock is mild currently and that using a conservative criteria to define "maximum safe" catches, further increases in annual catch to 600,000-800,000 mt could be accommodated.

Skipjack tuna - even though skipjack catches has trebled in the last decade, with recent catches being of the order of 1 million mt, CPUE by purse seiners and pole-and-line remains high and has shown a tendency to increase since the early 1980s. There are no currently known indicators that would suggest the stock as being heavily exploited. Recent tagging experiments suggests that the impact of fishing remains modest despite the increase in catch over the past decade and that maximum safe skipjack harvest of the order of 1.5-2.0 million mt could be sustained.

Bigeye - the current levels of catch, up to 150,000 mt by longline and 60,000 mt by surface fisheries, are sustainable as indicated by the stability of the longline CPUE time series and related abundance indices. However analysis of one age-structure indicates that this level represents moderate to high exploitation of age classes vulnerable to longline. Tagging results of surface fishery catch suggest that the current average exploitation rate of juvenile bigeye by the surface fisheries is no higher than those of yellowfin and skipjack which is believed to be modest.

Albacore - longline CPUE for the South Pacific albacore is high relative to CPUE in tropical tuna longline fisheries. However the longline CPUE time series has been fairly stable although recent levels have been the lowest on record. In the troll fishery, time series CPUE, although short, has been generally declining since the start of the fishery in the mid-1980s. Preliminary results from assessments using age-structured models, as well as tagging results, suggest that the surface fishery exploitation rates are low. It is also possible that higher catches of juvenile albacore could be sustainable. This however requires confirmation.

3.10.4 Management

As is obvious from the distribution and structure of tuna stocks in the Pacific region, management of these resources requires a regional approach. Management can be in the form of prohibition of certain fishing techniques employed, such as drift net, and limiting the number of fishing vessels in a particular fishery within a defined area. However the level of exploitation, especially that of skipjack, currently seems to be sustainable with some allowances for increase. At present the existing control

of fishing for tunas within the region is geared towards maximizing benefits to the South Pacific countries from the utilization of the tuna resources by distant water fishing nations (DWFN) fishing in their EEZ's through bi-lateral and multi-lateral agreements. The SPC Tuna and Billfish Assessment Programme is geared towards obtaining sufficient statistical and biological information on which to base management of the South Pacific tuna fisheries.

Current legislation/policy regarding exploitation: Controls for the off-shore tuna fishery, such as number of vessels permitted, gear restrictions, catch quotas, etc., are presumably part of the individual access arrangements with the foreign fishing interests active in the fishery. Three companies have access agreements: 1) Palau Marine Industries Corp. (PMIC) has an access agreement for maximum of 120 vessels, but only 93 were active in 1993; 2) Palau International Traders Inc. (PITI) has an access agreement for a maximum of 250 longliners but only 145 were active in 1993; 3) Kuniyoshi Fishing Company (KFC) has an agreement for a maximum of 70 vessels with only 11 in operation in 1993, (Economic Development Plan, Vol. 1, 1994). The Palau Maritime Authority is mandated under Title 27 of the PNC to:

⇒ develop and manage offshore fisheries in the Extended and Exclusive Economic Zone;
⇒ adopt regulations for the conservation, management and exploitation of all living resources of the Extended and Exclusive Economic Zone;
⇒ negotiate and conclude foreign fishing agreements;
⇒ issue foreign fishing permits.

Recommended legislation/policy regarding exploitation: Informal government policy is to:

* encourage on-shore infrastructure development to service the tuna fleet;
* maximisation of economic benefits through access fees and associated financial returns;
* increased employment opportunities for Palauans in the tuna industry;
* diversification of fishing effort from inshore to offshore activities.

Williams (1991) suggests that the two domestic tuna companies could produce around 5,000 mt per year with their existing shore facilities, and suggests separate assessment to determine whether tuna stocks could support such a level of effort. Diplock (1993) noted that PMA has not estimated the total allowable level of foreign fishing defined under PNC 164 as “that portion of the optimum yield of such fishery which will not be harvested by vessels of the Republic”. And without a knowledge of the state of the tuna stocks it is impossible to determine the optimum effort level to be applied or how this should be achieved. With the growing development in this area, research is necessary to define parameters and extent to be used to manage the tuna resource in a sustainable manner.

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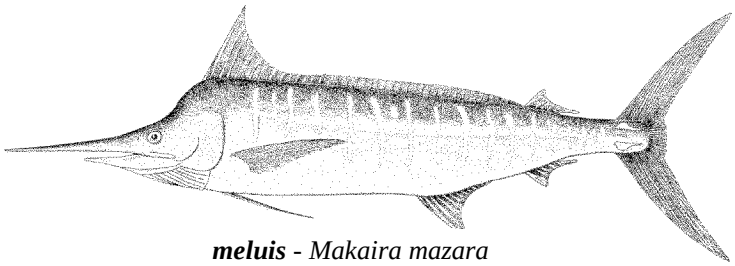
3.11 Other oceanic pelagic fishes

3.11.1 The Resource



meluis - *Makaira mazara*

Species present: Species included in this profile are those which are oceanic and pelagic in nature, excluding tuna species. The commercial tuna fleets also take considerable quantities of billfish, such as *Makaira mazara* (blue marlin - ***meluis***), *Tetrapterus audax* (striped marlin), *Makaira indica* (black marlin), *Xiphias gladius* (swordfish), *Istiophorus platypterus* (sail fish - ***tekrar***) and *Tetrapterus angustirostris* (shortbill spearfish). According to Perron *et al.* (1983) and data collected from commercial markets, other important oceanic pelagic species taken by artisanal and subsistence fishermen in Palau include, *Coryphaena hippurus* (mahi mahi or dolphin-fish - ***ersuuch***), *Elegatis bipinnulatus* (rainbow runner - ***desui***), *Scomberomorus commerson* (narrow-barred king mackerel - ***ngelngal***) and *Acanthocybium solandri* (wahoo - ***keskas***).

Distribution: These species are normally distributed throughout the oceans in varying abundance, determined mostly by food availability, but they are documented as being associated with Fish Aggregating Devices (FADs).

Geographical distributions of the billfish species are given in Nakamura (1985). Generally, they are primarily oceanic and epipelagic, inhabiting tropical and temperate waters, and seasonally, also the cold waters of all oceans. They are usually confined to the water layers above the thermocline but some may occur at greater depths.

These species are widely distributed throughout the Palau islands, and form an important part of the catch taken by trolling. Habitat preference appears to be depths less than 100 m from the continental (or outer reef) slope inshore to shallow coastal waters, and water temperatures warmer than 25°C. Adults are commonly associated with coral reefs, shoals and current interfaces. Wahoo and dolphinfish tend to be more oceanic and only move close to the reef when favourable conditions prevail. Scads and juvenile yellowfin and skipjack are often associated with coral bommies.

Biology and ecology: Smith (1992) notes that all of these fish species are predators, mostly on fish and squid. The larger coastal pelagics are usually opportunistic second level predators. Spawning is seasonal in many species, the timing varying between areas throughout the region (McPherson, 1988). Johannes (1981) considered that the double-lined mackerel, *Grammatorcynus bicarinatus*, spawns during full moon periods in Palau, over an eight month period. The biology of the coastal pelagic species in Palau has not been studied, but McPherson (1988) provides and overview for other areas in the Pacific and Lewis *et al.* (1983) provides data on pelagics studied in Fiji.

Some biological information for the billfishes is given Nakamura (1985). Sexes are separate and they are active and voracious predators but are occasionally preyed on by large oceanic fishes such as tunas, wahoo and dolphinfish particularly during their younger stages. The young are sometimes also taken by adult billfishes. Smith (cited above) also notes that billfishes are solitary while other species tend to form small to medium sized schools. Migrations associated with spawning are known for billfish and dolphinfish.

3.11.2 The Fishery

Utilization: Palauan fishermen are traditionally reef fishers, but pelagic species are taken by artisanal fishermen by trolling and incidentally to reef fishing. These fishes are consumed as fresh fish, with tuna used mostly to supply the high demand for sashimi in local restaurants. Thus oceanic pelagic species are important in the subsistence and artisanal fisheries with some species playing an important component

in the export market for sashimi.

In-house surveys conducted by DMR in 1990 and 1991 on catch per unit effort for the different methods used are as follows (Source: DMR Annual Reports for 1990 and 1991):

Method	# Trips	Species caught	CPUE
1990			
Trolling	5	ngelngal, wahoo, aii,	27.7 lbs/line/hr
	10	tuna,eropk	4.1 pcs/line/hr
Trolling	13		4.4 lbs/line/hr
2-day derby			
Speargun	7	ngyaoch, udech, mellemau,	16.3 lbs/gun/hr
(night)		keremlal, meyas, erangel	
Handline	6	keremlal, temekai, kedesau	16.1/lbs/line/hr
	5	melangmud, tiau	3.9 pcs/line/hr
1991			
Trolling	7	ngelngal, wahoo, aii	8.1 lbs/line/hr
Handline	7	keremlal, temekai, kedesau, melangmud, tiau	6.2 lbs/line/hr
Speargun (night)	7	ngyaoch, udech, mellemau, keremlal, meyas, erangel	21.0 lbs/gun/hr

Rochers and Matthews (1992) reported that the most important fish species to the commercial fishery in Anguar include ***desui*** (rainbow runner), ***keskas*** (wahoo), ***keremlal*** (humpback snapper), ***chudel*** (jobfish), ***sebus*** (deep-water snappers), ***katsuo*** (skipkack tuna), ***tekuu*** (yellowfin tuna) and ***kerengab*** (dogtooth tuna). ***Desui*** and ***keremlal*** are important for use during traditional customs. In Ngarchelong, three species were reported as important. These include, ***meluis*** (broadbill swordfish), ***maml*** (humphead wrasse), and ***chum*** (bluespine unicornfish), all of which are considered of "high status" because of their importance in customary uses or are unusually difficult and exciting to catch (Rochers and Matthews, cited above).

Production and marketing: Most pelagic species are landed at commercial markets in Koror, usually on ice, in round form. Some of the species are landed by industrial operations and form an important component of the exports for the sashimi market in Japan.

Catch statistics derived from published records of Japanese and Taiwanese longliners catches within the estimated EEZs of the South Pacific Commission area between 1962 and 1977 are summarized in Table 3.11.1 for Palau as reported in Skipjack Programme (1981). Catches are in numbers of fish and effort in 1,000 hooks and includes "other species" catches such as billfishes, marlins and sailfishes, which are discussed in this profile. Klawe (1978) converted the numbers of fish to weights but unfortunately, those for Guam, FSM, Northern Marianas and Palau were pooled together.

Table 3.11.1: Longliners catch in Palau waters from 1962 to 1977. Catches are in numbers of fish. (Source: Skipjack Programme, 1981).

Year	Country	Hks/1000	Blue-fin	Alba-core	Bigeye	Yellow fin	**Broad-bill**	**Str. mar**	**Blu. mar**	**Bla. mar**	**Sailfish**	Skip-jack	Small tuna
1962	Japan	2718	2	220	10217	46948	**299**	**185**	**2807**	**270**	**1968**	33	0
1963	Japan	1182	0	1126	4917	23295	**297**	**59**	**715**	**219**	**665**	1	0
1964	Japan	1151	14	749	3466	21007	**177**	**88**	**1443**	**121**	**817**	90	0
1965	Japan	4796	61	12626	13673	74169	**968**	**743**	**3198**	**501**	**2387**	489	0
1966	Japan	2634	23	4516	9502	38492	**416**	**111**	**1923**	**263**	**991**	88	0
1967	Japan	1849	38	532	6733	23425	**348**	**59**	**1031**	**253**	**688**	94	0
	Taiwan	2	0	5	6	39	**0**	**0**	**2**	**1**	**0**	0	0
1968	Japan	2358	21	570	10746	29979	**541**	**64**	**1404**	**270**	**353**	325	0
	Taiwan	17	0	1	124	630	**2**	**0**	**8**	**0**	**0**	0	4
1969	Japan	1258	2	1051	3943	19084	**176**	**43**	**588**	**87**	**161**	111	0
1970	Japan	1099	2	1083	3776	15214	**110**	**11**	**1091**	**77**	**190**	112	0
1971	Japan	934	0	732	3252	14152	**149**	**21**	**646**	**104**	**59**	12	0
	Taiwan	10	0	0	19	113	**0**	**0**	**9**	**1**	**1**	0	0
1972	Japan	855	3	643	4615	8726	**311**	**41**	**664**	**49**	**36**	14	0
	Taiwan	73	0	10	619	1551	**0**	**0**	**8**	**0**	**0**	0	0
1973	Japan	2007	2	1002	7836	37186	**271**	**97**	**2108**	**199**	796	186	0
	Taiwan	98	0	0	242	2782	**7**	**6**	**39**	**1**	0	0	0
1974	Japan	4067	7	1908	15621	79271	**466**	**122**	**2581**	**255**	397	350	0
	Taiwan	283	0	66	417	8892	**12**	**0**	**127**	**8**	31	0	0
1975	Japan	2995	5	1249	9429	50041	**374**	**33**	**1798**	**161**	128	58	0
	Taiwan	94	0	3	229	1788	**15**	**0**	**4**	**0**	0	0	0
1976	Japan	3441	0	753	12270	61146	**513**	**117**	**1195**	**195**	357	44	0

1977	Japan	1542	1	255	9105	25202	**196**	**14**	**584**	**44**	92	25	0

Other oceanic pelagic species recorded by Perron *et al*. (1983) as PFFA purchases during the 1976-1981 period is present inTable 3.11.2. ***Desui*** and ***ersuuch*** dominated landings at this market for species included in this profile, during the six years, with both peaking in 1978. Both species, together with ***ngelngal***, were landed at the market every year.

Table 3.11.2: Commercial purchases of other oceanic pelagic species at PFFA for the 1976-1981 period. (Source: Perron *et al*., 1983).

Species	Item	1976	1977	1978	1979	1980	1981
Meluis	Wt (lbs)	265	211				
	Value ($)	44	56				
Tekrar	Wt (lbs)					214	90
	Value ($)					91	54
Desui	Wt (lbs)	2,432	11,399	27,850	13,477	5,545	2,471
	Value ($)	459	1,901	4,275	2,422	1,374	541
Keskas	Wt (lbs)	120		105	533	1,803	568
	Value ($)	42		37	192	904	261
Ersuuch	Wt (lbs)	2,060	7,383	43,417	37,022	13,168	3,524
	Value ($)	286	791	6,658	5,873	2,810	1,222
Ngelngal	Wt (lbs)	1,540	400	158	1,173	4,640	5,825
	Value ($)	377	110	55	376	2,337	2,557
Adinges	Wt (lbs)	4,168				195	
	Value ($)	917				39	
TOTAL	Wt (lbs)	10,585	19,393	71,530	52,205	25,565	12,478
	Value ($)	2,125	2,858	11,025	8,863	7,555	4,635

Landings of oceanic pelagic fish species by the Japanese longliners operating under foreign access arrangement in Palau's EEZ from 1985 to 1989 are given in Table 3.11.3. The category "others" includes fosh species such as wahoo, barracuda, mahimahi etc. With the exception of 1985, other oceanic pelagic species make up about 5 per cent of the landings by the Japanese longliners during the period.

Table 3.11.3: Total landings (mt) by Japanese longliners operating under foreign access arrangements, 1985-1989.

Year	Alb	B/E	Y/F	**Strp-marl**	**Blue-marl**	**Black-marl**	**Sword-fish**	**Sailfish**	**Others**	Total	**Per cent Other Oceanic Pelagic Species**
1985	1.67	270.02	559.09	**2.53**	**32.66**	**3.94**	**17.6**	**0.1**	**57.43**	945.04	**12.1**
%	0.18	28.57	59.16	0.27	3.46	0.42	1.86	0.01	6.08	100.00	
1986	0.69	54.84	92.49	**1.37**	**4.33**	**0.84**	**2.71**	**0.08**	**0**	157.35	**5.9**
%	0.44	34.85	58.78	0.87	2.75	0.53	1.72	0.05	0.00	100.00	
1987	0.05	27.31	25.94	**0.04**	**0.77**	**0.16**	**0.73**	**0.06**	**0**	55.06	**3.2**
%	0.09	49.60	47.11	0.07	1.40	0.29	1.33	0.11	0.00	100.00	
1988	5.39	19.82	46.96	**0.04**	**1.81**	**0.09**	**0.68**	**0**	**0.03**	74.82	**3.5**
%	7.20	26.49	62.76	0.05	2.42	0.12	0.91	0.00	0.04	100.00	
1989	5.24	772.86	547.89	**1**	**41.7**	**2.38**	**13.22**	**0.25**	**1.7**	1,386.24	**4.3**
%	0.38	55.75	39.52	0.07	3.01	0.17	0.95	0.02	0.12	100.00	

Longline catches in Palau waters during the 1990-1993 year period are given in Table 3.11.4. Fish species discussed in this profile are in bold. Substantial amounts of marlin, swordfish and sailfish are caught by the longliners. The "other" column also constitutes fish species discussed in this profile as it normally comprises of mahimahi, wahoo, barracuda etc. The non-tuna oceanic pelagic species comprise between 3 to 10 per cent of the total annual longline catches. The non-tuna species catches are dominated by swordfish, sailfish, blue marlin and black marlin.

Table 3.11.4: Longline catches in Palau waters, by flag. Figures are in kg. (Source: FFA database).

Flag	Logsht. Days	Albcore	Yellow-fin	Bigeye	Blue-fin	**Stripe marlin**	**Black marlin**	**Blue marlin**	**Sword -fish**	**Sailfish**	**Other**	Shark	Total
1990													
China	1,540	3,267	90,054	162,816	540	**0**	**70**	**0**	**15,576**	**29,941**	**5,612**	23,007	332,423
Japan	2,013	6,177	749,952	747,085	0	**534**	**3,222**	**34,032**	**20,760**	**226**	**3,439**	0	1,567,440
Taiwan	5,143	3,800	331,941	309,634	1,385	**1,726**	**35,372**	**4,612**	**38,214**	**22,347**	**60**	73,759	827,993
Total	8,696	13,244	1,171,947	1,219,535	1,925	**2,260**	**38,664**	**38,644**	**74,550**	**52,514**	**9,111**	96,766	2,727,856
%		0.49	42.96	44.71	0.07	**0.08**	**1.42**	**1.42**	**2.73**	**1.93**	**0.33**	3.55	100.00
1991													
China	3,481	0	330,439	367,963	562	**0**	**0**	**0**	**36,378**	**62,090**	**39,498**	21,124	861,535
Japan	1,169	580	341,660	492,031	0	**1,156**	**2,642**	**22,375**	**10,382**	**435**	**1,877**	0	874,307
Taiwan	1,708	0	149,246	165,661	0	**185**	**579**	**142**	**179**	**614**	**13,719**	18,108	350,141
US	7	0	525	250	0	**0**	**0**	**0**	**0**	**0**	**0**	0	782
Total	6,365	580	821,870	1,025,905	562	**1,341**	**3,221**	**22,517**	**46,939**	**63,139**	**55,094**	39,232	2,086,765
%		0.03	39.38	49.16	0.03	**0.06**	**0.15**	**1.08**	**2.25**	**3.03**	**2.64**	1.88	100.00
1992													
China	6,942	0	851,157	916,982	0	**0**	**11,515**	**931**	**13,834**	**8,941**	**35,245**	11,036	1,856,583
FSM	6	0	250	360	0	**0**	**0**	**0**	**0**	**0**	**0**	0	616
Japan	780	300	144,418	187,828	160	**200**	**463**	**6,259**	**1,883**	**0**	**62**	0	342,353
Taiwan	3,103	1,370	379,219	524,331	440	**259**	**2,536**	**9,431**	**2,786**	**187**	**10,913**	3,259	937,834
Total	10,831	1,670	1,375,044	1,629,501	600	**459**	**14,514**	**16,621**	**18,503**	**9,128**	**46,220**	14,295	3,137,386
%		0.05	43.83	51.94	0.02	**0.01**	**0.46**	**0.53**	**0.59**	**0.29**	**1.47**	0.46	100.00
1993													
China	2,956	110	133,878	218,207	60	**427**	**16,653**	**1,911**	**16,240**	**1,808**	**3,272**	9,572	405,094
Japan	61	0	12,119	21,280	150	**0**	**0**	**1,795**	**209**	**0**	**0**	0	35,614
Taiwan	216	488	291,851	322,121	827	**4,031**	**6,595**	**40,239**	**21,207**	**3,754**	**615**	46,177	738,121
Total	3,233	598	437,848	561,608	1,037	**4,458**	**23,248**	**43,945**	**37,656**	**5,562**	**3,887**	55,749	1,178,829
%		0.05	37.14	47.64	0.09	**0.38**	**1.97**	**3.73**	**3.19**	**0.47**	**0.33**	4.73	100.00

Oceanic pelagic species landed at PFFA from 1990 to 1993 are presented in Table 3.11.5. Rainbow runner, king mackerel and wahoo were recorded as among the 22 most important finfish landed in 1990 at PFFA.

