Cook Islands
Fisheries Resources Profiles

Research And Information Division,

Cook Islands Ministry Of Marine Resources

FFA Report 93/25

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The South Pacific Forum Fisheries Agency (FFA) was approached by the Ministry of Marine Resources, Government of Cook Islands, to provide technical assistance in the compilation of a set of Fisheries Resources Profiles. While no specific terms of reference were provided by the Ministry, those used for the preparation of Profiles in other FFA member countries were followed:

1. With assistance from national fisheries staff, examine all closed and current files pertaining to fisheries resource matters in Cook Islands;

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

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

4. Based on the information examined, produce a comprehensive set of resource profiles for the fisheries and marine resources of Cook Islands.

The report was prepared before, during and after a two week visit of FFA's Research Coordinator, Mr. Andrew Richards, to Cook Islands in April 1993. This report provides an overview of the fisheries and marine resources identified as being of importance to the commercial, artisanal and subsistence fisheries sectors in Cook Islands. The main purpose is to provide the basic information required to assess the current levels of exploitation, and to identify the research and management requirements for future developments.

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

Preparation of the report was greatly facilitated by reference to seven previously prepared Profiles, commissioned by the Cook Islands Ministry of Marine Resources. Kelvin Passfield, Paul Dalzell and Tim Adams provided useful comments on a draft of this report. The Cook Islands Fisheries Bibliography (Gillett and Tearii, 1989) was an invaluable source of information.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACIAR	Australian Centre for International Agricultural Research
CICS	Cook Islands Conservation Service
C.I.F.	Cost, insurance and freight inclusive quotation
CPUE	Catch Per Unit Effort
DWFN	Distant Water Fishing Nation
EEZ	Exclusive Economic Zone
EVAAM	Establishment pour la Valorisation Activities Aquacoles de la Mer
FAD	Fish Aggregating Device
FAO	Food and Agriculture Organisation of the United Nations
FFA	South Pacific Forum Fisheries Agency
F.O.B.	Free on board
ICOD	International Centre for Ocean Development
IUCN	International Union for the Conservation of Nature
MMDC	Micronesian Mariculture Development Centre
MMR	Cook Islands Ministry of Marine Resources
N.Z.	New Zealand
ORSTOM	Office de la Recherche Scientifique et Technique Outre-Mer
PNG	Papua New Guinea
SCUBA	Self Contained Underwater Breathing Apparatus
SG	Singapore
SOPAC	South Pacific Applied Geoscience Commission
SPC	South Pacific Commission
SPREP	South Pacific Regional Environment Programme
TBAP	Tuna and Billfish Assessment Programme
UNCLOS	United Nations Convention on the Law Of the Sea
UNEP	United Nations Environment Programme
UNV	United Nations Volunteer
UPNG	University of Papua New Guinea
U.S.A.	United States of America
USP	The University of the South Pacific
WW II	World War II (1939-1945)

SUMMARY

Cook Islands is composed of 15 islands with a total land area of approximately 23,600ha. which fall naturally into northern and southern groups. The total population at the 1991 census was 18,552, the overwhelming majority of whom live in the southern group, principally on Rarotonga. The area of the Exclusive Economic Zone (EEZ) is over 1.8 million square kilometres.

Though the recent rapid development of a black pearl industry in Cook Islands has been impressive, in general terms the marine resources in Cook Islands' EEZ have yet to be fully developed. Fisheries and marine resources are predominantly utilised by Cook Islanders on a subsistence and artisanal basis. Responsibility for these resources is vested in the (Minister) Ministry of Marine Resources (MMR), headquartered at Avatiu, Rarotonga. Outer islands with fisheries personnel are Pukapuka, Manihiki, Aitutaki, Penrhyn, Palmerston, Mitiaro, and occasionally, Mangaia.

The government's stated priorities for the conservation and utilisation of fisheries and marine resources are to increase self-sufficiency in marine-sourced foods and encourage import substitution. MMR has recently been re-structured to promote these developments with an emphasis on project implementation.

Access fees paid by foreign longline fleets to fish for tuna in Cook Islands' EEZ have generated substantial income for the country over the years. However, the government is keen to establish a locally based small-scale longline fishery, possibly on a joint-venture basis with foreign investors. The results of trial long-lining by an MMR-operated vessel are encouraging.

Commercial deep-slope fisheries do not appear to be feasible, at least at Rarotonga, given the low catch rates. The deployment of Fish Aggregating Devices (FADs) has significantly boosted troll catches from small craft. Methods for cost-recovery from the fishing community should be explored by MMR, so that the government does not have to continually fund FAD repairs and replacement.

With worked and un-worked black pearls increasingly providing the bulk of income from merchandise exports, the development of the pearl farming industry at Manihiki has led the way in Cook Islands' aquaculture. The government is endeavouring to emulate this success in other locations, with research work to be carried out at a black pearl farming research and training facility being constructed on Penrhyn.

The aquaculture of other marine species has also recently received attention. Research by a United Nations Volunteer (UNV) attached to MMR, on the availability of mullet fry for aquaculture has provided useful base-line information should the government decide to revive previously unsuccessful mullet farming. UNVs have also been involved in research which has shown the unfeasibility of stocking milkfish in Lake Te Rotonui on Mitiaro and the technical (but not economic) feasibility of farming giant freshwater prawns on Rarotonga. It may be that rather than using introduced organisms for aquaculture, more use could be made of existing organisms such as sea grapes, edible molluscs and tilapia.

The construction in 1990 of the Araura Marine Research Station on Aitutaki, comprising a giant clam hatchery and quarantine facility, is a positive development for the eventual re-stocking of depleted giant clam stocks and screening of introduced marine species. Though the facility has recently been un-operational, every effort should be made to bring it back into production, as giant clam stocks have been reported to be under increasing harvesting pressure.

There is scope to strengthen and broaden the traditional trade of marine products from Palmerston and Rarotonga and to generally develop internal trade links between the islands in Cook Islands. Opportunities exist for the strengthening of Cook Islands' internal economy rather than focussing solely on the export of marine products. For example, although tilapia is not eaten on some islands

where it is found, people on other islands do eat it. The potential for inter-island trade in smoked fish such as tilapia or marine produce merits investigation.

The seeding of trochus at Aitutaki has provided people there with an alternative source of income. The Aitutaki trochus fishery is an excellent example of cooperation between MMR and the Aitutaki Island Council. Trochus stocks on Rarotonga appear to be increasing to the point where a fishery could be established there in the near future.

Cooperation between MMR and the island councils to successfully develop management measures for trochus at Aitutaki and pearl shells at Manihiki is heartening. There is scope for further development of the **ra'ui** system as a tool for community-based management of fisheries and marine resources. The example of Palmerston supplying Atiu with live land crabs with which to replenish depleted stocks is encouraging and worthy of active support by MMR.

The aquarium fish industry on Rarotonga is successful in terms of revenue generated and its apparent sustainability. Given its excellent provision of data on a timely basis, it is worthy of support. At present there is no coastal fisheries data collection scheme to provide the information required for development planning and the framing of management measures. MMR's plans to rectify this situation should be implemented as soon as possible and broadened to include data from regular market surveys. Regular updating of the Cook Islands Fisheries Resources Profiles will only be possible if production and marketing data is collected on a regular basis.

COOK ISLANDS EXCLUSIVE ECONOMIC ZONE (EEZ)

A. BACKGROUND

A.1 THE COUNTRY

Located between 156 and 167° W longitude and between 8 and 23° S latitude, the 15 islands of Cook Islands, which fall naturally into the northern and southern groups, have a land area of 23,622.6 hectares (Douglas and Douglas, 1989). Land areas for each of the islands are given in Table 1.

Table 1. Land area (ha) of the islands of Cook Islands

Southern Group	Land Area (ha)	Northern Group	Land Area (ha)
Rarotonga	6,717.6	Penrhyn	984.2
Mangaia	5,180.0	Manihiki	543.9
Atiu	2,692.8	Rakahanga	404.7
Mitiaro	2,227.8	Pukapuka	121.4
Mauke	1,842.1	Nassau	121.4
Aitutaki	1,805.0	Suwarrow	40.5
Manuae	616.7		
Palmerston	202.3		
Takutea	122.2	TOTAL	23,622.6

The islands of the northern group as well as Manuae and Takutea in the south are typical coral atolls formed around submerged volcanic peaks, generally enclosing a lagoon. The southern group islands, apart from Manuae and Takutea, are volcanic in origin with elevated encircling reef platforms adjacent to the coast. All are surrounded by recent coral reefs. Mangaia and Atiu are both surrounded by cliffs of ancient raised coral reef, known locally as **makatea** (literally translated: "white rock"). Mitiaro has lower cliffs, with a lake inside as the beginning of a lagoon.

The raised southern group islands have soils which range from heavily weathered and infertile in the older islands, to the highly productive younger soils of Rarotonga. Virtually all the land in the group is owned by Cook Islands Maori. Multiplicity of ownership is very common, often with many of the owners being absentees.

The elevated southern islands, particularly Rarotonga, support rich and varied vegetation including casuarina, barringtonia, hibiscus, palms, frangipani, poinciana and bougainvillea. Subsistence and small-scale commercial agriculture is widely practised with coconut, breadfruit, taro, arrowroot, citrus fruits, bananas, pawpaw and pineapple grown. Atoll vegetation is largely pandanus and coconuts.

The islands of Cook Islands lie within the hurricane belt and are influenced by the prevailing trade winds. In the north these winds are mainly from the east and in the southern group, from east-south-east. During the hurricane season from November to March, the climate is warm and humid. During the remainder of the year, the southern group is generally cooler than the north. The mean annual temperature at Rarotonga is 24°C and the average annual rainfall 2,000mm (Anon., 1986).

A.2 THE PEOPLE

Cook Islands Maori are Polynesian, and several tribes trace their ancestry back to Samoa and Raiatea (French Polynesia). By tradition there are also connections between the Rarotongans and the New Zealand Maori.

Constitutionally, Cook Islands is a self-governing state in association with New Zealand. Though the country is a full member of the South Pacific Forum, it continues to share with New Zealand, of which it was once a dependency, its policies in matters of defence and foreign affairs. Cook Islanders

have automatic citizenship of New Zealand which has become the place of residence for more than 20,000 Cook Island Maoris.

The population of Cook Islands which was in steady growth since the turn of the century until 1971, started its decline with the expansion of air services and availability of employment opportunities in the New Zealand labour market. Between 1971 to 1976 a sharp annual decline in population was experienced. This rate of decline decreased gradually to about 3.4 per cent. for the years 1981 to 1986 indicating a more stable population. The population was 17,614 in 1986, the 1991 census showing a 5.33 per cent. increase to 18,552. Table 2 shows the distribution of the population among the islands, (Anon., 1992a).

Table 2. Population distribution in Cook Islands at the 1991 census

Southern Group	Population	Northern Group	Population
Rarotonga	10,918	Penrhyn	503
Aitutaki	2,366	Manihiki	666
Mangaia	1,105	Rakahanga	262
Atiu	1,103	Pukapuka	670
Mauke	639	Nassau	103
Mitiaro	249	Suwarrow	10
		Palmerston	49
Southern Group, excluding Rarotonga	5,362	**Northern Group**	**2,263**
		At sea during census	9
		TOTAL	**18,552**

Rarotonga accomodated 58.9 per cent of the population in 1991 compared with 54 per cent in 1986. The proportion of population in the rest of southern and northern group was 28.9 per cent and 12.2 per cent respectively in 1991 (Anon., 1992a) compared with 32 per cent and 13 per cent in 1988 (Anon., 1988). The natural growth rate averaging 1.9 per cent. per year is moderate by Pacific standards. This rate is tempered further by continued emigration, mainly to New Zealand, of about 0.6 per cent annually to give a net annual growth rate of 1.3 per cent (Anon., 1992a). The age structure of the population from the 1991 census is given in Table 3 (Anon., 1992a).

Table 3. Age structure of Cook Islands' population, 1991

Age Group	Percentage
0 - 14	34
15 - 44	46
45 - 49	12
60+	8

A.3 THE ECONOMY

In 1986 the labour force was 6,511 with 6,145 employed and 366 unemployed. The unemployment rate in Cook Islands (5.6 per cent in 1986) is low by international standards and is not considered a major social issue in Cook Islands (Anon., 1992a). The structure of employment has changed substantially since 1971 (Table 4).

Table 4. Composition of employment by major industries (%)

	1971	1976	1981	1986
Agriculture and Fisheries	22.7	21.8	29.2	16.5
Manafacturing, Construction and Quarrying	20.9	14.9	12.4	14.0
Electricity and Water	1.2	1.5	2.4	2.5
Transport and Communication	9.0	8.1	10.0	9.4
Wholesale and Retail Trade	7.5	9.2	12.3	16.8
Other Services	32.4	33.5	29.3	33.3
Not Classified		3.8	4.3	1.9

The economy is characterised by considerable external support from New Zealand (including budgetary support), increasing financial assistance from bilateral and multilateral sources and continuing high levels of remittances from family members working overseas. The level of aid per capita in 1988 was US$535 (Anon., 1989). Tourism is the top foreign exchange earner followed by offshore merchant banking (Anon., 1992b).

The Gross Domestic Product (GDP) in 1990 was NZ$106,891,000, or NZ$5,841per capita. Of this the agriculture and fishing sector contributed 17.7 per cent (Izumi, 1992). Government revenue was about NZ$60 million in 1990, an increase of NZ$5 million over 1989. Taxes provide about 41 per cent of this with a further 10 per cent derived from customs duties. Total government expenditure in 1990 was NZ$60.1 million (Anon., 1992b).

Imports, worth NZ$83 million in 1990, are dominated by foodstuffs, manafactured goods and machinery, petroleum products and building materials. Imports of seafoods for 1990 and 1991 by country of origin are listed in Table 5. Over 30mt of assorted processed and unprocessed seafoods valued at over NZ$300,000 were imported from several countries in 1990 and 1991 (Statistics Office, Rarotonga).

Merchandise exports in 1991 were valued at NZ$9.4 million, a rise of 15.4 per cent from the 1990 figure of NZ$8.2 million. The bulk of the exports were manafactured goods valued at NZ$6.6 million comprising predominantly worked and un-worked pearls. With the development of the pearl farming industry in Manihiki, the 1991 export of pearls has elevated Japan to the top of the export destination list followed by New Zealand, Hong Kong, Australia and Hawaii. Table 6 lists the value of exported marine products in 1991 (Anon., 1992b).

Depopulation and the heavy input of aid from New Zealand have militated against intensive local development, although this is changing to some extent (Anon., 1989a). In common with other widely scattered island countries, the distances between the islands of Cook Islands pose severe problems of transport cost, time and logistics. Development is therefore concentrated on Rarotonga with its population of over 10,000.

Table 5. Weight (kg) and C.I.F. value (NZ$) of imported seafoods by country of origin, 1990 - 1991. (Source: Statistics Office, Rarotonga).

		1990		1991	
Description	Country of Origin	Quantity (kg)	Value (NZ$)	Quantity (kg)	Value (NZ$)
Live fish	U.S.A.	0	0	114	2,405
Fresh/chilled whole salmon or trout	N.Z.	500	1,409	45	1,612
Fresh/chilled other fish	N.Z.	120	774	355	2,072
Frozen Pacific salmon	N.Z.	0	0	10	600
Frozen flat fish	N.Z.	10	36	246	1,224
Skipjack tuna (whole)	Fiji	0	0	4	12
Frozen herrings	N.Z.	4	97	0	0
Frozen whole cod	N.Z.	20	147	0	0
	U.S.A.	100	689	0	0
Frozen whole fish	N.Z.	761	5,111	515	1,678
	U.S.A	40	229	200	1,723
Fresh/chilled fish fillets	N.Z.	0	0	222	3,147
	W.Samoa	1,466	15,001	1,236	10,707
Frozen fish fillets	N.Z.	4,878	30,956	3,744	18,405
	W.Samoa	6,144	61,893	663	7,510
Frozen fish meat	Fiji	0	0	4	21
	N.Z.	650	2,536	440	3,864
	W.Samoa	20	238	0	0
Fish meal	N.Z.	1,330	13,088	1,450	13,872
Fish livers & roes (dried, smoked, salted or brined)	N.Z.	0	0	12	275
Fish fillets (dried, salted or in brine)	N.Z.	312	2,462	284	442
Smoked fish (whole or fillets)	N.Z.	338	3,706	984	10,976
	U.S.A.	5	101	0	0
Crustaceans, in shell or not (salted or in brine)	N.Z.	20	188	0	0
Crustaceans, in shell or not (salted or in brine)	Australia	12	253	0	0
	N.Z.	489	8,425	368	6,327
	W.Samoa	100	2,875	10	155
	Am.Samoa	60	1,201	0	0
Oysters (live, fresh,	N.Z.	2,046	16,517	2,968	29,943
chilled, salted or brined)	U.S.A.	45	256	91	960
Scallops (live, fresh,	N.Z.	570	14,348	915	23,936
chilled, salted or brined)	U.S.A.	30	538	0	0
Mussels (live, fresh,	N.Z.	8,718	47,710	11,023	54,928
chilled, salted or brined)	U.S.A.	0	0	155	827
Cuttlefish & Squid (live, fresh, chilled or salted)	N.Z.	572	4,389	985	6,804
Octopus (live, fresh, chilled, salted or brined)	N.Z.	389	2,181	299	1,985
Molluscs (other kinds)	Australia	300	9,273	0	0
	N.Z.	3,190	57,745	4,828	95,693
	PG	0	0	120	423
	SG	1	25	0	0
	U.S.A.	143	4,559	20	191
TOTAL		33,401	308,956	32,310	302,744

Table 6. Number/Weight (kg) and F.O.B. value (NZ$) of exported marine products by country of destination, 1991. (Source: Statistics Office, Rarotonga)

Description	Country of Destination	Quantity (No./kg)	Value (NZ$)

Fish; live ornamental	Hawaii	6,843	122,745
	U.S.A	5,900	45,609
	Japan	1,256	36,991
	U.K.	292	4,208
	N.Z.	221	2,088
		14,512	**211,641**
Pearls; natural/cultured whether or not worked/graded	Japan	413	4,511,008
	Hong Kong	28	1,339,107
	Australia	15	472,970
	Switzerland	26	130,348
	Fr.Polynesia	2	102,343
	Germany	3	21,300
	U.S.A.	3	19,930
	N.Z.		13,000
	Indonesia		12,000
		490	**6,622,006**
Shells, simply prepared but not worked	Germany	14,600	172,383
	Japan	7,086	82,244
		21,686	**254,627**
Shells worked: coral and articles	N.Z.	89	381
		89	**381**
Ivory/bone/tortoise-shell/horn/antlers/coral/mother-of-pearl	N.Z.	165,870	252,106
	Japan	11,000	180,000
	Germany	30	448
		176,900	**432,554**
Articles of natural/cultured pearls/precious or semi-precious stones etc.	Fr.Polynesia	6	41,200
	N.Z.	3	360
		9	**41,560**
Total			**7,562,769**

A.4 FISHERIES AND MARINE RESOURCES

A.4.1 Institutions

Responsibility for the fisheries and marine resources of Cook Islands is vested in the (Minister) Ministry of Marine Resources (MMR), headed by a Secretary of Marine Resources. The Ministry was established under the Ministry of Marine Resources Act 1984. Previously it operated as the Fisheries Department, Ministry of Agriculture and Fisheries. It is administered through a headquarters office at Avatiu, Rarotonga. Outer islands with fisheries personnel are Pukapuka, Manihiki, Aitutaki, Penrhyn, Palmerston, Mitiaro, Rakahanga, Suwarrow and occasionally, Mangaia. As of September 1993, MMR had 78 staff members.

The Ministry currently has an organisational structure of 5 divisions:

a. Central Administrative Division, headed by the Chief Administrative Officer.
b. Programme Implementation Division, headed by a Director.
c. Research and Information Division, headed by a Director.
d. Scientific Research, with one scientist, headed by a Director.
e. Policy, Contract and Agreements Division, under the control of the Secretary.

Divisions a, b, c and d are under the control and supervision of an Executive Officer of the Ministry, who is responsible and accountable to the Secretary of the Ministry for the efficient and effective management of that division. An important aspect of the structure concerns the overall working relationship of the divisions, by which the thrust and priority of the whole Ministry is on Project Implementation. All other divisions of the Ministry provide support to the Project Implementation

Division. The Ministry projects and programmes are based on Government policies and directives (Anon., 1991a).

Regionally, the Ministry is associated with several organisations and institutions, including the South Pacific Regional Enivironment Programme (SPREP), South Pacific Commission (SPC), South Pacific Forum Fisheries Agency (FFA), South Pacific Applied Geoscience Commission (SOPAC) and The University of the South Pacific (USP).

A.4.2 Legislation

Acts and Subsidiary Legislation of Cook Islands relating to fisheries is summarised in Table 7 (Campbell and Lodge, 1993). There are two pieces of Subsidiary Legislation currently in draft form:

- Rarotonga Fisheries Protection Regulations 1992
- Penrhyn Fisheries By-Laws 1993

Table 7. Acts and Subsidiary Legislation of Cook Islands relating to Fisheries (after Campbell and Lodge, 1993).