Table 3.11.5: Monthly landings of oceanic pelagic fish species at PFFA from 1990 to 1993. (Source: DMR Annual Reports for 1990, 1991 and 1992, and DMR data).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990													
Desui		388	985	2,695	1,519	403	164	96	81				6,331
Ngelngal		201	451							71		1,001	1,724
Keskas	224	1,493	1,866	195	213	0	0	37	1,110	1,446	416	1,358	8,359
Total	224	2,082	3,302	2,890	1,732	403	164	133	1,191	1,517	416	2,359	16,414
1991													
Keskas	834	2,766	3,776	570	133	42	51		20	1,113	1,446	805	11,558
Ersuuch		56	3,078	4,219	3,001	38	63	666				26	11,147
Ngelngal	372	287	26							1,932	1,325	414	4,356
Meluis			30	111									141
Tekrar		71	67										138
Desui			28		56								84
Total	1,206	3,180	7,005	4,900	3,190	80	114	666	20	3,045	2,771	1245	27,424
1992													
Ersuuch	72	87	472							6			637
Keskas	439	250	1,662	2,592	287	390					439	75	6,573
Ngelngal	299	163	358	1,704		40	82	382	901	1,360	654	362	6,305
Meluis		165	0	0			0	0	0				165
Tekrar			58	0			0	0	0				58
Desui			600	251			61	106	73				1,091
Total	810	665	3,150	4,547	287	430	143	488	974	1,360	1093	437	14,829
1993													
Ersuuch	16	19	147	160	33								375
Ngelngal	266	567	1,151	145	58			22		179.0	133.0	249.0	2,770
Meluis	0		0	0	0					0	1,056.4	0	1,056
Desui	0		81	0	0					0	0	0	81
Keskas	101		185	261	556				403	302.0	1,453.0	895.0	4,156
Total	383	586	1,564	566	647			22	403	481	2,642.4	1144	8,438
PFFA 1993 ($)													
Ersuuch	6	7	51	56	12								131
Ngelngal	266	624	1,266	160	58			28		223.75	166	260	3,050
Meluis	0		0	0	0					0	840	0	840
Desui	0		54	0	0					0	0	0	54

Keskas	108		204	287	556		403	296.75	1,440	895.00	4,189
Total	380	631	1,575	503	626	28	403	5,20.5	2,446	1,155	8,264

Rrsuuch=mahimahi, ***Ngelgal***=king mackerek, ***meluis***=blue marlin, ***desui***=rainbow runner, ***keskas***=wahoo, ***tekrar***=sailfish.

The following oceanic pelagic species were landed at Oh's market during January-May,1993. Only 49 lbs (worth US$49.00) were recorded in the PMCI 1993 records.

Ohs Market

Palauan	Common		Jan	Feb	Mar	Apr
Ngelngal	king mackerel	(lbs)				80
		(US$)				88
Keskas	wahoo	(lbs)	47	178	86	
		(US$)	47	196	108	

The export of fish for sashimi by the two locally based companies, PITI and PMIC, for the 1991-1992 year period is presented in Table 3.11.6, by year, month, and species as recorded in the Maritime Authority database. A little less than 1 per cent (or about 20 mt) of "other oceanic pelagic species" made up the total export by PITI in 1991 while a little over 1 per cent (or about 17 mt) of the PMCI export was made of the same for the same year. The 1992 PITI fish export for sashimi indicated that "other oceanic pelagic species" made up only 0.2 per cent (or about 12 mt) for that year. PMCI data for the same year shows that the same fish category made up about 0.3 per cent (or about 3 mt) of its total export for sashimi. Thus a decrease both in composition and quantity was observed for other oceanic pelagic species for both years at both companies. However, there was a decrease in overall export for PITI from 1991 to 1992 while an increase was observed in the PMCI fish exports for sashimi during the same period.

Table 3.11.6: Fish exported for sashimi by the PITI and PMCI during the 1991-1992 period. (Source: Maritime Authority data). Figures in mt.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot	%
1991	**PITI**														
	Bigeye tuna	12.97	0.00	1.17	46.93	688.17	74.41	139.38	94.22	160.73	62.06	43.50	51.16	1,374.70	58.01
	Yellowfin tuna	10.79	0.00	21.23	110.16	195.47	60.33	195.30	106.19	134.01	58.64	38.25	45.00	975.37	41.16
	Bluefin tuna	0.00	0.00	0.00	0.00	0.00	0.00	2.65	0.00	0.00	0.00	0.00	0.00	2.65	0.11
	Blue marlin	**0.00**	**0.00**	**0.00**	**3.22**	**8.89**	**1.53**	**1.63**	**0.42**	**0.19**	**0.00**	**0.00**	**0.00**	**15.88**	**0.67**
	Swordfish	**0.00**	**0.00**	**0.00**	**0.12**	**0.52**		**0.57**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.21**	**0.05**
														2,369.81	100.00
	PMCI														
	Bigeye tuna	1.04	1.06	1.78	44.85	80.34	10.96	27.30	30.62	18.44	9.88	22.68		248.95	44.54
	Yellowfin tuna	0.16	3.74	17.69	45.74	103.48	16.29	18.00	42.94	12.21	25.42	12.10		297.77	53.27
	Bluefin tuna	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.00	0.00		0.59	0.11
	Blue marlin	**0.00**	**0.00**	**0.32**	**3.28**	**2.49**	**0.45**	**0.12**	**1.53**	**0.00**	**2.78**	**0.10**		**11.07**	**1.98**
	Swordfish	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.59**	**0.00**	**0.00**	**0.00**	**0.00**		**0.59**	**0.11**
														558.97	100.00
1992	**PITI**														
	Bigeye tuna	4.68	24.92	23.00	26.82	71.30	95.73	87.10	51.14	151.99	119.07	93.80	8.26	757.81	51.05
	Yellowfin tuna	5.54	3.61	6.43	16.32	69.71	105.81	35.00	51.14	187.40	136.81	89.60	16.29	723.66	48.75
	Blue marlin	**0.00**	**0.16**	**0.21**	**0.00**	**0.80**	**0.00**	**0.40**	**0.00**	**0.28**	**0.00**	**0.40**	**0.25**	**2.50**	**0.17**
	Swordfish	**0.00**	**0.10**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.29**	**0.00**	**0.00**	**0.00**	**0.39**	**0.03**
														1,484.36	100.00
	PMCI														
	Bigeye tuna	3.85	5.37	5.04	25.17	76.00	88.90	81.55	112.35	161.62	165.08	220.08	64.75	1,009.76	52.20
	Yellowfin tuna	5.51	2.32	2.62	20.26	50.34	69.41	67.03	96.21	157.35	188.76	199.57	60.01	919.39	47.53
	Blue marlin	**0.00**	**0.28**	**0.00**	**0.54**	**1.12**	**0.51**	**0.48**	**0.46**	**0.59**	**0.26**	**0.47**	**0.34**	**5.05**	**0.26**
	Swordfish	**0.00**	**0.00**	**0.00**	**0.00**	**0.22**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.22**	**0.01**
														1,934.42	100.00

BLZ=blue marlin, SWF=swordfish which include all billfish.

The South Pacific Commission conducted a FAD Development and Vertical Dropline Fishing Project in Palau from November, 1991 to October, 1992. Catch details reported were as follows:

No of sets	No. of droplines	No. of hooks	Total catch		Shark catch	kg/set	kg/dropline
12	33	495	755.5	745.0	62.3	22.8	

The project concluded that the vertical longline method for catching the targeted pelagic species *Thunnus albacares* and *Thunnus obesus* proved to be unproductive; only sharks were caught which have no commercial value. Trolling around the FADs was a more productive method but only small

yellowfin tuna and skipjack were caught. Trolling around the FADs during the project yielded 268 yellowfin tuna, 105 skipjack and 4 dolphinfish (Watt, 1992).

3.11.3 Stocks Status

There has been no research conducted in Palau on the status of the oceanic pelagic fish species. However, preliminary indications are that the resource could sustain a considerable increase in fishing pressure, and no major concern is apparent as these are not targeted specifically for any current industrial fishery. Further development of fisheries based on these species, e.g. gamefishing, is unlikely to have any detrimental effect on the stocks. Nevertheless, collection of catch data from such undertakings would be desirable.

3.11.4 Management

Current legislation/policy regarding exploitation: There is no legislation in place which specifically addresses the species included in this profile. Government policy to diversify fishing effort from inshore to offshore species may increase pressure on these species in future.

Recommended legislation/policy regarding exploitation: None is considered necessary at this time.

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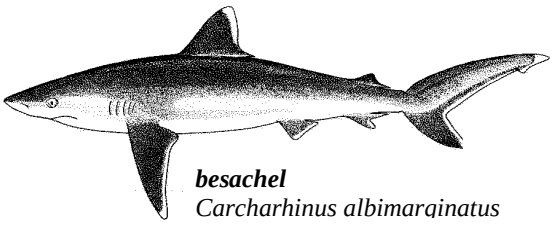
4. CARTILAGINOUS FISHES

4.1 Sharks (*chedeng*) and rays (*rull*)

4.1.1 The Resource



besachel
Carcharhinus albimarginatus

Species present: Shark species reported to have been caught in Palau waters included: *Carcharhinus albimarginatus* (silvertip shark - ***besachel***), *C. amblyrhynchos* (grey reef shark - ***mederart***, ***teongt***), *C. melanopterus* (blacktip reef - ***matukeyoll***), *Galeocerdo cuvier* (tiger shark - ***mochelas***), *Negaprion acutidens* (sicklefin lemon shark - ***metal***), *Triaenodon obesus* (whitetip reef shark - ***ulupscuchl***) (Helfman and Randall, 1973), *Sphyrna* sp. (hammerhead shark - ***ulachlchedeng***), *Rhizoprionodon* sp. (milk shark), and sand shark, *Ginglymostoma ferrugineum = Nebrius ferrugineus* (tawny nurse shark - ***metmut***), and *Stegostoma fasciatum*, Syn. *Stegostoma varium* (zebra shark - ***biall***). Perron *et al*. (1983) also listed *C. spallanzani = C. wheeleri* (blacktail reef shark) and *Tr. apicalis* which is now known as *Tr. obesus*. Dalzell and Preston (1992) reported an unidentified species caught during the deep-water bottomfishing around Palau. Compagno (1984) reported *Hexanchus griseus* (bluntnose sixgill shark), *Echinorhinus cookei* (prickly shark) as present in Palau.

Rays reported in Palau include, *Taeniura melanospilos* (black-blotched stingray - ***rrull***), *Dasyatus kuhlii* (blue spotted or Kuhl's stingray - ***dudek?***) and *D. bennetti* (***rrull***), *Aetobatus narinari* (spotted eagle ray - ***chochaio***), *Manta* sp. (manta rays - ***chouklemedaol***) and *Mobula* sp. (devil ray - ***chouklemedaol***).

Distribution: Smith (1992) notes that sharks occur from the reef and inshore areas through to the open oceans, at all depths. Nichols (1993) notes that "on a global basis, 55 per cent of the chondrichthyians inhabit the continental shelf area from the inter-tidal zone to a depth of 200 m". The same author also adds that the most common sharks in reefs and lagoons belong to the family Carcharhinus (the requiem sharks) including the black-tip reef shark and white-tip shark. Grey reef sharks as well as the larger species, including tiger sharks and hammerhead sharks, are found in deeper waters off coral reefs (Nichols, cited above).

Stingrays occur in all tropical and subtropical seas with most species found in coastal waters, estuaries, off beaches and river mouths, and on flat bottoms on sand or mud (Randall *et al*., 1990). Relatively few species occur in the vicinity of coral reefs. Eagle rays are found worldwide in tropical and warm temperate sea and are usually found inshore near reefs. Manta rays occur in all warm seas and are often seen far out to sea but are also encountered in the vicinity of coral reefs.

In 1993, ***rull*** was reported only 3 times as being purchased at Oh's market. These were from Koror, Airai and Ngatpang.

Biology and ecology: Compagno (1984 (a) and (b) gives some information on habitat, distribution, biology and ecology of the known species of sharks in the world. For reproduction, a variety of modes are utilized but fertilization is internal, with most species bearing their young alive in broods ranging from a few individuals to nearly one hundred (Smith, 1992). Sharks are generally slow growing with the majority of the commercially important species in the South Pacific having a long gestation period and low fecundity (Nichols, 1993). Furthermore, some species display sex and size segregation and females of some species may move inshore to give birth in selected nursery areas (Nichols, cited above).

"Stingrays feed on a variety of sand and mud-dwelling organisms, including crabs, prawns, worms, molluscs and fishes" (Randall *et al*., 1990). They give birth to fully developed young resembling

miniature adults. A few species of eagle rays, like mantas, can leap high into the air from the water. Young manta rays are born alive. Manta rays are among the largest fishes with some growing to a width of nearly 7 m weighing more than 1,300 kg (Randall *et al*., 1990). Manta rays use their cephalic flaps to direct planktonic food items into the mounth and can leap above the water surface.

There is no available information concerning work conducted in Palau on the biology and ecology of any shark or stingray species.

4.1.2 The Fishery

Utilization: As was generally practised in Polynesian culture, shark noosing was a tradition in Palau, which was considered a means of proving oneself to be a "real man". Shark noosing does not exist anymore in Palau. Sharks and rays were also normally caught by hand-thrown spears. Sharks and rays were considered the most prestigious, partly because of the danger involved in capturing them (Rochers and Matthews, 1992). Now spear guns, which consisted of a long shaft with either a single hardwood point or several barbed points clustered together, have replaced the traditional spears. The eagle ray is considered taboo in Palau "as killing of it will place a curse on the fisher".

Of the few landing data reported by Perron *et al*. (1983) from 1976 to 1981, ***chedeng*** and ***rrull*** were two of the commercial marine animals with lowest landings and value at PFFA. No shark were reported in the commercial markets between 1990 and 1993. However, ***rull*** was reported as being sold in the same years but quantity is of no significance. In 1993, the three occasions in which ***rull*** were purchased had different sources, Koror, Airai and Ngatpang.

Oceanic sharks form an incidental by-catch of the longline operations, but only the fins are retained, the carcasses being discarded at sea.

Production and marketing: No data is available on the current utilisation of shark and ray resource on any level in Palau.

A shark fishing survey was carried out by the South Korean Fisheries Research and Development Agency between May 12-21st 1975 around Angaur Island, Ngeremlengui Channel, Ngeremdui Reef and Ngkesol Reef, using baited longlines. The survey resulted in a catch of 136 sharks, mostly hammerheads, milk sharks, white tip reef sharks and sand sharks. Average size ranged from 1-3 m with an average of 1.4 m (DMR unpublished data). However, no commercial fishery targeting on sharks has developed.

Perron *et al*. (1983) recorded the following ***chedeng*** and ***rrull*** landings at PFFA during the 1976-1981 period as recorded with each year's total in Table 4.1.1.

Tabel 4.1.1: ***Rull*** (ray) and ***chedeng*** (shark) purchases recorded at PFFA for the 1976-1981 period. (Source: Perron *et al*., 1983).

		1976	1977	1978	1979	1980	1981
Rrull	Weight (lbs)	0	0	0	0	0	40.00
	Value ($)	0	0	0	0	0	24.00
Chedeng	Weight (lbs)	0	0	35	124	0	181
	Value ($)	0	0	8.75	12.35	0	0.00
Total sharks & rays	Weight (lbs)			35	124		221
	Value ($)			8.75	12.35		(24)
Total Marine Animals Landing Weight (lbs)		225,647.45	317,158.50	298,198.64	476,325.75	452,946.75	217,442.00
Total Marine Animals Landing Value ($)		74,436.04	98,868.16	78,677.75	149,799.26	225,599.29	116,668.88

Shark landings as by-catches of the SPC deep-bottom fishing surveys in Palau waters from 1979 to

1988 are presented in Table 4.1.2. Of the total deep-water fish landing in the northern and central Palau, shark comprised about 8 per cent. During the May 17 - October 20, 1983 fishing expeditions around several states, shark made up 19 per cent of the total deep-water fish landing. About 12 and 8 per cent of the catch were recorded around Koror and northern area respectively. No sharks were caught during deep-water fishing in the southern area.

Table 4.1.2: Shark landings as by-catches during the SPC deep-water fishing trials in Palau. (Source: Dalzell and Preston, 1992).

Fishing trial	No. trips	Reel hours	Total deep-bottom fish landed (kg)	Shark species	Shark landing (Wt)	Shark % wt of Total Landing	Shark landing Nos.	Shark % nos	Ave. weight
Date: 13 Nov 79 - 21 Jan 80.									
Area: Northern & central Belau									
	11	660	2,136	Unidentified	164.0	7.7	8	1.1	20.5
				Total	164.0	7.7	8	1.1	20.5
Date: 17 May - 20 Oct 83									
Area: Ngardmau, Koror, Peleliu, Kayangel, Melekeok, Ngchersar, Ngiwal, Ngaraard, Anguar, Ngcherlong									
	42	1,500	2,136.0	*C. albimarginatus*	767.0	9.0	20	0.8	38.4
				C. amblyrhynchos	77.0	0.9	3	0.1	25.7
				Unidentified	779.0	9.1	5	0.2	155.8
				Total	1,623.0	19.0	28	1.1	58.0
Date: 14 Oct 87 - 27 Apr 88									
Area: Koror									
	13	287	565.8	*C. albimarginatus*	45.0	8.0	1	0.4	45.0
				C. amblyrhynchos	15.0	2.7	1	0.4	15.0
				Unidentified	5.0	0.9	2	0.8	2.5
				Total	65.0	11.5	4	1.6	16.3
Date: 14 Oct 87 - 27 Apr 88									
Area: Southern area									
	3	76	225.3		0	0	0	0	0
Date: 14 Oct 87 - 27 Apr 88									
Area: Northern area									
	7	164	512.9	*C. albimarginatus*	5.0	1.0	1	0.5	5.0
				Unidentified	36.5	7.1	2	1.0	18.3
				Total	41.5	8.1	3	1.5	13.8

Shark landings data available from longline operations in Palau are recorded in Table 4.1.3 for the PITI longliners during the 1987-1990 period, and in Table 4.1.4 for all longliners operating in Palau water for the 1990-1993 year period. A very high shark composition (21.8 per cent or 27 mt) of the total longline catch was recorded in 1989. A high shark catch (16 mt or 9 per cent of the total catch for that year) was also recorded in 1987.

Table 4.1.3: Total landings by PITI longliners, 1987-1990. Value in mt.

Year	Bigeye	Yellow-fin	Blue marlin	Black marlin	Broad-bill	Sword-fish	Sailfish	**Shark**	Other	Total	% Shark
1987	99.60	39.40	2.50	2.50	0.00	15.00	0.50	**16.00**	0.00	175.50	9.12
1988	590.60	659.70	5.70	19.10	0.00	9.70	0.00	**0.00**	0.00	1,284.80	0.00
1989	48.50	42.00	0.00	1.50	0.00	2.30	2.30	**27.00**	0.00	123.60	21.84
1990*	1,671.00	65.70	0.00	0.00	23.10	18.40	0.00	**0.80**	0.00	1,779.00	0.04

*1990 data January-June only; ** data represents only those that were exported for sashimi.

Longline catches in Palau waters during the 1990-1993 period, as presented in Table 4.1.4, indicate that sharks comprise between about 0.5 and 5 per cent of the total landings. In terms of weight, combined shark landings for all longliners range from about 14 mt to 97 mt per year. It is noted that no sharks were recorded in catches of the Japanese longliners in Palau waters from 1990-1993 (this is probably because only fins are taken).

Table 4.1.4: Longline catches in Palau waters, by flag. Figures are in kg. (Source: FFA database).

Year/ Flag	Logsht. Days	Albcore	Yellow-fin	Bigeye	Blue-fin	Stripe marlin	Black marlin	Blue marlin	Sword-fish	Sailfish	Other	**Shark**	Total
1990													
China	1,540	3,267	90,054	162,816	540	0	70	0	15,576	29,941	5,612	**23,007**	332,423
Japan	2,013	6,177	749,952	747,085	0	534	3,222	34,032	20,760	226	3,439	**0**	1,567,440
Taiwan	5,143	3,800	331,941	309,634	1,385	1,726	35,372	4,612	38,214	22,347	60	**73,759**	827,993
Total	8,696	13,244	1,171,947	1,219,535	1,925	2,260	38,664	38,644	74,550	52,514	9,111	**96,766**	2,727,856
%		0.49	42.96	44.71	0.07	0.08	1.42	1.42	2.73	1.93	0.33	**3.55**	100.00
1991													
China	3,481	0	330,439	367,963	562	0	0	0	36,378	62,090	39,498	**21,124**	861,535
Japan	1,169	580	341,660	492,031	0	1,156	2,642	22,375	10,382	435	1,877	**0**	874,307
Taiwan	1,708	0	149,246	165,661	0	185	579	142	179	614	13,719	**18,108**	350,141
US	7	0	525	250	0	0	0	0	0	0	0	**0**	782
Total	6,365	580	821,870	1,025,905	562	1,341	3,221	22,517	46,939	63,139	55,094	**39,232**	2,086,765
%		0.03	39.38	49.16	0.03	0.06	0.15	1.08	2.25	3.03	2.64	**1.88**	100.00
1992													
China	6,942	0	851,157	916,982	0	0	11,515	931	13,834	8,941	35,245	**11,036**	1,856,583
FSM	6	0	250	360	0	0	0	0	0	0	0	**0**	616
Japan	780	300	144,418	187,828	160	200	463	6,259	1,883	0	62	**0**	342,353
Taiwan	3,103	1,370	379,219	524,331	440	259	2,536	9,431	2,786	187	10,913	**3,259**	937,834
Total	10,831	1,670	1,375,044	1,629,501	600	459	14,514	16,621	18,503	9,128	46,220	**14,295**	3,137,386
%		0.05	43.83	51.94	0.02	0.01	0.46	0.53	0.59	0.29	1.47	**0.46**	100.00
1993													
China	2,956	110	133,878	218,207	60	427	16,653	1,911	16,240	1,808	3,272	**9,572**	405,094
Japan	61	0	12,119	21,280	150	0	0	1,795	209	0	0	**0**	35,614
Taiwan	216	488	291,851	322,121	827	4,031	6,595	40,239	21,207	3,754	615	**46,177**	738,121
Total	3,233	598	437,848	561,608	1,037	4,458	23,248	43,945	37,656	5,562	3,887	**55,749**	1,178,829
%		0.05	37.14	47.64	0.09	0.38	1.97	3.73	3.19	0.47	0.33	**4.73**	100.00

No shark was recorded at PFFA, PMCI and Oh's markets during the 1990-1993 period. However, ***rull*** purchases were recorded at each market as follows:

		1991	1992	1993
Rull	(Weight lbs)	874.00	669.75	92.50
	Value ($)	719.23	517.29	73.93

The 1993 rull purchase was recorded at Oh's market although its records cover only January-May and were from Koror, Airai and Ngatpang states.

The South Pacific Commission conducted a FAD Development and Vertical Dropline Fishing in Palau from November, 1991 to October, 1992. Fish species targetted were bigeye and yellowfin tuna. However, only sharks were caught as indicated below:

No of sets	No. of droplines	No. of hooks	Total catch	(kg)	Shark catch (kg)	kg/set	kg/dropline
12	33	495	755.5	745.0	62.3	22.8	

The project concluded that the vertical longline method for catching the targeted pelagic species *Thunnus albacares* and *Thunnus obesus* proved to be unproductive; only sharks were caught which have no commercial value.

4.1.3 Stocks Status

There is no data available on the shark and ray resource in Palau. Landing data is also incomplete.

4.1.4 Management

Current legislation/policy regarding exploitation: There is no legislation that deals with the

utilisation of the shark and ray resources.

Recommended legislation/policy regarding exploitation: Since there is no fishery that specifically targets this resource, there does not seem to be a requirement for a policy with regards to its exploitation.

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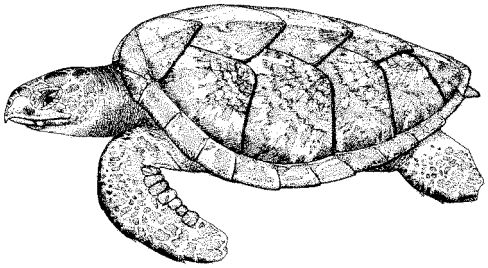
5. REPTILES

5.1 Turtles

5.1.1 The Resource



ngasch - *Eretmochelys imbricata*

Species present: Five sea turtle species have been reported to occur in Palau. These include: *Eretmochelys imbricata* (hawksbill turtle - ***ngasch***), *Chelonia mydas* (green turtle - ***mlob***), *Lepidochelys olivacea* (Olive ridley turtle), *Dermochelys coriacea* (leatherback turtle) and *Caretta caretta* (loggerhead turtle - ***bekuu***). However, only the first two, hawksbill and green turtles, occur in any significant numbers, and have established feeding and nesting populations (Milliken and Tokunaga, 1987; Maragos, 1994).

Rochers and Matthews (1992) report loggerhead turtle as a rare visitor together with olive ripley, and leatherback as being occasionally sighted (Maragos *et al*., 1994).

Distribution: Sea turtles are marine reptiles which have inhabited the earth for over 100 million years. Eight species of turtles exist worldwide with all but one occurring in the Pacific region. The most frequently seen species in the Pacific are the hawksbill and green turtles, although the leatherback (*D. coriacea*), loggerhead (*C. caretta*) and olive or Pacific Ridley (*L. olivacea*) turtles also occur. Details of the geographical distribution of all sea turtles are reported in Márquez (1990) as summarised below for the two most important species found in Palau:

Hawksbill turtle: this species, together with green turtle, is the most tropical of all sea turtle species and is distributed throughout the central Atlantic and Indo-Pacific regions. Nesting is widespread with very few major nesting places and is confined between the 25° N and 35° S, mostly within the tropical region. It is more common in the vicinity of reefs and is also seen in shallow waters which has seagrass or algal meadows, including coastal lagoons and bays.

Green turtle: this species is widely distributed in tropical and subtropical waters, near continental coasts and around islands. It is rare in temperate waters and together with hawkbill, is also the most tropical of the marine turtles. The normal latitudinal range is within the northern and southern limits of the 20° C isotherms.

Groombridge (1982) states that in Palau, hawksbills occur in relative abundance, with nesting reported on many islands, but notes that predation probably occurs for 80 per cent of the nests. Diffuse year-round nesting is reported on Ngaruangl, Kayangel, Garukoru, and the Ngarekeklau Islands, North of the main island of Babelthuap, and also on many of the rock islands South of Koror, including Ulong, Ngemelis, Eil Malk, Peleliu and Angaur Islands.

The major nesting area for hawksbill in Palau is the Ngerukewid Islands (or Seventy Islands), which constitutes Palau's only protected area for turtles, and near-by small islets. The two most important beaches are Eomogan and Ngerugelbtang. Occasional nestings occur on Aulong, Ngeangas, Ngobadangel, Unkaseri and Abappaomogan (Pritchard, 1981). The most important nesting sites for green turtles are Merir and Helen Islands in the Southwest group, with some nesting occuring on Tobi,Sonsorol and Pulo, Anna Islands in the Southwest, and Kayangel, Ngaruangl and Peleliu (Pritchard, 1981). In a survey conducted in August 1992 on Peleliu and Ngemelis, and beaches along the east coast of Babeldoab, Geermans and Honigman (1993) found no signs of recent nesting of hawksbill and green turtles. They concluded that the sites visted were not significant turtle nesting areas.

"The Rock Islands of Palau are an important nesting ground for possibly the largest nesting

population of endangered hawksbill turtle in Oceania north of the equator" (Atkinson and Guilbeaux, 1992).

Rochers and Matthews (1992) provided the following information concerning turtles in Palau as a result of an interview-survey conducted in eight of Palau's states in August-September, 1992:

Anguar: hawksbill turtle is the most commonly sighted species off Anguar although green sea turtles are also seen. The hawksbills are often seen in Garangaoi Cove and are believed to feed outside the reef around the entire island while the greens feed in the area ***medal a iwaiu***? Loggerheads are only rare visitors to the island. Turtle nesting occur in Ngerbelau and Ngeruchei.

Kayangel: green and hawksbill turtles are the most commonly sighted species with occasional sightings of loggerhead. Turtles nest on Ngajangel (ocean side away from the inhabited and disturbed areas of the lagoon), Ngariung (lagoon-side beaches) and Ngarapalas (northeast and south west side). Important turtle feeding areas were reported to exist on the lagoon side of Ngajangel and Ngariyung islands.

Melekeok: green and hawksbill turtles are found in the offshore waters and are not frequently caught.

Ngarchelong: green and hawksbill turtles feed in the vicinity of Itechel and known to nest on Ngerchur and Ngerkeklau islands north of Ngerchelong. Turtles are caught when the adults come to shore to nest but are also caught with speargun at night when sleeping. During daytime, they are chased by power boats. Eggs are collected.

Ngatpang: in 1992, residents estimated that resident green and hawksbill turtles in Ngeremlengui, Ngatpang and Aimeliik area number about 50.

Ngchesar: green and hawksbill turtles are mainly near Bdebidel.

Ngeremlengui: greens and hawksbill are common with occasional sightings of loggerhead and rarely, leatherback. Turtle resting areas were reported to be found in Luksuriubl, Ngetbengul and Ngermarsch while Ngesbokkel and Usas as nesting areas. Feeding areas for turtles known here inlcude, Bkullengriil, Usas, Ngemolei, Ngesbokl and Elmolech.

Peleliu: green and hawksbill turtle species are most commonly sighted.

Maragos (1994) reported that current hawksbill nesting of any significance is limited to only several small groups of islands in the southern lagoon (Ngerukeuid, Kmekumer, Ulong, Ngkesiil and Omekang), and a few islands around Babeldaob (Ngerduais, Ngerechur, Ngerkeklau and a few islands off the west coast. Green turtle nesting of significance is limited to Merir Island, which probably is still Micronesia's most important nesting area for this species. Minor nesting occurs at Ngeruangl Island and probably also Ngerebelas and Ngeriungs Islands at Kayangel atoll in the north and Anguar Island in the south. Feeding areas for both hawksbill and green turtles are concentrated at Helen Atoll, Anguar Island, Peleliu Island, and the southern lagoon, and off the major seagrass beds off east, north and west Babeldaob, south of Orepr and Sar Passage (Maragos, 1994).

Biology and ecology: Many life history details are lacking for all turtle species. Main biological characteristics include slow growth, high natural mortality of the young, and an apparent compulsion to return to well established nesting sites. Nesting is reported to occur throughout the year in Palau, with peaks between July-August for greens and May-September for hawksbills. Gestation period is around 60-70 days, with mean clutch sizes of around 100 eggs.

The primary nesting sites for *C. mydas* are Merir and Helen's Reef. Some nesting also occurs on Tobi, Sonsorol and Pulo Anna. Nesting is sporadic and year-round. No recent data regarding nesting numbers are available. *E. imbricata* nests on small beaches in the Seventy Islands area of the Rock Islands and occasionally on Ulong, Nelangas, Ngebedangel, Unkaseri and Bablomekang. Few data on nesting numbers are available, but Maragos (1991) reports the Palau population of nesting hawksbills to be the

largest in Oceania North of the equator. Peak nesting occurs July-August, and sporadically all year. The extensive Palau lagoon appears to be a major foraging area.

In the Pacific, hawksbills are considered the least migratory species, whereas greens are highly migratory (Vaugh, 1980).

The hawksbill turtle feeds on a diet of invertebrates, sponges and soft corals. The green turtle, by contrast, is mainly herbivorous, feeding on seagrasses and algae. Because the seagrass beds often do not occur close to suitable breeding beaches, green turtles may have to migrate from a resident habitat to breeding beaches and back at intervals. Loggerheads and olive Ridleys are also carnivorous and, with the hawksbill, do not appear to migrate to the same extent as the green turtle, though some long distance movement has been recorded (Pickering, 1983). Movements of the olive Ridley are particularly poorly known. The loggerhead nests mainly outside the tropics, on subtropical and warm temperate coasts.

While green turtles often nest together in large numbers at sites called “rookeries”, the nesting of the hawksbill is diffused, with no great concentrations of nests. The single largest known green turtle rookery is Raine Island, on the northern Great Barrier Reef in Queensland, with 80,000 nesting females per year (Pickering, 1989). Other major rookeries occur around Australia, on the Caribbean coast of Costa Rica (Tortuguero), the Pacific coast of Mexico, Ascension Island, the coasts of Oman and Pakistan and islands in the Mozambique Channel (Pickering, 1989). Hawksbill nesting density is low throughout its range, with moderate concentrations in a few localities such as the Torres Straits islands of Queensland, the southern Red Sea and the Gulf of Aden and the Arnavon Islands near Santa Ysabel in Solomon Islands.

There is evidence that 7-14 months after hatching, young green and hawksbill turtles spend their time drifting passively in beds of floating seaweed, such as *Sargassum* spp., in the deep ocean. Green turtles are then thought to spend a developmental period in inshore estuarine, coastal and reef habitats before moving to their main resident areas (Pickering, 1989).

Age at first sexual maturity in green turtles has been estimated to be between 8 and 13 or more years (Márquez, 1990). The same author reported that in captivity (Cayman Turtle Farm), green turtles reach 35 kg in about three years and start to reproduce in less than 10 years.

5.1.2 The Fishery

Utilization: Turtles are caught using spears from a canoe or spearguns, often with SCUBA gear. Some fall prey to gill nets. Sea turtles were important in traditional Palauan culture as sources of food (meat and eggs). Marriage bowls, known as 'womens' money' or ***toluk*** are made out of turtle shell and represent the private property and wealth of the woman. The production of ***toluk*** was an important traditional use of hawksbill, but turtles seem to be too small in size for this anymore. Some local craftsmen still produce ***toluk***; small ones for the tourist trade and larger ones reserved for custom use. However, the main exploitation of sea turtles today remains the collection of eggs. Commercial exploitation and export of shell occurred during the German and Japanese periods of occupation. The meat of *C. mydas* is particularly popular in Palau. The meat of *E. imbricata* was once considered taboo to all except old women to eat. Prior to 1971, the shell of hawksbill formed the basis of an important traditional carving industry for fish hooks, combs, spoons, cups and ornaments. Today this trade has largely died out, only a few artisans produce curios for sale to tourists.

It was estimated in the late 1980s that 90 per cent of all nests were raided by illegal egg collectors (Milliken and Tokunaga, 1987).

Hawksbill turtle are still illegally harvested in Palau. This include intense egg poaching. Turtles are infrequently caught using either a spear or speargun for subsistence use (Rochers and Matthews, 1992).

The same authors wrote that in Anguar and Kayangel, turtles are not frequently caught but are only caught for subsistence. Turtles were used to be caught for special occasions in Ngarchelong but now it seems it is for sport. The capture of about two turtles per six months for subsistence in Ngatpang was reported by Rochers and Matthews (1992) and that turtle hunters claim that the best time for catching is ***mengeai*** which is during the first and third quarters of the moon, the period of little tidal variations. In Ngchesar, turtle is caught as an incidental of other fisheries while in Ngeremlengui it is caught mainly for special occasions and customs or when pork is not available. Nets, hooks and spearguns are used. From interviews by the above authors, residents of Peleliu claimed that the local population catch adult turtles mainly for special occasions such as birth ceremonies or marriages. However, they claimed that people from Koror come there to collect turtle eggs. The best time for catching turles is during the breeding season (June-September) when they are also caught while laying eggs. Hunting for turtles is not common now but when they are, the large ones (more than 3 feet) are especially sought.

Perron *et al*. (1983) included ***ngasch*** and ***mlob*** in their list of commercial marine animals of Palau.

Production and marketing: The level of exploitation of the adult turtle stock for food is not known, although poaching of nests and meat consumption are known to be high. Palau had been covered by the USA ratification of CITES since 14 January 1974. However, Palau status now is different since it has become independent. CITES Annual Reports record very few illegal imports of turtle shell from Palau.

The main market for turtle shell has traditionally been Japan, where hawksbill shell (***'bekko'***) is in high demand. Japan holds a reservation on hawksbill under CITES, and imports around 30 tonnes per year from sources world-wide.

In Palau, turtle meat continues to be consumed at the subsistence level, but few data on volume are available. Perron *et al*. (1983) listed ***ngasch*** and ***mlob*** as commercial marine animals of Palau. However, landing data at PFFA for the 1976-1981 period did not include any purchase records of any sea turtles.

Green turtle is listed as threatened and can therefore only be harvested for subsistence or custom use. Maragos (1994) reported that for over 20 years, the sea turtle hatchery and head-start program that operated out of MMDC, and which ceased in 1991, collected about 25 per cent of the turtle eggs from the Rock Islands with most of the remaining 75 per cent illegally poached. During June and July, 1992, a survey to assess the feasibility of a long term study of hawksbill sea turtle nesting was conducted by the University of Georgia Sea Turtle Assistance Program in cooperation with the Palau Division of Marine Resources. The survey involved 303 individual beach checks on seven beaches in the Ngerukewid Islands, four in the Kmekumer Island Group and 3 in the Omekang Island Group. Of the 13 nests identified, 9 were intact and 4 poached. One nesting turtle was encountered and 1 poaching attempt interrupted (Atkinson and Guilbeaux, 1992).

Although illegal under the US Endangered Species Act, smuggling of turtle products from Palau does occur by US, Japanese and other tourists.

5.1.3 Stocks Status

Sea turtles are generally declining throughout the world, primarily due to over-exploitation for food, habitat destruction, and entanglement with fishing nets and other debris (Groombridge, 1982). The IUCN lists five of the seven species of sea turtle as endangered (including the hawksbill) and another as 'vulnerable'. All species are on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which prohibits any commercial trade.

Available information indicates that hawksbill numbers are declining in Palau. Maragos (1991) reports that nesting activity has declined to half its former level due to chronic egg poaching (over 75 per cent

nests destroyed), hunting of adults, tourism and recreation activities in the Rock Islands disturb nesting sites, and all remaining eggs were taken by the "head-start" programme. The Sea Turtle Project, set up in 1982 within the MMDC, aimed to supplement the adult population of hawksbills by increasing hatchling survival rates through the 'head-start' programme, whereby hawksbill eggs were transplanted from nesting sites to MMDC for incubation. The hatchlings were kept in water tanks for 6-12 months, then tagged and released to the wild. Facilitating a viable ranching capability for hawksbills within the country was a long-term goal. MMDC turtle project staff had estimated the total number of nests for the whole archipelago at between 120-180 nests per year, with over 50 per cent occurring in the Ngerukewid Island Reserve.

Table 5.1.1 presents nesting information for hawksbills in the Rock Islands. According to Sone (1989), an average 71 per cent of nests were raided by poachers between 1982 and 1988. Nesting periodicity data are given in Table 5.1.2. No seasonal trends are apparent. Table 5.1.3 provides information on hawksbill nesting sites by area. The Seventy Islands (in the Rock Islands Group), Kmekumel and Omekang are the three most important nesting areas.

Table 5.1.1: Yearly hawksbill turtle nest site survey results, Rock Islands. (Source: Sone, 1989).

Year	No. boat trips	No. nests found	No. nests with eggs	% lost to poachers	No. eggs collected
1982	23	56	23	59	1,491
1983	32	81	21	74	1,840
1984	25	71	17	76	2,031
1985	74	57	10	82	994
1986	39	54	17	69	2,189
1987	53	76	28	63	3,461
1988	52	56	14	75	1,858
Total	298	451	130	71	13,864

Table 5.1.2: Monthly number of hawksbill turtle nests found, 1982-1988. (Source: Sone, 1989).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Tot**
1982	-	3	6	9	3	10	1	7	9	3	3	2	**56**
1983	12	1	7	6	4	5	10	11	3	9	7	6	**81**
1984	5	8	3	6	7	9	6	6	4	4	7	6	**71**
1985	9	6	2	1	8	9	6	7	2	5	-	2	**57**
1986	1	3	1	3	10	12	6	3	3	1	3	8	**54**
1987	4	7	6	10	3	2	5	1	12	2	3	21	**76**
1988	8	3	2	6	4	15	8	9	0	1	-	-	**56**
Total	**39**	**31**	**27**	**41**	**39**	**62**	**42**	**44**	**33**	**25**	**23**	**45**	**451**

Table 5.1.3: Yearly number of nests found, by location, 1982-1988. (Data from Sone, 1989).

Location	1982	1983	1984	1985	1986	1987	1988	Mean
Ngebedangel	3	2	1	5	0	2	0	1.86
Biduul	0	1	0	0	1	4	0	0.86
Ulong	0	5	5	0	0	4	0	2.00
Kmekumel	10	13	8	8	11	30	17	13.86
'70' Islands	23	22	18	14	15	15	18	17.86
Iyuuch	0	0	0	0	0	3	7	1.43
Omekang	8	9	7	15	9	1	5	7.71
Kisaks	0	0	0	0	0	0	0	0.0
Ngeremdiu	0	0	1	4	0	2	0	1.00
Breu	0	7	0	0	6	4	0	2.43
Ngkesiil	3	6	3	2	5	6	6	4.43
Ngeremeyaus	0	0	0	1	2	1	2	0.86
Moir	0	0	0	3	0	0	0	0.43
Ngeruwauch	2	0	0	1	2	2	0	1.00
Oiyars	0	0	0	0	3	0	0	0.43
Suuch	1	1	0	4	0	1	0	1.00
Others	-	1	-	-	-	1	1	
Not recorded	6	14	28	-	-	-	-	
Total	**56**	**81**	**71**	**57**	**54**	**76**	**56**	**64.43**

A survey (involving 24 survey days) conducted during the June-July period in 1992 visited 14 previously identified nesting beaches which include 7 areas in the Ngerukewid Islands, 4 in the Kmekumer Island Group, and 3 in the Omekang Island Group. A total of 303 individual beach checks and 10 patrol nights were made. Thirteen nests were identified with 9 intact and 4 poached. Four false crawls were sighted, 1 nesting turtle encountered, 1 poaching attempt interrupted and 7 turtles sighted in the water (2 hawksbill, 1 green and 4 unidentified) and reamains of 1 speared hawksbill was found within Ngerukewid (Atkinson and Guilbeaux, 1992).

Maragos (1994) notes that harvesting and poaching of turtles and eggs is exceeding natural sustainable rates at all of the islands, and turtle populations everywhere are declining.

5.1.4 Management

Current legislation/policy regarding exploitation: Sea turtles are protected under Title 24 (Environmental protection) of the Palau National Code. Chapter 12 (protected sea life), subchapter I: Turtles, are summarised as follows:

- ⇒ no hawksbill shall be killed or taken on shore, or their eggs taken;
- ⇒ turtles caught and killed at sea must be greater than 27 inches carapace length in the case of hawksbills, and 34 inches carapace length for green turtles;
- ⇒ no sea turtle of any size may be taken or killed between June 1st and August 31st, nor between 1st December and 31st January, inclusive;
- ⇒ notwithstanding the above, taking of sea turtle and their eggs is only allowed for scientific purposes when authorised by the President;
- ⇒ violators of these provisions face six months in jail or fines not more than $100, or both.

One major nesting site, the Ngerukewid Islands, is a designated nature reserve. The USA Endangered Species Act apparently used to apply to Palau. *C. mydas* is listed as threatened and may be taken by residents only, and "if such taking is customary, traditional and necessary for sustenance of such resident and his family".

Recommended legislation/policy regarding exploitation: Currently, enforcement of the existing law is weak. The advent of powered boats in recent years has facilitated wide-spread raids on nesting sites by egg collectors throughout the archipelago, including the Ngerukewid islands, where technically no unauthorised boat is allowed entry.

Maragos (1991) reports that the turtle headstart project has not demonstrated any success in enhancing wild populations, as despite 2,400 juveniles released between 1982-1990, only 2 tagged turtles have been reported re-captured.

Maragos (1991) suggests the following measures to reverse the current trend towards extinction of the Palauan hawksbill population:

- ∗ immediate curtailment of the head-start programme (this was done in July, 1991);
- ∗ establish resident enforcement presence on nesting beaches;
- ∗ disguise or hide nests to reduce poaching;
- ∗ institute data collection and tagging studies at nesting sites;
- ∗ regulate construction, recreation and tourist activity near nesting sites;
- ∗ incorporate the above in a reserve programme for the Rock Islands, with increased public education of turtles and training of national staff in turtle conservation.

Continuation of existing turtle conservation programmes and expansion of protected nested areas, plus improved protection of the existing protected nesting sites and enforcement of laws protecting wild adults, is highly recommended.

Maragos *et al*. (1994) report that "concerted conservation actions are needed to prevent the virtual extirpation of nesting sea turtles from Palau. These include resurrection of traditional controls, enforcement and surveillance by the National government, and in support of state government efforts, designation of new protected areas, and rehabilitation of nesting sites".

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5.2 Crocodiles - *ius*

5.2.1 The Resource

Species present: A single species of crocodile, *Crocodylus porosus* (salt-water crocodile - ***ius***), occurs in Palau (Messel and King, 1991), although Kimura (1968) reports two other species from the islands, but these were likely to be mis-identification.

Distribution: The saltwater crocodile occurs from the Southern tip of India eastward to the Banks Islands in Vanuatu and is the widest ranging species of crocodilian. The current distribution encompasses 18 countries, including Australia, Bangladesh, Brunei, Myanmar, Cambodia, China, India, Indonesia, Malaysia, Palau, Papua New Guinea, Philippines, Singapore, Sri Lanka, Solomon Islands, Thailand, Vanuatu and Vietnam (U.S. Fish and Wildlife Service, 1993).