Cook Islands Act 1915	
Commercial Fishing Regulations 1951	*Repealed by Marine Resources Act 1989*
Fishing Ordinance 1950	*Repealed by Marine Resources Act 1989*
Continental Shelf Act 1964 (No.28 of 1964) (New Zealand Act extending to Cook Islands)	
Am. Act 17 of 1977	
Conservation Act 1975 (No.16 of 1975)	
Trochus Act 1975 (No.4 of 1975)	*Repealed by Marine Resources Act 1989*
Fisheries Protection Act 1976 (No.4 of 1976)	*Repealed by TS & EEZ Act 1977*
Territorial Sea and Exclusive Economic Zone Act 1977 (No.16 of 1977)	*Repealed in part by Marine Resources Act 1989*
s.19 Exclusive Economic Zone (Foreign Fishing Craft) Regulations 1979	
Ministry of Agriculture and Fisheries Act 1978 (No.13 of 1978)	
Am. Act 15 of 1984	
Am. Act 34 of 1989	
The Pearl and Pearl-Shell Penrhyn, Rakahanga and Manihiki Lagoons) Act 1982 (No.8 of 1982)	*Repealed by Marine Resources Act 1989*
Ministry of Marine Resources Act 1984 (No. 15 of 1984)	
Conservation Act 1986-87 (No. 29 of 1986-87)	
Marine Resources Act 1989 (No. 33 of 1989)	
Am. Act 5 of 1990	
Am. Act 1 of 1991	
Outer Islands Local Government Act 1987 (No. 25 of 1987)	
ss.15 & 16 Aitutaki Fisheries Protection By-Laws 1990	
s.15 Manihiki Pearl and Pearl-Shell By-Laws 1991	

The Marine Resources Act 1989 forms the cornerstone of Cook Islands' control over the exploitation of the resources of its Territorial Sea and Exclusive Economic Zone. The Act provides for the licensing and control of fishing vessels and fishing activities within the Territorial Sea and Exclusive Economic Zone (Williamson, 1990).

Matters to do with the environment are the responsibility of Cook Islands Conservation Service (CICS). The CICS is headed by a Director, a position which was established in 1975, and currently has a staff of 14, about half of whom are based in Rarotonga.

The Director administers the Conservation Act 1986-87, which is the relevant statute relating to marine conservation and pollution prevention. The object of the Act is to make provision for the

protection and conservation of the natural resources of the Cook Islands and the territorial sea of the Cook Islands and to establish national parks, reserves and historic sites (Williamson, 1990). Funding has recently been approved for a Marine Education Programme, to be administered by CICS (Kelvin Passfield, pers.comm.).

A.4.3 Educational Institutions

The Department of Education is responsible for the administration and implementation of the education system in Cook Islands, in accordance with the 1987 Education Act. Education is compulsory for all pupils aged between 5 and 15 years.

Pre-school education is available on all populated islands and is administered by the Parent Pre-School Committee. The Department provides one teacher per school. The entry age is 4 years, the Maori language being used extensively at this level.

Primary level education commences at the age of 5 and continues for 6 years. Schooling throughout this level of education is compulsory. A national syllabus is followed by all schools. The schools are encouraged to teach Maori, especially in the earlier years. There is also an emphasis on agriculture, mathematics and science. There are 29 primary schools in the country of which 24 are government and 5 private or church-run. Nine of these schools are on Rarotonga.

Secondary education in the Cook Islands is defined by the 1987 Education Act as Forms 1 to 5. There are 7 colleges, 3 on Rarotonga and one on each of the southern group islands except Mitiaro. Tereora, the national college of the Cook Islands also offers the New Zealand 6th Form Certificate Course and a 7th Form USP Foundation Course for senior students from all other colleges.

High Schools are defined as facilities which incorporate all three levels of pre-tertiary education; pre-school, primary and secondary. There is a single principal and administration for all levels. There are 9 such institutions in the Cook Islands, 6 of which are in the northern group.

The University of the South Pacific (USP) operates an extension service in the Cook Islands, offering courses at the degree and diploma level while at the same time providing vocational and community level educational programmes. The Teachers Training College on Rarotonga closed down in 1981 as a result of a teacher surplus. Subsequently students were sent to New Zealand or Fiji to receive their training. However, in recent years the teaching profession has seen a steady exodus of members to the private sector and other government departments. Consequently, in 1988 the college re-opened to provide one year pre-service training (Anon., 1988).

Students enrolled overseas are mainly in New Zealand and Fiji with some in Western Samoa, Papua New Guinea (PNG) and Australia. Up to 100 students and trainees receive education or vocational training each year under various aid programmes. Marine science courses for Cook Islanders are available at UPNG, USP and in Australia at the Australian Maritime College, Tasmania and James Cook University of North Queensland.

A.4.4 Management And Development Plans

National Development Objectives

In 1988, the Cook Islands Government identified 5 broad national development policies to encompass its endeavours over the 5 year plan period 1988-1992 (Anon., 1988). These policies are consistent

with the first development plan's objectives, but are narrowed down for more realistic and practical purposes.

1. To raise the level of prosperity of the people of Cook Islands (to stem further migration).
2. To attain a larger measure of economic independence.
3. To ensure that economic development proceeds in a manner compatible with social, cultural and natural values.
4. To promote a more equitable distribution of the benefits of development.
5. To cooperate closely with Pacific neighbours and other nations in economic affairs and other matters of mutual interest.

In conjunction with the National Development Objectives, government policies for the conservation and utilisation of marine resources in Cook Islands (Anon., 1991a) are two-fold:

- To increase ... self-sufficiency in food and protein production from the sea at affordable prices at both the household and national level.

- To expand rapidly the development in areas offering the greatest potential for import substitution.

In striving for these aims, the government will pursue a policy of sound economic exploitation, management and conservation and will:

- Provide technical advice and assistance in project feasibilities, as well as support locational visits by interested project developers with on-the-job training.

- Carry out pilot and research projects to assess technical and economic feasibilities.

- Establish a loan scheme to provide capital for project establishment.

- Provide an on-going business advisory service to farmers to assist them in their conservation and exploitation of the marine resources of Cook Islands.

A.4.5 The Fisheries

Cook Islands has a 200 mile economic zone (EEZ) of 1,830,000 sq.km. which was declared in 1977 and is a signatory to the United Nations Convention on the Law of the Sea (UNCLOS). Marine resources in Cook Islands' EEZ have yet to be fully developed, as the capacity to handle these resources is lacking (Anon., 1988). The fisheries may be conveniently divided into commercial fisheries for tuna and aquarium fish, mariculture of pearls, and subsistence and artisanal fishing for a variety of species.

In recent years, tuna fishing rights have been granted to foreign longline fishing fleets in exchange for the payment of access fees which are re-negotiated annually. While these agreements have generated substantial income for the country, the government is investigating the potential of establishing a small-scale longline fishery based on larger (>15kg) albacore tuna (*Thunnus alalunga*). An export fin-fishery which has become consolidated during the past 4 years is the Rarotonga-based aquarium fish fishery. At present this fishery consists of one company which employs local divers.

Rapid developments in the mariculture of round pearls using the black-lip pearl shell, *Pinctada margaritifera* have led to the development of a black pearl industry in Cook Islands. Efforts are also

being made to commercially develop milkfish (*Chanos chanos*) culture and capture fisheries based on trochus shell (*Trochus niloticus*).

It may be said however, that much of the use made by Cook Islanders of their fisheries and marine resources is for subsistence and artisanal purposes. Catches in general are for home consumption and supplying local market needs. The establishment of Fish Aggregation Devices (FADs) for troll fishermen has stimulated the production of pelagic fish species including several tunas; skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*) and albacore (*Thunnus alalunga*).

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B. FISHERIES RESOURCES PROFILES

Fin-fishes [**Ika**]

1. Lagoon and Reef [**Tai Roto e te Akau**

1.1 INSHORE FISH

1.1.1 The Resource

Species Present: Sims *et al.*(1988) list 27 species (Table 8) in the "Lagoon and Reef" category on their poster, "Seafoods of the Cook Islands", though many more species than these are used for food and for sale. For example, though only 1 species of parrotfish is represented on the poster, Anon. (in press) states that 13 species of parrotfish, of the family Scaridae have been recorded from Palmerston (Profile 1.2). Similarly, 4 species of mullet of the family Mugilidae have been recorded from Palmerston (Profile 1.3).

Clerk (1981) lists 128 species in this category which are recognised by people on Mangaia. In an 85 day survey of the fish at Manihiki, Bullivant and McCann (1974) collected 103 species of fish from the reef and lagoon. The dominant families recorded by them were Holocentridae (Squirrelfish) and Mullidae (Goatfish), each with eight species. A total of 88 coral-reef fish species were recorded at Palmerston and Suwarrow by Grange and Singleton (1985) who spent 13 days at the former and 3 days at the latter. Their list shows Chaetodontidae (Coral fish/Butterflyfish/Angelfish), Acanthuridae (Surgeonfish/Unicornfish) and Labridae (Wrasse) to be numerically abundant.

Distribution: The differences in the results of the surveys at Palmerston/Suwarrow and Manihiki reflect the sampling bias of SCUBA observations used during the former survey compared to nets, lines and poisons used during the latter (Grange and Singleton, 1985). It is assumed that the lagoon and reef fish described in the various surveys are found throughout Cook Islands, with minor variations in species composition from island to island. An exception to this is the extreme scarcity of the whitespot parrotfish *Scarus forsteni* at Palmerston compared to its prevalence in food fish catches on other islands in Cook Islands (Anon., in press).

Biology And Ecology: The many species listed in this category have very divergent life histories and biological parameters. Documented knowledge of the biology and population dynamics of food fish such as the scarids, lethrinids, lutjanids, carangids and serranids, has improved significantly in recent years, partly due to the fact that these families are circum-tropical in distribution. Information recorded throughout their range assists in providing a fundamental understanding of the biology of the same species in the South Pacific (Wright, 1993).

1.1.2 The Fishery

Utilisation: The lagoon and reef fishery is important to the subsistence and artisanal fisheries sectors. On Pukapuka, the entire population lives in three villages on the lagoon side of the northern islet and relies predominantly on the reefs for food (Andrews, 1987).

Table 8. Names of "Lagoon and Reef" fin-fish listed on the poster, "Seafoods of the Cook Islands".

Common	Scientific	Cook Islands Maori
Milkfish	*Chanos chanos*	Ava
Bonefish	*Albula neoguinaica*	Kiokio
Queenfish	*Scomberoides lysan*	Rai
Garfish	*Hyporhamphus dussumieri*	I'e, tikoroto
Bigeye scad	*Selar crumenophthalmus*	Ature
Warty-lipped mullet	*Crenimugil crenilabis*	Kanae
Mackerel scad	*Decapterus macarellus*	Koperu
Yellow-finned goatfish	*Mulloidichthys vanicolensis*	Vete

Silver rabbitfish	*Siganus argenteus*	Morava
Unicornfish	*Naso unicornis*	Ume
Yellowfin surgeonfish	*Acanthurus xanthopterus*	Parangi
Black surgeonfish	*Ctenochaetes striatus*	Maito
Five-banded parrotfish	*Scarus ghobban*	U'u, pakati, pa'o
Napoleon wrasse	*Cheilinus undulatus*	Maratea
Topsail drummer	*Kyphosus cinerascens*	Pipi, nanue
Bigeye bream	*Monotaxis grandoculis*	Mu
Orange-spotted emperor	*Lethrinus kallopterus*	Tamure
Red snapper	*Lutjanus bohar*	Anga-mea
Black-tipped cod	*Epinephelus fasciatus*	Atea
Marbled cod	*E. microdon*	Apuku
Brown cod	*E. tauvina*	Patuki
Peacock cod	*Cephalopholis argus*	Roi, patuki roi
Lunar-tailed cod	*Variola louti*	Oka
Squirrel fish	*Myripristes berndti*	Ku
Brown moray	*Gymnothorax javanicus*	A'a pata
Bullseye	*Priacanthus* sp.	Ku pa
Green triggerfish	*Pseudobalistes flavimarginatus*	Kokiri

While the inhabitants of Palmerston Atoll rely heavily on fish as their main protein source (Grange and Singleton, 1985), for many years the fishermen there have been the major external source of fish and other seafoods to the constantly expanding Rarotongan retail and restaurant trades (Anon., in press). Records kept at the Ministry of Marine Resources in Rarotonga indicate that inshore fish species are heavily fished on most of the islands. Raumea (1992) reports that the lagoon and reef species on Mangaia constituted 70 per cent of the fish landed, showing the importance of these species to the local diet.

Capture methods vary widely from traditional to modern. On Pukapuka, fishing practices are traditionally based but have taken advantage of modern technology; modern dinghies and outboard motors are preferred when available (Andrews, 1987). Clerk (1981) gives a detailed account of the fishing methods previously used by men on Mangaia where lines, nets and poisons were common. The 3 most common fishing methods presently used on Mangaia are rod-fishing, netting and spearfishing (Raumea, 1992). Generally speaking, gill net mesh sizes range from 3.8-7.6cm. Palmerston fishermen possess probably the widest range of fishing techniques of any atoll in Cook Islands and are always ready to adopt or adapt any new fishing method (Anon., in press).

Some reef and lagoon species are avoided because of their known implication in cases of ciguatoxin poisoning. In Penrhyn for example, people avoid eating napoleon wrasse [**Maratea**]. In Cook Islands, most poisonings of people are caused by the eating of black surgeonfish [**Maito**], unicornfish [**Ume**], brown moray [**A'a pata**], red snapper [**Anga-mea**] and some cods. On Atiu, parrotfish have also been implicated in cases of ciguatera fish poisoning (Losacker, 1992). Marketing of grouper and coral trout from Palmerston was banned in 1988 because of the concern that these fish contained ciguatoxin (Bill Marsters, Fisheries Officer, pers.comm.).

Production And Marketing: There are very few current figures available for the lagoon and reef fin-fish catch in Cook Islands (but see Profile 1.2). Statistics are available on the 1978 artisanal catches by type of fish and island in the southern group. Total artisanal fish and other seafood catches for 1978 were estimated to be 1,114mt of which 71 per cent was caught around Aitutaki and 14 per cent around Rarotonga. Mangaia accounted for 8 per cent, Mauke for 3 per cent, and Atiu and Mitiaro each supplied 2 per cent of the total catch (Anon., 1979a). On Aitutaki, reef and lagoon fish are sold to

local hotels for NZ$5-6 per kg. (Jamie Whitford, Fisheries Biologist, pers.comm.). Commercial fishing occasionally takes place at Manuae which is owned by the people of Aitutaki. Income from sales of fish from Manuae may be used for community projects for the benefit of Aitutaki people. Reef fish from Manuae (emperors, parrotfish) currently sells in Rarotonga for NZ$5-6 per kg.

1.1.3 Stock Status

As early as 1955, it was noted that the reef fish stocks at Rarotonga were over-fished (van Pel, 1955). The proliferation of Tahitian-style spearguns has further aggravated this situation, so that near heavily populated areas on Rarotonga and Aitutaki, fish are less abundant in the lagoons than was formerly the case. It is also felt that more fishing now takes place outside the lagoon than occurred previously (Sifa Fukofuka, Fisheries Development Officer, pers.comm.).

1.1.4 Management

Current Legislation/Policy Regarding Exploitation: Since 1985, spearfishing has been banned in the Pukapuka lagoon by the traditional governing body, the Island Council to protect the small, easily speared groupers and coral cod (*Epinephelus* and *Cephalopholis*) which are highly valued as food. Conservation practises are regularly reviewed by the Island Council, which includes two representatives from each village (Andrews, 1987).

The Aitutaki Fisheries Protection By-Laws (1990) ban the use of SCUBA while spearfishing, gathering any species of fish and setting or gathering any set net or collecting of fish from any such net. There are also comprehensive laws regarding netfishing, namely; hauling of nets, restrictions on nets in channels, set nets and drag nets. There is also a by-law banning the use of any explosive or poisonous substance to capture fish.

The Rarotonga Fisheries Protection Regulations (1992) define a "restricted area" around Rarotonga including "...the waters and seabed between mean high water mark and a line measured at right angles seaward from the outer limits of the reef to a distance of 500m". There is a ban on the use of SCUBA in the restricted area to catch or take fish, set or gather a net, collect fish from any such net or capture fish with the intention of removing such fish from the restricted area. There are restrictions on the use of nets in channels, set nets and drag nets.

Recommended Legislation/Policy Regarding Exploitation: Despite bans on the use of SCUBA while spearfishing, enforcement is difficult and this practice does occur. Fisheries awareness programmes, especially in schools, may be effective in curbing the use of SCUBA while spearfishing.

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1.2 PARROTFISH [**U'u, Pakati, e te vai atura**]

1.2.1 The Resource

Species Present: Parrotfish are classified as belonging to the Family Scaridae. Cook Islands Maori nomenclature differentiates between sizes and colour morphs (although some species groups are lumped together), and varies widely between islands. Thirteen species of parrotfish have been recorded from Palmerston (Table 9) with one other species, the swarthy parrotfish (*Scarus niger*) known to occur on Suwarrow (Sims, 1988c).

Table 9 Parrotfish species occurring on Palmerston Atoll (After Sims, 1988c)
[I.P. = Initial Phase; T.P. = Terminal Phase]

Common Name	Species	Palmerston Name	Common Habitat	Max.Length (cm)
Bicolour parrotfish	*Cetoscarus bicolor*	Kakatavake	Outer reef	50
Pacific longnose parrotfish	*Hipposcarus longiceps*	Re'i	Ubiquitous	50
Minifin parrotfish	*Scarus altipinnis*	Black show - I.P. Blue show - T.P.	Ubiquitous	50
Bridled parrotfish	*S. frenatus*	Pakati - I.P. Koti - T.P.	Outer reef	40
Reefcrest parrotfish	*S. frontalis*	Akau	Outer reef	40
Bluebarred parrotfish	*S. ghobban*	Rotea - I.P. Mamaringa - T.P.	Ubiquitous	50
Steephead parrotfish	*S. microrhinus*	Greenfish - small Posho - large	Ubiquitous	50
Globehead parrotfish	*S. globiceps*	Pakati - I.P. Koti - T.P.	Outer reef	20
Palenose parrotfish	*S. psittacus*	Pakati - I.P. Koti - T.P.	Outer reef	20
Redtail parrotfish	*S. pyrrhurus*	Pakati - I.P. Koti - T.P.	Lagoon and outer reef	20
Schlegel's parrotfish	*S. schlegeli*	Tomore	Lagoon and outer reef	20
Bullethead parrotfish	*S. sordidus*	Pakati - I.P. Koti - T.P.	Lagoon and outer reef	20

The four larger, more common species, *H. longiceps, S. altipinnis, S. frontalis* and *S. microrhinos* (commonly misidentified as *S. gibbus*, a Red Sea species) comprise the bulk of the commercial catch in the Palmerston parrotfish fishery (Anon., in press).

Distribution: The four most common species in the Palmerston fishery are also abundant throughout the northern group atolls, but occur more rarely on the high islands of the southern group. Several smaller species, including *S. forsteni, S. sordidus* and *S. schlegeli* are common on most islands (Sims, 1988c).

The most frequented habitat for each species is indicated in Table 8. There is a tendency for the larger parrotfish to move onto the reef flat to feed at high tide and to retreat to the outer reef slope at low tide. Parrotfish are generally associated with a specific area of reef, but may range over a wide area while feeding during the day, particularly when in large schools. The size of any established territory appears to be highly variable and it is not known how long an individual will remain in the same territory (Sims, 1988c).

Biology And Ecology: Randall *et al.* (1990) give a succinct account of the biology of parrotfish. According to these authors, parrotfish have evolved from the wrasse family but are distinct in having fused teeth in the jaws (sometimes called a "beak"), unique pharyngeal dentition, a very long intestine, no true stomach and by being herbivorous. They feed mainly on benthic algae which they scrape from dead coral rock, at the same time removing some of the surface layer of limestone. A few of the larger parrotfish feed in part on live coral.

Little is known of the population dynamics of parrotfish, and until recently, there was no reliable information on age structure, growth and mortality. Lou and Moltschaniwskyj (1992) have found daily otolith growth increments in juvenile parrotfishes which can be used in age estimates for juveniles. Lou (1992) has validated annual growth bands in the otolith of tropical parrotfish, using *S. schlegeli* as a target species. Scales also displayed regular periodic check marks and these provided relatively reliable aging estimates for the younger fishes up to 5 years.

Parrotfish usually exhibit two strikingly different adult colour patterns. The first mature phase, sometimes only female but more often both male and female, is called the initial phase (I.P.). Females of most species in this phase are able to alter their sex to male and undergo a change in colour to the terminal phase (T.P.).This is usually gaudier than the colour of the initial phase and often dominated by green. Some of the species have juvenile colour patterns very different to that of the adults; several have dark brown stripes (Randall *et al*., 1990).

Many of the species have two patterns of reproduction: group spawning of initial-phase fish from aggregations in which males greatly outnumber females and pair spawning by an initial-phase female and a terminal male. In both cases, eggs and sperm are released into the sea at the peak of a very rapid upward rush. Terminal males tend to establish sexual territories and maintain harems of females. In Cook Islands, only *S. schlegeli* is reported to form spawning aggregations, at Palmerston (Sims, 1988c).

The diversity of spawning behaviour exhibited by scarids means that it is not possible to describe a generalised pattern applicable to the group. However, at least some members of the family are reported to spawn on a lunar rhythm (Johannes, 1978b; 1981a in Wright, 1993). Larvae may settle after drifting for a week or more, but settlement could be delayed until currents carry them over suitable habitats. Little is known of the patterns and periodicity of parrotfish settlement and recruitment, although fishermen from the atoll islands report greater abundances of *S. schlegeli* (juveniles or I.Ps) in the spring (Sims, 1988c).

1.2.2 The Fishery

Utilisation: Parrotfish are caught in Cook Islands for subsistence and commercial use. The four large species found at Palmerston comprise the bulk of the commercial catch there and are occasionally taken by subsistence net fishermen in the northern group atolls. The smaller species taken at Palmerston are primary targets for spear-fishermen in the south and represent a significant proportion of the subsistence catch (Sims, 1988c).

At Palmerston, parrotfish have for many years formed the basis of the commercial lagoon and reef fishery. From the 1960's to the 1980's, due to their abundance and ease of capture in the **rau** fishery (using coconut fronds tied together and used as a "scare line" seine to surround a school of fish), parrotfish were shipped "in-the-round" to Rarotonga on ice. Since 1985, as improved handling and processing techniques have been developed, higher value parrotfish fillets have replaced whole fish in the trade to Rarotonga (Anon., in press).

The **rau** method of parrotfish capture has gradually fallen into disuse in the northern group atolls and was apparently last used on Palmerston in 1987. This decline follows the increased availability of monofilament gill nets and the increase of fishing activity on an individual rather than a community-based level.

Monofilament gill nets are used as the basis of set and drive net techniques which result in rather different parrotfish species catch compositions. Set gill nets, used on reef flats and in lagoons, take

higher proportions of *H. longiceps* and *S. microrhinos*. Drive netting on the reef crest takes a greater proportion of *S. frontalis* and *S. altipinnis*. As the fish are severely damaged in the net, they are unable to be kept alive in holding cages. Drive netting therefore only developed commercial significance on Palmerston once freezers became established and the fish could be held until the arrival of a freezer vessel (Sims, 1988c). Palmerston Islanders now use 8.9 - 10.2cm stretched mesh monofilament gill nets, though efforts are being made to introduce larger (12.7cm) mesh sizes (Bill Marsters, Fisheries Officer, pers.comm.).

Tahitian-style spear-guns have been in use in Cook Islands since the late 1940's and underwater spear-fishing is now one of the most productive, widely employed fishing activities. It is conducted both outside the reef and in the lagoons of the atolls. Daytime spear-fishing is generally restricted to the outer reef slope, but increased use of underwater torches has resulted in a marked increase of night-time spear-fishing for "resting" parrotfish on the reef crest and in the lagoons. Spear-fishing using SCUBA occurs on Rarotonga (Sims, 1988c), and to a lesser extent on Aitutaki, where it is banned.

Nearly all parrotfish species are vulnerable to spear-fishing although larger species such as *S. altipinnis* and *S. microrhinos* are less frequently taken. On the atolls where food-fish are generally more abundant, smaller parrotfish are often not considered worthy targets. Some incidental sale of excess spear-fishing catches occurs, particularly on Rarotonga, with parrotfish forming a substantial portion of such sales (Sims, 1988c).

In the past, long, multi-pronged throw-spears were widely used on the reef crest of most islands. The method is still preferred by some fishermen but has generally fallen into disuse. The throw-spear fishery is essentially a subsistence activity as fish are badly damaged by the spear-head and thereby rendered unsaleable. Although all the larger parrotfish are targeted, *Caranx* spp. and *Naso* spp. are also commonly taken. Parrotfish are also taken by hook-and-line fishing both as target species and as a by-catch in fishing for drummer [**Pipi, nanue**] (*Kyphosus cinerascens*). *H. longiceps* and *S. altipinnis* are the main parrotfish species caught by this method (Sims, 1988c).

Production And Marketing: The commercial parrotfish fishery on Palmerston, originally based on sporadic shipping of small volumes of smoke-dried parrotfish to Rarotonga, progressed to whole parrotfish on ice and then plastic-wrapped, frozen parrotfish fillets. Some fishermen are now blast-freezing and vacuum-packing fillets, adding further value to the product (Bill Marsters, Fisheries Officer, pers.comm.).

Sims (1988c) states that prior to 1988, approximately 15-20mt of parrotfish per year was shipped from Palmerston to Rarotonga. Recent parrotfish fillet production from Palmerston is given in Table 10 (Bill Marsters, Fisheries Officer, pers. comm.), corresponding to approximately 10mt of fillets per year (16mt whole weight).

Parrotfish fillets from Palmerston are blast-frozen and shipped in 12kg and 1kg blocks to Rarotonga where they are sold for NZ$11.00 per kg. This compares with approximately NZ$6.50 per kg. in 1988 (Bill Marsters, Fisheries Officer, pers.comm.).

Table 10. Production of parrotfish (kg) from Palmerston Atoll, 1992-93 (Source: Bill Marsters, Fisheries Officer, pers.comm.)

Shipment date	Species	Pack	Weight (kg)
11.01.92	*H. longiceps*	Plastic wrapped fillets (15kg pack)	1,156

	S. altipinnis (blue show) *S. microrhinus* (Posho) *H. longiceps*		
	S. microrhinus (black show)	Plastic wrapped fillets (1kg pack)	950
01.06.92	Parrotfish	Vacuum packed fillets	2,126
01.07.92	Parrotfish	Vacuum packed fillets	832
21.09.92	Parrotfish	Vacuum packed fillets	11
	Parrotfish	Plastic wrapped fillets	1,421
28.11.92	Parrotfish	Vacuum packed fillets	1,950
12.02.93	Parrotfish	Vacuum packed fillets	1,954

1.2.3 Stock Status

Anon. (in press) used commercial catch volumes, catch composition, length frequency data and results of survey fishing to quantify the status of parrotfish stocks at Palmerston. Informant's reports of decreases in average size and decreased abundance of the most heavily fished species could not be absolutely confirmed by the data at hand. Sims (1988) stated that the closure of the commercial parrotfish fishery by the Palmerston Island Council in 1988, more than any biological data, reflects the concern held by the islanders for the status of the resource. However, in December 1988, 4 months following the closure of the fishery on Palmerston, the Island Council ordered it to be re-opened (Bill Marsters, Fisheries Officer, pers.comm.).

Parrotfish stocks on Rarotonga are heavily exploited, where it is reported that the abundance of parrotfish has decreased (Sifa Fukofuka, Fisheries Development Officer, pers.comm.). On Aitutaki, there is also a reported decline in parrotfish abundance through over-fishing by the subsistence gillnet fishery (Sims, 1988c).

1.2.4 Management

Legislation/Policy Regarding Exploitation: The Aitutaki Fisheries Protection By-Laws (1990) ban the use of SCUBA while spearfishing, gathering any species of fish and setting or gathering any set net or collecting of fish from any such net. There are also comprehensive laws regarding netfishing, namely; hauling of nets, restrictions on nets in channels, set nets and drag nets. There is also a by-law banning the use of any explosive or poisonous substance to capture fish.

The Rarotonga Fisheries Protection Regulations (1992) define a "restricted area" around Rarotonga including "...the waters and seabed between mean high water mark and a line measured at right angles seaward from the outer limits of the reef to a distance of 500m". There is a ban on the use of SCUBA in the restricted area to catch or take fish, set or gather a net, collect fish from any such net or capture fish with the intention of removing such fish from the restricted area. There are restrictions on the use of nets in channels, set nets and drag nets.

Recommended Legislation/Policy Regarding Exploitation: Public marine education programmes are recommended for Aitutaki, where compliance with the current regulations is reported to be at a low level.

The move to replace currently used small-mesh gillnets with 12.7cm mesh gillnets in the Palmerston Island parrotfish fishery should be encouraged. Data collection and analysis for the commercial parrotfish fisheries should be instituted where it does not already occur.

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1.3 MULLET

1.3.1 The Resource

Species Present: Four species of mullet (Family Mugilidae, Order Mugiliformes) are recorded; warty-lipped mullet [**Kanae**] (*Crenimugil crenilabis*), diamond-scale mullet [**Ka'a**] (*Liza vaigiensis*), shovel-headed mullet [**Wowa**] (*Chaenomugil leuciscus*) and Engel's mullet [**Wowa**] (*Valamugil engeli*).

Distribution: Mullets occur in all tropical and temperate seas, usually near shore, frequently in brackish estuaries and fresh water. *C. crenilabis* is known from east Africa to the Line and Tuamotu Islands, while *L. vaigiensis* is distributed from east Africa to the Red Sea and Tuamotu Islands (Randall *et al.*, 1990). In Cook Islands, *L. vaigiensis* and *V. engeli* are recorded at Manihiki by Bullivant and McCann (1974). Clerk (1981) noted the presence of *C. crenilabis* and *L. vaigiensis* at Mangaia. *C. crenilabis, L. vaigiensis, C. leuciscus* and *V. engeli* are present at Palmerston (Anon., in press).

Biology And Ecology: Mullets are algal grazers and detrital feeders and as such are usually found in association with shallow sand or reef habitats (Anon., in press). They may also consume insects, fish eggs and plankton. *L. vaigiensis* forms large schools, frequently in mangrove areas while *C. crenilabis* occurs in schools, in sandy lagoons and on shallow seaward reef flats. It is reported to spawn in large aggregations after dark (Randall *et al.*, 1990). Anon. (in press) states that no seasonal pattern of abundance is reported for either *C. crenilabis* or other mullets at Palmerston. There is no awareness among Palmerston fishermen of any reproductive seasonality in the mullets and the timing and location of spawning is unknown. The sexes are separate and are not distinguishable externally.

1.3.2 The Fishery

Utilisation: Mullet are an important edible food fish in Cook Islands (Fujino and Raumea, 1993), being taken for subsistence and artisanal purposes. On Mangaia, mullets form 6.5 per cent of the catch (Raumea, 1992). On Palmerston, Anon. (in press) reports that although some fishing of mullets occurred traditionally using the **rau** as for parrotfish, the fishery has really only reached a significant level with the recent introduction of gillnets. The fishery for *C. crenilabis* is highly lunar and tidally influenced. Activities are concentrated on a few nights each side of the full moon when the *C. crenilabis* feed in the reef shallows close to the beach, on full tide. The gillnet is worked from a small dinghy or large sack and set to seaward of signs of a mullet school. The fish are driven into the net by walking, splashing and stone-tossing inshore.

The other species of mullet at Palmerston sometimes occur in association with *C. crenilabis* schools and larger individuals may be taken in the gillnet. Smaller mesh gillnets (5.1cm) are set in suitable areas for short periods at night on ebbing tides, to catch smaller *L. vaigiensis* and *C. leuciscus* for use as bait.

In the early 1970's, interest was expressed in the commercial cultivation of mullet in the estuaries and lagoons of the southern group islands. This was proposed both to provide local protein supplements and as export-oriented industries (Uwate *et al.*, 1984) but took little account of the condition of the waters in which such developments were to take place (Sims and Charpy, 1992). In order to provide base-line data for further attempts at mullet culture, a mullet fry survey on Rarotonga was carried out from September 1991 to November 1992. Fry of *C. crenilabis* and *C. leuciscus* was collected, the former dominating the catches by a ratio of 5:1. Fry were available throughout the year with a peak between February and April. Because of high construction costs of fish farming ponds, the utilisation of a natural inlet at Nagatangiia was recommended for mullet farming (Fujino and Raumea, 1993). Tuara (1991c) reports that trials have shown Lake Te Rotonui on Mitiaro does not have the optimum conditions for *C. crenilabis* and *L. vaigiensis.*

Production and Marketing: Anon. (in press) reports that using 10.2cm stretched mesh gillnets, *C. crenilabis* at Palmerston ranged from 330-500mm fork length (0.7-1.9kg). Catches of up to 600 fish in one set are reported, but 100 or less per set appears more usual. In smaller mesh nets, several hundred fish may commonly be taken. Sizes of *C. leuciscus* typically ranged from 200-280mm fork length.

Large mullet caught on Palmerston for the Rarotongan market were formerly gilled, gutted and frozen. Prices ranging from NZ$2.50-3.00 were commonly paid to fishermen (Anon., in press). The current price paid by restaurants, hotels and motels is NZ$4.00 per kilogram. Anon. (in press) observed that the most promising opportunity for improved returns to fishermen would seem to be in the production of smoked mullet. It was also noted however that the lack of suitable timber or sawdust on Palmerston restricts opportunities for such developments. Small mullet are stored for use as ground bait or occasionally rigged as trolling baits.

1.3.3 Stock Status

While no estimates of the status of stocks are available, Anon. (in press) observed that the resource of large and small mullets on Palmerston appears under-utilised.

1.3.4 Management

Current Legislation/Policy Regarding Exploitation: None at present

Recommended Legislation/Policy Regarding Exploitation: None required unless commercial production commences.

References

Anon., in press. The marine resources of Palmerston Atoll, Cook Islands. A report of a survey carried out in September 1988. Technical Report No.2. Inshore Fisheries Research Project, South Pacific Commission, Noumea, New Caledonia and FFA Report No. 89/16(b), Research Coordination Unit, Forum Fisheries Agency, Honiara, Solomon Islands. Final Draft. 57p.

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Randall, J.E., G.R.Allen and R.C.Steene. 1990. *The complete diver's and fishermen's guide to fishes of the Great Barrier Reef and Coral Sea*. Crawford House Press, Bathurst, Australia. 507p.

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Uwate, K., P.Kunatuba, B.Raobati and C.Tenakanai. 1984. A review of aquaculture activities in the Pacific Islands region. Pacific Islands Development Program, East-West Center, Honolulu. 22 chapters.

1.4 MILKFISH [**Ava**]

1.4.1 The Resource

Species Present: The milkfish [**Ava**] (*Chanos chanos*).

Distribution: This species is distributed in the tropical and sub-tropical seas of the Indo-Pacific. Its range extends from east Africa and the Red Sea to southern California and the west coast of Central America (Shokita *et al.*1991).

Biology And Ecology: Milkfish is warm-stenothermal, surviving at temperatures between 20°C-33°C. It becomes weak at temperatures below 20°C to 15°C and dies at temperatures below 12°C. Its ecology is little known. In its reproductive season, schools of adult fish exceeding 1m in body length and 10kg in weight briefly come to coastal waters to spawn. Milkfish produce epipelagic eggs which hatch into larvae that are carried by currents. Juveniles of 11-15mm body length gather in brackish water in shallow sandy areas, mouths of rivers and lagoons. The young fish disappear from coastal waters approximately 4 weeks later.

Among the larger seawater fishes, milkfish is unique in its feeding habits since it is a herbivore feeding on green algae (Cyanophyta) and diatoms. Pond reared milkfish juveniles may grow to 300g in 8 months and mature sexually in 5-6 years (Shokita *et al.* 1991).

1.4.2 The Fishery

Utilisation: Milkfish is listed as a seafood in Cook Islands (Sims, *et al*, 1988). It is not eaten traditionally on Mitiaro, the site of several introductions of this species to Lake Te Rotonui (Stephenson, 1987).

In 1990, milkfish fry were purchased by the Ministry of Marine Resources from the northern group of Cook Islands for introduction to Lake Te Rotonui. In 1991, a further introduction to the lake was made with fish purchased from the Oceanic Institute in Hawaii (Fujino and Patia, 1993).

Production and Marketing: There have been 2 harvests of milkfish from Lake Te Rotonui, the most recent monitoring collection taking place in January 1993. A 7.6cm stretched mesh gillnet was used to catch 33 milkfish with standard lengths ranging from 23.5-36.5cm. The green algae *Coelosphaerium* sp. was noted in the stomachs of 12 of the fish caught. Calculations show that it has taken from 1.5-2.8 years for the milkfish to grow from fry to the usual market size of 30cm standard length (Fujino and Patia, 1993).

Fujino and Patia (1993) recommend that the Mitiaro Milkfish Project be managed by Mitiaro residents at a supplementary subsistence level with technical support by the Ministry of Marine Resources. This is because of the high stocking rate, expensive management costs, lack of infrastructure and low estimated growth rate of milkfish in the lake.

1.4.3 Stock Status

The status of milkfish stocks in Cook Islands is not known. Stocks in Lake Te Rotonui on Mitiaro are reported to be depleted and will need to be re-stocked (Cook Islands Ministry of Marine Resources).

1.4.4 Management

Current Legislation/Policy Regarding Exploitation: None at present

Recommended Legislation/Policy Regarding Exploitation: Fujino and Patia (1993) have prepared a draft management plan for milkfish in Lake Te Rotonui, Mitiaro.

References

Fujino, M. and T.Patia, 1993. Report of milkfish monitoring collection in Mitiaro in January 1993. Cook Islands Ministry of Marine Resources Internal Report, January 1993. 6p.

Shokita, S., K.Kakazu, A.Tomori and T.Toma (eds.). 1991. *Aquaculture in tropical areas.* Midori Shobo Co. Ltd., Tokyo, Japan. 360p.

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1.5 SMALL PELAGICS (BAITFISH)

1.5.1 The Resource

Species Present: There are small pelagic fishes from a number of families, which are commonly given the collective name of "baitfish". The most commonly targeted small pelagics in Cook Islands are the mackerel scad [**Koperu**] (*Decapterus macarellus*) and the big-eye scad [**Ature**] (*Selar crumenophthalmus*).

Distribution: These 2 species are widely distributed throughout Cook Islands (Anon., in press), although more species tend to be found around the higher islands.

Biology And Ecology: The majority of small pelagic species are planktivores, form schools and are often seasonal. They occupy a range of habitats from estuarine waters, coral reefs and lagoons to the open ocean. Both mackerel scad and big-eye scad occur outside the reef at Palmerston and are usually found in mid-water schools. Neither species is highly abundant at Palmerston and their abundance is not reported to be seasonal there (Anon., in press).

Little is known about the reproductive biology, recruitment and patterns of abundance of either species. Both are often found far offshore, but are not recognised as migratory species. Big-eye scad are abundant in inshore areas of Palmerston from June until August (Bill Marsters, Fisheries Officer, pers.comm.). The fishery in Rarotonga for big-eye scad is distinctly seasonal (May-June), with the movement of the fish into the lagoon, and the Avatiu and Avarua passages and harbours, probably associated with the breeding season (Anon., in press).

1.5.2 The Fishery

Utilisation: Mackerel scad and big-eye scad are valued for being the best available bait for a number of hook-and-line fisheries and as a food-fish in their own right. On Palmerston, they are always utilised for bait or house-hold consumption and are not exported. As bait, they may be used whole for tuna downlining and drop-stoning. Occasionally, whole mackerel scad are used as troll bait for wahoo

and dolphin fish. Both species make excellent chum [**paru**] because of their high oil content and fillets or strips of them are the preferred bait in a number of other fisheries (Anon., in press).

On Palmerston, big-eye scad are normally taken offshore by jigging with lures from a boat. A light line is rigged with 3 hooks, the lures made from bosun bird feathers and a small weight attached. Fishing for this species occurs mostly at night, 3-5 days after the full moon. Occasionally gill nets are used to take big-eye scad but because of problems with sharks they have short soak times and are not very productive (Anon., in press).

Mackerel scad are almost exclusively fished at dusk, for the first hour or two after sunset. The fishing area is the deeper water beyond the reef, usually in depths from 40-60m. They are lured to the surface by a diver who spits out mouths-full of coconut or taro chum above a school. Once at the surface, more chum attracts the fish to within range of short (0.5m) fishing rods. The fishermen work from in the water beside the boat, dangling small lures of white cotton thread tied to a small barbless hook or bent pin. The fish are lifted up out of the water in one smooth motion to prevent escape (Anon., in press).

Production And Marketing: The dual value of these species as food and bait have resulted in a very heavy demand for them, especially at Rarotonga, to the extent that some fishermen import baitfish from New Zealand. Palmerston baitfish command high prices in the off-season at Rarotonga, when available, but freight rates of NZ$1.30 are prohibitive (Cook Islands Ministry of Marine Resources). Their value could be further enhanced as tuna fisheries develop around the Rarotongan Fish Aggregating Devices (FADs).

The current price, excluding freight charges, for **Koperu** at Rarotonga is NZ$2.00 per kilogram, while that for **Ature** is NZ$1.00 per kilogram. MMR is presently investigating the possibility of importing grey mullet as bait from New Zealand, at a landed cost of NZ$1.50 per kilogram (Cook Islands Ministry of Marine Resources).

Increases in the volume of the mackerel scad fishery could be achieved by the introduction of the Hawaiian Opelu (lift-hoop) net, together with establishment and maintenance of regular mackerel scad aggregation sites (Anon., in press). Initial fishing trials at Rarotonga in late 1989 using the Opelu net were inconclusive, as no target fish were sighted (Paulo, 1989). Further trials using the Opelu net were conducted at Rarotonga in 1990, with encouraging results (Kelvin Passfield, pers. comm.).

1.5.3 Stock Status

The status of Cook Islands' small pelagics stocks is unknown. There are reported declines in abundance of mackerel scad on Rarotonga, where schools are now smaller and are found less frequently (Anon., in press). Concerted data collection programmes required for both species to assist in predicting the behaviour of stocks to increased fishing pressure.