As a result of heavy and sustained hunting throughout Palau since the post-war years, the eradication and excessive hunting in the late 1970s and early 1980s, the number of crocodiles in Palau has been severely reduced. During a recent survey, Messel and King (1991) surveyed 112 km of waterways throughout the Republic that were considered to provide suitable habitat for *C. porosus*. Only 42 animals were sighted, 17 of which were spotted on Belilou Island, and 17 in Ngerdok Lake. It is evident that the crocodile population, although widely distributed over the islands, is at an acutely low density.

Crocodiles in Palau seem to concentrate in three regions; mangrove and coastal waterways, freshwater ponds and swamps of Peleliu Island; the lakes, ponds, and drainages of Ngerdok Lake as well as its associated downstream estuaries on easy Babeldaob island; and the rivers, streams and estuary of Ngermeduu Bay on west Babeldaob island (U.S. Fish and Wildlife Service, 1993).

Rochers and Matthews (1992) reported residents of Angaur as occasionally seen crocodiles in the various abandoned phosphate mining pits around the island. Maragos (1994) reported excellent mangrove habitat off eastern Babeldaob for saltwater crocodile with Lake Ngerdok, upslope from Melekeok Village as one of Palau's premier nesting habitats for crocodiles. According to residents, crocodiles inhabit nearby streams and mangrove. However, only one animal was reported in Airai Bay during extensive surveys by Messel and King (1991). In 1992, residents in Melekeok estimated 60-100 crocodiles living in the area while only 5 was estimated in Ngchesar. A few crocodiles were found by Messel and King (1991) off the river mouths in Ngeremeduu Bay and further north off the Irur River and off the coastal fringe from the Iweong to Iwekei Rivers. The authors estimated that mangrove habitat off western Babeldaob is extensive enough to support several hundreds or more crocodiles. Crocodiles have been reported in several of the lakes in the southern lagoon area. One of the largest populations of crocodiles in Palau was reported by Messel and King (1991) within the mangrove and seagrass embayment to the northeast of Peleliu, mostly on the northern estuary and tidal creek. The other being in Lake Ngerdok off eastern Babeldaob.

Biology and ecology: The following information was taken directly from U.S. Fish and Wildlife Service (1993).The saltwater crocodile is the largest of the 23 living species of crocodilians. A female deposits 40 to 60 eggs during the wet season from May through July. Hatching has been reported to occur in Palau in August and September after an incubation period of about 90 days. They have fast growth particularly in its early years with wild females reaching more than 5 feet (1.3 m) in five years. Males reach sexual maturity at about 15 years of age and females at 10 years. No growth data are available for Palau but could be comparable with these. Vertebrates are the principal food source. Sub-adults and juveniles prey heavily on crustaceans, crabs and shrimp and insects where crabs are not common. Slow-moving fish may also be captured. Movement is restricted in four years old or younger to within 10 km while older animals can move up to 21 km.

5.2.2 The Fishery

Utilization: Messel and King (1991) give an account of the history of crocodile exploitation in Palau. First reports of crocodile capture date from between 1898 and 1905. Individuals were between 2 and 3 feet in length (Motoda, 1937; 1938). Fifty four crocodiles were caught between 1915 and 1936. Information on crocodile exploitation is lacking from 1947 (when Palau became a Trust Territory of the US) and 1958. In 1965, a local fisherman was killed by a 12 feet 7 inch (3.83 m) crocodile on Koror, which resulted in public hatred for the wild crocodile population, and concerted hunting and systematic eradication of the resource commenced. In 1968, a Bill was introduced in the Congress of Micronesia providing a bounty for the killing of crocodiles, which were considered as a public menace. Between 1967 and 1968 a survey was carried out by commercial crocodile shooters to determine the viability of a crocodile fishery, but only 23 crocodiles were sighted, which did not indicate a viable fishery.

In 1969, the Government of Palau, under US Administration, granted exclusive rights for three years to an Australian big-game association to hunt crocodiles and sell the skins and remains. This enterprise failed after only two months, having shot only 85 animals, presumably due to the very low numbers of crocodiles available for exploitation. A local hunter active in 1972 reportedly shot almost 200 animals, but this enterprise also ceased. Other commercial ventures exploiting wild crocodiles in Palau have all failed.

Animals continue to be taken from the remaining wild population for sale of skins and meat although large scale commercial operation can not be supported by the low population. “On request for meat or skin, the animals are slaughtered and frozen and sold to tourists and possibly local restaurants. Meat and skins sold to tourists are packed in insulated cool boxes and placed in personal luggage where they remain undetected on export (US Fish and Wildlife, cited above).

A ranching venture for tourist attraction started in Palau in about 1990, near Koror. This venture currently holds 43 animals (24 big ones of 4-14 feet and 19 small ones) which were all collected from the wild. The animals are fenced in a small mangrove area with concrete walls about 4 feet high and wire on top. The pond is divided into two units separating the big crocodiles from the small ones. Feeding is only done once a fortnight using live chickens, as crocodiles would not take dead ones. One big crocodile may take about 5 chickens during one feeding. Entrance fee to the ranch is $3.00 for adult and $2.50 for children.

Production and marketing: Crocodile skin is in demand for high value leather products. East asian markets, particularly Japan, are major buyers. Crocodile skin can not be sold in Europe because of CITES regulations. *C. porosus* has the most valuable hide of any crocodile on the market, which is why Japan and Singapore took reservations on the species under CITES. Lobbying by conservation groups resulted in Japan removing its reservation in November 1989, and Singapore is reportedly going to follow suit. However, many lucrative markets currently exist for wild caught skins.

Other than the anecdotal figures given above under the Utilisation section, no production figures are available for Palau except those presented inTable 5.2.1. DMR (1991) reports that 212 lbs of crocodile were exported during 1990 (from the flight manifest of the commercial air carrier, Continental Air Micronesia Airlines).

Perron *et al*. (1983) listed ***ius*** as one of the commercial marine animals of Palau. Data collected of marine animals purchased by PFFA market from 1976 to 1981 recorded ***ius*** only twice within the period as given in Table 5.2.1.

Table 5.2.1: Crocodile (***ius***) purchases recorded at PFFA for the 1976-1981 period. (Source: Perron *et al*., 1983).

Year		Weight (lbs)	Percent Annual All Species Landing Weight	Value (US$)	Per cent Annual All Species Value	Price $/lb
1978	***ius****	995.00	0.33	303.25	0.39	0.31
1979	***ius****	140.00	0.03	49.00	0.03	0.35

*It is very likely that ***ius*** reported was crocodile meat.

5.2.3 Stocks Status

The saltwater crocodiles were once widespread throughout the main islands of Palau but have suffered from a poor image leading to eradication and excessive hunting in the late 1970s and early 1980s. According to Messel and King (1991), *C. porosus* is nearing extinction in Palau due to the past policy of the US Administration, supported by Palauan conservation officials, to eradicate crocodiles which have been traditionally viewed by the general populace as vermin and a threat to humans. A total of only 42 individual crocodiles were sighted in 112.4 km of waterways surveyed. The authors considered that around 75 per cent of all inland waterways that provide a habitat suitable for crocodiles, and around 50 per cent of the coast, were covered during the survey. The largest remaining populations (but very small) of crocodile in Palau, occur in Lake Ngerdok off eastern Babeldaob and in the mangrove swamps off northeast Peleliu, each comprising around 17 animals. No other viable crocodile populations are believed to exist in Palau. Maragos (1994) reports that Ngemeduu Bay once supported large populations of crocodiles but many were taken from the area for the menagarie, leaving a small residual population. On the basis of this survey, the authors calculate that the total crocodile resource numbers less than 150 individuals.

There is no reliable data concerning crocodile numbers in previous years. No population studies have been undertaken prior to 1991, and crocodiles skin export statistics have not been maintained over the years, but anecdotal information indicates that the population may have been in excess of 1,500 animals in all size classes in past years.

U.S. Fish and Wildlife Service (1993) notes that "although the taking of animals for meat and skins is primary hunting threat, there is some vengenance killing by local people. In addition, crocodiles are cited as competing with humans for food (mangrove crabs and fish) in Palau. It is also believed that crocodiles' presence is detrimental to the development of the tourist/sport diving business" and "while population numbers are probably very low, a closer estimation of real numbers can only be determined by more complete surveys of inland and coastal habitats".

Crocodile populations are also affected in Palau by habitat loss as is evident where road building, housing and commercial development are resulting in encroachment of freshwater and mangrove wetland habitat vital to crocodiles. Also, the existing laws are inadequate. It is believed that rats and feral cats feed on eggs and hatchling crocodiles though not confirmed (US Fish and Wildlife Service, 1993).

5.2.4 Management

Current legislation/policy regarding exploitation: Since Palau has become independent, protection of local crocodile population under ESA no longer applies. However, efforts have been attempted to modify the Palauan Code to protect endangered species. A Palauan Endangered Species Act has been prepared and exists in the form of proposed legislation, House Bill No. 4-5-2S, (US Fish and Wildlife Service, 1993).

Recommended legislation/policy regarding exploitation: Messel and King (1991) conclude that unless urgent measures are put in place to protect the species, *C. porosus* will soon become extinct in the wild in Palau, and its range will be further diminished. Ranching is not viable, due to the already very low numbers of wild crocodiles.

Recommended management options for the protection of the crocodile resource in Palau include:

* retention of wild crocodiles status on Appendix I of CITES;

* an immediate total export ban on skins until wild populations recover, and/or crocodile farms become productive and registered with CITES Secretariat;
* national and state governments consider banning the killing and taking of wild crocodiles, except where they present a danger;
* the government to institute setting up of crocodile reserves for on-growing young animals, and licensing trappers to take large animals for breeding on farms;
* US Fish and Wildlife Service and Palau Bureau of Resources and Development work together to seize crocodiles currently held in small farms and place in a single, large licensed one;
* licence the only existing large, private farm to receive crocodiles from licensed trappers in order to expand the 'gene bank' of captive crocodiles in Palau, for commercial and conservation propagation. A single large farm would have more potential to reach economic viability;
* US Fish and Wildlife Service should assist with setting up additional captive breeding farms, stocked with animals procured overseas;
* Palauan authorities should encourage wildlife tourism based on boat tours of scenic waterways with small and large crocodiles;
* establishment of crocodile reserves on Babelthuap, West coast and Southern waterways;
* government should increase public awareness and crocodile conservation material to schools, rural areas, etc.; and
* status of *C. porosus* to be monitored and evaluated once every three years.

US Fish and Wildlife Service (1993) recommends inclusion of crocodiles in the list of threatened or endangered species in the regulations promulgated under the Palauan Endangered Species Act. Under the recovery plan recommended in the same document, the following actions were mentioned:

* stabilize current populations by establishing and managing at least three protected areas;
* secure illegally held captive crocodiles and reintroduce them into the wild;
* protect the crocodiles under Palauan law and increase enforcement of wildlife laws;
* increase public awareness.

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6. FLORA

6.1 Mangroves

6.1.1 The Resource

Because of the important role the mangroves contribute to the coastal fisheries resources, they are treated as a resource for these profiles.

Species present: The following mangrove species have been recorded to occur in Palau: *Bruguiera gymnorhiza* (oriental mangrove - ***denges***), *Bruguiera* sp. (***kodenges***), *Lumnitzera littorea* (***mekekad***), *Rhizophora mucronata* (***tebechel***), *Sonnerratis alba* (white mangrove - ***urur***). In addition, Canfield *et al*. (1992, quoted in Maragos, 1992) also recorded, *Rhizophora apiculata* (the red mangrove) in the Ngeremeduu Bay. *S. alba* and *R. apiculata* are the dominant trees within the bay.

Distribution: Mangrove area in Palau has been estimated to cover a total area of 45 km^2. Their distribution by State, together with estimated coverages by other habitat types and land area is given in Table 6.1.1, arranged in descending area of mangrove area.

Table 6.1.1: Estimated fishing area habitats by state. (Source: DMR 1990 Annual Report).

State	Mangrove (km^2)	Fringing reef (km^2)	Barrier reef (km^2)	Lagoon (km^2)	Atoll reef (km^2)
Airai	7.9	22.7	4.0	30.0	0
Ngardmau	7.2	13.8	11.0	22.5	0
Ngetpang	6.3	2.7	7.1	15.0	0
Peleliu	4.9	35.5	0	0	0
Ngeremlengui	4.0	7.5	12.3	15.0	0
Ngaraard	3.4	23.2	17.3	23.8	0
Aimeliik	2.8	8.2	27.0	55.0	0
Ngerchelong	2.1	23.0	81.3	325.0	0
Ngchesar	1.8	6.9	4.7	23.0	0
Melekeok	1.7	8.4	0	0	0
Koror	1.6	19.2	100.0	500.0	0
Ngiwal	1.3	5.8	0	12.1	0
Anguar	0.0	2.6	0	0	0
Sonsorol	0.0	8.3	0	0	0
Tobi	0.0	7.0	0	103.0	57.9
Kayangel	0.0	0	0	12.1	7.1
TOTAL	**45.0**	**194.8**	**264.7**	**1,136.5**	**65.0**

Bright (1991) estimated 700 hectares of mangroves in the Ngermeduu Bay watershed, making up 44 per cent of the total Babeldaob mangrove area.

Maragos (1993) reported the following information concerning the occurrence of mangroves on the main Palau islands:

Northern Barrier Reef Area: mangrove forests are well developed as small pockets within embayments around the Ngerchelong peninsula.

Eastern Babeldaob: mangroves are well developed and extensive along the east coast of Babeldaob, and are concentrated in shallow embayments. The mangrove fringe along the entire coast is almost continuous except for parts of Ngaraard, Ngerchelong and Melekeok coast. The most extensive mangrove stands are in Airai and Ngaraard but significant stands are found on sites such as; Lukes, Ngatmel, Bischerad, Ngriil, Kekerelel Dormechol, Ngkeklau-Ogiil, Ngiwal, Ngeriungs, Ngchesar, Ngerngesang, Ngerdorch, Ngchesechang, Oikull, Ngerduais, Ngerduais, Ngrikill (Airai Bay), Yelch,

Ngerusar, Ngetkib, Ngchesechang.

Western Babeldaob: western Babelboad contains the most extensive mangrove swamps in Palau with the largest stand in the Ngeremeduu Bay and the continuous fringe along the coast from Aimeliik to Airai. Mangrove forests in this area consist of small pockets in the north which become larger towards the south and cover an area of 32.2 sq. km. The largest stands are found in Urrung Telong, Telong to Iuellang, Ngeremasech, Ngerdesiur to Imeong, Ngeremeduu Bay, Ngerasech, Turangel, Bad, Ngereklmadel, Ilabis, Ngerulaol, Medorm, Ngechemiangel, Ngerkeai, Ngerdeiar to Imiul and Airai.

Southern Lagoon: mangroves are concentrated around the island of Oreor (Koror) with major stands at Ngesaol, Ngerbeched-Ikelau-Ngerkeseuaol, Medalaii-Meketi, and Ngerbobe. Small patches are found at Ngerekebesang. Mangroves are absent in the Rock Islands outside of Peleliu with the exception of only very small clusters in a few marine lakes and protected coves.

Peleliu: Outside of Babelbaod, Peleliu contains the largest mangrove swamp in Palau which provides critical habitat for one of only two remaining breeding populations of saltwater crocodiles. It has three major stands; Mocheingel, Ngermelt, and an area off Blood Nose Ridge.

6.1.2 Resource Importance and Uses

Utilization: The importance of mangroves and mangrove habitats to coastal fisheries have been well documented throughout the world. Apart from the provision of a buffering zone, preventing erosion and protecting land from wave action etc. mangrove areas are extremely productive areas supporting various fisheries, providing nursery and feeding grounds for a host of brackish and marine animals. Maragos (1994) noted that in Palau, mangrove crabs and mangrove clams are confined to mangrove habitats. They currently provide an essential habitat for the endangered saltwater crocodile and several sea birds as well as supporting a variety of native shellfish and finfish resources.

Maragos (1994) mentioned excessive woodchipping and sawmill industries as potentially destructive to mangroves. (It is not clear whether this referred to “story-board” production or any other existing undertaking locally). In Palau, mangrove wood is considered a valuable building material. The wood is used mainly for the construction (for posts and the top frame) of traditional “summer houses” which are used as resting houses. A lot of these houses exist in Babeldaob. Sometimes the mangrove wood is used for building outdoor cooking houses. Wood (diameter 2-3") are used to make fences to keep pigs in. Poles of a few feet in height are rooted to the ground at a few inches apart in the shape of the fence. Mangrove root outcrops are used to form frames for traditional fish traps. During the Japanese time, the bark of mangroves was used in the production of dye. However, this practise does not seem to exist anymore. Palauans do not specifically cut mangroves for firewood as the resources is considered a valuable building material. Only mangrove from rotting “summer houses” are used for firewood. Wood of *Bruguiera* sp. and *S. alba* are used for the production of storyboards.

Rochers and Matthews (1992) report the uses of mangrove in Palau as follows:

B. gymnorhiza - building
Bruguiera sp. - building, storyboards
L. littorea - building
R. mucronata - building
S. alba - building and storyboards.

Mangrove areas are, in a few cases, used for aquaculture. Mangrove trees have been cleared for the construction of ponds (e.g. milkfish farm in Koror which is probably the only surviving farm from a few attempted). The crocodile ranching for tourist attraction in Koror is in a mangrove area but only a

very small area is used.

Production and marketing: There is no information available on level of utilization.

6.1.3 Stocks Status

Maragos (1994) notes that mangroves are still relatively intact and healthy in Palau except in the vicinity of some poorly planned dock, road, and channel projects (Melekeok, Ngetpang) where mangroves have been filled in or walled in causing them to die. The same author also notes that excessive harvesting for woodchipping and sawmill industries is potentially destructive. Road construction along the Ngetpang river has smothered and killed large stands of freshwater swamps in Ngeremeduu Bay.

6.1.4 Management

Current legislation/policy regarding exploitation: There does not seem to be any legislation that specifically protect mangroves in Palau.

Recommended legislation/policy regarding exploitation: Mangroves need to be protected under specific legislation.

Maragos *et al*. (1994) made the following recommendations:

- some mangrove areas need to be established as preserves as part of a larger protected areas especially Ngeremeduu Bay, northeast Peleliu, the mouth of the Ngerdorch River, and Airai Bay.
- national Government to assist in the enforcement of state laws to discourage unauthorised harvesting and cutting by “outsiders”.
- upland soil erosion control especially for road, airfield, and land clearing to avoid destruction of coastal ecosystems including mangroves.

There is a need to introduce legislation, under the appropriate ministry, for the conservation of mangroves and for their protection from the effects of other developments.

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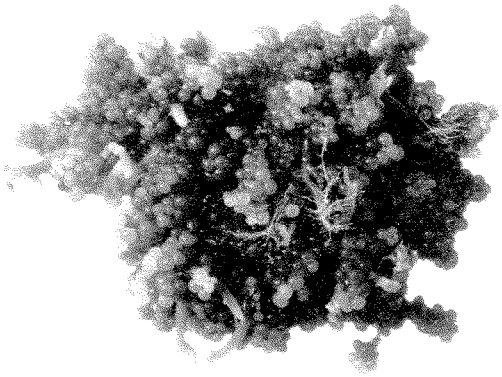
6.2 Seaweeds

6.2.1 The Resource



Caulerpa sp.

Species present: Palau has a relatively rich and diverse marine flora. Seaweeds collected by DMR staff during 1990 and 1991 included the following major species:

Halimeda discoidea	*Halimeda lacunalis*
H. simulans	*Cladophoropsis vaucheriaeformis*
H. opuntia	*Tydemania expeditionis*
H. discoidea	*Dictyota bartayresii*
H. incrassata	*Padina minor*
H. micronesica	*Galaxaura fasciculata*
H. tuna	*Actinotrichia fragilis*
H. macrophysa	*Amphiroa foliacea*
Boodlea coacta	*Hypnea pannosa*
Caulerpa racemosa	*Gracilaria crassa*
Caulerpa sp	*Valonia ventricosa*
Avrainvillea lacerata	*Peyssonnelia obscura*
Rhipilia orientalis	*Cholorodesmis fastigiata*
Gelidiopsis sp.	*Dictyosphaeria versluysii*
Gelidium pusillum	*Amphiroa fragilissima*
Liagora clavata	*Ceramium mazatlanense*
Champia sp.	*Polysiphonia scopulorum*
Caulacanthus okamurae	

Distribution: Presumably generally widespread. The above species were collected from Ngerngesang reef flats, Ngchesar Passage, Ngetngod inner reef, Todai reef and Jellyfish Lake (DMR unpublished data).

Biology and ecology: Some seaweed species have been intensively grown in aquaculture enterprises since they require only sunlight and nutrients in the water. Predation by rabbitfish, *Siganus* sp., cyclones, diseases, and inconsistent and unreliable market and value, have contributed to the failure of some of these mariculture undertakings in the South Pacific.

6.2.2 The Fishery

Utilisation: Subsistence and small scale artisanal fisheries exist in some of the South Pacific countries based on the use of *Caulerpa* sp. and *Gracilaria* sp. for food. The major commercial use of seaweed in the region is for phycocolloids for the production of agar and carrageenin, which are used in the food, cosmetic, medicinal and other industries. Major culture areas are Taiwan, Philippines and Kiribati. Harvested weed is sun-dried, compressed and baled, and then shipped for processing overseas. A number of FFA member countries (eg. Fiji, Tonga and Western Samoa) have attempted to develop small-scale commercial seaweed farms, with mixed success.

The seaweeds, e.g. *Caulerpa racemosa* etc, found in Palau, are not consumed by the local population. However, the resource is known to be collected for food by the Philippino population based in Palau.

Marketing: Prices paid for food-grade agar to Japan from 1984-1986 were $10-21 per kg (Armisen and Galatas (1987).

Production and marketing: No commercial fishery currently exists for seaweeds in Palau. Subsistence uses are not documented.

6.2.3 Stocks Status

No information is available.