1.5.4 Management

Current Legislation/Policy Regarding Exploitation: None at present.

Recommended Legislation/Policy Regarding Exploitation: None possible until stock assessments have been completed.

References

Anon., in press. The marine resources of Palmerston Atoll, Cook Islands. A report of a survey carried out in September 1988. Technical Report No.2. Inshore Fisheries Research Project, South Pacific Commission, Noumea, New Caledonia and FFA Report No. 89/16(b), Research Coordination Unit, Forum Fisheries Agency, Honiara, Solomon Islands. Final Draft. 57p.

Paulo, W.H. 1989. Hawaiian style decapterus ('Opelu) exploratory fishing in Vava'u, Kingdom of Tonga and Rarotonga of the Cook Islands. 4p.

1.6 AQUARIUM FISH

1.6.1 The Resource

Species Present: Many species of fish on the reefs of Rarotonga have been identified as having commercial value in the aquarium fish trade (Table 11). The flame angel (*Centropyge loriculus*) and red hawk (*Neocirrhites armatus*), two of the higher value species, are present in sufficient numbers to support a small export industry (Passfield and Evans, 1991).

Table 11. Commercially valuable aquarium fish species on Rarotongan reefs and their approximate habitat depth (m). (Source: Passfield and Evans, 1991)

Scientific Name	Common Name	Av. Depth (m)
*Centropyge loriculus**	Flame Angel	21
C. flavissimus	Lemon Peel	8
C. heraldi	Herald	20
*C. multicolour**	Multicolour	70
*Pomacanthus imperator**	Imperator	15
*Neocirrhites armatus**	Red Hawk	8
Anthias ventralis	Deepwater Bass	30
Thalassoma lutescens	Yellow Wrasse	15
Coris gaimardi	Wrasse	?
C. aygula	Twin Spot Wrasse	?
Macropharyngdon pardalis	Leopard Wrasse	?
Labroides rubrolabiatus	Cleaner Wrasse	16
Chaetodon pelewensis	Butterfly Fish	14
C. ulietensis	Butterfly Fish	16
Cirrhilabrus sp.*	Blue Velvet	22
Canthigaster bennetti	Orange Spot Puffer	12
Ostracion cubicus	Box Fish	?
O. meleagris	Box Fish	?
Chrysiptera galba	Yellow Damsel	15

* Indicates higher fish value.

Distribution: Surveys on Mangaia and Aitutaki have located many of the the aquarium fish species listed above, including the flame angel, lemon peel, imperator, red hawk and multicoloured angelfish. Valuable aquarium species have been found in shallow water in the northern group, such as Pukapuka (Passfield and Evans, 1991).

Biology and Ecology: Tropical reef fish either spawn pelagic eggs or brood their larvae. Butterfly Fish (Chaetodontidae) and Wrasse (Labridae) are examples of indisriminate spawners whose eggs hatch into planktonic larvae. Up to 90 per cent of aquarium fish species spawn this way. Larvae drift in the ocean currents for a length of time, depending on the particular species and the current. They may travel thousands of kilometres from their origin, before settling on a suitable reef habitat. Flame angels and red hawks have planktonic stages for between 3 and 4 months, occasionally stretching to 8 months, depending on currents.

Brooding fish lay eggs on the bottom and usually defend the eggs from predators until they hatch. The newly hatched larvae hide in the reef until they are large and fast enough to escape predation. Common spawners of this type are clown and damsel fish (Pomacentridae) and some gobies (Gobiidae).

1.6.2 The Fishery

Utilisation: Commercial marine aquarium fish collecting started in Rarotonga in 1988. One foreign-owned company, "Cook Islands Aquarium Fish", was given permission to operate outside the reef of Rarotonga by the Cook Islands Government. It now has at least one local partner. This is a small operation, utilising only one or two divers. The company has had difficulty securing reliable divers on a permanent basis (Table 12). Other foreign companies have expressed interest in operating in Cook Islands (Passfield and Evans, 1991).

Table 12. Effort Statistics for 22 divers in the aquarium fish business (Weeks of diving per year), 1989 - 1992. (Source: Ian Bertram, Fisheries Biologist, pers.comm.)

Diver	1989	1990	1991	1992	TOTAL
01	52	10	8	6	76
02	6	-	-	-	6
03	1	-	-	-	1
04	2	-	-	-	2
05	-	2	-	-	2
06	-	34	-	-	34
07	-	36	52	24	112
08	-	24	52	52	128
09	-	4	-	-	4
10	-	7	-	-	7
11	-	46	14	-	60
12	-	3	-	-	3
13	-	-	38	-	38
14	-	-	4	17	21
15	-	-	2	-	2
16	-	-	20	-	20
17	-	-	-	1	1

18	-	-	-	6	6
19	-	-	-	20	20
20	-	-	-	2	2
21	-	-	-	2	2
22	-	-	-	20	20
TOTAL	61	166	190	150	567

Only the southern group has the infrastructure needed to support a small-scale aquarium fish export business. Rarotonga has an outer reef perimeter of approximately 34km and a narrow lagoon. The width of reef slope accessible to the fish collector is approximately 200m, giving an approximate fishable area of 7sq.km. Beyond this the water becomes too deep to dive safely. Aitutaki has a reef circumference of 43km and also has a large lagoon.

Aquarium fish are usually collected by divers using SCUBA, small-mesh barrier nets and hand-held scoop nets. The divers work between 7 to 70m and time spent in deeper water is limited because of decompression problems. A medium-sized vessel (5-8m) is used as the dive boat. On board the vessel are special tanks for keeping the fish alive and as unstressed as possible. Some collectors use pumps to re-circulate the sea water in the tanks.

The barrier net ranges in length from 2 to 15m. The larger nets are set where schooling fish have been seen and they are chased into the barrier net. The smaller nets are set partly around small coral rubble areas in which one or two target fish have been seen. The fish are then scooped up using the hand-held scoop nets, or if they have become enmeshed, are taken by hand. Some fish are caught solely by 2 scoop nets.

The red hawk hides between the branches of coral heads and needs to be flushed into the barrier net. Coral is sometimes broken to reduce cover and trap the fish. The method of breaking the coral is called "notching", which is the removal of coral branches in the middle of the coral head. This is done so as to give the best chance for re-growth of the coral. Because of the skill required to do this correctly, only the most experienced collectors are permitted to collect this species. As the breaking of coral heads is a sensitive issue, the company has advised its employees to only notch coral heads that have previously been notched.

The collected fish are placed in a small holding bucket until the dive is finished. A hypodermic needle may be used to pierce the air bladder of each fish to reduce problems associated with decompression. Alternatively, the fish bucket is attached to a decompression line for 2 to 3 hours.

An aquarium system at the warehouse/holding facility keeps the fish alive until shipped to the wholesaler overseas. At the first sign of any disease problems, the water is treated with anti-biotics. Great care is taken with water quality with all incoming water being filtered and water and oxygen content controlled. Water is changed regularly, preferably by pumping direct from an unpolluted area of ocean (Passfield and Evans, 1991).

Production And Marketing: Table 13 summarises the catch and effort for the years 1989 to 1992. During this time, the catch composition has changed as various fish have become target species.

Table 13. Catch numbers and effort of the aquarium fish fishery in Rarotonga, 1989 - 1992 (Numbers in parenthesis indicate catch per unit effort). (Source: Ian Bertram, Fisheries Biologist, pers.comm.)

	1989	1990	1991	1992

Effort (Diver weeks)	61	166	190	150
Total Catch	9739 (159.7)	17619 (106.1)	9606 (103.2)	17568 (117.1)
Flame Angel Catch	3785 (62.0)	6325 (38.1)	6652 (35.0)	5362 (35.8)
Red Hawk Catch	2434 (39.9)	5045 (30.4)	7800 (41.1)	7569 (50.5)

Fish are packed individually into doubled polythene bags, separated by a liner of newspaper. The bags are inflated with pure oxygen, sealed and packed tightly in lined cardboard boxes prior to being air-freighted to overseas markets in the United States, Europe and Japan. Fish prices ex-Rarotonga range from NZ$1-10 per fish, with some deep water species reaching NZ$30.00. The average return is reported to be approximately NZ$7 per fish. Larger volumes are more economic to send due to minimum freight rates (100kg). The peak selling season for aquarium fish in the United States and Europe is from June to August. Currently exports from Rarotonga average in excess of 400 fish per week. The viability of the Cook Islands aquarium fish industry relies on 2 main species, flame angels and red hawks as these are not readily available from other countries.

1.6.3 Stock Status

The overall CPUE of the Rarotonga collecting operation is quite constant from 1989 to 1992, indicating that the stocks are not being over-fished (Table 13). Individual CPUEs for the main target species, flame angels and red hawks generally support this contention. However, Bertram (1993) notes that the yield of Flame Angels is approaching MSY, indicating that monitoring of the catches of this species is urgently required.

1.6.4 Management

Current Legislation/Policy Regarding Exploitation: Management is limited at present to a ban on fishing inside the lagoon by the expatriate fish collector. However, there are no regulations covering local Cook Islanders fishing inside the lagoon. Legislation has been proposed which will prohibit the use of SCUBA for the collection of reef fish. While designed to prevent the uncontrolled spearing of reef fish by underwater fishermen using SCUBA, it will effectively prevent the further operations of the present operator. Since the company has provided detailed catch, effort and economic data on the operation since its inception, some means may be found to allow the present company to continue its operations.

Recommended Legislation/Policy Regarding Exploitation: With only one exporter operating, few restrictions appear necessary. Concern over the "notching" of coral to permit the collection of certain species of aquarium fish has been addressed by an investigation of the company's operations and the preparation of a report of its findings (Anon., 1992d). The recommendations of this report are reproduced below. Other management options include the setting of quotas for each species and a ban on the fishing of Red Hawks to prevent coral notching.

It would be prudent to limit the number of companies operating to the one that is there at present. There is scope for one or two local collectors to become involved in collecting species not found outside the reef.

Two areas of the lagoon (small areas of Tikioki and Muri) have been surveyed with a view to establishing marine reserves. If they come into being, fish collection will be banned inside and outside the reef in these two zones.

<u>RECOMMENDATION A:</u>

1. That formal legislation be introduced for the island of Rarotonga to prohibit activities that would damage coral in the lagoon, on the reef and outside of the reef to a depth of 200 feet (70m) of water.

2. That all commercial activities/operations for the harvesting and exploitation of marine resources in the Cook Islands EEZ be licensed and to be subject to the control and management of the Minister and the Ministry of Marine Resources.

3. Conditions for the issuance of licence should include appropriate measures for control and conservation of stock, observer and inspection status, local staff training.

4. That formal procedures and areas of responsibility for the exporting of aquarium fish and fish catch be established.

5. That the Monetary Board reviews the registration of Cook Islands Aquarium Fish Ltd.as a foreign company in accordance with the Cook Islands Development Investment Act 1977.

RECOMMENDATION B:

1. That Rarotonga's ornamental and aquarium fish be designated "Fishery or Fisheries" for the purposes of conservation and management and that a Management Plan to be established as matter of urgency.

2. That a research and studies programme be instituted as soon as possible concerning the growth and life-cycle of ornamental and aquarium fish stocks.

3. That fish "reserve parks" be established around the lagoons and reefs of Rarotonga.

4. That the collection and exporting of ornamental and aquarium "fishery" be licensed.

References

Passfield, K. and J.Evans. 1991. Aquarium Fish. Marine Resources Profile No.7, Ministry of Marine Resources, Rarotonga.

2. Outer Reef [**Tua**]

2.1 REEF-ASSOCIATED FISHES

2.1.1 The Resource

Species Present: The reef-associated fishes represented in the troll catch from Cook Islands are presented in Table 14.

Table 14. Names of some reef associated fishes in Cook Islands (Source: Sims *et al.*, 1988)

Common	Scientific	Cook Islands Maori
Bluefin trevally	*Caranx melampygus*	Titiara
Black trevally	*C. lugubris*	Ru'i
Great Trevally	*C. ignobilis*	Urua
Great barracuda	*Sphyraena barracuda*	Ono
Forster's seapike	*Sphyraena forsteri*	Tatu
Dogtooth tuna	*Gymnosarda unicolor*	Varu

Distribution: These pelagic species are found throughout the South Pacific and Cook Islands.

Biology and Ecology: These fish are all carnivorous. In contrast with Oceanic species [**Moana**], reef-associated fish appear to maintain long periods of reef residence and are caught throughout the year. Some species such as *C. lugubris* are found in deep water.

2.1.2 The Fishery

Utilisation: On Palmerston Atoll, there is a small down-lining fishery for *C. lugubris* which occurs throughout the year. Smaller fish of 1-2kg are taken year round, with larger fish up to 15kg mostly being taken between October and December. The incidental catch of this fishery yields a variety of holocentrids (Squirrelfish), serranids (Groupers and Cods), lutjanids (Snappers) and lethrinids (Emperors). *C. ignobilis* and *C. melampygus* are taken rarely (Anon., in press).

The reef-associated fishes are also taken by trolling at Rarotonga and rod fishing on the outer reef slope at Palmerston. Bamboo rods of up to 4.3m are used to fish for carangids, the line being selected to match the rod and the target species (Anon., in press).

Production And Marketing: Apart from a small amount of catch data from Palmerston (Bill Marsters, Fisheries Officer, pers.comm.), catch figures for reef associated fishes in Cook Islands are generally not available. The *C. lugubris* fishery and its by-catch form a small proportion of the total harvest of finfish on Palmerston, with occasional exports of these fish to Rarotonga (Anon., in press).

At Aitutaki, reef associated pelagic fish may be sold to hotels for NZ$5-6/kg (Ian Guinea, Professional Fisherman, pers.comm.).

2.1.3 Stock Status

There is no information available on the status of the stocks of reef associated fishes in Cook Islands. Anon. (in press) states that Palmerston Island fishermen report no significant decrease in the size or abundance of fish in the *C. lugubris* fishery. It is unlikely that at the present level of fishing these stocks are over-exploited.

2.1.4 Management

Current Legislation/Policy Regarding Exploitation: None at present

Recommended Legislation/Policy Regarding Exploitation: Anon. (in press) has noted that coral reef demersal fisheries have a history of being rapidly overfished under commercial pressures. Several management options are suggested should management of the Palmerston *C. lugubris* fishery be deemed necessary.

References

Anon., in press. The marine resources of Palmerston Atoll, Cook Islands. A report of a survey carried out in September 1988. Technical Report No.2. Inshore Fisheries Research Project, South Pacific Commission, Noumea, New Caledonia and FFA Report No. 89/16(b), Research Coordination Unit, Forum Fisheries Agency, Honiara, Solomon Islands. Final Draft. 57p.

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3. Deep Bottom [O'onu]

3.1 DEEP-SLOPE FISHES

3.1.1The Resource

Species present: The deep-slope or deep-bottom/deep-water fish families represented in the drop-line fishing catch from Cook Islands are presented in Table 15.

Table 15. Percentage catch composition by numbers and weight from SPC dropline fishing in Cook Islands (after Dalzell and Preston, 1992).

Family	Common Name	% by No.	% by Wt.
Etelinae/Apsilinae	Deep-water snappers	67.10	50.7
Lutjanidae	Shallow-water snappers	1.80	2.0
Lethrinidae	Emperors	1.50	1.2
Serranidae	Groupers	15.40	9.4
Carangidae/Scombridae	Trevallies, Jacks, Tunas and Mackerels	4.80	9.9
Gempylidae	Oilfish and Snake mackerels	0.70	4.7
Sphyraenidae	Barracudas and Sea-pikes	0.05	0.1
Other teleosts		6.90	6.7
Sharks		2.00	15.2

The etelines are mainly red snapper [**Paru marau**] (*Etelis carbunculus*) and flower snapper [**Paru renga**] (*Pristipomoides zonatus*) while the serranids are dominated by Powell's cod [**Marau renga**] (*Saloptia powelli*) (Dalzell and Preston, 1992). Other important species are snake mackerel [**Manga**] (*Promethichthys prometheus*), castor-oil fish [**Vena**] (*Ruvettus pretiosus*) and amberjack [**Paru komuri**] (*Seriola rivoliana*) (Sims *et al*., 1988).

Distribution: Deep-slope species are distributed throughout Cook Islands, different species predominating in catches taken at different locations. At Rarotonga, eteline snappers (65per cent.) and serranids (12.5 per cent) dominate the catch, whereas at Penrhyn, eteline snappers accounted for only 30 per cent of the catch, with serranids (15.4 per cent) and carangids/scombrids (16.8 per cent) making major contributions (Dalzell and Preston, 1992). At Palmerston, Anon. (in press) reports that 60 per cent of the landings were eteline snappers (*E. carbunculus* and *P. zonatus*) with other major contributions from the serranids (20.3 per cent) and *S. rivoliana* (13.2 per cent).

Biology And Ecology: Deep-slope fishes, especially snappers, tend to have slow growth with low recruitment which results in them being highly susceptible to over-fishing. They are usually top-level carnivores (Smith, 1992).

3.1.2 The Fishery

Utilisation: Deep-slope species are taken for subsistence purposes in Cook Islands, the oily species such as *P. prometheus* [**Manga**] and *R.. pretiosus* [**Vena**] being particularly highly prized.

Downlining for *P. prometheus* is an important fishing activity on Atiu (Jamie Whitford, Fisheries Biologist, pers.comm.) and Rarotonga. Both these species are taken by deep-water night fishing on the outer reef slope, with moonless calm nights being preferred. The bait is set several metres or more off the bottom, from around 200-800m depth. Powell, (1986) describes the gear and method commonly used to catch *P. prometheus* in Cook Islands. The preferred bait is flyingfish [**Maroro**] or a fish of high oil content such as mackerel scad [**Koperu**] or bigeye scad [**Ature**]. No traditional fishery exists for deep-slope snapper in Cook Islands, these fish probably only being caught occasionally when fishing for [**Manga**] or [**Vena**] or close to the bottom (Anon., in press).

Commercial dropline fishing for deep-slope species has not become established in Cook Islands despite a strong demand for fish, especially in Rarotonga. *R.. pretiosus* are occasionally exported to Rarotonga from Palmerston for sale, but their market potential may be hindered by the laxative properties they induce. *P. prometheus* are usually not exported to Rarotonga because of the high esteem in which they are held as foodfish. This, combined with the irregularity of the fishery leads to preference to freeze them for later consumption rather than sell any excess (Anon., in press). The lack of interest in commercial dropline fishing may also be partly due to poor catch rates experienced at Rarotonga, which Dalzell and Preston (1992) say could be expected to decline to around 1.1kg/line-hour given a fishing effort that approached Maximum Sustainable Yield (MSY).

Production And Marketing: There are no available estimates of production of deep-slope fishes for Cook Islands. Catches of up to 10 *P. prometheus* per night are common, with occasional catches of 20-40. These fish typically weigh 2.0kg each and may fetch NZ$6-10 per kilogram at market in Rarotonga (Sifa Fukofuka, Fisheries Development Officer, pers. comm.). The current price at Rarotonga for most deep-slope fish species is between NZ$5 - 7 per kilogram (Kelvin Passfield, pers.comm.).

3.1.3 Stock Status

Dalzell and Preston (1992) estimate that the size of the unexploited biomass of deep slope stocks in Cook Islands is 413mt, which might be expected to yield between 41.3 and 123.8mt/year at MSY. From SPC drop-line surveys, catch rates around Rarotonga ranged between 1.9 and 2.5kg/line-hour with a mean of 2.2kg/line-hour, while at Penrhyn the mean CPUE was 11.2kg/line-hour. Catch rates at Palmerston ranged between 0.9 and 9.3kg/line-hour with a mean of 4.7kg/line-hour. Higher catch rates recorded at Palmerston and in the northern group generally, often reflect the larger sizes of individual fish caught, in a comparatively unexploited fishery e.g. *E. carbunculus* caught at Palmerston have exceeded 20kg whereas at Rarotonga, a 2kg specimen of this species would be considered large (Kelvin Passfield, pers. comm.).

3.1.4 Management

Current Legislation/Policy Regarding Exploitation: None at present

Recommended Legislation/Policy Regarding Exploitation: Exploitation guidelines may be required should commercial deep-slope fishing commence. These should be based on potential yields estimated for other Pacific Island countries.

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4. Oceanic [**Moana**]

4.1 TUNA

4.1.1 The Resource

Species present: The most important commercial tuna species in Cook Islands waters are albacore [**To'evere**] (*Thunnus alalunga*), yellowfin [**A'ai**] (*T. albacares*) and bigeye [**Tuava**] (*T. obesus*). Other tuna species caught artisanally are skipjack [**Au'opu**] (*Katsuwonus pelamis*) and dog-toothed tuna [**Varu]** *Gymnosarda unicolor*).

Distribution: Yellowfin and bigeye occur throughout the tropical and sub-tropical waters of the Pacific Ocean and there are no obvious barriers to movement. However, there is some evidence that interchange of yellowfin between the eastern and western Pacific is limited. Skipjack are highly mobile and are capable of unrestricted movement throughout the Pacific Ocean. For adult skipjack, it seems that the movement between the eastern and central Pacific is more limited than that between the Philippines and eastern Indonesia to 150°W. It has been recently suggested that albacore in the North and South Pacific constitute separate stocks and that albacore throughout the Pacific be considered as a single stock (Hampton, 1993).

All the species caught in Cook Islands are pelagic or highly migratory. There are definite seasons when each species, or certain size-and-age classes of each species are more common. Skipjack and small yellowfin tuna are highly abundant in surface waters from November to March. Larger yellowfin are found in deeper water throughout the autumn, winter and spring. Dog-tooth tuna appear to maintain long periods of reef residence and are taken throughout the year. The tuna seasonal patterns around Palmerston are reported to be more extended than those further south (Anon., in press).

Albacore are never caught at the surface in Cook Islands, usually being taken at depths of 180m or more on vertical longlines or droplines around FADs. Based on 1991 logsheet data from Korean longline vessels, peak periods of fishing activity by these fleets are from January to March and July to September which coincide with the optimum catch periods for albacore (Bertram, 1993).

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

4.1.2 The Fishery

Utilisation: Tunas are caught by subsistence, artisanal and commercial fishermen in the Cook Islands. The subsistence and artisanal operations provide catches for home consumption and the local market. Skipjack, yellowfin and albacore are all taken in these fisheries which provide a significant source of fresh fish and employment.

Trolling is the most commonly utilised subsistence and artisanal fishing method targeting tuna. Prior to the 1970's, trolling was conducted from 6-7m long sailing cutters and 3m paddling canoes. Now the Rarotongan artisanal fleet numbers more than 50 outboard-powered (25-60hp) aluminium and plywood runabouts, ranging in length from 4.3 to 4.9m, and a few Yamaha fibreglass boats of 5.6-6.4m. These vessels, with a crew of 2-3, troll up to 4 monofilament handlines (75kg test) at speeds up to 8 knots along the reef edge and around Fish Aggregating Devices (FADs) which have been deployed in a programme which commenced in late 1986 (Anon., in press). There are at present 4 FADs around Rarotonga, situated at Avarua (S 21° 09.647' W 159° 45.022'), Ngatangia (S 21° 15.938' W 159° 42.011'), Rutaki (S 21° 15.568' W 159° 50.521') and Black Rock (S 21° 10.638' W 159° 50.471'. There are also FADs deployed, or planned for deployment at Atiu, Mangaia, Mauke, Mitiaro and Aitutaki (Sifa Fukofuka, Fisheries Development Officer, pers.comm.). Until now, the government has taken responsibility for repairing and replacing FADs, but there is scope for the fishermen themselves to bear some of these costs on a "user-pays" principle.

Larger tuna such as yellowfin are also targeted by the drop-stone method of down-fishing, in depths from 70m to 200m. On atolls such as Palmerston, this is usually only conducted on the leeward side of the atoll at specific tuna "holes". A handline of 30 to 70kg test monofilament nylon line is used with a single tuna-circle hook. Ground bait [**paru**] is used, packed together with a flat stone weight around the baited fishing hook. The **paru**, stone and bait is wrapped in a broad breadfruit or wild hibiscus leaf, tied with a slip-knot. Cotton cloth is also used as a wrapping material. The knot is released by a firm tug at the required depth. The bait and paru is preferably of a very oily fish such as mackerel scad [**Koperu]** (*Decapterus* spp.) or big-eye scad [**Ature**] (*Selar crumenopthalmus*) (Anon., in press).

Licensed Korean longliners have operated in Cook Islands EEZ, but outside Territorial Seas (12 miles) since 1980 and Taiwanese longliners since 1981. At present 50 Taiwanese longliners are licensed to operate, targeting albacore tuna. Fishing areas for Korean and Taiwanese longliners are predominantly within the northern group (Latitude 9-15°S, Longitude 155-167°W). However, these vessels have occasionally been reported operating in the southern group (Latitude 5-22°S, Longitude 155-165°W (Bertram, 1993). Numbers of Taiwanese and Korean longliners licensed to fish in Cook Islands' waters from 1981-1993 with associated fees paid in US$ are given in Table 16.

Cook Islands is currently a party to the Treaty on Fisheries between the Governments of Certain Pacific Island States and the Government of the United States of America (US Multilateral Treaty). Approximately US$160,000 is received annually for being a party to the Treaty. Payments to Cook Islands for the period 1988-1992 totalled US$580,366 (Anon, 1993a). Cook Islands also receives approximately US$60,000 worth of project aid and US$16,000 as technical assistance (Evans, 1991).

Under the Treaty, additional fees are to be paid by the U.S. if their vessels wish to engage in fishing within the Cook Islands EEZ. Cook Islands' waters appear well suited to longline fishing for tuna since they hold more of the deeper swimming species such as albacore, yellowfin and bigeye. Because the Treaty is essentially for purse seine vessels, U.S. vessels tend to fish elsewhere (Evans, 1991).

A Tahitian owned longliner operated on a trial basis for 3 months from September to November during 1991, targeting albacore. The test fishing licence issued to the vessel permitted it to operate within the Territorial Seas. The vessel, "Noella K" fished in the area Latitude 8° 25'-21° 48'S, Longitude 158°2'-161°31'W. It was hoped that the vessel would provide data which would assist with the assessment of tuna stocks in Cook Islands' waters. A government-owned 8.84m mini horizontal longline vessel "Ton 7" commenced test fishing in 1989. The fishing area is predominantly along the coast of Rarotonga, 2 miles north of Avatiu Harbour (Fukofuka, 1991).

Production: Information on the catch and effort of the subsistence and artisanal troll and drop-stoning fisheries is scanty. Catch rates are reported as being significantly higher at Palmerston than those from Rarotonga. Savins (1989) reports an average catch of approximately 3 tuna, each weighing 8kg for a 1-2 hour morning trolling trip around the FAD's off Rarotonga. For 4 trolling lines, this equates to an approximate catch rate of 4kg/line.hour or 0.5 fish/line.hour. Catches are subject to seasonal variation.

During a 3 month fishing period, the "Noella K" caught 13mt of fish, 5.9mt of which was albacore. The average weight of the albacore taken was 20.9kg, their lengths ranging from 98 to 109cm. The average catch rate in kg per 100 hooks for all species was 39.7kg (16.4 for albacore) and in numbers per 100 hooks was 1.6 (0.8) (Bertram, 1993).

In 1991, the "Ton 7" made 22 fishing trips with an average catch rate for albacore of 19.5kg/100 hooks (approximately 1 fish/100 hooks). However, in 1992 the average catch rate for albacore decreased to 10.6kg/100 hooks. The weight of the albacore taken ranged from 15 to 28kg with an average weight of 19kg (Bertram, 1993).

Marketing: The Taiwanese vessels unload their catches in Pago Pago, American Samoa, receiving approximately US$2,000 per mt for albacore with weights varying between 18 and 24kg. The fish caught by the "Ton 7" were sold to local restaurants and small food take-aways. The price for tuna averaged NZ$6/kg (Fukofuka, 1991). Anon. (in press) reports that fishermen on Rarotonga selling direct to restaurants and the public receive NZ$6.00/kg for yellowfin while the price paid for whole, gutted tuna to Palmerston Islanders by the reefer boat and fish retail company was NZ$3.00/kg. MMR reports a growing demand for fresh tuna from retail outlets and hotels at Rarotonga.

A seafood survey conducted on Rarotonga in late 1988 (Zoutendyk and Paulo, 1989) gives a price of NZ$5.50/kg for fresh whole yellowfin and NZ$7.50/kg for imported yellowfin fillets from Western Samoa. In the same survey, fresh whole skipjack tuna is listed at NZ$5.00/kg. The survey report notes that Rarotonga fishermen supply most of the fresh fish used in the island's restaurants, but that there is much room for improvement of the quality of fresh fish sold. In 1991, yellowfin fillets from Western Samoa were being imported for NZ$11.30/kg, but the volume of imported fillets had dropped steeply from the 1990 levels (Statistics Office, Rarotonga).

4.1.3 Stock Status

There has been no recent assessment of tuna stocks for Cook Islands' EEZ. A recent assessment of stock status of yellowfin, skipjack, bigeye and albacore tuna for the SPC statistical area has been made by the SPC's Tuna and Billfish Assessment Programme (Hampton, 1993). In summary;

- Further increases of yellowfin catches in the western Pacific could be sustained, possibly to around 600,000-800,000mt per year on average, but confirmation would be desirable.

- Further increases in western Pacific skipjack catch to around 1.5-2.0 million mt per year on average would appear to be biologically sustainable.

- Current levels of bigeye catch, about 150,000-200,000mt per year Pacific-wide are sustainable.

- Increased catches of juvenile albacore could be sustained, but this requires confirmation.

Total tuna catches for the SPC statistical area for 1992 were 1.049 million mt, down 7 per cent from the 1992 revised estimate of 1.129 million mt, the first time that estimated annual catches for this area have declined since 1985. This slight decline was attributed to a drop in purse seine caught skipjack during 1992, following particularly high skipjack landings during 1991 and a significant decrease in catches by the Korean purse seine fleet. Total yellowfin landings and purse seine yellowfin catches increased during 1992.

Longline activity during 1992 was relitavely stable, aside from the continued shift from large, distant water vessels to small, regionally based sashimi vessels. Japanese distant water pole-and-line effort continued to decrease during 1992 with a significant decline in catches. No high seas driftnet fishing was reported in 1992 with a slight decrease in catches of albacore trollers during the 1991/92 season (Anon., 1993b).

4.1.4 Management

Current Legislation/Policy Regarding Exploitation: The management of the tuna fishery in the Cook Islands EEZ is the responsibility of the Ministry of Marine Resources, under the 1989 Marine Resources Act.

Recommended Legislation/Policy Regarding Exploitation: Cook Islands receives very little if any catch and effort data from the DWFN. Collection of such data from DWFNs was expected to commence in 1993, but this has not eventuated. This situation should be rectified if realistic assessments of stock status are to be carried out.

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Table 16. Numbers of Taiwanese and Korean longline fishing vessels licensed to fish in Cook Islands' EEZ, 1981-1993 with associated fee payments (US$'000) (Source: Cook Islands Ministry of Marine Resources).

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Taiwan													
No.	-	90	80	50	29	49	55	42	48	44	49	54	50
Fee	-	90.0	80.0	57.0	34.0	53.0	82.8	75.6	108.0	113.9	139.5	156.5	142.3
Korea													
No.	137	115	60	41	50	44	48	40	71	60	40	-	-
Fee	100.0	110.0	70.0	53.0	57.0	69.0	80.0	76.0	150.0	144.9	100.0	-	-

4.2 OTHER PELAGICS

4.2.1 The Resource

Species Present: This category includes all the non-tuna pelagics: billfish - including blue marlin (*Makaira nigricans*), black marlin (*Makaira indica*), striped marlin (*Tetrapturus audax*), broadbill swordfish (*Xiphias gladius*), sailfish (*Istiophorus platypterus*) and others; wahoo [**Pa'ara**] (*Acanthocybium solandri*); dolphin-fish [**Ma'i ma'i**] *Coryphaena hippurus*) and rainbow runner [**Roroa**] (*Elagatis bipinnulatus*).

Distribution: All the pelagic gamefish which occur in the central South Pacific are known by Cook Islands fishermen. Wahoo show a definite difference in size seasonality; larger individuals occurring from May through to September with smaller fish more frequently taken from October to December (Anon., in press).

Biology And Ecology: All these species are predators, mostly of fish and squid. The billfish are solitary many of the others tend to form small to medium sized schools. Some species such as barracuda appear to maintain long periods of reef residence and are taken throughout the year (Anon., in press). The billfish and dolphin-fish undergo migrations believed to be associated with spawning. Large barracudas are potentially ciguatoxic.

4.2.2 The Fishery

Utilisation: Most subsistence and artisanal catches are made by trolling from outboard-powered (25 - 40hp) aluminium and plywood runabouts, ranging in length from 4.3 to 4.9m. These vessels troll up to 4 monofilament handlines (75kg test) at speeds up to 8 knots along the reef edge and around Fish Aggregating Devices (FADs). On Palmerston, whole fresh flying fish [**Maroro**] (F. Exocoetidae) or mackerel scad [**Koperu**] (*Decapterus macarellus*) are used when targeting larger fish.Trolling close to the reef where there is a greater chance of wahoo, dog-tooth tuna or barracuda strikes, wire leader lines are used (Anon., in press). At Rarotonga, squid lures are commonly used, but fresh baits are preferred when available (Kelivin Passfield, pers. comm.).

Production And Marketing: Mead (1988) reports that Rarotongan troll fishermen take their best catches from the FADs, with the most productive time being from half an hour before, until just after, sunrise. During an evaluation of the FADs under different conditions and at different times of the day, Mead (1988) found that the most productive trolling presentation around the FADs proved to be a variety of small feathers and squids and one large lure trolled on the sub-surface line. The 60 hours of trolling, most often with 4 lines, recorded a catch of 3.0kg/hour and a CPUE of 1.1kg/line hour. The majority of the 181.6kg catch, by weight, was taken on the sub-surface line. It consisted of only four species; bluefin trevally [**Titiara**] (*Caranx melampygus*), wahoo, skipjack tuna and yellowfin tuna, with wahoo and yellowfin tuna together accounting for 95.8 per cent of the total by weight.

Anon.(in press) reports that the prices paid to Palmerston fishermen for whole gutted wahoo and dolphinfish is between NZ$3.50-4.00/kg. The current price for wahoo fillets paid to Palmerston fishermen is NZ$11.00/kg. (Bill Marsters, Fisheries Officer, pers.comm.). Fishermen on Rarotonga selling direct to restaurants and the public get NZ$7.00/kg for fresh, whole wahoo and dolphinfish (Sifa Fukofuka, Fisheries Development Officer, pers. comm.).

4.2.3 Stock Status

There is no stock assessment information available on the non-tuna pelagic fishes caught either for subsistence or commercial purposes. The pelagic fish resource is unlimited from the perspective of small-scale commercial fisheries.

4.2.4 Management

Current Legislation/Policy Regarding Exploitation: There is no current legislation regarding the exploitation of the above species.

Recommended Legislation/Policy Regarding Exploitation: None is considered necessary at this time. Utilisation of FADs may need to be regulated to minimise gear conflicts.

References

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4.3 FLYINGFISH [**Maroro**]

4.3.1 The Resource

Species Present: A number of different species of flyingfish (all of the family Exocoetidae) are common in the oceanic waters of Cook Islands (Anon., in press). It has been estimated by Parin (In Gillett and Ianelli, 1991) that there are 16 species of flying fish which occur near Samoa. Though most of these species probably occur in Cook Islands waters, only three species have so far been positively identified from Cook Islands; *Cheilopogon atrisignis, Ch. unicolor* (also called *Ch. antoncichi*) and *Cypselurus poecilopterus* (Gillett and Ianelli, 1991).

Distribution: Flyingfish common in the tropical Pacific have limits of distribution bounded by 40° S and 40° N (Kovalevskaya, 1982 in Gillett and Ianelli, 1991). However, no accurate data on flyingfish distribution and abundance exist, due to the taxonomic difficulties associated with the family Exocoetidae. The 2 types of adult flying fish recognised by fishermen on Palmerston apparently represent different species (Anon., in press).

Biology And Ecology: Flyingfish are schooling, pelagic fishes found near the ocean's surface where they feed on small fishes and plankton. Gillett and Ianelli (1991) state that some authors partition flyingfish species into two groups, neritic (coastal) and oceanic. An oceanic species doesn't require coastal habitat for any stage of its life history, in particular, spawning. Coastal species, on the other hand, use the coastal environment for some stage of their life cycle, typically to spawn. Little is known of their life history, although fishermen on Palmerston Atoll report that both species recognised there breed from October to December. Mokoroa (1984) describes a breeding aggregation of flyingfish which occurs on the outer reef of Atiu in early December.

Growth of tropical flyingfish is rapid, in common with many other pelagic species. Dalzell (1993) describes the growth and mortality of Pacific species of flyingfish.

4.3.2 The Fishery

Utilisation: As in many areas of the tropical Pacific, flyingfish are captured in Cook Islands for local consumption, being a highly regarded foodfish and also as prime trolling bait for pelagic or reef-associated gamefish. In Rarotonga, the season for flyingfish is generally from the end of October to the end of March (less limited seasonality at Palmerston) fishing usually being conducted on dark nights by scoop netting from the bow of a small runabout. Fishing may still occur a week or more either side of the new moon, but only during the moonless hours.

The fishing area of flyingfish is just behind the breakers, approximately 250m offshore but ranging from 50 to 500m or more. On Palmerston, fishing is generally limited to the lee of the island, as fairly calm seas are necessary to allow sighting of fish and accurate scooping (Anon., in press and Savins, 1989).

At Palmerston, flyingfish fishing is conducted by a crew of 2, a helmsman to control the outboard motor and a net man who is roped securely into the bow of the dinghy. In Rarotonga, flyingfish fishing is almost entirely a single-handed operation, with a joystick and the throttle mounted in a specially designed cockpit in the bow of the runabout (Anon., in press). While searching for fish, the scoop net is held against the joystick with one hand, leaving the other hand free to operate the remote control (Savins, 1989).

In the Palmerston flyingfish operation, the net man wears a helmet with a powerful, generator-driven spotlight attached. The scoop net is constructed from a pole of 2.5m or more in length, with a shallow net at one end. The net gape is approximately 0.3m wide and 0.7m long.

Fish are spotted in the light and the net man scoops them up either before they take flight, while on the wing, or as they land again. If fish are scarce, an individual fish is chased until it is either captured or escapes. If fish are plentiful or if the boat is in the middle of a dense school, individual fish are not chased as others quickly come within the spotlight beam (Anon., in press).

Production And Marketing: At Palmerston, flyingfish fishing trips may be up to 4 hours long during which time 300 to 400 flyingfish could be taken. A catch rate of approximately 100 fish/hour equates to around 25kg/hour (Anon., in press). In Rarotonga, trips may be as long as 6 hours for an average catch of 200 flyingfish. Exceptionally, 400 fish per trip may be taken (Savins, 1990).

Flyingfish are sold in Rarotonga for NZ$1.00 each, generally 5 on a string for NZ$5.00 (Savins, 1990). Palmerston flyingfish are usually shipped to Rarotonga in whole, frozen form. It is unlikely that the Rarotongan market would pay more than NZ$1.00/fish (approx. NZ$4.00/kg). Of this, fishermen on Palmerston receive NZ$3.00 per/kg, representing for the short commercial life of this fishery, a significant income for the island (Anon., in press).

Subsistence catches of flyingfish at Palmerston are probably around 1 or 2 mt/year. Exports to Rarotonga on a commercial basis have probably amounted to between 2 and 3mt/year over recent years (Anon., in press). There are currently 4 dinghies involved in the fishery at Palmerston (Bill Marsters, Fisheries Officer, pers.comm.).

4.3.3 Stock Status

Nothing is known about the status of the flyingfish stock in Cook Islands. It is assumed that the resource is virtually unlimited. Gillett and Ianelli (1991) state that several biological characteristics of flyingfish appear to be favourable from a fisheries development perspective. They appear to be short lived, fast growing, highly fecund animals with a wide-ranging distribution. This indicates that overfishing, at least to the moderate catch levels observed in locally developed fisheries, is unlikely.

4.3.4 Management

Current Legislation/Policy Regarding Exploitation: This is covered under the Marine Resources Act 1989. There is no specific legislation relating to flyingfish.

Recommended Legislation/Policy Regarding Exploitation: Based on the information available, there is no need to consider managing the flyingfish fishery. As the demand for flyingfish from Palmerston only arises when there is an under-supply in Rarotonga, the Palmerston fishery will always be limited in its development opportunities by the Rarotongan local fishery (Anon., in press).

References

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4.4 SHARKS [**Mango**]

4.4.1 The Resource

Species Present: Dalzell and Preston (1992) list 4 species of sharks taken as by-catch during dropline fishing surveys in Cook Islands; white-tip shark (*Carcharinus albimarginatus*), grey reef shark [**Papera**] (*C. amblyrhynchos*), black-tip shark (*C. melanopterus*) and reef white-tip shark [**Ngarara**] (*Triaenodon obesus*). The silky shark (*C. falciformis*) is recorded by Anon. (in press) and the hammerhead shark [**Mango iravaru**] (*Sphyrna* sp.) by Clerk (1981).

Distribution: *C. albimarginatus*, *C. amblyrhynchos*, *C. melanopterus* and *T. obesus* are recorded from Aitutaki, Penrhyn, Rarotonga and Palmerston (Dalzell and Preston, 1992), but are likely to be found throughout Cook Islands. *C. falciformis* is recorded from Palmerston (Anon., in press) and *Sphyrna* sp. from Mangaia (Clerk, 1981).

Biology And Ecology: Nichols (1993) provides a brief overview of the biology of sharks. In general, sharks are difficult to age, have a relatively slow growth rate (except when very young), and females tend to reach greater maximum lengths than males. The majority of commercially important shark species in the FFA region are ovoviviparous or viviparous, have a long gestation period and low fecundity. Shark species usually display sex and size segregation and females of some species may move inshore to give birth in selected nursery areas.

The characteristics of low fecundity, long gestation, slow growth, and often very localised movements result in many shark populations being very prone to recruitment over-fishing. This fact is becoming very apparent in almost all commercial shark fisheries, especially off the Atlantic and Pacific coasts of the US, and in the Australian and New Zealand shark fisheries.