6.2.3 Management

Current legislation/policy regarding exploitation: There is no existing legislation that specificaly addresses the exploitation of seaweeds in Palau.

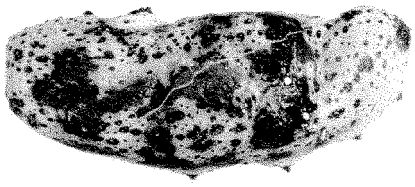
Recommended legislation/policy regarding exploitation: Current utilisation by the local population is limited and seems only for subsistence. The level of exploitation by the Philippino community is not known. It would be necessary to obtain data on the resource and level of exploitation.

Reference

Armisen R. and R. Galatas. 1987. Production, properties and uses of agar. In *Production and utilisation of products from commercial seaweeds*. (D.J. McHugh. Ed.). pp. 1-57. FAO, Rome.

7. OTHER RESOURCES

7.1 Sea cucumber



bakelungal *- Holothuria fuscogilva*

7.1.1 The Resource

Species present: Ilek (1991) noted that at least five of the commercially important sea cucumber species are found in Palau, and include:

Holothuria (Microthele) nobilis	- black teatfish (***bakelungal***)
Holothuria fuscogilva	- white teatfish (***bakelungal***)
Thelenota ananas	- prickly redfish (***temetamel***)
Actinopyga mauritiania	- surf redfish (***badelelid***)
H. scabra	- sandfish (***molech***)

Actinopyga miliaris, *A. echinites* (***cheremrum***) and *Stichopus variegatus* (***ngemis***) were identified by the same author as of high value in the local subsistence and commercial levels. Other sea cucumber species known to be edible or of commercial value in Palau, as reported in DMR (1992 Annual Report) and Matthews and Oiterong (1991), include: *H. difficilis* (***ederngor***), *H. flavomaculata* (***sengill***), *H. verrucosa* (***sekesakel***), *H. fuscopunctata* (***delal a molech***), *Stichopus* sp. (***irimd***), and *Bohadschia argus* (***meremarech***). [Matthews and Oiterong, 1991, labelled ***irimd*** as *Holothuria* sp.].

Richmond (1991) and Birkeland and Richmond (1992) listed the following additional sea cucumber species found in Palau, although their use in any fishery is not known:

Bohadschia graeffei, *B. marmorata*, *B. vitiensis*, *B. bivittata*, *Holothuria* (*Halodeima*) *atra*, *H. edulis*, *H. hilla*, *H. impatiens*, *H. leucospilota*, *Stichopus chloronotus*, *Thelenota anax*, *Actinopyga palauensis*, *Synapta maculata* and *Synaptula media*.

Distribution: Sea cucumbers are found throughout the world at depths from shallow coastal seas to the abyssal plain (Preston, 1993). Species of commercial value tend to predominate tropical coastal waters. Because bacteria constitutes the major nutritional component for most holothuroids, "the complex relationship between bacterial populations and sediment structure may have a major influence on the distribution of holothuroids" (Preston, cited above).

Sea cucumbers are found throughout Palauan reefs. They are most abundant in areas from the west coast, south-east coast of Babeldaob to Koror down to Peleliu. Reefs at Kayangel were reported by Rochers and Matthews (1992) as an important area for the collection of sea cucumbers for the production of bêche-de-mer. Sea sucumber is the most significant invertebrate fishery in Melekeok with ***molech***, ***ngimes*** and ***irimd*** as the main species which are also collected for bêche-de-mer production. Sea cucumbers are common off the Melekeok Reef flats (Maragos, 1994). At Ngchesar, many types of sea cucumbers are present and are common on reef flats. In Ngatpang, ***ngimes***, ***cheremrum***, ***irimd*** and ***molech*** are four species that are collected for commercial and subsistence purposes.

Mattews and Oiterong (1991) reported that *A. miliaris* and *A. echinites* (***cheremrum***) occur throughout Palau and are normally found under rocks or in seagrass beds during daytime. *H. scabra* (***molech***) is found in silty sand often near estuaries and in seagrass beds. This species is believed to emerge from the sand in rising tides and is easy to find in seagrass beds and soft sandy bottom near mangroves. *S. variegatus* (***ngimes***) is also found in seagrass beds within the inshore areas while *Holothuria* sp. (***irimd***) is normally collected from seagrass beds where *Enhalus* sp. and *Halimeda* sp. plants are common.

In a survey in 26 sites in 1991 within the Ngermeduu Bay area on the west coast of Babeldoab, Richmond (1991) reported several sea cucumber species of commercial value present in quantity on the sandflats at the inner mouth of the channel. The occurrences of each sea cucumber species for the 26 sites surveyed were recorded as follows:

Species	# Sites species occurred in	Species	# Sites species occurred in	Species	# Sites species occurred in
Actinopyga echinites	2	*B. vitiensis*	1	*H. scabra*	5
A. mauritiana	2	*Holothuria atra*	10	*Synapta maculata*	1
A. miliaris	2	*H. edulis*	10	*Synaptula media*	1
A. palauensis	3	*H. fuscogilva*	1	*Stichopus chloronotus*	3
Bohadschia argus	10	*H. hilla*	1	*S. variegatus*	9
B. bivittata	1	*H. impatiens*	1	*Thelenota ananas*	9
B. graeffei	5	*H. leucospilota*	1	*T. anax*	4
B. marmorata	2	*H. nobilis*	4		

In an invertebrate survey in 47 sites from Velasco Reef in the north to Angaur in the south in 1992, Birkeland and Richmond (1992) reported that commercially valuable sea cucumber species were less abundant than expected in several sites. Occurrence of those sea cucumber species observed were as follows:

Species	# Sites Species Observed in	Species	# Sites Species Observed in
Bohadschia argus	6	*H. edulis*	5
B. graeffei	5	*H. nobilis*	1
B. marmorata	1	*S. chloronotus*	3
B. vitiensis	2	*Stichopus variegatus var hermanii*	1
Holothuria (Halodeima) atra	9	*Thelenota ananas*	13
		T. anax	2

Biology and ecology: Conand (1989) reviews what is known of the biology of the main species of holothurian exploited commercially in the South Pacific. Additional information is provided in Preston (1993). Summaries of information from both sources on certain species of commercial interest are given in Appendix 7.1.1.

It is known that most aspidochirote holothurians are deposit-feeders, swallowing the upper few millimetres of sediment on which they live. The sediment consists of inorganic compounds, organic detritus, micro-organisms and their own or other animals' faecal material, with bacteria making up the major nutritional component for most species. They generally feed continuously or have a daily rhythm in their feeding frequency, often related to light levels. Species that live in reef flat areas "vacuum" the surfaces of their habitat, cleaning off the film of sediment that settles there.

The study of Conand (1988) on sea-cucumbers in New Caledonia shows that sexes are separate and spawning is seasonal, occurring in the cooler months. *H. nobilis* attains sexual maturity at around 600 g wet weight for 50 percent of the population. Size at first maturity for other species is apparently highly variable.

7.1.2 The Fishery

Utilisation: Sea cucumbers have always been an important component of the subsistence fishery in Palau. However, additional pressure has been placed on this resource with the introduction of commercial production of bêche-de-mer. Commercial fishing for sea-cucumbers has been active since the 1930's (Ilek, 1991). During 1991, the commercial fishery was carried out by relatively few small-scale artisanal fishermen. Interviews indicated that a sea cucumber fisherman, with a crew of 2-3 men, worked on average 25 days per month, depending on weather conditions, during which time between 1-2.5 tons of sea cucumber were collected (between 400-500 animals per day). The

following reefs were major collection sites: Tkulchomelochel, Ngeremdiu, Ngederrak, Ngeskesau, Ngerchong, Ngerecheu, Uchelbeluu, Ngiwal, Melekeok, Ngerchelong and Kayangel reefs. The fishermen usually process the catch themselves. Collection methods have not been documented, but are presumably free diving, wading on reef flats and the use of weighted spears on lines in deep lagoon areas. No commercial export of bêche-de-mer was reported for 1992 and 1993.

A. miliaris (***cheremrum***) is a popular species in Palau; animals are cleansed, cut transversely and pickled for subsistence consumption, or sold on local markets by the bag, mostly by women for extra income. *B. argus* (***meremarech***) is also important for subsistence use; only the gonads, polian vesicles and the yellow 'noodles' (extruded organs of cuvieri) are eaten. *H.scabra* (***molech***) is also a popular subsistence food, and occasionally appears in local markets. It is preferred when cooked by boiling, although the young ones are consumed raw after removing the skin by scraping or peeling. They are sold in the market cooked (Matthews and Oiterong, 1991). *H. verrucosa* (***sekesakel***) is collected mainly for subsistence and is consumed raw after the viscera are removed. *S. variegatus* (***ngimes***) is collected both for subsistence and domestic commercial markets. Collection of this species is called ***olengimes***. It is the intestines of this species that are used for consumption. They are thus collected in the morning while the intestines are clean and free of sand (i.e. before the animals commence feeding). The animal is cut open, viscera extracted and the rest thrown back to the sea to regenerate. The intestines are sold at the markets in jars or in plastic bags. ***Irimd*** (*Holothuria* sp.) is collected at low tide from within seagrass beds. Fishing for this species is known as ***omatairimd***. The animals are kept in seawater during collection. After collecting, the animals are placed in a basket or sack, salt is added and the sack shaken and rubbed against a rock to clean and remove the outer skin layer. The process is stopped when the outer layers of the animals turns white. They are then rinsed in seawater and put in a bucket of freshwater mixed with amra fruits (***titimel***) or vinegar (Matthews and Oiterong, cited above).

In a survey conducted in 1991 in seven states in Palau on women's role in fisheries, 91 per cent of the women interviewed indicated participating in sea cucumber collection as a method of seafood collection (Matthews and Oiterong, 1991). On sea cucumber species typically collected, *S. variegatus* was named by 94 per cent, *A. miliaris* by 85 per cent , *H. scabra* by 72 per cent, *Holothuria* sp. by 54 per cent, and *H. verrucosa* by 41 per cent. Table 7.1.1 gives sea cucumber species as indicated by the survey as those collected in greatest numbers for states in which interviews took place. The figures represent percentages of responses. Percentages of those who collect for subsistence use are also given for each species and state.

Table 7.1.1: Sea cucumber collection and subsistence use by Palauan women. Figures are in percentages of responses. (Source: Matthews and Oiterong, 1991).

Species	Aimeliik	Airai	Koror	Ngaraard	Ngardmau	Ngatpang	Ngeremlengui	Total
S. variegatus (ngimes)	100	88	100	92	100	100	80	94
subsistence	29	43	75	36	43	33	25	45
A. miliaris & echinites (cheremrum)	100	100	58	83	86	100	80	85
subsistence	14	13	100	30	17	33	25	33
Holothuria sp. (irimd)	71	100	67	17	29	67	40	54
subsistence	40	25	75	50		50	50	45
H. scabra (molech)	43	38	8	0	0	33	20	17
subsistence		67	100					33
B. argus (meremarech)	0	0	8	0	0	0	0	2
subsistence			100					100
H. verrucosa (sekesakel)	0	13	0	0	0	0	0	2
subsistence								
H. fuscopunctata (delal a molech)	0	13	0	0	0	0	0	2
subsistence								

Production and marketing: Detailed production figures for this fishery have not been collected on a regular basis. Ilek (1991) recorded fisheries statistics from Micronesia for the 1922-1938 year period, of which estimated landings for Palau sea cucmber were recorded (Table 7.1.2). The weight figures for the

years 1922 to 1935 were estimated from value figures using the approximation of 30 ¥/kg, by M. Izumi of South Pacific Commission.

Table 7.1.2: 1922-1938 estimates of sea cucumber landings in Palau. (Source: Ilek, 1991).

	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932
Weight (kg)	98,726	168,674	90,950	96,449	139,980	61,732	139,007	201,523	61,203	34,524	7,123

	1933	1934	1935	1936	1937	1938
Weight (kg)	9,050	83,712	80,840	61,705	30,229	65,646

Sea cucumber production for 1986 was estimated to total 6,522 lbs (2,935 kg) of dried product, made up principally of *H. scabra* and *T. ananas*. Air cargo export data for Continental Air Micronesia for January-November (excluding September) 1990 indicated that around 4,680 pounds (2,106 kg) of sea cucumber were exported. Preliminary results from a DMR questionnaire survey of fishermen active in this fishery indicate that during 1991, an average 20,000 animals (equivalent to 5,000 lbs of finished product) were being collected every 25 days. The fishery was therefore considered considerable. Two export shipments of bêche-de-mer were recorded for 1991; one weighing 1,620 kg (3,600 lbs) and the other 235 kg (522 lbs) making a total of 1,855 kg (4,122) for the year. Species composition of the 1,620 kg shipment is given in Table 7.1.3, in decreasing order of quantity. The data indicates that *H. nobilis* (black teatfish - ***bakelungal***) made up 60 per cent of the shipment.

Table 7.1.3: Species composition of one of the two shipments recorded in 1991.
(Source: DMR 1991 Annual Report).

Species	# pieces	Wt (kg)	Wt (lbs)	% total weight
Holothuria nobilis (***bakelungal***)	6,706	991	2,202	61.3
Thelenota ananas (***temtamel***)	1,042	227	504	14.0
H. fuscigilva (***bakelungal***)	822	184	409	11.4
Stichopus variegatus (***ngimes***)	1,948	141	313	8.7
Actinopyga sp. (***eremrum***)	263	35	78	2.2
H. scabra (***molech***)	130	21	47	1.3
Unidentified	93	13	29	0.8
A. mauritiana (***bad el eled***)	81	5	11	0.3
Total	**11,085**	**1,617**	**3,593**	**100.0**

Ilek (1991) presents price range data for the 5 most valuable species present in Palau, as detailed below:

Species	Common name	Palauan name	Price range ($/Kg)
Holothuria (Microthele) nobilis	black teatfish	***bakelungal***	11.44-28.84
Holothuria (Microthele) fuscogilva	white teatfish	***bakelungal***	19.27-37.71
Thelenota ananus	prickly redfish	***temtaml***	n.a.
Actinopyga mauritiania	surf redfish	***bad el eled***	7.76-21.69
Holothuria scraba	sandfish	-	n.a.

No export of beche-de-mer were recorded for 1992 and 1993.

From surveys and interviews conducted in 1991 by Matthews and Oiterong (1991), some informations were obtained concerning sea cucumber production by women on the subsistence and artisanal levels as presented in Tables 7.1.4 (a)-(d) taken directly from the same reference.

Table 7.1.4(a): Catch and effort information for ***cheremrum*** (*A. miliaris* and *A. echinites*) as collected by women. Figures represent state averages. (Source: Matthews and Oiterong, 1991).

	Aimeliik	Airai	Koror	Ngaraard	Ngardmau	Ngatpang	Ngeremlengui	Average
Average catch (pieces)	236	51	37	179	131	218	198	150
Time spent (hr)	2	2	2	2	2	3	2	2
Trips per month	3	3	2	2	3	3	3	3

Per cent sold	90	78	0	82	90	88	92	74
CPUE (pieces/hr)	118	24	19	81	66	73	86	68
Production per month (pieces)	708	153	74	358	393	654	594	450

Table 7.1.4(b): Catch and effort information for ***molech*** (*H. scabra*) as collected by women. Figures represent state averages. (Source: Matthews and Oiterong, 1991).

	Aimeliik	Airai	Koror	Ngatpang	Ngeremlengui	Average
Average catch (pieces)	93	37	30	100	100	72
Time spent (hr)	2	1	1	1	1	1
Trips per month	5	2	2	2	1	2
Per cent sold	84	36	0	90	0	42
CPUE (pieces/hr)	43	37	30	100	100	66
Production per month (pieces)	465	74	60	200	100	144

Table 7.1.4(c): Catch and effort information for ***ngimes*** (*S. variegatus*) as collected by women. Figures represent state averages. (Source: Matthews and Oiterong, 1991).

	Aimeliik	Airai	Koror	Ngaraard	Ngardmau	Ngatpang	Ngeremlengui	Average
Average catch (pieces)	78	100	83	116	114	133	190	116
Time spent (hr)	2	1	2	2	2	2	3	2
Trips per month	4	3	2	3	2	2	2	3
Per cent sold	70	72	29	75	88	84	87	72
CPUE (pieces/hr)	49	71	46	53	71	78	63	62
Production per month (pieces)	312	300	166	348	228	266	380	348

Table 7.1.4(d): Catch and effort information for ***irimd*** (*Holothuria* sp.) as collected by women. Figures represent state averages. (Source: Matthews and Oiterong, 1991).

	Aimeliik	Airai	Koror	Ngaraard	Ngardmau	Ngatpang	Ngeremlengui	Average
Average catch (pieces)	98	99	136	105	125	125	92	111
Time spent (hr)	2	2	2	3	3	2	5	3
Trips per month	1	2	1	1	2	2	7	2
Per cent sold	70	51	13	48	100	40	45	52
CPUE (pieces/hr)	54	50	68	35	42	63	18	47
Production per month (pieces)	98	198	136	105	250	250	644	222

Table 7.1.5 presents prices for sea cucumber species sold at the local markets by women. Because of the differences in sizes of species, no attempt has been made to compare prices per piece between the different species. However, of the five species recorded, selling of ***sekesakel*** earns more income per sale and specimens are sold individually.

Table 7.1.5: Market prices of sea cucumber species sold by women.. (Source: Matthews and Oiterong,, 1991).

Species	Unit price	Average amount sold	Income per sale
Cheremrum	$1.00-1.50 per 3 pieces	20 pieces	$7.00-11.00
Molech	$1.00 per 10 pieces	100 pieces	$10.00
Ngimes	$1.00-1.50 per 20 pieces	200 pieces	$10.00-15.00
Irimd	$1.00-1.50 per 10 pieces	100 pieces	$10.00-15.00
Sekesakel	$0.25 per piece	75 pieces	$18.75

7.1.3 Stocks Status

According to Ilek (1991), fishing pressure on sea-cucumber stocks had increased considerably over the past decade as fishermen enter the fishery to produce dried product for export, resulting in a general decline in abundance of the commercially valuable species. Subsistence fishing, especially on Koror and Airai reefs, is also considerable.

A two day transect survey conducted in May 1977 at Helen Reef resulted in 337 sea-cucumbers, principally *Holothuria sp.* (71 per cent), and *T. ananus* (28 per cent), found in 15.8 km of transects. The total standing population based on this survey was estimated to be 11,500-31,500 animals (Patris and McHugh, 1977).

A recent survey into sea-cucumber stock abundance using quadrat techniques along transect lines indicated generally low resource abundance in Koror and Airai, but this work was carried out on the main collection areas mentioned above, and was of short duration (Ilek, 1991). Highest population densities were recorded for *Thelenota ananas* in a protected reserve (Ulong Channel). Interviews with local fishermen active in the fishery in 1991 indicate that the relative abundance of sea-cucumbers is as follows, in decreasing order of abundance: *Holothuria nobilis, Thelenota ananas, H. fuscogilva, Actinopyga miliaris, Holothuria scraba and Actinopyga mauritiana.*

The University of Guam Marine Laboratory and Palau's Marine Resource Division were reportedly conducting a collaborative study on the abundance and distribution of the more important species of sea cucumber in the Republic. However, details or results of that study could not be found.

Future prospects for viable small-scale commercial fisheries based on sea-cucumbers exported to South-east Asia from Pacific Island states are promising (van Eys, 1990).]

During the survey by Matthews and Oiterong (1991), responses by women on sea cucumber species that are harder to find were as follows (figures represent percentages of the total number of women interviewed who indicated that they are harder to find):

	Aimeliik	Airai	Koror	Ngaraard	Ngardmau	Ngatpang	Ngeremlengui	Average
S. variegatus	0	25	33	0	0	33	0	13
A. miliaris & *A. echinites*	0	13	42	8	0	0	0	13
Holothuria sp.	0	0	0	33	0	0	0	7
H. verrucosa	0	0	0	25	0	0	20	7
H. scabra	14	0	8	0	0	0	0	4

The results of the survey conducted in 26 sites in 1991 within the Ngermeduu Bay area on the west coast of Babeldoab by Richmond (1991) are reported under the “Distribution” section. The author reported several sea cucumber species of commercial value were present in quantity on the sandflats at the inner mouth of the channel. The survey did not record numbers of sea cucumbers observed per site. Birkeland and Richmond (1992) reported that commercial sea cucumber species were less abundant than expected in several sites of the 47 surveyed from Velasco Reef in the north to Angaur in the south.

7.1.4 Management

Current legislation/policy regarding exploitation: Section 4 (7) of the Marine Protection Act of 1994 prohibits the commercial export of black teatfish (*Holothuria nobilis* - ***bakelungal***), white teatfish (*H. fusgogilva* - ***bakelungal***), sandfish (*H. scabra* - ***molech***, ***delal a molech***), prickly redfish (*Thelenota ananas* - ***temetamel***), and surf redfish (*Actinopyga mauritiana* - ***badelchelid***), except those cultured.

Section 4 (6) of the same Act prohibits fishing while using any form of underwater breathing apparatus other than a snorkel.

Section 6 of the Act authorises the Minister of Resources and Development to promulgate such regulationsas deemed necessary to protect the species identified in Section 4 from overharvesting.

Recommended legislation/policy regarding exploitation: The exploitation of sea cucumber resources in many Pacific island countries for the production of bêche-de-mer for export has almost all been characterised by “boom-and-bust” cycles. These have been mainly caused, not by the export nature of the development but rather it is by the absence of management strategies guiding the exploitation. Bêche-de-mer production has contributed not only as a foreign exchange earner but it has offered an alternative means of income generation for local communities. It is a potential resource for export development provided guidelines are in place to ensure sustainable utilisation.

However, the lack of available information on the population dynamics and existing fishery makes it difficult to establish management requirements. Baseline data on catch rates, areas of production, species and size composition of the catch, and fishing effort are required, especially for the areas of known high exploitation.

In Vanuatu, Chambers (1990) recommended the following:

> "the correct strategy with regard to bêche-de-mer harvesting (in Vanuatu) is to collect intermittently from sites which are both large enough and support sufficient densities of commercial species to be economic. Stocks should then be left for however long it takes them to recover to economic levels."