4.4.2 The Fishery

Utilisation: In Rarotonga, shark flesh is not commonly consumed. Shark-skin leather was previously used in the crafting of drums for traditional dancing [**pau mangau**], but it has now been replaced by goat-skin (Passfield, 1989). The livers of some species of deep-water sharks is rich in squalene oil, used in the manafacture of perfumes and medicinal products. There are plans to grant a licence for commercial test fishing for deep water gulper sharks (*Centrophorus* sp.) in Cook Islands waters (Jonah Tisam, Government Advisor, pers.comm.).

Production and Marketing: There is little no information available on the production and marketing of sharks in Cook Islands. In Rarotonga, consumer acceptance of shark flesh is generally low. However, as more fishermen engage in down-lining around FADs, the incidental catch of sharks has been increasing, and on occasion, shark flesh has been sold to take-away food shops on Rarotonga for NZ$8.00 per kilogram. Careful handling is required to produce shark fillets that do not have a strong smell of ammonia (Kelvin Passfield, pers. comm.). There has been interest expressed by local and overseas business interests in the export of dried shark fins (Cook Island Ministry of Marine Resources).

4.4.3 Stock Status

Very little information is available on shark stocks in Cook Islands waters, though sharks are reported to be abundant in the northern group (Passfield, 1989).

4.4.4 Management

Current Legislation/Policy Regarding Exploitation: None at present

Recommended Legislation/Policy Regarding Exploitation: Shark processing, utilisation and marketing trials could be conducted in areas where sharks are abundant, such as the northern group. Exploitation guidelines may be required should commercial longlining for deep-water sharks commence.

References

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5 Freshwater [**Kau Vai**]

5.1 FRESHWATER EEL [**Tuna**]

5.1.1 The Resource

Species Present: The Pacific short-finned eel, *Anguilla obscura*. The Pacific long-finned eel, *A. megastoma* has also been recorded from Cook Islands (Ege in Jellyman, 1988), but its presence is unconfirmed.

Distribution: The Pacific short-finned eel is widespread in the South Pacific region from Papua New Guinea to the Society Islands and Rapa (Allen, 1991). In Cook Islands, it is found in lakes on Mitiaro (Jellyman, 1988) and Mangaia (Clerk, 1981). Eels have been seen in streams on Rarotonga

(Masatoshi Fujino, Fisheries Biologist; Kelvin Passfield, pers.comm.), and in the Ootu area of Aitutaki (Passfield, 1993).

Biology And Ecology: *A. obscura* is known to occur in small creeks as well as swamps and lakes, growing to a maximum length of approximately 100cm (Allen, 1991). In Lake Te Rotonui on Mitiaro, Jellyman (1988) sampled 264 eels using fyke nets and gaffs. The length of these eels ranged from 35.0 to 84.5cm TL.

Recruitment of juvenile eels (<50mm) into the lake must be via underground conduits. Once inside the lake, it is assumed that the eels lead a cryptic life in the algal substrate of the lake until they reach 30-35cm when they leave cover to feed.The adult eels burrow in the algal substrate. The sex ratio of males to females is approximately 5:1 (Jellyman, 1988).

To determine the diet of the eels, Jellyman (1988) examined 117 stomachs, of which nearly 40 per cent were empty. The remaining stomachs contained fish, fish remains and algae, the fish being tilapia, *Oreochromis mossambicus*.

Analysis of marks on eel otoliths led Jellyman (1988) to conclude that the eels in Lake Te Rotonui were aged between 6 and 28 years. Their rate of growth was faster than that recorded for most studies of New Zealand eels but generally less than that for European eels. The distribution of age classes indicated a strong likelihood of recruitment of juveniles from the sea being both intermittent and limiting.

5.1.2 The Fishery

Utilisation: Eels are exploited for subsistence purposes on the islands of Mitiaro, Mangaia, Mauke and Atiu, using traps and lines. They are usually consumed locally, though some may be sent alive in tins of water to Rarotonga and other nearby islands for sale (Cook Islands Ministry of Marine Resources).

Production And Marketing: Jellyman (1988) reported that only one man regularly visits Lake Te Rotonui to gaff eels. His estimate of catch was 30-50 eels per visit with up to 100 on an exceptional day. Fishing was reported to be carried out 3-4 days per week all year round. These figures equate to an annual catch of between 4,680 - 10,400 eels.

At present, the fishery for eels on Mitiaro is seasonal, from June to August. Only 3 fishermen use hook and line and the fisheries officer has 2 fyke nets for sampling (Masatoshi Fujino, Fisheries Biologist, pers.comm.). The catch per unit effort using fyke nets has been estimated at 3.14 eels/night (Jellyman, 1988). In 1987, seven eels could be sold for NZ$25.00 (Stephenson, 1987).

5.1.3 Stock Status

Jellyman (1988) used a mark-recapture experiment to estimate the size of the eel population in Lake Te Rotonui on Mitiaro. Tentative estimates were from 3,960 to 12,540 eels greater than 35.0cm long, with equivalent standing stocks of 20.7-65.6kg/ha. Jellyman (1988) states that the Mitiaro eel resource is not large and does not have the potential to support a significant eel fishing industry. He concludes that the present level of harvest is all that the fishery can sustain and no expansion of the present fishery should be considered.

5.1.4 Management

Current Legislation/Policy Regarding Exploitation: There is currently no legislation specifically relating to eels.

Recommended Legislation/Policy Regarding Exploitation: None required at present.

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5.2 TILAPIA

5.2.1 The Resource

Species Present: The Mozambique tilapia, *Oreochromis mossambicus*.

Distribution: The natural distribution of the Mozambique tilapia is limited to Africa and the Near East. Cook Islands received finglerlings of *O. mossambicus* from the Sigatoka Agricultural Station, Fiji in 1955. The purpose of this introduction was most probably for aquaculture, with the aim of providing an additional source of food for local populations. Populations of *O. mossambicus* are now well established in freshwater habitats and brackish water areas of Cook Islands (Nelson and Eldridge, 1989). Tilapia are present in water bodies on Rarotonga, in Lake Te Rotonui on Mitiaro (Jellyman, 1988), in Lake Tiriara on Mangaia and in brackish water bodies on Atiu (Masatoshi Fujino, Fisheries Biologist, pers.comm.).

Biology and Ecology: Tilapias are of the Family Cichlidae. All tilapia species were considered to belong to the genus *Tilapia*, but in recent years, mouth-brooding species have been classified into *Oreochromis* or *Sarotherodon*, (Shokita *et al.*, 1991). *O. mossambicus* is sexually dimorphic with males being larger and more brightly coloured than females.

Just before the breeding season, a male forms a territory and makes a conical shaped breeding site or nest. Subsequently, the male lures a female into the nest to mate. After oviposition, the male releases sperm to fertilize the eggs and the female holds the fertilized eggs in her mouth (Shokita *et al.*, 1991). In Lake Te Rotonui, Jellyman (1988) found many nests around the lake margins, up to 30cm across and 10cm deep being actively guarded by males.

Male tilapia in Lake Te Rotonui dominated fyke net catches by approximately 8:1. The smallest sexually developed male found was 81mm in length, while females matured at approximately 77-78mm. Ovaries contained eggs of different sizes, probably indicative of several spawnings per year. Lengths of 290 tilapia ranged from 51-202mm with no indication of year classes in the length-frequency histogram (Jellyman, 1988).

Jellyman (1988) took scales from 100 tilapia and using scale checks which he assumed were annual in formation, he back-calculated the growth of the fish. Results are given in Table 17.

The results show that though males grow faster than females, growth is very slow. The conclusion reached by Jellyman (1988) from these results is that in the absence of significant predatory pressure and no human exploitation, the tilapia in Lake Te Rotonui have become a stunted population characterised by their prolific numbers and slow growth rate.

5.2.2 The Fishery

Utilisation: On Atiu and Mangaia people catch tilapia for subsistence purposes, using traps, hook-and-lines, spears and gillnets. Mitiaro people have proposed that tilapia in Lake Te Rotonui be converted to fishmeal, as they do not consider it a suitable food-fish (Masatoshi Fujino, Fisheries Biologist, pers.comm.).

In early 1993, a total of 1,000 hybrid, red tilapia fry were imported from Fiji, to test their potential for aquaculture. There was a high mortality rate (80 per cent) in transit, but the surviving fish were placed in the Matavera Experimental Ponds on Rarotonga. A further 1,000 fry have been ordered from Fiji Fisheries Division, Suva (Cook Islands Ministry of Marine Resources).

Table 17. Back-calculated length at previous age for *O.mossambicus*.(Source: Jellyman, 1988).

		Age Class					
		1	2	3	4	5	6
Males	n	14.0	13.0	13.0	11.0	5.0	3.0
	mean length (mm)	51.0	82.0	120.0	139.0	147.0	159.0
	S.D.	11.5	16.8	23.6	24.5	24.5	30.6
Females	n	6.0	6.0	4.0	3.0	1.0	
	mean length (mm)	57.0	79.0	97.0	109.0	137.0	
	S.D.	7.6	6.6	4.7	7.1		

Production And Marketing: There are no reports of the subsistence production of tilapia from any of the islands where it is present. The larger of the lakes on Mitiaro, Lake Te Rotonui has a total

surface area of 70ha (at 2m above mean sea level) although this could increase to 114ha at maximum levels. The area of open water is approximately 52ha (Jellyman, 1988).

There are ample food supplies of blue-green algae *Coelospharerium* sp. in the lake which are consumed by tilapia (Jellyman, 1988). Based on tilapia production figures from freshwater lakes in Papua New Guinea of between 8-40kg/ha/year (Coates, 1985), the potential production of tilapia from Lake Te Rotonui is estimated to be 0.9-4.6mt/year.

5.2.3 Stock Status

Jellyman (1988) reported that tilapia were abundant in Lake Te Rotonui on Mitiaro. There are no reports of the status of tilapia stocks from the other islands where it is present.

5.2.4 Management

Current Legislation/Policy Regarding Exploitation: There is currently no legislation concerning tilapia.

Recommended Legislation/Policy Regarding Exploitation: The use of tilapia for aquaculture purposes is worthy of investigation.

References

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6 Other Seafood [**Te Vai Atura**]

6.1 TURTLES

6.1.1 The Resource

Species Present: Eight species of sea turtles live in the world's oceans, two of which are commonly found in Cook Islands. These are the hawksbill turtle (*Eretmochelys imbricata*) and the green turtle [**'Onu**] (*Chelonia mydas*).

Distribution: Both species are recorded as nesting on Manihiki, Pukapuka, Penryhn (UNEP/IUCN, 1988) and Palmerston (Anon., in press) while Rakahanga is recorded as a nesting site for green turtles (UNEP/IUCN, 1988). On Palmerston, the green turtle is commonly found in the lagoon and regularly rests on a number of islets while the hawksbill turtle is considerably more rare (Anon., in press). Green turtles have also been observed nesting on Suwarrow (Kelvin Passfield, pers. comm.).

Biology And Ecology: The basic stages of the life cycles of sea turtles are similar for all species, though many accounts are based on that of the green turtle which is the most well-studied. Most studies of sea turtles have focussed on their nesting behaviour on land and there are major gaps in information about the main portion of their lives, that which they spend in the sea.

The female turtle lays her eggs at night in a nest she digs in the sand. The size of the egg clutch depends on the number of times she has already laid that season but is generally between 90 and 140 eggs. She will lay about 3 to 7 times, 10 to 15 days apart during her nesting season.

The eggs take around 48 to 70 days to hatch, depending on the sand temperature. The sex of the hatchlings is determined by the temperature of the nest; if the nest is hot then most turtles will be female and if the nest is cool then the majority of the hatchlings will be male. In the mid-temperature range, the sex ratio can vary, depending on the local weather conditions. Moving the eggs after about 4-6 hours after laying usually causes the embryo within the egg to die. Disturbing nests will reduce turtle hatching success by altering the nest structure and may increase its vulnerability to predation (Smith, 1992).

Immediately before hatching, the juvenile's rostrum tips are pointed to facilitate the breaking of the egg-wall from inside. The juvenile which hatches first stimulates others to do the same. The juveniles form a packed mass, taking a few days to climb upward through the sand before emerging on the surface (Shokita *et al.*, 1991).

By hatching together, the number killed by predators on the beach (e.g. ghost crabs, birds) and in the water (e.g. sharks and fish) are reduced, as the predators cannot eat them all at once. The hatchlings locate the direction of the water by its lighter colour, so any lights inland of the hatching nest can disorient them. After reaching the sea, the hatchlings immediately swim for the open ocean, only stopping after several days. They then rest and begin feeding on planktonic animals near the surface.

Little is known of the juvenile and sub-adult stages of the sea turtle's life history as it is extremely rare to find young sea turtles in nature. It is thought that the juveniles drift for several years in the open ocean, perhaps taking refuge amongst floating seaweed and feeding on organisms associated with the seaweed. In that time they make one or more circuits of the full ocean gyres before changing to a bottom-dwelling existence around reefs and islands (Smith, 1992).

Sub-adult and adult green turtles are herbivorous, feeding on seagrass and algae growing in shallow water. The kinds of plants consumed differ from place to place, probably reflecting differences in vegetation at each site. The hawksbill turtle is known as a carnivore, eating mainly sponges (Shokita *et al.*, 1991).

In the wild turtles mature very slowly, taking approximately 25 years (Hawaii) and 30 years (Australia) to reach sexual maturity. Males that are sexually mature can be identified by the long tail protruding from under the shell. Once turtles are mature, they will commence long migrations back to the area where they were hatched (Smith, 1992). Turtles are known to migrate extensive distances between islands, but it is likely that younger turtles will remain on one island. On Palmerston, it is reported that when the local juvenile out-growing programme was in operation, there were significantly greater numbers of younger turtles to be found on the island (Anon., in press).

Mating occurs in the vicinity of nesting areas. Around Palmerston Atoll this is from May to August (Anon., in press). The female is receptive to males for about 1 week, during which time she will mate with a number of males and store their sperm. The male is sexually active for about 1 month and mates with a number of females. After mating, the males migrate back to their feeding areas. The females will move up to 100km to their nesting beaches. Green turtles nest seasonally from November to March on Cook's and Tom's Islets at Palmerston and less often at Primrose, Bird and North Islets (Anon., in press). After completing the nesting cycle, females will migrate back to the feeding area. The same female will not usually breed in successive years, but will wait from 2-8 years (a 3 year

cycle is common) before breeding again. It is thought that turtles commonly live longer than 30-40 years (Smith, 1992).

6.1.2 The Fishery

Utilisation: According to Palmerston Islanders, the nesting areas on the various islets are the best areas for turtle hunting. Turtles are also taken opportunistically throughout the year from inside the lagoon and on the outer reef. When a turtle is captured, it is normally butchered and portions distributed among the households in the village where it is either barbecued or baked in an earth oven [**umu**].

Anon. (in press) reports that free-hand spears, spear guns, harpoons, gaffs, fishing lines and ropes have commonly been used at Palmerston for the capture of turtles, though since the banning of spearing in 1976, they are now taken by hand, noose or gaffing at night.

Turtle gaffing was recently introduced and has replaced spearing. It is mainly used at night when turtles are stationary, sleeping or resting. Fishing line or rope with a loop or noose at one end is also used for capturing turtles while they are mating, as they are then floating on the surface in pairs and may be approached without fear of the turtles escaping. If a turtle is sighted in the lagoon, it is chased by the dinghy until the turtle tires. An islander then jumps from the dinghy and captures the turtle. Sometimes turtles are captured on land when they come ashore to nest. Turtle eggs are not eaten, but tracks will be followed to a nest and the eggs examined to determine the time from laying to calculate the night when the turtle will return (Anon., in press).

An attempt at turtle farming in Cook Islands, initiated by the South Pacific Commission in 1974 was not successful. One reason for this was the lack of stocks of food suitable for turtles (Brandon, 1977).

Production And Marketing: There are no statistics on the production of turtle meat and shells. It is reported that at Palmerston, perfect, large turtle shells are often sold to visiting yachtsmen for up to NZ$200 each (Anon., in press). Live turtles are sometimes transported from Palmerston to Rarotonga for sale. However, mortality rates during transit are high, due to handling-induced stress (Kelvin Passfield, pers. comm.).

6.1.3 Stock Status

There is no information available on the stock status of sea turtles in Cook Islands. Recent information suggests that sightings of turtles are becoming less frequent in most of the islands of Cook Islands and Palmerston may now be the atoll most frequently used by nesting turtles (Bill Marsters, Fisheries Officer, pers.comm.).

6.1.4 Management

Current Legislation/Policy Regarding Exploitation: In 1976, a ban on the use of spears was introduced to the Palmerston Island turtle fishery by the Island Council. This was in response to the number of turtles being found dead on the reef bearing spear scars (Anon., in press).

Recommended Legislation/Policy Regarding Exploitation: Anon. (in press) recommends that the current ban on spearing remain in place and that bans on the taking of mating and nesting turtles and turtle eggs (except for the rearing of juveniles) should be considered. It is further recommended that the traditional practice of each household on Palmerston being required to annually hatch and raise 3

juvenile turtles through to 1 year old, be re-introduced. Similar action should be taken at a community level throughout Cook Islands.

Documentation of catch and marketing information is vitally important for effective management of the resource. If it is shown that large numbers of turtles are taken for commercial sale or for shipping to friends and family in Rarotonga, consideration should be given to restricting the taking of turtles to a strictly subsistence level.

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6.2 SEA GRAPES[**Rimu**]

6.2.1 The Resource

Species Present: Sea grapes [**Rimu**] *Caulerpa racemosa*, one of the tropical Chlorophyceae, belonging to the Family Caulerpaceae. Many species are included in the genus *Caulerpa* but only a few are used as food (Shokita *et al.*, 1991).

Distribution: Sea grapes are widely distributed in the tropical Pacific (Shokita *et al.*, 1991) and are found throughout Cook Islands (Sims *et al.*, 1988), especially at Rarotonga, Aitutaki, Atiu and Mangaia (Cook Islands Ministry of Marine Resources).

Biology And Ecology: In the genus *Caulerpa*, thalli appear superficially as if they have differentiated leaves, stems and roots which are green in colour. Seaweeds of this group are characterized by having many nuclei in one cell, like a single closed tube full of cytoplasm. Reproduction may be sexual or vegetative, the latter likely being an adaptation to a less favourable environment. Under favourable conditions, branches of *Caulerpa lentillifera* grow at approximately 2cm per day, a characteristic which is exploited in cultivation (Shokita *et al.*, 1991).

Caulerpa is a purely marine stenohaline alga and will die even in slightly brackish sea-water. The salinity should not be lower than 30 ppt. For strong growth, the growth site should be protected from the destructive effects of wind and waves (Trono, 1988).

6.2.2 The Fishery

Utilisation: Sea grapes are a subsistence food in Cook Islands, traditionally collected by hand and eaten fresh as a salad, to accompany other food (Jonah Tisam, Government Advisor, pers.comm.). Throughout the Pacific Islands and S.E.Asia, several species and varieties of *Caulerpa* may be utilised as fresh food, mainly through the gathering of natural stocks (Trono, 1988). On Aitutaki, it is reported that there is some commercial exploitation of sea grapes (UNEP/IUCN, 1988).

In Okinawa, Japan and Cebu, Phillippines several species of *Caulerpa* are cultivated commercially (Shokita *et al.*, 1991). Considerable quantities of sea grapes in the fresh, brine-cured and salted form have been exported to Japan and Denmark from the Philippines and the prospects of mass production of this seaweed are promising (Trono, 1988). South (1993) notes that a consultant for the Commonwealth Science Council has recommended that studies should be made of the possibility of farming *C. racemosa* in Fiji.

Production And Marketing: There is no information available for the subsistence production of sea grapes in Cook Islands.

6.2.3 Stock Status

There is no information available to indicate stock status of sea grapes.

6.2.4 Management

Current Legislation/Policy Regarding Exploitation: None at present.

Recommended Legislation/Policy Regarding Exploitation: None required at present. The potential for farming sea grapes in Cook Islands should be investigated.

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6.3 SEAWEED

6.3.1 The Resource

Species Present: The *Kappaphyces alvarezii* variety of *Eucheuma* commercial red seaweed was introduced to Cook Islands in 1987 from Fiji to test its potential for aquaculture production. (Cook Islands Ministry of Marine Resources).

Distribution: *Eucheuma* spp. are distributed from the Indian Ocean to the western Pacific Ocean. *E. cottonii* and *E. striatum* are cultivated in the Philippines (Shokita *et al.*, 1991). The Cook Islands introduction was made in Aitutaki lagoon only.

Soon after planting, Cyclone Sally destroyed the culture lines, thus liberating the *Eucheuma* plants within the Aitutaki lagoon (Anon., 1988). It is reported that research officers sighted no *Eucheuma* plants in Aitutaki lagoon in 1992, in the course of a trochus shell survey (Tim Adams, SPC Senior Inshore Fisheries Scientist, pers. comm.).

Biology and Ecology: The complex life histories and reproductive strategies of tropical seaweeds are generally poorly understood. In the tropics, seasonal growth and reproductive phenomena occur, although not always as markedly in cooler regions. Tropical seaweeds are subjected to heavy grazing pressures, particularly from herbivorous fish such as Rabbitfish (*Siganus* spp.) (South, 1993).

6.3.2 The Fishery

Utilisation: Also known as phyco-colloids or gums, seaweed colloids are water-soluble carbohydrates which are used as thickening agents. Their uses, based on their thickening properties, cover a wide range of products in a variety of industries. Colloids occur in seaweeds as part of their structural

components, together with cellulose and so form an appreciable proportion (20-30 per cent) of the dry weight of seaweed.

Eucheuma seaweeds are cultured commercially for the production of a colloid known as carrageenan. *E. cottonii* has a particularly high content of a type of carrageenan known as kappa-carrageenan. Nearly all the world demand for this colloid is in the food industries of developed countries, where it is used as a suspending, thickening and gelling agent (McHugh and Lanier, 1983).

Production And Marketing: The major culture areas are Taiwan, Philippines and Indonesia. Approximately 17,000mt of carrageenan and 7,000mt of semi-refined product were produced worldwide in 1989 (Smith, 1992). In the South Pacific, Kiribati leads in the production of *Eucheuma*, with much smaller amounts being produced in Fiji.

The growth trials at Aitutaki were not successful (Anon., 1988). There is no subsistence or commercial production of *Eucheuma* seaweed in Cook Islands.

6.3.3 Stock Status

The status of *Eucheuma* stocks in Cook Islands is unknown. It is thought that none of the plants introduced into Aitutaki lagoon have survived, given that this species has no holdfast for anchorage and because it reproduces asexually, does not produce spores (Tim Adams, SPC Senior Inshore Fisheries Scientist, pers. comm.).

6.3.4 Management

Current Legislation/Policy Regarding Exploitation: None at present

Recommended Legislation/Policy Regarding Exploitation: A revival of seaweed growth trials is not recommended at present. It may be worthwhile to establish whether *Eucheuma* plants are present in Aitutaki lagoon.

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6.4 SEA URCHINS

6.4.1 The Resource

Species Present: The slate-spined sea urchins [**Atuke**] (*Heterocentrotus mammillatus* and *H. trigonarius*), pink sea urchin [**Kina**] (*Echinometra mathaei*), long-spined sea urchins [**Kina Vana**] (*Diadema savignyi* and *Echinothrix diadema*), and edible sea urchins [**Vana**] (*Tripneustes gratilla*).

Distribution: Sea urchins are found throughout Cook Islands, though the species composition varies from island to island. McKnight (1974) in a survey at Manihiki noted the presence of *E. diadema*, *E. mathaei* and *H. trigonarius*. A marine reserve baseline study on Rarotonga by Passfield and Zoutendyk (1989) mentions the presence of *E. mathaei, Diadema* sp., *H. mammillatus* and *T. gratilla.* In an ecological survey of the lagoon near the Sheraton Hotel site on Rarotonga, Evans (1993) noted that of 1,057 sea urchins recorded, the overwhelming majority were *E. mathaei*, with only a few *D. savignyi* and *Echinothrix* sp. Clerk (1981) noted that on Mangaia, all the genera mentioned above were present.

Biology And Ecology: Sea urchins are closely related to starfish and sea cucumbers. They have a calcified external shell, known as a "test", with mobile external spines. The hard tests of sea urchins can be a variety of colours from black to white, with red, green and purple common colours for various species of edible sea urchin. They move and feed with a hydraulic system that enables them to move their spines, stick to the sea floor and move their jaws (McShane, 1992).

Sea urchins feed on seaweed that they break up with their jaws. Because they have no bulky muscles, much of the energy derived from food can go towards reproduction. Up to 25 per cent of their weight can be gonad, or "roe". Sea urchins generally have a seasonal reproductive cycle, so that the quality of the roe varies throughout the year. The quality and quantity of sea urchin roe is also dependent on the amount of available food (McShane, 1992).

McShane (1992) states that sea urchins are generally considered slow growing and long lived animals. They move slowly and tend to form large aggregations on reef surfaces. *E. mathaei* are usually found in dense aggregations under thickets of branching corals or on surfaces of rocks (Shokita *et al.*, 1991). Common predators of sea urchins include lobsters and large fish.

Despite the high value of many sea urchin fisheries, there is little known about their growth, mortality or recruitment. Because of their wide and patchy distribution on coastal reefs, estimates of biomass are very difficult to make. It is known that recruitment of sea urchins can be highly variable but the effects of heavy fishing on recruitment are unclear (McShane, 1992).

6.4.2 The Fishery

Utilisation: Passfield and Zoutendyk (1989) report that *H. mammillatus* and *T. gratilla* are occasionally harvested for food on Rarotonga. Raw sea urchin roe are eaten as a subsistence food, often with fresh sea-grapes [**Rimu**] (*Caulerpa racemosa*). On Rarotonga, a face-mask, snorkel, sharp spear and diver's knife are used for gathering sea urchins. They may be speared at almost any time of the day since many urchins turn dark in the shallow water, making harvesting easy (Dieudonne, 1992).

Sea urchin roe is highly prized as a delicacy by Japanese consumers who eat approximately 50,000mt (whole weight) of sea urchins each year. While local Japanese production (mainly *T. gratilla*) is falling, sea urchin fisheries outside Japan in the USA (California, Washington, Maine, Oregon, Alaska), Mexico, Canada and Chile have flourished. However, these fisheries are also in danger of over-exploitation (McShane, 1992).

A curio manafacturer in Rarotonga purchases the spines of **Atuke** for making wind-chimes and other ornaments for the tourist trade. These spines often originate in the northern group (Kelvin Passfield, pers. comm.).

Production And Marketing: There are no figures available for production and marketing of sea urchins in Cook Islands.

6.4.3 Stock Status

There is very little data is available for stock estimates anywhere in Cook Islands. Passfield and Zoutendyk (1989) state that on Rarotonga, sea urchins occur in high densities on the reef flat with lower densities occurring on the coral micro-atolls within the lagoon. *E. mathaei* is the most abundant, with maximum densities of approximately 18 per m^2 and average densities of 9 per m^2 in suitable habitat. Low numbers of *H. mammillatus* and *T. gratilla* were observed during this survey. Numbers of *H. mammillatus* in Aitutaki Lagoon are reported to be low (Jamie Whitford, Fisheries Biologist, pers.comm.).

6.4.4 Management

Current Legislation/Policy Regarding Exploitation: There is currently no legislation specifically concerning sea urchins**.**

Recommended Legislation/Policy Regarding Exploitation: None at present. Legislation may be required if commercial harvesting of sea urchins commences.

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6.5 SEA CUCUMBERS [**Rori**]

6.5.1 The Resource

Species Present: There are approximately 1,200 species of holothurians (sea cucumbers) distributed world-wide, some 12 species being considered of commercial value (Anon., 1979b). The species of commercial or subsistence value found in Cook Islands are listed in Table 18. Rarotongan names do not apply to all the islands of Cook Islands (Zoutendyk, 1989).

Table 18. Names of sea cucumbers found in Cook Islands of subsistence[#] and/or commercial* importance and other common species (after Zoutendyk, 1989).

Common	Scientific	Rarotongan
	Synapta maculata	A'ei
	Holothuria hilla	Kanaenae type
	Stichopus horrens	Ngata type
Prickly redfish	*Thelenota ananas*	Ngata type*
	Holothuria leucospilota	Rori ka'a[#]/Matu rori
Greenfish	*Stichopus chloronotus*	Rori matie*
	Holothuria cinerascens	Rori pua[#]
Surf redfish	*Actinopyga mauritiana*	Rori puakatoro*[#]
Lollyfish	*Holothuria atra*	Rori toto*[#]
Black teatfish	*H. nobilis*	Rori-u*
Leopardfish	*Bohadschia argus*	?*

Clerk (1981) reports that the species recognised on Mangaia include *H. atra, H. leucospilota, H. nobilis, H. pervicax* and *A. mauritiana*. Several commercially important species abundant in other parts of the tropical Indo-Pacific, such as the white teatfish (*Holothuria fuscogilva*) and sandfish (*H. scabra*), one of each of which has been reported from Rarotonga, deepwater redfish (*Actinopyga echinites*) and blackfish (*Actinopyga* sp.) are extremely rare or have not yet been recorded from Cook Islands (Zoutendyk, 1989).

Distribution: *H. leucospilota* and *H. atra* are commonly found on Aitutaki, Palmerston and Rarotonga together with *S. chloronotus*, *H. cinerascens* and *H. hilla*. Although not as common, *B. argus* is present on the three islands mentioned above. The rarer species mentioned above are probably more abundant in the northern Cook Islands than in the colder waters of the southern group (Zoutendyk, 1989).

Biology And Ecology: Relatively little is known about the biology of sea cucumbers, most research to date has concentrated on taxonomy. Smith (1992) reports that a study at the University of Guam Marine Laboratory has shown that sea cucumbers have distinct periods of reproductive activity, take 2-3 years to attain the age of first reproduction and have relatively low levels of natural recruitment. The high frequency of juvenile *A. mauritiana* found on the reef flat on Rarotonga indicates this to be where recruitment occurs for this species (Zoutendyk, 1989).

Some species are known to undergo asexual fission and a few species are hermaphroditic, but the majority are dioecious (Cannon and Silver, 1986). Most species reach their peak spawning period during the summer and some species have a second winter peak (Cannon and Silver, 1986). Sea cucumbers are primarily detritivores, feeding on the organic content of sand, mud and surface films though a few non-commercial species are suspension-feeders (Preston, 1992).

A.mauritiana is common on the reef flats and slopes of Palmerston, Aitutaki and Rarotonga. It is most abundant in the surf zone, with numbers decreasing moving onto the outer reef flat away from the surf. *H. nobilis* and *T. ananas* are much less common, the former being found in shallow waters, on sand around coral heads where the inner reef flat meets the lagoon. On Rarotonga, *H. nobilis* was found to be most abundant near reef passages while *T. ananas* was found outside the reef, at 30m depth.

H. leucospilota and *H. atra* may be found in shallow lagoon waters, all the way to the surf-exposed outer reef flat. However, the former is most abundant under rocks and other reef flat cover while the latter may be found exposed on sandy substrate. *S. chloronotus* and *B. argus* can be found from the outer reef flat to the lagoon floor (Zoutendyk, 1989).

6.5.2 The Fishery

Utilisation: There are both subsistence and commercial fisheries for sea cucumbers in Cook Islands. In Rarotonga and some of the southern group islands such as Mangaia, several species are a traditional source of subsistence food, gathered mainly by women. However, the subsistence use of sea cucumbers seems to be declining, except for the use of their mature gonads [**matu rori**] or body wall and it has never been practised in the northern group (Zoutendyk, 1989).

H. leucospilota is important on Rarotonga for subsistence purposes. A knife is used to make a slit along the body wall so that the mature gonad [**matu**], which appears as a mass of white strands can be easily removed. The process is referred to as **matu rori** and takes place from October to January when the gonads develop and mature. Once the **matu** is harvested, it is commonly eaten raw immediately, or later with lemon juice or banana. It is also eaten fried with eggs (Zoutendyk, 1989).

H. cinerascens is also important on Rarotonga as a local food source. The body is scraped of all attached debris and the tentacle end is cut off to remove the internal organs. Although **matu** may be found and eaten, it is the body wall which is sought. This is prepared by salting for 1-2 days after which it is eaten with lemon juice. It is also used in a traditional seafood mixture [**mitiore**], which may also be made with octopus [**Eke**], rough turban snail [**Ariri**] and giant clam [**Pa'ua**] (Zoutendyk, 1989).

A. mauritiana is sought for its body wall which is prepared by gutting the animal, cutting off the outer skin and slicing the body wall into strips. The strips are then cut part-way through into cubes, salted and wrapped with breadfruit leaves for up to three days. During this time the strips are checked periodically and when the desired tenderness is achieved, they are eaten cold, or warmed by placing the wrapped pieces on the embers of a fire (Zoutendyk, 1989).

Production And Marketing: The dried product made from sea cucumbers is known as bêche-de-mer or trepang. It is produced by a process of boiling, cleaning, drying and in some cases, smoking. The finished product, which has a rubbery texture, is normally re-hydrated by repeated soaking or boiling prior to consumption. It is considered a delicacy and an aphrodisiac in China and South-east Asia where it is principally consumed (Preston, 1993).

The early trade to Chinese markets from the South Pacific peaked in the 1920's and early 1930's. In 1934-35, Palmerston and some of the northern group islands were exporting dried *A. mauritiana*. Cessation of shipping services terminated the trade and with the advent of WWII, bêche-de-mer export was virtually stopped throughout the Pacific (Zoutendyk, 1989).

The expansion of Chinese communities in the West, notably in Canada, USA and Australia, has led to the growth of non-traditional markets for bêche-de-mer. This has been further accelerated by international trade and currency regulation, especially in mainland China, which has led to the increasing use of certain types of bêche-de-mer as a barter currency (Preston, 1993).

Because most of the valuable species are either rare or have not yet been recorded in Cook Islands, only *A. mauritiana* may have commercial potential. Trial processing of this species on Rarotonga showed that at marketable size (8-10cm, 50-70g) it is approximately 7 per cent of its live weight and 44 per cent of its live length. Because of this drastic weight loss, approximately 14kg of live *A. mauritiana*, between 10-20 individuals weighing 0.7 to 1.4kg each, are needed to produce 1kg of marketable bêche-de-mer (Zoutendyk, 1989).

CIF prices offered in 1989 for Cook Islands bêche-de-mer by Hong Kong and Singapore importers were as follows; *A. mauritiana* (50g/ 10cm) US$4.50/kg, *H. nobilis* (70g/12cm) US$5.50/kg, *H. atra* (20g/10cm) US$1.20/kg (Zoutendyk, 1989). McElroy (1990) presents export prices of several types of bêche-de-mer obtained in mid-1990. The prices he quotes for the above species are; *A. mauritiana* US$7-8/kg, *H. nobilis* US$11-12/kg, *H. atra* US$2-4/kg. There are no records of recent exports of bêche-de-mer from Cook Islands.

Preston (1993) states that if appropriately managed, sea cucumber fisheries have significant potential to regularly contribute to the export earnings of small island nations. However, because of the limited reef area and relatively small stocks of commercial species such as *A. mauritiana* in Cook Islands, Zoutendyk (1989) is of the opinion that there may only be potential for artisanal fisheries supporting a small number of people on each island.

6.5.3 Stock Status

According to Zoutendyk (1989), stocks of sea cucumber species used for subsistence purposes, though limited in size, appear to be stable. Except on Rarotonga, where *A. mauritiana* has been gathered and sold on a small scale, sea cucumber stocks are not presently being exploited commercially. Cook Islands' relatively limited stocks of sea cucumber would be appreciably impacted should commercial exploitation expand.

6.5.4 Management

Current Legislation/Policy Regarding Exploitation: None at present

Recommended Legislation/Policy Regarding Exploitation: Because of their sessile nature and their relatively low stock status, sea cucumbers in Cook Islands will need to be managed conservatively. A

list of recommended management measures that could be applied to Cook Islands' sea cucumber fisheries (Zoutendyk, 1989) are listed below:

- harvest bans during **rori** breeding seasons, which for some species in New Caledonia seem to be from November to January, and from June to July for **rori-u**. If possible, these times should be confirmed for Cook Islands.

- dividing any reef area to be harvested into sections, and each section opened to harvesting during a certain time period on a rotational basis (this equates to the traditional **ra'ui** system). Alternatively, all the reef area could be harvested during certain time periods over the course of a year (i.e. one day a month). Either of these should lessen harvesting pressure during breeding seasons and allow time for stocks to recover.

- rotate harvests between participating islands, and pool bêche-de-mer produced in Rarotonga. This will make it easier to get enough bêche-de-mer to fill containers for export, and also relieve pressure on individual islands.

- the establishment of quotas and minimum size limits for each species, to ensure that total depletion of any species will not occur (larger animals are the most valuable anyway). The current limit for all species in Fiji is 7.6cm, and 15cm in Queensland, Australia.

- the establishment of permanent survey sites, to be surveyed before, after and between harvests. These will be used to monitor harvesting pressure on the **rori** populations, their recovery from harvests, and seasonal variation. Results from these surveys should be used to determine when harvests are feasible, and to set their quotas.

- the establishment of a reserve area, which may help in the recruitment of stocks.

- limiting entry at first to a few (maybe to those who first show interest) on each island, to help prevent over-harvesting. Entry could then be increased, according to the potential of the exploited stocks.

- the keeping of good records from the time of harvesting to sale. These records should include; harvesting date, time, duration, location, catch (species, amount and weight); processing times and methods, noting any variations; dry weights of bêche-de-mer and price obtained.

- banning the use of SCUBA from harvesting, except for any species found only in very deep waters.

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6.6 COCONUT CRAB [**Unga**]

6.6.1 The Resource

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

Distribution: Coconut crabs have a wide tropical Indo-Pacific distribution, from Mauritius in the west Indian Ocean to the Tuamotu Archipelago in the eastern Pacific. A 1984 mail survey of 28 countries, mainly in the Pacific and south-east Asian regions (Brown and Fielder, 1988) revealed that coconut crabs were now considered abundant, in varying degrees in only in 6 localities; Solomon Islands, Vanuatu, Chuuk (Federated States of Micronesia), Tokelau, Niue and Marshall Islands. The remaining countries indicated that the species was either only locally common or rare.

Recent genetic research has shown that while the *Birgus* populations in Vanuatu and Solomon Islands probably constitute a single stock, the Indian and Pacific Ocean populations are probably 2 distinct stocks. In the Pacific, there was some indication that coconut crab populations in Niue and Cook Islands are also separate independent populations (Fletcher, 1993).

In Cook Islands, the coconut crab is common on most islands but has become extremely scarce on islands with a significant human population (Rongo, 1992). It is reported to occur on Pukapuka, Suwarrow (UNEP/IUCN, 1988; Lavery, 1990), Mangaia (Clerk, 1981), Takutea, Mauke, Atiu (Anon., 1992c) and Palmerston (Anon., in press). On the latter, it is mainly found on the outlying islets and rarely occurs on the main island (Anon., in press).

Biology And Ecology: Coconut crabs are omnivorous scavengers, hiding in holes in the sand or under coconut trees and shrubs during the day, emerging at night to forage along beaches and over coral rocks. The species is the largest and least marine dependent of the land crabs. Growth is very slow and heavily influenced by environmental factors, which is a key reason why the species cannot be commercially cultured. Large adults may attain a weight of 4 kg (Brown and Fielder, 1988). Reese 1971 in Smith (1992) estimated that size at maturity is around 7.6-12.7cm carapace width for crabs on Eniwetok, at an age of four to eight years. Fletcher (1988), working in Vanuatu, estimated a 600g crab to be 12 to 15 years old. Moulting takes about a month and is carried out in a shallow hole plugged with earth forming a visible hump on the surface.

Reese 1971 in Smith (1992) reports that mating generally occurs from May to September, with a peak in July to August. On Mangaia, it is reported that adult coconut crabs spend several months in their burrows on the **makatea**, emerging for spawning in October or November (Clerk, 1981). The female carries the eggs under her abdomen attached to hairs. After about one month the female moves to the shore and releases the eggs into the sea. After hatching, the larvae remain planktonic for around four

to five weeks before settling, developing a shell and becoming amphibious. The young crab will carry a shell for around nine months, becoming increasingly terrigenous (Brown and Fielder, 1988). As they grow they move further inland away from the coast.

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

6.6.2 The Fishery

Utilisation: Coconut crabs are eaten throughout the Cook Islands where they occur. On Mangaia, Clerk (1981) reports that the greatest of delicacies is the soft oily tail section of the coconut crab. The high regard for coconut crabs as subsistence food on Palmerston means that they are very rarely sold (Anon., in press). It is reported that coconut crabs are taken at Suwarrow, especially on Anchorage Islet, when inter-island cargo boats call there for a stop-over (Kelvin Passfield, pers. comm.). This is despite the fact that licenses are required to take coconut crabs at Suwarrow (see Section 6.6.4 "Management").

Production And Marketing: Most hunting for coconut crabs on Palmerston is done at night with the use of flashlights and is reported to be most successful when there is no moon and the ground is wet with recent rain. However, some can still be caught on moonlit nights or during the day by digging up the holes or smoking the crabs out (Anon., in press). On Mangaia, the taking of coconut crabs is an all-male activity (Clerk, 1981).

It is likely that on Mangaia, as in other parts of the Cook Islands, all fishing was once more extensively guided by **arapo**, the nights of the lunar month, certain prey being known to be plentiful on particular nights. There are periods of the lunar months when crabs and lobsters are thought to be most plentiful, these peak periods occurring around the new and full moons. The most favourable nights for coconut crab are considered to be the 3 following the new moon (Clerk, 1981).

Though coconut crabs are not exploited commercially in Cook Islands, a specimen of 12cm carapace width can be sold at Rarotonga for NZ$10.00 (Cook Islands Ministry of Marine Resources).

6.6.3 Stock Status

Current coconut crab stock status is unknown for most areas of Cook Islands, though Lavery (1990) reports that relitavely large numbers of *B. latro* still inhabit some of the islands of Suwarrow. In 1989, people on Palmerston reported that coconut crab numbers were not decreasing and that the species is not heavily hunted (Anon., in press). Recent reports from Palmerston suggest that coconut crabs are now scarce on some islets of the atoll (Bill Marsters, Fisheries Officer, pers. comm.).