Conand (1989) and Preston (1993) describe several options available for the management of sea cucumber resources for sustainable utilisation. One such means is the application of minimum size limits regulations. Conand (1989) notes:

> "the seasonal fishing ban can hinder exports, since the buyers on the Hong Kong and Singapore markets have always insisted that suppliers should be regular. A longer closed season can be considered where yields drop drastically. It is difficult to enforce closures of fishing zones and their boundaries must respect local customs, when these non-mobile resources are exploited under a system of traditional ownership. Limiting fishable sizes tends to favour recruitment. When applied to catches, such restrictions are hard to verify but when applied to the processed product, they are realistic and can be checked through exports. The limits should be set out on the basis of scientific results relating to size at first sexual maturity".

Length and weight values for processed bêche-de-mer with corresponding total wet length and weight at first sexual maturity have been calculated for some species with commercial value. These can be used as a basis for setting legal size on the processed product (Conand, 1989). However, the author notes "that these are minima and that better knowledge about growth remains essential so as to be able to leave individuals undisturbed for one or more breeding seasons before harvesting them".

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Appendix 7.1.1: Biological Information on some species of sea-cucumbers exploited commercially in the Pacific (Conand 1989; and Preston, 1993).

H. scabra and *H. scabra* variety *versicolor* (the "sandfish"): Sexes are separate and sex-ratio does not significantly diverge from 1:1, with individuals showing a single annual sexual cycle. Reproduction is sexually and takes place mainly during the warmer months, peaking in October-December, with absolute fecundity ranging from 9-12 x 10^6 oocytes per gram of ovary weight. Sizes at first sexual maturity for *H. scabra* and *H. scabra* var. *versicolor* were found to be 140 g and 320 g drained weight respectively with corresponding lengths of 16 cm (total weight 184 g) and 22 cm (total weight=490 g). Growth is difficult to measure, however, Shelley (1985) studied the species length-frequency and concluded that in the size range of 10-25 cm *H. scabra* were growing at 0.5 cm per month, equivalent to an average monthly whole weight increase of 14 g. Juveniles (recruits) are rarely seen and Shelly (1981 - quoted in Preston, 1993) did not find any juveniles of *H. scabra* less than 60 mm in length. Length-weight relationship for *H. scabra* has been calculated by Conand (1989) to be Log W = 2.28 Log L-6.35 (correlation coeficient=0.78) and Shelly (1981) $W = 3.06L^{1.61}$ (correlation coeficient=0.75) while that for *H. scabra* var *versicolor* is Log W=2.26 Log L-5.97 (correlation coefficient 0.76) (Conand, 1989). (L in cm and W in g).

H. nobilis (the "black teatfish") and *H. fuscogilva* (the "white teatfish"): Sexes are separate with a ratio of about 1:1. Reproduction is sexual. A five-stage maturity scale has been identified which is typical for the family Holothuriidae and details are given in Conand (1989). Male and females develop synchronously and for *H. nobilis*, spawning occurs during the cold months (June-August) while *H. fuscogilva* spawns in the warmer months, peaking in November-January. Spawning periods for these two species do not overlap. (Fission can be induced in *H. nobilis*). Absolute fecundity for *H. nobilis* was estimated to be between 13 and 78 million oocytes with *H. fuscogilva* recording lower fecundity of between 8 and 14 million oocytes per gram of ovary weight. Total weights at first sexual maturity were estimated to be 800 g and 1,175 g for *H. nobilis* and *H. fuscogilva* respectively. Juveniles are only rarely seen. Length-weight relationship was calculated by Conand (1989) for *H. nobilis* to be Log W=2.34 Log L-6.39 (correlation coefficeint=0.80) and for *H. fuscogilva* W=11.94 L-2712 (correlation coefficient=0.70). (L in cm and W in g).

A. echinites (the "deep-water redfish"): Sexes are separate with a ratio of about 1:1. Spawning takes place during the warmer months, peaking in January-February, with absolute fecundity ranging from 4 to 25 million oocytes. Drained weight at first sexual maturity is 75 g corresponding to total weight of 90 g and total length of 12 cm. Shelly (1985) estimated the growth parameters of this species in PNG to be; L_∞= 23 cm, K=0.78 with a monthly length increase of 0.60 to 0.9 cm corresponding to a monthly weight increase of 1 to 5 g. Conand (1988 - quoted in Preston, 1993) gave estimates for growth and mortality parameters to be: L_∞=29.5 cm, K=0.09 and M=0.64. Length-frequency data for this species in New Caledonia showed the absence of animals less than 40 mm in length (Conand 1986, quoted in Preston, 1993). Length-weight relationship was calculated as $W=0.68\ L^{2.00}$ (correlation coefficient =0.61) (Shelley, 1982, quoted in Preston, 1993).

A. miliaris (the "blackfish"): Little is known about this species. Some observations on spawning in natural environment during February and early March on the Great Barrier Reef suggests that reproduction takes place in the hot season. Measurements of small specimens, in July 1982, weighing 5 to 30 g (3 to 9 cm) indicated their growth rates were approximately 1 cm (5 g) per month assuming these were spawned in February of the same year. The Length-weight relationship for this species was calculated by Conand (1989) to be $W=0.824 \times 10^3\ L^{2.441}$ (correlation coefficient=0.96).

T. ananas (the "prickly redfish"): Spawning occurs during the warmer months, probably from January to March. Fecundity is not high with absolute fecundity ranging from 2 to 7 million oocytes per gram of ovary weight. First sexual maturity is reached at total length of 30 cm (total weight of 1,230 g and drained weight of 1,150 g). Conand (1988, quoted in Preston, 1993) gave growth parameters for this

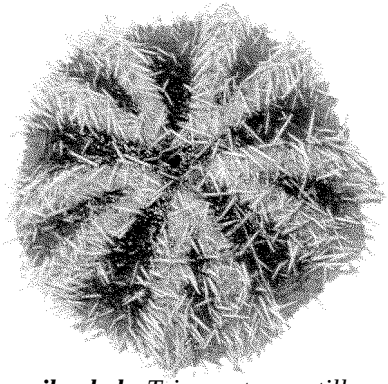
species as; L_{∞}=66.3 cm, K=0.20, M=0.63 and Length interval=160-640. The species is long-lived, with a low mortality and high asymptotic length. In New Caledonia no animals were recorded with lengths less than 180 mm. Using growth and mortality estimates, Conand (1988, quoted in Preston, 1993) estimated the biomass of theoretical cohorts of this species as it aged which enabled her to estimate the average length at which the biomass of the cohort is greatest and fishing will give the highest yields ("critical length"). The critical length was found to be 28 cm, slightly lower than the length at first sexual maturity. The length-weight relationship was calculated to be $W=1.27 \times 10^{-3} L^{2.441}$.

H. atra (the "lollyfish"): The lollyfish is the most common and abundant species on the tropical shore. Asexually reproduction through fission is thought to be very important in this species and the products of fission may comprise up to 70 percent of the population. Growth and mortality parameters were estimated in Conand (1988-quoted in Preston, 1993) as: L_{∞}= 324 mm, K=0.11, M=1.02 and Length interval=130-220. The length-weight relationship has been calculated to be Log W=2.13 Log - 5.64 (correlation coefficient=0.90).

A. mauritiana (the "surf redfish"): This species is widespread in the tropical Indo-Pacific region and its habitat is restricted to outer reef flats subject to strong waves and currents. Its diet is mainly of plant debris. Reproduction is sexual but fission can be induced in this species. Absolute fecundity was estimated to be between 22-33 million oocytes per gram ovary weight. The growth and mortality parameters have been calculated to be L_{∞} = 340, K=0.12, M=1.45, and length interval=70-280 (Conand, 1988, quoted in Preston, 1993).

7.2 Sea urchins

7.2.1 The Resource



ibuchel *- Tripneustes gratilla*

Species present: Sea urchins are collected for subsistence fishery and rarely reach the market. Species of importance given in DMR (1992) include: *Tripneustes gratilla* (short spine sea urchin - ***ibuchel***), *Hemicentrotus pulcherrinus* (***ibuchel***), *Strongylocentrotus pileolus* (***ibuchel***), *Diadema setosum* (***choalech***) and *Toxopneustes pileolus* (***duduomel***). They are collected every time large numbers are found and are a popular food item.

Distribution: ***Ibuchel*** are usually found in areas of eelgrass beds and corals where the water is clearer while ***choalech*** are usually found in the reef around Palau and prefer areas of ample currents.

Matthews and Oiterong (1991) reported that ***ibuchel*** is one of the invertebrates typically collected by women in the seven states they surveyed i.e. Aimeliik, Airai, Koror, Ngaraard, Ngardmau, Ngatpang, and Ngeremlengui. It was indicated as one of the invertebrates collected in greatest numbers by women in Ngeremlengui. ***Ibuchel*** is one of the most important marine invertebrates in Anguar while both ***ibuchel*** and ***choalech*** are important in Ngeremlengui (Rochers and Matthews, 1992).

During the rapid ecological assessment of 47 sites from Velasco Reef to Angaur, Birkeland and Richmond (1992) found echinoids to be scarse, especially Kayangel, where only *Echinostrephus* and evidence of *Heterocentrotus* were recorded and species of *Echinometra*, *Diadema*, *Echinothrix* absent. Species recorded and the number of sites they occurred in during the survey are as follows:

Species	# Sites species occurred in	Species	# Sites species occurred in
Brissus latecarinatus	1	*Eucidaris metularia*	1
Echinometra mathaei	1	*Heterocentrotus mammillatus*	1
Echinostrephus aciculatus	14	*Hespilia globulus*	1
E. molaris	3	*Parasolenia gratiosa*	1
		Tripneustes gratilla	?

The only site with abundant echinoids was Saipan Harbour on Angaur. However, in a survey, during June, 1991, of 26 sites in the Ngermeduu Bay area, Richmond (1991) recorded eleven species of sea urchins and sand dollars. The number of sites in which each species were located were given by the same author as summarised below (those recognised as important species are in bold):

Species	# Sites occurred in	Species	# Sites occurred in
Clypeaster japonicus	2	*Echinothrix calamaris*	1
Diadema savignyi	2	*E. diadema*	2
D. setosum	**2**	*Heterocentrotus mammillatus*	6
Echinometra mathaei	1	***Toxopneustes pileolus***	**1**
E. oblonga	1	***Tripneustes gratilla***	**1**
Echinstrephus aciculatus	2		

Biology and ecology: During the survey conducted by Matthews and Oiterong (1991) some collectors indicated that sea urchin tend to aggregate in June and that the gonads are ripe then especially one or two days before and after the full moon. Few indicated that they also collect large quantities in November to December.

7.2.2 The Fishery

Utilization: Sea urchins are collected mostly for subsistence. Rochers and Matthews (1992) reported that ***ibuchel*** is one of the the most commercially important invertebrates in Anguar while both ***ibuchel*** and ***choalech*** are important invertebrate species in Ngeremlengui. They are also collected when requested by individuals or restaurants. The survey conducted by Matthews and Oiterong (1991) in seven states showed that ***ibuchel*** is one of the invertebrates typically collected by women during reef gleaning and that it is one of the invertebrates collected in greatest numbers in Ngeremlengui but solely for subsistence. Table 7.2.1 records the percentages of women interviewed that indicated ***ibuchel*** as an invertebrate typically collected.

Table 7.2.1: Percentages of women indicating that ***ibuchel*** is typically collected during their reef gleaning. (Source: Matthews and Oiterong, 1991).

	Aimellik (n=7)	Airai (n=8)	Koror (n=12)	Ngaraard (n=12)	Ngardmau (n=7)	Ngatpang (n=3)	Ngeremlengui (n=5)	Total (n=54)
Ibuchel	29	63	17	58	71	67	40	46

Matthews and Oiterong (1991) reported that women collect as much ***ibuchel*** as they can during June when these sea urchins are found in large numbers containing large ripe gonads. Other sea urchin species, e.g. *Diadema setosum* (***choalech***) are seldom collected because of their long spines thus taking longer to collect and prepare, which often involves a whole day. However, this species seems to be well liked as a fisherwomen interviewed by the above authors claimed that she could not collect enough to meet demands from buyers. ***Choalech*** are collected using tongs and up to 1,000 animals are collected at a time. They are placed in a large basket made of chicken wire with bamboo handles on two opposite sides. The full basket is shaken under water until the long spines are broken off. The gonads are extracted and those from 12 to 18 urchins are placed in a large empty urchin shell and sold for $2.50.

Production and marketing: No figures are available on the level of sea urchin production both on the subsistence and commercial levels. Harvesting, however, is confined to periods when gonads are ripe. Matthews and Oiterong (1991) recorded market prices for species sold by women as presented in Table 7.2.2. The figures indicate that for a defined unit used in the sales of invertebrate species, ***choalech*** has the third highest unit price, after ***chemang*** and ***kelat***, although it involves the highest number of individual animals per unit. However, it is the highest income earner per sale of the species listed.

Table 7.2.2: Market value of species sold by women. (Matthews and Oiterong, 1991).

Species	Unit price	Average amount sold	Income per sale
Sea urchin (*choalech*)	**$2.50 per 15 piecces**	**750 pieces**	**$125.00**
Ark shell (***kikoi***)	$1.25 per 10 pieces	500 pieces	$62.50
Mangrove crab (***chemang***)	$5.00 per lb	8 lbs	$40.00
Coconut crab (***kelat***)	$2.75 each	8 pieces	$22.00
Sea cucumber (***sekesakel***)	$0.25 each	75 pieces	$18.75
Sea cucumber (***molech***)	$1.00 per 10 pieces	100 pieces	$10.00
Sea cucumber (***cheremrum***)	$1.00-1.25 per 10 pieces	80 pieces	$8.00-10.00
Giant clam (***kim***)	$1.00-1.50 per 3 pieces	20 pieces	$7.00-11.00
Giant clam(***oruer***)	$1.00-1.50 per 9 pieces	72 pieces	$8.00-12.00
Sea cucumber (***ngimes***)	$1.00-1.50 per 20 pieces	200 pieces	$10.00-15.00
Sea cucumber (***irimd***)	$1.00-1.50 per 10 pieces	100 pieces	$10.00-15.00
Land crab (***rekung***)	$ 0.35-0.50 per lb	50 lbs	$17.50-25.00
Smoked or fried fish	$2.25-2.50 per lb	40 lbs	$90.00-100.00
Fish	$0.85-1.10 per lb	50 lbs	$42.50-55.00
Mangrove clam (***ngduul***)	$0.10-0.25 each	200 pieces	$20.00-50.00

7.2.3 Stocks Status

No information is available on the status of the sea urchin resource in Palau. However, interviews conducted in 1991 by Matthew and Oiterong showed that, overall, about 40 per cent of the women interviewed in seven states in Palau stated that ***ibuchel*** is harder to find and that 2 per cent (from Koror only) indicated that ***duduomel*** is harder to find. The interview results are given in Table 7.2.3, by state. The highest percentages indicating ***ibuchel*** as being harder to find were from Ngaraard and Ngatpang (60 per cent each), followed by Ngardmau and Ngeremlengui.

Table 7.2.3: Per cent response indicating species which are harder to find. (Source: Matthew and Oiterong, 1991).

	Aimellik (n=7)	Airai (n=8)	Koror (n=12)	Ngaraard (n=12)	Ngardmau (n=7)	Ngatpang (n=3)	Ngeremlengui (n=5)	Total (n=54)
Ibuchel	14	13	42	67	57	67	40	43
Duduomel	0	0	8	0	0	0	0	2

Out of 26 sites surveyed by Richmond (1991) in the Ngermeduu Bay area, D. setosus was observed in only 2 sites, while *To. pileolus* (***duduomel***) and *Tr. gratilla* (***ibuchel***) were each observed in one site.

During the rapid ecological assessment of 47 sites from Velasco Reef to Angaur, Birkeland and Richmond (1992) found only *Echinostrephus* and evidence of *Heterocentrotus* in the area and that species of *Echinometra*, *Diadema*, *Echinothrix* were absent.

Maragos (1994) reported that in Ngchesar in the Tab area, sea urchins have disappeared, probably as a result of the dredging which has been operating in the area since 1980.

7.2.4 Management

Current legislation/policy regarding exploitation: There is no specific legislation that deals with the exploitation of sea urchins.

Recommended legislation/policy regarding exploitation: There seems to be no need for any specific legislation with regards to the exploitation of the sea urchin resource. A major consideration involves the general conservation of habitat which should be dealt with under destructive fishing methods and management of land-based developments.

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7.3 Sponges

7.3.1 The Resource

Species present: Species of the genera *Hippospongia* and *Spongia* are the main commercial species. Bakus (1990) lists the following species from Palau:

Asteropus sarassinorum, Bysidea herbacea, Xestospongia pacifica, Dysidea sp., Cinachyra sp., Stylotella urantium, Neofibularia sp., Axinella sp., Hyrtios sp., Jasplakina nux.

In a survey of macroinvertebrates in the Ngermeduu Bay area on the west coast of Babeldoab Island, Richmond (1991) recorded the following sponge species as present there:

Dysidea sp., *Heteronema erecta*, *Phyllospongia foliascens*, *Psammaplysilla purpurea*, *Stylotella agminata*, *Spongia officinalis* and *Terpios* sp.

Sponge species identified by Birkeland and Richmond (1992) during their rapid ecological assessment of 47 sites from Velasco Reef to Angaur include:

Adocia turquoisia, *Asteropus sarasinorum*, *Callyspongia* sp., *Clathria reinwardti*, *Cliona* sp., *Cribrochalina olemda*, *Dysidea herbacea*, *Dysidea* spp., *Heteronema erecta*, *Ircinia* spp., *Phyllospongia foliascens*, *Psammaplysilla purpurea*, *Spirastrella coccinea*, *Spongia officinalis*, *Stylotella aqminata*, *Terpios fugax*, *T. viridis*, *Terpios* spp., and *Xestospongia exiqua*.

The farming of bath sponge initiated in 1935 was believed to have used the species, *Spongia officinalis* from local stocks (Maragos, 1994).

Distribution: There are more than 5,000 species of sponge world-wide, of which only around 15 have some commercial value (Josupeit, 1990). They grow in a wide variety of habitats, ranging from sea depths of 0-30 m. Field sampling of sponges was carried out on West and South reefs around Babelthuap, and Peleliu during 1990, which indicated a rich and diverse sponge fauna (Bakus, 1990). Birkeland *et al*. (1990, cited in Maragos, 1994) reported that sponges were common off the Melekeok Reef flats but thrive in many lagoon environments in Palau particularly off Babeldaob. Birkeland and Richmond (1992) during the 1992 Rapid Ecological Assessment noted that sponges, especially ***Dysidea*** and ***Terpois***, dominated some of their 47 study sites from Valesco Reef to Angaur. At one site, the substratum was dominated by sponges, *D. herbacea* and *T. viridis*. The authors noted that these species may have rapidly occupied cleared substrata following the typhoon in November, 1990. The number of sites in which each species was recorded were as follows:

Species	# Sites occrred in
Adocia turquoisia	4
Asteropus sarasinorum	12
Callyspongia sp.	1
Clathria reinwardti	12
Cliona sp.	3
Cribrochalina olemda	3
Dysidea herbacea	35

Species	# Sites occurred in
Dysidea spp	7
Heteronema erecta	22
Ircinia spp	4
Phyllospongia foliascens	13
Psammaplysilla purpurea	9
Spirastrella coccinea	2
Spongia officinalis	2

Species	# Sites occurred in
Stylotella aqminata	13
Terpios fugax	9
T. viridis	5
Terpios spp	6
Xestospongia exiqua	3

In a survey of macroinvertebrates in 26 areas within the Ngermeduu Bay area in 1991, Richmond (1991) recorded the following sponge species with the corresponding number of sites in which they were found:

Species	# Sites occurred in
Dysidea spp.	8
Heteronema erecta	10
Phyllaspongia foliascens	6
Psammaplysilla purpurea	7

Species	# Sites occurred in
Stylotella aqminata	5
Spongia officinalis	8
Terpios spp.	7

The same author noted that the sites closest to the mouth of Ngermeduu Bay had an abundance of suspension feeders including sponges.

Biology and ecology: Commercial sponges are slow growing. A cut sponge planted in Palau was reported to take a minimum of 18-24 months to reach minimum commercial size, which is as large as a fist (Cahn, 1948, cited in Croft, 1989). Work is required to refine culture techniques, and growth studies for varying habitats (Uwate *et al.*, 1984). However, culture techniques and processing have been vastly improved by the Pohnpei (FSM) sponge culture project. Sponges are non-motile, filter-feeding invertebrates with high regenerative capability, hence they can be cultured from small cuttings. Sponges are one of the main food items of the hawksbill turtles.

7.3.2 The Fishery

Utilization: Natural commercial sponges are in high demand and are used mainly for bathing and the application of cosmetics because of their absorbancy and softness (Wilkinson, 1989). They are also used in hospitals, in industry as lubricant applicators, by artisans and craftsman and for general household use (Lindsay, 1994). Sponges are generally collected by diving, either free or using SCUBA. Collected sponges are left to die, then returned to seawater in order to remove the outer pellicle (skin) easily. The sponge is then beaten, bleached and dried. The end product is light in weight, high in value and non-perishable. The Caribbean and Mediterranean are major producing areas of natural sponges. Main markets are in the US and Europe. Prices paid depend on the diameter of the sponge, large (>15cm) sponges sold for around $21.20 in 1988 in France. The commercial sponge farming in Pohnpei (FSM) seems to be successful technically.

Sponges are a principal food of hawksbill turtles (Maragos, 1994). No commercial fishery for sponges exists in Palau. Subsistence uses, if any, are not documented. Farming of bath sponge, *S. officinalis*, in Palau was initiated by a Japanese in 1935 using local stocks. This operation was terminated at the outbreak of World War II (Maragos, 1994). A proposal to re-establish sponge culture was submitted to Division of Marine Resources in 1990. Objectives were to locate existing stocks of bath sponge, *S. officinalis*, in Palau, train Palauans in cutting and culturing techniques, establish a demonstration farm on the sea-bed off MMDC, and to determine the feasibility of sponge-clam farming in Palau. No action has been taken yet. Palau seems ideally placed, with the presence of considerable in-country expertise in mariculture, to undertake sponge culture.

Production and marketing: Japanese scientists initiated the culture of bath sponges 50 years ago in Micronesia, but the advent of the war prevented commercial operations (Smith, 1988). The sponge culture initiated by Japanese interests in 1935 produced marketable sized sponges in 18-24 months. However, few records of this work exist (Cahn, 1948). The enterprise ceased at the outbreak of the Pacific war, and was not re-vitalised.

Recent disease outbreaks on sponges in the Mediterranean has lead to a short-fall of supply to the European market. Japan and the USA appear well supplied at present (Josupeit, 1990). However, natural sponges seem to be in high demand. However, local tourist markets for sponge do exist and can be more lucrative.

No information on production on any level exists in Palau.

7.3.3 Stocks Status

There is no commercial harvesting of sponge in Palau. The sponge resource can therefore be considered virgin.

7.3.4 Management

Current legislation/policy regarding exploitation: The harvesting of sponges is controlled in Palau under Title 24: Environmental Protection, chapter 12: Protected Sea Life, subchapter II: control of sponge harvesting, of the Palau National Code, as follows:

(a) no sponges (unless??) artificially planted or cultivated shall be taken or molested except by permission of the President;
(b) violators face fines of up to $100 and/or 6 months in jail.

Recommended legislation/policy regarding exploitation: No additional legislation is required for the wild stock as it is not exploited at present. It seems that the word “except” or “unless” is missing from (a) above under “current legislation/policy regarding exploitation”, between the words ‘sponge’ and ‘artificially’. As the sentence stands, it means that only the taking of wild sponges is allowed. The sentence should probably read “No sponges EXCEPT artificially planted or cultivated shall.....”.

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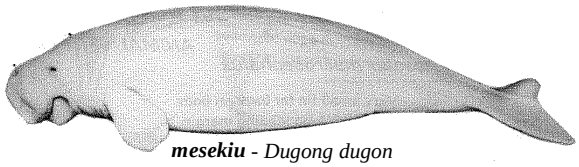
7.4 Dugongs (*mesekiu*)

7.4.1 The Resource



mesekiu *- Dugong dugon*

Species present: A single species, *Dugong dugon* (the dugong - ***mesekiu***), exists in Palau.

Distribution: "The dugong's range extends throughout the tropical and subtropical coastal and island waters of the Indo-Pacific from East Africa to Solomon Islands and Vanuatu, and between about 26-27° north and south of the equator. The distribution spans the waters of over 40 countries. Over much of this range, dugongs are now believed to be represented by relict populations separated by large areas of unsuitable habitat or regions where they are close to extinction or extinct" (Nishiwaki and Marsh, 1985, quoted in Marsh *et al*., 1992). The species occupies an important position in shallow-water ecosystems along the subtropical and tropical coasts of the Indian and Western Pacific Oceans (Heinsohn *et. al.*, 1977; Nishiwaki and Marsh, 1985). They inhabit sheltered shallow bays and channels, and feed extensively on sea grass growing to a depth of up to 30 m below low-water datum. In the Pacific region, they are present in large numbers in some parts of Papua New Guinea (Hudson, 1977), New Caledonia and the Solomon Islands (Nishiwaki and Marsh, 1985), Yap and Guam (Nishiwaki *et al*, 1979), and Palau (Brownell, *et al* 1981). Large populations of dugongs, perhaps the most numerous remaining in the world, are found in Australia (Anderson, 1986; Heinsohn *et al* 1978; Marsh, 1986; Prince *et al* 1981). The Vanuatu archipelago forms the easternmost limit of the dugong's distribution (Marsh, 1983).

A small, isolated population occurs in Palau. Aerial surveys carried out in 1977, 1978, 1983 and 1991 indicate that the population is small and its distribution has remained constant. Animals were observed throughout the archipelago, but with relatively few individuals South of Malakal Harbour.

"Surveys, including that in 1991 by Marsh *et al*. (1992), did not report dugongs in the main lagoon, barrier and ocean reefs north of Babeldoab. However, dugongs regularly forage from the extensive seagrass beds off the northern end of Babeldaob, Ngos Reef, the islands of Ngerchur and Ngerkeklau, and lagoon waters off the island. The highest densities of dugongs is reported along the west side of Ngerchelong peninsula, just south of the northern lagoon". Marsh *et al*. (1992) reported dugongs as regularly visiting the fringing reefs and lagoons off eastern Babeldaob with more frequent sightings where well-developed seagrass beds are present, particularly Ngerchelong, Ngiwal, Ngchesar and eastern Airai. Large populations have also been reported off Ngardmau, Aimeliik and particularly in lagoon and near the western barrier reef, as far south as Ngerdiluches.

Maragos (1994) reported that dugongs feed on seagrass beds in many areas of the south lagoon. "Many were reported in Ngerderrak Reef-Ngemelachel Harbour area, and some off Sar Passage, Denges Pass, Ngermedang Island, Ngeruktal Island, Ulbesechel Island, and the lagoon near Mutiaur Point off the southwestern barrier reef". Grazing typicaly occurs in lagoonal areas with relatively low seagrass biomass in waters more than 7 m deep (Marsh *et al*., 1992).

Biology and ecology: Distantly related to the elephant, the dugong (*D. dugon*) is a massive but inoffensive herbivorous mammal that is restricted to the sea. It is the only herbivorous mammal species that is strictly marine. It is the only existing member of the family Dugongidae. The only other member in the family, Steller's sea cow, was hunted to extinction within 30 years of its discovery in the 18th century. There are only four remaining members of the mammalian order sirenia (seacows) which include *D. dugon* and three manatee species, *Trichechus inunguis* (the Amazonian manatee), *T. senegalensis* (the West African manatee) and *T. manatus* (the West Indian or Caribbean manatee). Man is the only major predator, and due to hunting and habitat destruction, the species is rare or endangered over most of its range. Reproductive and recruitment rates are poorly known for this species in the Pacific. Marsh *et al.* (1984) estimate that the dugong matures around 10 years of age, and produces one

calf every three years. Marsh (1992) noted that on the average, one female has a calf every five years. However, estimates of the average interval between calves for various Australian populations range from approximately 3-7 years. The gestation period is about one year and a single calf is usually born. Although a calf begins to eat seagrasses soon after birth, it can suckle for up to 2 years and the cow-calf bond seems to be extremely well-developed. Studies in Australia have investigated the trophic interaction of dugongs as primary herbivores with their environment. Analysis of the stomach contents indicate that they consume a wide variety of tropical and subtropical seagrasses preferring to feed on small delicate seagrasses and dig up the whole plant including the rhizomes, making a distinctive feeding trial. Algae are also eaten. Surveys by Marsh *et al*. (1992) in the Koror area near the lighthouse indicated dugong feeding trails at depths of 7-10 m in a mixed-species seagrass bed containing *Enhalus acoroides*, *Thalassia hemprichii*, *Halodule uninervis*, *Halophila ovata*, *Cymodocea rotundata* and *Syringodium isoetofolium*.

Dugongs are very long-lived having a potential life span of 60-70 years or more (Marsh and Naika, 1983). Because dugongs are such slow breeders, mortality must also be very low for a dugong population to be maintained. By analogy with other wild mammals, mortality is expected to be higher in juveniles than in adults. Adult survivorship therefore needs to be very high (of the order of 95% per year or more) for population maintenance. Thus dugongs are extremely susceptible to over-exploitation which is obviously why their status is now so vulnerable.

7.4.2 The Fishery

Utilization: *D. dugon* is listed by the International Union for the Conservation of Nature (IUCN) as vulnerable, and it is severely depleted or extinct from much of its original range (Nishiwaki and Marsh, 1985). Hunting of dugongs for food in Palau has taken place for many years; traditionally hunting was carried out with heavy spears (Kramer *In:* Johannes, 1981). Rathbun *et. al.* (1988) cite the use of turtle spears, firearms and dynamite. Animals killed have presumably been for domestic consumption. Interviews with local people indicate that poaching, usually at night during full-moon, is an on-going problem (Marsh *et al*., 1992).

Dugong meat is consumed at home and carved ribs used in the production of jewelry.

Production and marketing: Marsh *et al*. (1992) conducted interviews with 5 dugong hunters and knowledgeable residents from Koror, Peleliu, Anguar and Babelthaup in 1991 with the following results:

> *Hunting place*: Dugongs are poached regularly with 4-7 hunting teams (at least two men each) operating out of Koror. Hunting is mainly in Koror area especially the region close to the lighthouse. Hunting also takes place along the west coast of Babelthaup.
>
> *Catch method*: Hunting is performed at night from dinghies powered with 35 hp outboard motors. Most are harpooned after being chased. Use of dynamite seem to have ceased in 1978. Hunters claimed never used nets but some knew nets are an effective method.
>
> *Catch*: 11 dugongs were claimed by one informant as being killed in 1990 near Babelthaup and 2 near Kayangel. Residents in Peleliu claimed last dugong killed there was in 1984.
>
> *Use*: Hunting is for meat but more for sport than economic necessasity and that the illegality of dugong hunting adds to the thrill. Hunting is often timed to obtain meat for special occasions. Meat is frozen for home consumption, particularly for festive occasions, rather than sold. Meat may be served to guests without informing them. Many people, especially women disapprove of killing dugongs. Atlas vertebrate for jewelry is now of minor relevance

though one hunter used to give dugong ribs to a carver. Jewelry locally crafted from dugong ribs is on sale at four stores in Koror.

No actual data is available on level of exploitation.

7.4.3 Stocks Status

Dugong numbers have greatly reduced in the recent past and in many areas it is now extinct or greatly reduced in numbers. Declines have been caused by overhunting, accidental mortality from boats and fishing nets, pollution and loss of the seagrass beds which provide its stable food (Chambers *et al* 1989).

In Micronesia (Yap, Guam and Palau) dugongs are rare and must be considered in danger of extinction. In Melanesia (PNG, Solomon Islands, New Caledonia and Vanuatu) dugong numbers have decreased in recent years and the long-term prospects of the dugong in Papua New Guinea must be considered as uncertain unless the hunting rate is reduced (Chambers *et al*, 1989). In New Caledonia and Solomon Islands the status of the dugong is not known, but it is hunted in both countries.

The first aerial surveys of dugongs in Palau were carried out by Brownell *et. al.* (1981) in 1977 and 1978. The population was estimated to total around 50 animals, which was considered to be too small to sustain continued poaching.

Maragos (1994) reported that dugong distribution in Palau used to range as far south as Peleliu and as far north as Kayangel. However recent surveys indicate that they are restricted to the main islands.

Rathbun *et al.* (1988) describe the results of an aerial survey carried out in 1983 to assess the dugong's status and distribution. Suitable dugong habitat was estimated at 1,380 sq. km within the country, with very rich sea grass beds; the dugong population therefore appears not to be resource limited. The 1983 survey spotted a maximum of 7.5 animals per flight hour over the entire archipelago, with lowest counts recorded over the Southern areas and highest along the Western side of Babelthuap Island. These figures indicate a very low population level in Palau as compared with Australian populations of the species where up to 150 animals per flight hour have been recorded under similar survey conditions, indicating that the dugong resource in Palau is small, a result confirmed by another survey carried out in 1991.

The aerial survey conducted in August 1991 sighted only 26 dugongs (including 4 calves). The rate at which dugongs were sighted per unit flight-time was lower than that for any other survey (Marsh *et al*., 1992). Using the annual sustainable level of exploitation of 2 per cent females, the same authors calculated that at least 250 female dugongs (500 dugongs altogether) are required to maintain harvesting 5 female dugongs a year. The current population in Palau waters is believed to be unable to sustain this level of exploitation and that unless the poaching is stopped urgently, dugongs will become extinct in Palau.

7.4.4 Management

Current legislation/policy regarding exploitation: Throughout its range, dugongs are considered an endangered species (IUCN,1982). In Palau, it is protected under the Palau National Code, Title 24, Environmental Protection, Division 2: Wildlife Protection, Chapter 12: Protected Sea Life, Subchapter IV: Dugongs, § 1231 Conservation of dugongs, as follows:

(a) No person shall kill, trap, capture, wound, possess, transport, restrain or otherwise have under his control any dugong or part or product thereof, except as provided for in subsections (b) and (c).

(b) The President may, upon cause shown, grant a permit for the capture, restraint, or transportation of dugong subject to such terms, conditions and restrictions as he may deem fit and proper.
(c) If any dugong is accidentally caught in a fishing net,trap, wire, or by any other fishing method, it must be released immediately if still alive. If found dead in such fishing apparatus, the person who found it must notify the chief executive officer of the state where found. The chief executive officer shall ascertain that the dugong was caught inadvertently and found dead and, after establishment these facts, shall release the dead dugong to the person who found it.
(d) A person found guilty of violating this section shall, upon conviction, be imprisoned for a of not more than six months, or fined not more than $50.00, or both for the first offense; for every offence thereafter, the convicted person shall be imprisoned for not more than one year, or fined not more than $100.00, or both.

The dugong is also listed as endangered on the IUCN list of endangered species.

Recommended legislation/policy regarding exploitation: Small isolated populations of animals such as the dugong, which has low fecundity and slow reproductive rates are very susceptible to extinction through over-exploitation. The Palauan dugong population is subject to persistent poaching. Members of the IUCN Sirenia Specialist Group who visited Palau in 1991 believe that unless the law is enforced, the species faces extinction in Palau.

Long-term monitoring of population numbers and mortality levels in Palau, coupled with a public education and awareness exercise on dugong conservation, and a reduction in the level of human exploitation are necessary for preservation of the native population (Rathbun *et al.*, 1988). Enforcement of existing legislation must be a priority.

The most serious threat to dugongs in Palau is poaching. Marsh *et al*. (1992) made the following recommendations:

* strengthen and enforce the legislation banning the hunting of dugongs with application of more severe laws such as confiscating the hunter's boat and motor;
* national conservation law officers should be appointed as soon as possible;
* the present law allowing a person who finds a dugong dead in fishing apparatus to keep it after reporting the incident to the relevant official should be modified to prevent hunters from using it to circumvent the ban on poaching;
* the illegal sale of jewelry made from dugong bone be stopped as soon as possible;
* launch a culturally appropriate public education program to act as a deterrant against poaching by making it less socially acceptable. Public awareness could be increased through various means like the media;
* incorporate information on dugong conservation in school curriculum;
* map the sub-aquatic vegetation of Palau which can be used to determine, together with information on the distribution of dugongs, design and siting of marine reserves. Small reserves set aside specifically for dugongs would not be appropriate as individual animals move through much of the archipelago.

Maragos (1994) recommended:

* a complete ban on all hunting, increase enforcement of existing laws, promotion of a widespread educational program and local (State) government empowerment.
* establishment of protected areas for dugongs which must be large enough to accommodate for the movement and range of the animals. Two such areas are, northwest or western Babeldaob and southern lagoon of the main islands.

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7.5 Corals (including precious corals)

7.5.1 The Resource

Species present: An estimate of 425 stony coral species belonging to 78 genera and 6 subgenera have been recorded in Palau since 1938. Most of these individual species are listed in Maragos (1991). These numbers are comparable to those of the highest coral diversity areas and the Palau archipelago supports more species, genera, and families of corals than any other area in Micronesia or Polynesia (Maragos, 1994). The genera *Acropora* and *Porites* dominate coral occurrence on reefs in Palau. Some species of soft corals found in Palau are given under the "Distribution" section of this profile.

Antipathes dichotoma (black coral - ***ngesngas***), *Corallium elatius* and *C. monojoi* (***ngesngas***) corals have been identified as occuring in Palau waters. Another black coral species found in Palau resembles the fern black coral, *A. ulex*, in Hawaii. Several shallow-water gorgonians, having limited potential for jewelry and artifacts, also occur in Palau (Grigg, 1975). Maragos (1991) lists black corals, *Antipathes* and *Cirrhipathes*, as occurring in survey sites off Ngeremeduu Bay, eastern Babeldaob, and the Southern Barrier Reef of Palau.

Distribution: Coral reefs are tropical, shallow water ecosystems, largely restricted to the area between the latitudes 30°N and 30°S (Sheppard and Wells, 1988). Generally, vertical distribution of corals is determined by light and the actual depth limit depends on water transparency and no reefs develop in areas where annual minimum temperature is below 18°C (Achituv and Dubinsky, 1990).

The precious pink corals, *Corallium* spp., are distributed at depths of 5 to 1,500 m in the Mediterranean Sea, the eastern Atlantic between Portugal and Senegal, the northern Philippines to Japan and along the Hawaiian Archipelago (Carleton and Philipson, 1987). They grow best on solid substrata in areas of strong currents. In the Pacific, however, pink corals grow in deeper zone to that of black corals, and thus their distribution is not normally contiguous. No commercial beds of pink coral have been identified in the South Pacific.

Black corals are found throughout the tropical, semi-tropical and temperate seas, but are harvested commercially only in tropical regions, the Caribbean, the Indo-Pacific and the Hawaiian chain of islands, and have been identified in the waters of most island countries in the South Pacific (Carleton and Philipson, cited above). They are normally found in depths of 10 to 110 m, mostly on sediment-free hard substrate, and often in areas of strong currents (Parrish, 1988). Large samples have been located attached to solid coral or rock rises, banks or ridges swept by strong currents and thus clear of silt, sand and rubble.

Most of the islands of Palau are surrounded by a complex of fringing and barrier reefs. Maragos (1994) gives summary information on Palau's coral reefs habitat area for each state as given in Table 7.5.1.

Species diversity is highest in the lagoon environments of the main Palau islands. Maragos (1994) gives the following coral species diversity for some of these areas as:

- southern lagoon - 181 species and 61 genera at 11 sites;
- western Babeldaob - 166 species and 59 genera at 6 sites supplementing 200 species reported off Ngeremeduu Bay;
- eastern Babeldaob - 195 species and 59 genera at 10 sites;
- northern barrier reef - 165 species and 62 genera at 14 sites.

Table 7.5.1: Summary information on Palau's coral reefs by State. (Source: Maragos, 1994).

State	Islands	Lagoon and Passes			Fringing reefs		Barrier reefs		Atoll reefs		Reef holes
Units →	Numbers	Km^2	Km	# patch reefs	Km^2	Km	Km^2	Ocean side km	Km^2	Km	Numbers
Aimeliik	2	55.0	"	231	8.2	"	27.0	"	0	0	40
Ngetpang	17	15.0	"	14	2.7	"	7.1	"	0	0	2
Ngeremlengui		15.0	" 79.7	16	7.5	" 189.9	12.3	" 57.4	0	0	14
Ngardmau		22.5	"	16	13.8	"	11.0	"	0	0	141
Ngerchelong	2	325.0	141.5	240	23.0	20.8	81.3	62.7	0	0	15
Ngaraard	2	23.8	"	43	23.2	"	17.3	"	0	0	5
Ngiwal	1	12.1	"	0	5.8	"	0	"	0	0	0
Melekeok	2	0	" 50.9	0	8.4	" 58.5	0	" 22.0	0	0	0
Ngchesar	1	23.0	"	86	6.9	"	4.7	"	0	0	7
Airai	41	30.0	20.1	17	22.7	11.6	4.0	6.8	0	0	87
Koror	491	500.0	112.8	683	19.2	-	100.0	86.4	0	0	100
Peleliu	13	0	0	1	35.5	12.7	0	0	0	0	5
Anguar	4	0	0	0	2.6	13.4	0	0		0	0
Sonsorol	2	0	0	0	8.3	25.5	0	0	0	0	0
Tobi	2	103.0	53.8	85	7.0	2.0	0	0	57.9	61.7	2
Kayangel	5	12.1	9.6	25	0	0	0	0	7.1	13.6	0
TOTAL	585	1,136.5	468.4	1,457	194.8	241.3	264.7	235.3	65.0	75.3	418

Coral diversity has been reported as slightly less diverse in the more isolated coral islands and atolls such as:

* Kayangel Atoll - 126 species in 47 genera at 9 sites
* Ngeruangl and Velasco - 145 species in 52 genera at 7 sites
* Anguar - 134 species in and 44 genera at 7 sites

Maragos (1994) reported that certain habitats, all reef slope, support the highest coral abundance and diversity in Palau. These are:

* lagoon edge of large deep passes
* lagoon patch reefs or fringing reef fingers removed from heavily silted areas
* deeper ocean reef slopes off the western sides of the barrier reef
* semi-protected ocean walls or drop-offs

In a survey of of stony corals in 21 sites off Ngermeduu Bay, eastern Babeldoab and the Southern Barrier Reef of Palau in 1991, Maragos (1991) recorded a total of 214 species belonging to 67 genera and 6 subgenera within the area. Exceptional coral species diversity was observed in lagoon habitats off Babeldoab Island. The same author noted that the combined soft coral and stony coral fauna in the viscinity of Ngeremeduu Bay was among the richest, exceeding 100 species in many sites. Huge colonies of *Tubastraea micrantha* was reported along the channel walls of Toachel. The end of Ulong Channel supported a huge mound of *Pavona claves* (15 m in diameter and 5 m high) and continuous plates of *Turbinaria* up to 20 m long and 9 m in vertical relief along the slope. Platforms of *Acropora* (*Isopora*) *brueggemanni* occurred at depths of 3-10 m on the channel floor at the end of Rebotel Channel. Spectacular bowl shaped colonies of *Echinopora lamellosa* alternating with colonies of *Turbinaria peltata* were reported at Itebang Mlengui at a lagoon fringing reef north of the Toachel Mlengui channel. A nearby patch reef had large colonies of *Pachyseris rugosa*. However, extensive fields of staghorn coral thickets (*Acropora* spp.), fingercoral platforms, *Porites cylindrica*, and sheets of the brain coral, *Diploastrea heliopora*, were more common in Palau (Maragos, cited above). Large fields of small mushroom corals, *Fungia* spp., and extensive patches of the rare bowl coral, *Zoopilus echinatus*, were also reported.

A copy of the survey conducted by Maragos and Meier (1993) called, Reefs and Corals of the main Palau Islands: In Rapid Ecological Assessment of Palau, Part II, was not available.

Black and red corals are important invertebrates collected in the waters around Peleliu and Kayangel (Rochers and Matthews, 1992). A black coral survey conducted in Palau in late 1973 to June 1974 inside and outside Palau Lagoon had the following results as reproduced from Grigg (1975). Large colonies were located on sunken Japanese vessels in the survey area.

	Inside the Lagoon	Outside the Lagoon
Range of average basal diameter of largest colonies	0.74 - 2.12 cm	3.00 - 6.35 cm
Range of average height of largest colonies	1.34 - 1.93 m	up to 3 m
Density, colonies per length reef	0.20 - 0.25 m	1.0 m
Depth range	6 - 36 m	35 - 75 m

Those from outside the lagoon were larger, higher and occur in higher densities.

Samples of *C. elatius*, believed to have been collected between Peleliu and Angaur, were confiscated from a Japanese fishing vessel and were found to be of high quality (Grigg, 1975).

In the 1991 survey of stony corals off Ngeremduu Bay, eastern Babeldoab, and the southern Barrier Reef of Palau, Maragos (1991) reported the following relative abundance of black corals for stations in which they occurred:

	Station 1	Station 7	Station 11	Station 12	Frequency of occurrence (%)
Antipathes	-	occasional	-	-	4
Cirrhipathes	occasional	common	common	occasional	16

During surveys of marine macroinvertebrates in 26 sites in the Ngermeduu Bay area in 1991, Richmond (1991) recorded the occurrences of black corals and relatives, pink corals and soft corals as follows:

Species	# Sites in which species was recorded	Species	# Sites in which species was recorded
Antipatharia (black corals and relatives)			
Antipathes fruticosa	3 out of 26 sites	*Cirripathes flagellum*	5 out of 26 sites
Antipathes sp.	5 out of 26 sites	*C. spiralis*	9 out of 26 sites
Cirripathes anguina	15 out of 26 sites		
Gorgonacea (pink corals)			
Anthogorgia sp.	7 out of 26 sites	*Melithaea ocracea*	2 out of 26 sites
Ellicella plexauroides	10 out of 26 sites	*Plexaura flava*	9 out of 26 sites
E. rubra	7 out of 26 sites	*Rumphella aggregata*	2 out of 26 sites
Junceella fragilis	8 out of 26 sites	*Subergorgia mollis*	3 out of 26 sites
J. juncea	2 out of 26 sites	*S. pulchra*	3 out of 26 sites
Melithaea esperia	2 out of 26 sites	*S. verriculata*	3 out of 26 sites
M. flabellifera	8 out of 26 sites	*Wrightella tongaensis*	5 out of 26 sites
Alcyonacea (soft corals)			
Alcyonium gracillimum	8 out of 26 sites	*Sarcophyton elegans*	13 out of 26 sites
Cespitularia sp.	1 out of 26 sites	*Sarcophyton* sp.	14 out of 26 sites
Cladiella digitulata	8 out of 26 sites	*Snularia flexibilis*	20 out of 26 sites
Dendronepthya gigentea	13 out of 26 sites	*Snularia* sp.	16 out of 26 sites
Dendronepthya sp.	10 out of 26 sites	*Stereonepthya* sp.	7 out of 26 sites
Lobophytum sp.	5 out of 26 sites	*Xenia* sp.	3 out of 26 sites
Nephthea sp.	11 out of 26 sites		

Birkeland and Richmond (1992), during surveys in 47 sites from Velasco Reef to Anguar, observed Antipathes corals (black corals and relatives), Gorgonacea (pink corals) and Alcyonacea (soft corals)

as follows:

Species	# Sites in which species was recorded	Species	# Sites in which species was recorded
Antipatharia (black coral and relatives)			
Antipathes sp.	5 out of 47 sites	*Cirripathes spiralis*	12 out of 26 sites
Cirripathes anguina	18 out of 47 sites		
Gorgonacea (stony pink corals)			
Anthogorgia sp.	2 out of 47 sites	*Melithaea flabellum*	2 out of 47 sites
Anthoplexaura sp.	3 out of 47 sites	*Melithaeid* spp.	8 out of 47 sites
Ellicella plexauroides	2 out of 47 sites	*Plexaura flava*	10 out of 47 sites
E. rubra	3 out of 47 sites	*Rumphella aggregata*	5 out of 47 sites
Ellicella sp.	1 out of 47 sites	*Subergorgia mollis*	1 out of 47 sites
Euplexaura robusta	15 out of 47 sites	*S. pulchra*	2 out of 47 sites
Junceella fragilis	9 out of 47 sites	*S. suberosa*	5 out of 47 sites
J. juncea	15 out of 47 sites	*S. verriculata*	5 out of 47 sites
Melithaea flabellifera	1 out of 47 sites	*Wrightella tongaensis*	4 out of 47 sites
Alcyonacea (soft corals)			
Alcyomium utinomii	6 out of 47 sites	*Nepthya* sp.	27 out of 47 sites
Asteropicularia randalli	0 out of 47 sites	*Sacophyton birkelandi*	2 out of 47 sites
Cladiella digitulata	15 out of 47 sites	*S. elegans*	22 out of 47 sites
Dendronepthya spp.	13 out of 47 sites	*S. galucum*	32 out of 47 sites
Lemnalia sp.	20 out of 47 sites	*S. trocheliophorum*	26 out of 47 sites
Litophytum sp.	13 out of 47 sites	*Scleronephthya* sp.	4 out of 47 sites
Lobophytum crassum	19 out of 47 sites	*Sinularia abrupta*	7 out of 47 sites
L. crebriplicatum	18 out of 47 sites	*S. densa*	28 out of 47 sites
"	8 out of 47 sites	*S. flexibilis*	26 out of 47 sites
L. denticulatum	25 out of 47 sites	*S. frondosa*	1 out of 47 sites
L. pauciflorum	22 out of 47 sites	*S. polydactyla*	13 out of 47 sites
"	16 out of 47 sites	*Siphonogorgia* sp.	2 out of 47 sites
Lobophytum sp.	1 out of 47 sites	*Stereonephthya* sp.	8 out of 47 sites
Minabea aldersladei	1 out of 47 sites	*Xenia* sp.	5 out of 47 sites

Biology and ecology: Growth in coral is optimal only within a fairly narrow range of water temperature and salinities and thus varies considerably from area to area. Some *Acropora* grow fast (up to 20 cm per year) while *Favia* and *Porites* grow very slowly (Lewis, 1985; and Veron, 1986). Massive corals such as *Montastrea* and *Platygyra* may grow only 0.4-2.0 cm a year (Buddemeier and Kingzie, 1986, quoted in Wells *et al.*, draft). Achituv and Dubinsky (1990) notes that maximal growth usually occurs only down to 30-40 per cent of subsurface irradiance (the irradiance immediately below the water surface) and rarely is any significant reef formation found below 10 per cent irradiance. Reproduction is both sexual and asexual. Harrison and Wallace (1990) record that sexual reproduction patterns include hermaphroditic or gonochronic species with broadcast spawning or brooding modes of development with hermaphroditic broadcast spawners being the dominant group. Several asexual processes of reproduction can result in the formation of new colonies or solitary corals. These processes include fragmentation of established colonies, budding and transverse or longitudinal fission, single polyp bail-out, detachment of groups of polyps as drifting polyp balls and asexually produced planulae. Spawning has been observed mostly at night between dusk and mid-night.

In a study conducted in late June 1992 on reproduction in Palauan corals using 11 *Acropora* species, 3 *Porites* species and *Echinopora lamellosa*, (representing coral species known to be broadcast spawners), all specimens had undergone spawning by June 30, 1992. The absence of developing gonads in any of the sample indicated that spawning is probably quite synchronized within and between species rather than occurring over a more protracted period (Kenyon, 1992?).

Black corals are relatively fast growers, increasing at about 2 inches (5.08 cm) per year. Large specimens of black tree coral (*Antipathes* spp.) can grow to several meters in height and spread, with main stem diameters of forty to fifty millimeters, and up to 70 mm in the largest specimens. More commonly, branch and main stem diameters are of the order of 10-20 mm (Carleton and Philipson,

1987). Black whip coral (*Cirrhipathes* spp.) has been known to grow to 5-6 meters in length and is usually unbranched. Base diameters are up to 25 mm with more common sizes being 10-15 mm.

As with all other corals, gorgonians (including pink corals) grow by asexual reproduction within any one colony. Periodically, single-sex colony develop gametes (sperm or eggs) in sexual reproduction. The sperm are released and find their way into the polyps of sedentary female colonies. The fertilized eggs develop into larvae which are released into the current and travel as plankton for a period of one to fourteen days then they settle. If the environment is conducive for growth, they metamorphose into an anchored polyp which starts to divide asexually and form the base of a new colony (Carleton and Philipson, 1987). Pink corals are much slower growers than black corals, more typical of reef building corals, growing at about quarter of an inch (0.64 cm) a year.

7.5.2 The Fishery

Utilization: Maragos (1994) reported that corals that have been washed ashore are collected to make ***chaus*** (lime powder for betel nut chewers) in Kayangel. Corals used for ***chaus*** has been reported as significant in Ngerchelong, Ngeremlengui, Peleliu in the main islands. ***Chaus*** production is an "everyday activity" in Angaur. Coral is collected from all around the island and the crushed and processed coral is sold in markets in Koror (Rochers and Matthews, 1992).

Recently, corals have been targeted as one of the marine products exported via the aquarium fish export.

Production and marketing: No figures are available on the exploitation level of coral for use in the production of ***chaus***.

No export figures on the export of coral for aquarium purposes were reported for 1992. Between September and December, 1993, 474 hard coral pieces (valued US$1,186), 48 polyrock pieces (valued US$1,440) and 669 soft coral pieces (valued US$2,648) were exported to the US via the aquarium trade. Details of species exported are presented in Table 7.5.2.

Table 7.5.2: Export of coral for aquarium purposes between September and December, 1993 from Palau. (Source: DMR database).

Common name	Species	No. of pieces	Price rate ($/piece)	Total value ($)
Stony corals				
Acropora Sp.	*Acropora* sp.	8	20.00	160.00
Acropora Sp.	*Acropora* sp.	24	6.00	144.00
Budding Goniopora	*Gonipora* spp.	263	1.80	473.40
Long Pulse Coral	*Xenia flongata*	1	1.20	1.20
Plant Rock (1.00/lbs.)	*Calarius substantrate*	1	1.00	1.00
Plate Coral (LongTentacle)	*Heltofungia actiniformis*	109	2.40	261.60
Plate Coral (Short Tentacle)	*Heltofungia actinifurmis*	41	1.80	73.80
Plate Coral Green	*Heltofungia actinifurmis*	17	2.40	40.80
Roductus Giant Mushroom	*Urvillei* spp.	10	3.00	30.00
Total		**474**		**1,185.80**
Polyrock				
Green/Orange Polyrock (1/STYRO)	*Zoanthus* spp.	48	30.00	1,440.00
Total		**48**		**1,440.00**
Soft coral				
Devil's Hand Leather	*Sarcophyton trocheliophorum*	274	2.50	685.00
Home Grown Leather	*Sarcopython trocheliophorum*	4	2.50	10.00
Leather Coral Brown	*Sarcophyton trocheliophorum*	189	2.50	472.50
Leather Coral Green	*Sarcophyton trocheliophorum*	88	7.50	660.00
Lime Mushroom Leather	*Sarcophyton* sp.	107	7.50	802.50
Mushroom Soft Coral	*Sarcophyton* sp.	7	2.50	17.50
Total		**669**		**2,647.50**

Limited amounts are collected for jewelry and artifacts. No production figures are available.

7.5.3 Artificial Propagation of hard and soft corals.

The Palau Biotech Inc. had initiated ranching of both hard and soft corals for export in the aquarium trade. Soft coral "branches" are cut from the "mother" organism and planted in the nursery the company has set up in a lagoon. These plantings are protected from predators using a mesh wire used in giant clam nurseries. For hard corals, a "mother" coral head is brought up and the growing tips (about 3-4" in length) carefully cut off. These "tips" are placed in tanks to grow. Experiments have been initiated to "cement" the cut end of the cuttings into small blocks and let the coral grow from there as a base. The operator reckoned that it would take only a few months for the growing coral to cover the artificial base. This has been successfully demonstrated in the land-based operation. The "cemented" coral cuttings will be taken out to the nursery for grow-out. The operator believes that the clipped portion of the "mother" corals will be able to regrow to its former length within a year, making clippings from the same mother coral possible in a yearly cycle (it was noted that some *Acropora* species grow about 10-15 cm a year). The company intends to lease a coral bed from the Government for them to use as "mother" stocks for the clippings.

7.5.4 Resource Status

Maragos (1991) noted that exceptional variety and abundance of corals occur off the southern and eastern barrier reef of Palau. Maragos (1994) review the status of coral reefs in Palau as follows:

Barrier reefs: "All of the main Palau Islands are surrounded by barrier reefs except the northern atolls of Ngeruangl and Kayaangel, and the southern raised limestones island of Anguar. Threats to barrier reefs include mechanical and oil spill impacts from shipwrecks and use of destructive fishing methods such as dynamite and use of the household bleach, "Chlorox".

Fringing reefs: "The main Palau Islands are virtually surrounded by fringing reefs. Dredging and filling operations for channels, docks, and construction materials and sedimentation from upland soil erosion caused by land clearing, fires, road construction and other development activities have made their effects on this resource. Reef flats off southern Babeldaob (Airai, Aimeliik, Ngchesar) are covered with reddish soils eroded from previous or ongoing road and airport construction. Some dredge and fill operations, e.g. the docks at Ollei, Melekeok and Ngetpang have not been designed to minimize sedimentation on adjacent reefs".

The dredging at Tab, Ngchesar has been operating since 1980 and many corals in the area have turned "brownish" or dead (Maragos, 1994).

The level of collection of coral for ***chaus*** does not seem, at present, to be serious as washed up coral pieces are mostly used in some areas. Crown of thorns is found throughout Palau but only in small numbers. An infestation occurs periodically in the Ngederrak Reef region but have not been serious.

Natural disaster, e.g. Typhoon Mike, also breakup corals.

In a survey of invertebrates in 47 sites from Valesco Reef to Angaur in 1991, Birkeland and Richmond (1992) a large aggregation of the gastropod *Drupella* sp. eating a colony of *Acropora* in one of the sites. Only 6 crown-of-thorns starfish were observed although a dense aggregation was reported earlier at the outer end of Malakal Channel. An outbreak occurred in this area in 1979.

No other information could be located on the precious coral resource status in Palau apart from that reported under the "Distribution" section of this profile.

7.5.5 Management

The relationship between people and reefs was simple and direct prior to industrialized society. On islands, people used and often depended upon reefs as sources of food and materials. If the reefs deteriorated, the food supply and resource base for humans declined (Kenchington, 1988). As Van't Hof (1988) puts it, "coral reefs and associated systems and their resources have always been used as a source of food and material" and that " small island nations, in particular, have been and continue to be, dependent to a large extent upon their nearshore marine environment". Certain traditional management regimes seem to have existed which presumably evolved to avoid damage to reefs and the subsequent consequences. However, the same author writes:

> "Growth of human populations in areas where reefs are accessible, the introduction of new technologies and the development of economies have placed many pressures on coral reefs. The likelihood of being able to manage these pressures depends in part on the extent to which the well-being of coral reefs is important to the economic well-being of the impacting human society. The management of environments is thus the management of human impacts and activities".

Actituv and Dubinsky (1990) note that as far as the evolution of coral reefs is concerned, corals reached their peak in the past, and at the present time they are in decline. On the importance of corals, Sheppard and Wells (1988) note that coral reefs rank among the most biological productive and diverse of all natural ecosystems, their high productivity stemming from efficient biological recycling, high retention of nutrients and a structure which provides habitat for a vast array of other organisms.

In addition to the value corals and coral reefs offer in sustaining all types of marine fisheries resources and other ecological balances within the marine environment, corals can also offer an additional opportunity for "small-scale" development where the resource is sufficient and that management guidelines to ensure sustainable utilization are rigorously adhered to. But as is typical of all harvestable resources, sustained utilization require proper assessment research from which the results can be transcribed into management approaches. Analysis of supply and demand is basic to management. The supply takes into account information on basic biology and estimates of maximum sustainable yield obtained from research while demand considers the consumer, socio-economics of the industry and analysis of optimum sustainable yield (Grigg, 1976, quoted in Gomez, 1983). In Phuket Thailand, the most effective strategy for managing coral reefs is to prevent damage while allowing sustainable uses to take place with reasonable controls (Lemay and Chansang, 1989). Corals are slow growing and damaged reefs have been known to take many, many years to recover.

In efforts to manage coral and coral reefs, there is always a tendency to over-emphasize one cause of the problem while overlooking others. Integrated planning and management involving the cooperation of different government departments on different aspects of the resources is vital for success. Initiation of a public education programme on the effects and consequences of the continuing use of certain destructive means of extracting marine food resources from the reefs, as well the direct and indirect effects of other land-based development on the resources, is a necessity.

Current legislation/policy regarding exploitation: The Marine Protection Act of 1994 defines fish to mean any species of animals, other than birds, which lives in the sea. Thus corals, which are animals living in the sea, are included in this Act. Section 4 (6) makes it illegal to fish while using any form of underwater breathing apparatus other than a snorkel. Legislation for aquarium fish is covered under that profile.

Section 3 of the Regulations on the Collection of Marine Resources for Aquaria and Research, December 1994, requires any person who takes or attempts to take more than five specimens or

pieces of aquarium species, except cultured specimens, for aquarium purposes, local aquarium use, or for scientific, maricultural or medical research or for other purposes in a single, except those specimens taken incodentally in permitted dredging operations, shall have a valid Aquarium Collecting Permit issued by the Minister of the Ministry of Resources and Development. Section 5 of the regulations makes only Palauans eligible as holders of Aquarium Collection Permits by January 1997. Section 11 of the regulations prohibits the export of hard corals and marine rocks unless cultures, or from permitted dredging operations or is allowed under a valid Marine Research Permit. "Cultured" organism is defined in the regulations as to mean a specimen or a group of specimens certified by the Division of Marine Resources as such and satisfying the interpretation of the term "bred in captivity" recommended by CITES.

Recommended legislation/policy regarding exploitation: Several approaches to the management of the utilization of corals have been implemented in several countries. Kenchington (1988) lists three preliminary steps to the establishment of effective management as follow:

* define the problem;
* generate awareness of the problem amongst those who will suffer if the problem is not solved or benefit if it is solved;
* develop a management approach and a credible plan which will persuade those most concerned that management can and should address the problem.

He concluded that "the immediate challenge in many communities and countries is to interpret the scientifically documented threats and to establish that the benefits of management to sustain coral reef areas will outweigh the costs - in this the scientific research community has a key role".

The use of certain gear and some traditional fishing methods needs to be prohibited if persuasion through educational programmes to abandon their use is insufficient or ineffective.

Approaches in managing coral utilization for the aquarium trade can be broadly summarized under the three categories summarized below, (after Gomez, 1983 and Wells *et al*., draft). Even though both reef-corals and precious corals (including black corals) can be accommodated under the same management approaches, they should be treated separately.

Total ban: this prohibits the harvesting of corals either for export or for local domestic uses either commercially or traditionally. This is probably the only feasible way of preventing excessive damage to reefs when sustainable figures are not available.

Limited use: several options can be taken into account under this category. Commercial export as opposed to commercial domestic use can be distinguished, as well as commercial as opposed to traditional (non-commercial). This should be applied in conjunction with "Regulated Harvesting", below. Management strategies for the black coral resources is recommended under this category, in that harvesting is allowed for the local small cottage industry but exports of unprocessed product be prohibited.

Regulated harvesting: in the event that sustainable yields are available and that harvesting is allowed, management would be necessary for sustainable utilization. Allowances under "Limited Use" (above) can be regulated under this category. Some general guidelines for consideration include:

* licensing and permitting
* quotas
* minimum size limits
* prohibition of use of certain gear and method
* restriction of species collected
* zonation of areas for collection
* restriction on numbers of operators (if commercial)

∗ restricted duration if permit given

An important aspect in fisheries resource management that is gaining recognition in some South Pacific countries is the application of community-based resource management. This is of particular importance where commercial exploitation of shallow-reef resources is concerned. One of the considerations in the Exploitation Guidelines used in the aquarium fish trade in Fiji is to involve resource custodians in the collecting process to the maximum extent practicable (Lewis, 1985). This tends to spread the benefits wider than a few within the operator's circle. The Exploitation Guidelines used in Fiji for the aquarium fish trade are appended as Appendices 7.5.1. Additional information as provided in Wells *et al.* (draft) are also included.

Maragos (1991) after conducting a survey of stony corals off Ngeremeduu Bay, eastern Babeldoab, and southern Barrier Reef of Palau, noted that the richness of the reef environs makes good sense to establish a protected area in the region that encompasses the embayment, surrounding watersheds and offshore reef, lagoon and channel habitats.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES): This convention was entered into force, by certain countries, on 1 July 1975 and it now has a membership of more than 150 nations. The aim of the Convention is to establish world-wide controls over trade in endangered wildlife and wildlife products - in recognition of the fact that unrestricted commercial exploitation is one of the major threats to the survival of species. For this purpose, endangered species of wild animals and plants are listed in three appendices to the Convention. Depending on their agreed degree of protection, the export and import of live specimens, and of parts or derivatives, is either prohibited or subjected to uniform licensing requirements recognized by all member countries. Appendix I include all species threatened with extinction which are or may be affected by trade. Trade in specimens of these species is subject to particularly strict regulation and is only authorized in exceptional circumstances. Appendix II include all species which although not necessarily now threatened with extinction, but may become so unless trade in specimens of such species is subject to strict regulation in order to avoid utilisation incompatible with their survival. Appendix III include all species which any Party identifies as being subject to regulation within its jurisdiction for the purpose of preventing or restricting exploitation, and as needing the cooperation of other parties in the control of trade.

The provisions of the Convention concerning the trade of certain animals, e.g. corals, are applicable. Under the convention, the following corals are listed as Appendix II species (Anon, 1991):

- all species in the order Scleractinia (stony corals);
- all species in the order Antipatharia (black corals);
- all species in the family Milleporidae, *Millepora* spp. (fire corals);
- all species in the order Coenothecalia, *Heliopora* spp. (blue corals); and
- all species in the family Tubiporidae, *Tubipora* spp. (organ-pipe corals).

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