6.6.4 Management

Current Legislation/Policy Regarding Exploitation: There is currently no national legislation governing coconut crab exploitation. The only island with legislation governing the taking of coconut crabs is Suwarrow, which was declared a National Park on 29.06.78 under Section 11 (1) of the Conservation Act 1975. Licences may be issued for the culling of coconut crabs under this legislation (UNEP/IUCN, 1988).

On Pukapuka, the villages govern the opening and closing of their **motus** to visitors and the taking of coconut crabs. Such closures, known as **ra'ui** which also apply to adjacent areas within the lagoon, may last up to 6 years (UNEP/IUCN, 1988).

Recommended Legislation/Policy Regarding Exploitation: Because coconut crabs are very slow growing and have low and highly variable recruitment, they are highly vulnerable to over-exploitation. Pressure on the stocks could be alleviated by the setting of some type of catch limit (bag limit or minimum carapace size limit) or wider imposition of a **ra'ui** system as used on Pukapuka (Anon., in press). Lavery (1990) recommends that measures be undertaken to protect this species from harvesting at Suwarrow, because of their apparent incapability of locally supporting a long-term (commercial) fishery of any size or even a long-term artisanal fishery anywhere in their Indo-Pacific range.

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6.7 MUD CRAB [Upaku]

6.7.1 The Resource

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

Distribution: The mud crab *S. serrata* is found at Aitutaki where fishermen take it with traps and by hand in the muddier sections of the lagoon (UNEP/IUCN, 1988). Juvenile mud crabs are numerous in the back swamps of Ootu, Aitutaki (Passfield, 1993). The mud crab is not mentioned in Bullivant's (1974) report on Manihiki crabs, but is recorded from Avana on Rarotonga (Cook Islands Ministry of Marine Resources).

Biology And Ecology: Mud crabs become sexually mature at about 120mm carapace width, around two to three years of age. Perrine 1978 in Smith (1992) recorded a lunar periodicity of the seaward movements of spawning females at Pohnpei, with a peak around the new moon. Except for those migrations, the crabs in the study did not move more than 0.6 mile (1km). Each female will produce around 5 million eggs per spawning. These hatch to produce planktonic larvae, which flow back on the tide and are recruited to the mangroves near the parental biomass (Nichols, 1991). Juveniles (20-80mm carapace width) remain in the mangroves at low tide. Sub-adults (80-120mm) and adults (>120mm) migrate to intertidal habitats at high tide, retreating again at low tide (Nichols, 1991). Perrine 1978 in Smith (1992) found that burrows were used primarily by male crabs for temporary shelter.

6.7.2 The Fishery

Utilisation: The mud crab is highly considered as a subsistence food on Aitutaki. Some are occasionally sold to Aitutaki's hotels and resorts (Jamie Whitford, Fisheries Biologist, pers.comm.). It is commonly caught with traps and nets (Cook Islands Ministry of Marine Resources).

Production And Marketing: There is very little data available on mud crab production and marketing. Large mud crabs are reported from Ootu, Aitutaki where 7-8/night is considered a good catch (Jamie Whitford, Fisheries Biologist, pers.comm.). These crabs are occasionally sold to hotels on Aitutaki, large specimens bringing NZ$15-20 each.

6.7.3 Stock Status

There have been no assessments of mud crab stocks in Cook Islands. Numbers of mud crabs at Avana, Rarotonga are reported to be declining (Cook Islands Ministry of Marine Resources).

6.7.4 Management

Current Legislation/Policy Regarding Exploitation: There is no specific legislation covering the taking of mud crabs.

Recommended Legislation/Policy Regarding Exploitation: There is insufficient information on which to formulate policies and therefore a study of the mud crabs at Ootu, Aitutaki is indicated.

Passfield (1993) recommended that size limits be imposed on the taking of mud crabs at Ootu, Aitutaki and a total ban placed on the taking of female mud crabs from the same area.

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6.8 BUTCHER LAND CRAB [**Tupa**]

6.8.1 The Resource

Species Present: The butcher land crab [**Tupa**] (*Cardisoma carnifex)* and the closely related *C. hirtipes*. Bullivant (1974) identified these 2 species of *Cardiosoma* in a 1960 collection of crabs from the land, reef and lagoon at Manihiki.

Distribution: Land crabs are found throughout the Cook Islands. On Palmerston, it is reported that they are abundant along the shoreline, under coral slabs and among the islet's vegetation on all except Home Islet (Anon., in press). Clerk (1981) reports that some people on Mangaia believed that there were two types of **Tupa**, one of which was formerly found in the interior, in the area of the lakes and swamps. Because of a general scarcity of land crabs on Atiu, the people of Palmerston made a donation of 500 mature crabs to Atiu in October 1992 (Bill Marsters, Fisheries Officer, pers.comm.).

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

6.8.2 The Fishery

Utilisation: Land crabs are caught with traps and nets, and used primarily for subsistence purposes (Cook Islands Ministry of Marine Resources). Passfield (1993) reports that on Aitutaki, they are commonly eaten by local people. On Palmerston, they are eaten occasionally, but are mainly used as chum and bait when hook-and-line fishing for Maori wrasse [**Maratea**] (*Cheilinus undulatus*), big-eye emperor [**Mu**] (*Monotaxis grandoculis*) or other lethrinids, (Anon., in press). They are easily collected alive by hand at night (Anon., in press), especially during their spawning migrations.

Production And Marketing: Anon.(in press) states that the low level of utilisation of land crabs on Palmerston could possibly be increased, with good market potential for them in Rarotonga. On Aitutaki, Rongo (1992) reports that **Tupa** have been heavily exploited in the past.

6.8.3 Stock Status

No data is available for stock estimates anywhere in Cook Islands. On Mangaia, numbers of land crabs are said to have declined greatly in recent years (Clerk, 1981). Rongo (1992) reports that on Aitutaki, it is feared that this local food source may become scarce. Anon. (in press) states that there is an abundant supply of **Tupa** throughout the year on Palmerston.

6.8.4 Management

Current Legislation/Policy Regarding Exploitation: There is currently no national legislation concerning land crabs.

Recommended Legislation/Policy Regarding Exploitation: Until more information is collected concerning exploitation and some estimates of stocks are available, it will be difficult to recommend

any legislation or policy. While management of land crabs may not be required on Palmerston, stocks on other islands such as Aitutaki, Mangaia and Atiu may require management.

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6.9 LOBSTER [**Koura tai**]

6.9.1 The Resource

Species Present: Passfield (1988) reports that the most abundant and largest species of rock lobster in Cook Islands is the double-spined spiny lobster, [**Koura tai**] (*Panulirus penicillatus*), though the smaller and less commercial long-legged spiny lobster (*P. longipes femoristriga*) is reported to be present. The slipper lobster [**Koura papa**], probably *Parribacus caledonicus*, occurs in low numbers.

Distribution: *P. penicillatus* occur thoughout the tropical Indo-Pacific region. All the species present are distributed throughout Cook Islands. Clerk (1981) reports the presence of spiny and slipper lobsters on Mangaia. Anon., (in press) states that *P.penicillatus* are abundant on the reefs at Palmerston.

Biology And Ecology: *P. penicillatus* occupy a limited range of habitats. They are usually found only in the shallow surf zone of reef fronts and are reported to prefer windward slopes (Prescott, 1988) . In Cook Islands, they are also common on the leeward side of islands. During the day, they usually remain well back in holes and crevices in the reef, while at night they come out to feed and may be found on the reef flat or seaward of the reef crest down to 4m (Passfield, 1988). In Micronesia, they are found from 0.3-4.9 m deep, but their greatest concentration is from 1.2-1.8m deep (Smith, 1992).

P. longipes femoristriga occupies a habitat in clear water just on the lagoon side of active reef edges amongst dense coral growth. The slipper lobster is uncommon and occupies the surge zone with *P. penicillatus*.

Sexes are separate in lobster and easily distinguished by external characters. Most *P. penicillatus* populations have a predominance of females. However, at Palmerston, fishermen recognise the dominance of males in the catch (Anon., in press).

Carapace size at sexual maturity for *P. penicillatus* in Palau is 10cm and in Solomon Islands 7.5-7.9cm (MacDonald, 1982 in Nichols, 1991; Skewes, 1990). *P. penicillatus* at Palau reproduce throughout the year, with about 40 per cent of females being ovigerous (bearing eggs) in any month (MacDonald, 1979 in Smith, 1992). It is likely that the same situation occurs in Cook Islands with a large proportion of the females at Palmerston usually in berry (Anon., in press).

After fertilisation, the eggs are carried externally by the female for periods of up to 1 month. Between 8 and 11 broods may be carried per year, with brood sizes of between 100,000 and 500,000 for carapace lengths of 7.0cm and 13.0cm respectively (Prescott, 1988). Larvae of tropical lobsters remain planktonic for many months, perhaps as long as six to ten months (MacDonald, 1971b in Smith, 1992). Therefore recruitment may occur from spawning adult populations a considerable distance away.

Like other crustaceans, lobster grow by a process of ecdysis, or successive moulting of smaller to larger shells with males attaining a significantly greater size than females. Males taken during a survey on Palmerston ranged in size from 7-15cm carapace length, with females ranging from 7-11cm (Anon., in press).

6.9.2 The Fishery

Utilisation: Passfield (1988) reports that each of the islands in Cook Islands supports a fishery for spiny lobster to some degree, though usually only for subsistence. Commercial landings are only known from Rarotonga, Aitutaki, Palmerston and Rakahanga.

As in many of other island countries in the Pacific, *P. penicillatus* in Cook Islands can be caught by hand on the reef flats at night, either side of a low tide. At Palmerston, dark nights are favoured, preferably in the early evening. There, the third or fourth nights after full moon and a few nights around the new moon are considered best, with light supplied by pressure lanterns. All sectors of the reef are fished. Very occasionally, small numbers of lobster are taken by spearing when sighted during daytime diving (Anon., in press).

On some islands such as Rarotonga, some free diving is done at night using torches in which case lobsters are taken by hand or speared. Most effort is exerted on the leeward side of the reef but with favourable weather conditions, the southern and eastern reef areas are also fished (Passfield, 1988). In areas such as Suwarrow where lobsters are abundant, they can be taken by hand during daytime at low tide, by walking on the reef and searching in holes with the aid of a face-mask (Kelvin Passfield, pers. comm.).

Production And Marketing: There is very little information on the seasonality of lobster catches. On Palmerston, lobsters are taken throughout the year (Anon., in press) but in some areas seasonal trade winds may affect accessibility to the lobsters.

Ten to fifteen lobster/night is regarded as a good catch on Palmerston although exceptional catches of up to 40/night are occasionally taken. In a good catch, 20 per cent of the lobsters would have a total weight of over 2kg each and the remainder in the 1-2kg range (Anon., in press). Consignments of whole green lobster to Rarotonga from Palmerston are typically 20 - 50kg/month, depending on the schedule of coastal vessel servicing the atoll (Bill Marsters, Fisheries Officer, pers.comm.).

Passfield (1988) reports that during a crayfish resource survey on Palmerston, free diving and reef walking were used to indicate catch rates and abundance. Free diving was the most effective, producing 4 lobster/man/hour, with an average of 2.2/man/hour. The average whole weight for each lobster was 0.92kg, giving an average catch rate of approximately 2kg/hour. George (1972) reported catches in optimal conditions of 800 lobster over a 2 week period by 5 men at Palmerston and 40 lobster/night by 3 men at Aitutaki.

Although there is no information available on the level of subsistence harvest in Cook Islands, Passfield (1988) gauged it to be well below the estimated potential catch of 8.32mt. Passfield (1988) estimated whole lobster yields for each of the islands in Cook Islands, using estimates of 126 lobster/km of reef edge and an estimated annual potential yield of 20kg/km of reef edge (Prescott, 1988). He assumed that the entire reef circumference provides suitable habitat for lobster.

Commercial catches of lobster are usually sold to the resorts and restaurants on Rarotonga and Aitutaki, either directly by the fisherman or through a wholesaler. In October 1988, prices of NZ$8.00-13.00/kg were paid to fishermen for whole green lobster, the lower price being offered by wholesalers (Passfield, 1988). At that time, whole frozen green lobsters from Western Samoa cost NZ$15/kg. A survey conducted by Passfield (1988) indicated that restaurant owners on Rarotonga were prepared to pay up to NZ$30.00/kg for green lobster tails. The current price paid to local fishermen in Rarotonga is NZ$15/kg for whole green lobsters. Lobsters are imported from Australia and New Zealand at a cost of NZ$15-25/kg (Statistics Office, Rarotonga).

6.9.3 Stock Status

There is no information available on the status of the spiny lobster stocks in Cook Islands. The imposition of previous local bans (eg. 6 month ban on lobster export from Palmerston in August 1988) indicate a general realization that the resource is under pressure.

6.9.4 Management

Current Legislation/Policy Regarding Exploitation: There is no specific reference to spiny lobster in the current Cook Islands legislation.

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

Anon., (in press) argues against seasonal harvest restrictions as the berried females occur year round. As recruitment is probably not dependent on the local reef stock (Passfield, 1988) there is little to be gained in prohibiting the taking of females with eggs.

In relation to minimum size limits, Passfield (1988) advises that a minimum legal size should be set in order to promote the taking of larger lobster. He argues that as the growth rate is quite fast, an undersized lobster will quickly grow to a size such that it offers a higher return to the fisherman for his effort. He recommends a minimum carapace length of 80mm as a legal size limit for lobster for both subsistence and commercial fisheries, as this is just over the size at sexual maturity for females.

Passfield (1988) also suggests that rotational short-term closures of reef sectors (**ra'ui**) may also be a useful management tool in commercial fisheries, allowing time for lobster densities to build up to a level where the fisherman can obtain higher return for his effort.

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6.10 BANDED PRAWN-KILLER [**Varo**]

6.10.1 The Resource

Species present: The banded stomatopod or prawn-killer [**Varo**] (*Lysiosquilla maculata*), also known as the mantis shrimp.

Distribution: Most mantis shrimp are tropical, but some live in temperate waters (Barnes, 1968). *L. maculata* is the most common and widely distributed species of the Genus *Lysiosquilla* in the Indo-West Pacific region (Angsinco *et al.*, 1986). In Cook Islands, its presence has been reported from Ootu, Aitutaki (Passfield, 1993) and it almost certainly occurs in other areas of the country.

Biology And Ecology: *L. maculata* is known to be the largest species of the Order Stomatopoda. Barnes (1986) describes mantis shrimps as being dorso-ventrally flattened and elongate, their most distinctive feature being the second pair of thoracic appendages, which are enormously developed for raptorial (adapted for snatching) feeding. The inner edge of the movable finger is provided with long spines or shaped like the blade of a knife. The adult female mantis shrimp is usually distinguished from the male by its distinct tangerine colour at the mid-dorsal abdomen, which indicates developing ovaries. Generally the females are larger than the males. Angsinco *et al.* (1986) found the modal size range of mantis shrimp in the Philippines to be 225-230mm, at which size males weighed 125-250g and females 180-330g.

Most mantis shrimps live in burrows excavated in the bottom sediments or live in coral crevices. *L. maculata* lives in burrows on sand and mud banks from the inter-tidal down to the reef breaker zone, in areas covered by fine coral-sand substrates (Angsinco *et al.*, 1986). The burrows are characterised by either a volcano-like mound of sediments or a funnel-shaped crater, showing a "J" or "L" shape, with openings proportional to the animal's size. A study of *L. maculata* in the Philippines by Angsinco *et al.* (1986), showed that each burrow was usually inhabited by a pair of mantis shrimps, male and female. In the inner burrow wall, the sediment is held together by a sticky substance which is probably excreted by the mantis shrimp. In a population of mantis shrimp (*Squilla mantis*) off the Ebro delta in the northwestern Mediterranean Sea, frequency of occurrence of *S. mantis* decreases with depth, the resource being most abundant at depths shallower than 60m (Abelló and Martín, 1993).

Many species of mantis shrimp leave the burrow to feed and swim with a looping motion. They feed on small fish, crustaceans and other invertebrates, the prey being caught and killed by an extremely rapid extension and retraction of the movable finger of the second large pair of thoracic appendages. This method of feeding can effectively cut a prawn in two with one slice (Barnes, 1968).

Recruitment of *S. mantis* in the Mediterranean Sea tends to occur in shallow waters. Females spawn about 18 months after settlement and may remain in their burrows between spawning and hatching (Piccinetti and Piccinetti Manfrin, 1971 in Abelló and Martín, 1993). Mantis shrimp spawning may take as long as 4 hours. The agglutinated egg mass which is 2-3cm in diameter is carried by the smaller chelate appendages and is constantly turned and cleaned. The female does not feed during brooding, which occurs inside the burrow (Barnes, 1968).

Abelló and Martín (1993) state that few attempts to estimate growth in stomatopods have been performed. In *S. mantis* from the Mediterranean Sea, growth is fast and similar for both sexes. Life-span from settlement is estimated to be around 18 months, with *S. mantis* exhibiting a high natural mortality (Abelló and Martín, 1993).

6.10.2 The Fishery

Utilisation: On Aitutaki, *L. maculata* are caught with traps, baited hooks and by hand for subsistence consumption and occasional sale (Jamie Whitford, Fisheries Biologist, pers.comm.). In the past, the second pair of thoracic appendages have been used as chiefly head-dress decoration (Kelvin Passfield, pers. comm.).

Production And Marketing: Aitutaki fishermen take banded prawn-killers on sand banks in the muddier sections of the lagoon. They are occasionally sold to local hotels and restaurants (Jamie Whitford, Fisheries Biologist, pers.comm.). There is no price information available.

6.10.3 Stock Status

In a study in the Philippines, Angsinco *et al.* (1986), 57 mantis shrimps were observed from 46 identified burrows in an area of 16ha, at a density of 3.56 shrimps per ha. In a nearby 10ha area, the density was 4.2 mantis shrimps per ha. Although there are no recorded studies of the stock status of mantis shrimp in Cook Islands, Rongo (1992) reports that on Aitutaki this species is heavily exploited and locally threatened.

6.10.4 Management

Current Legislation/Policy Regarding Exploitation: There is currently no legislation regarding banded prawn-killers in Cook Islands.

Recommended Legislation/Policy Regarding Exploitation: Passfield (1993) recommends that size limits should be imposed for the taking of banded prawn-killers on Aitutaki and a total ban placed on the taking of female **Varo.** It would be worthwhile conducting a survey to estimate the density of mantis shrimp in areas of Cook Islands where they are heavily exploited, such as Aitutaki.

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6.11 FRESHWATER PRAWNS

6.11.1 The Resource

Species present: Apart from the introduced giant freshwater prawn *Macrobrachium rosenbergii*, there are six species of freshwater prawns recorded in Cook Islands: the long-armed prawn [**Koura vai**] (*Macrobrachium lar*), *M. latimus*, *M. australe*, *M. aemulum*, *Cardina weberi* and *Atyoida pilipes* (Kelvin Passfield, pers. comm. quoting Gerald McCormack *in litt*.).

Distribution: Long-armed prawns have an Indo-Pacific distribution from East Africa to the Marquesas. They are found naturally in fresh water bodies on some of the southern group islands such as Mangaia (Clerk, 1981). The giant freshwater prawn *M. rosenbergii* is not found naturally in Cook Islands. It was introduced in 1992 from French Polynesia by the Ministry of Marine Resources, for commercial farming trials on Rarotonga.

Biology And Ecology: In order to grow, all freshwater prawns have to regularly cast their exoskeleton in a process called moulting. There are 4 distinct phases in the life cycle of the freshwater prawn; egg, larva, post-larva and adult. The time spent by each species of *Macrobrachium* in the different phases of its life cycle and its growth and maximum size varies, not only specifically but according to environmental conditions, mainly temperature. The life cycle of *M. rosenbergii* is summarised in New and Singholka (1982). *M. lar* has a maximum total length of 181mm. Juvenile stages inhabit brackish or salt water (Holthuis, 1980).

6.11.2 The Fishery

Utilisation: Being a large sized prawn, *M. lar* is probably fished wherever it occurs. It is a traditional subsistence food on Mangaia (Clerk, 1981). Attempts in the Indo-Pacific to commercially culture *M. lar* have been unsuccessful, due to its slow growth rate relative to that of *M. rosenbergii* (Lui Bell, Fisheries Biologist, pers.comm.).

A technical officer of the Ministry of Marine Resources undertook an attachment with EVAAM in Tahiti early in 1992 to learn about the rearing of *M. rosenbergii*. Upon his return to Cook Islands, he was provided with 10,000 post larvae and pelletised food for a pilot project. Three x 250m^2 ponds were prepared on private land at Matavera on Rarotonga near a good water supply.

Two of the ponds were each stocked with 5,000 post larvae while the third was left empty. There was initial mortality of approximately 15 per cent in the first 4 weeks, followed by approximately 20 per cent more mortality. The ponds were harvested on 25 May 1993 yielding 5,000 prawns weighing 80kg live weight, indicating that prawn farming is technically feasible. Very high costs for imported feed (NZ$8.00 per kilogram) preclude an economically viable operation at this stage. Further work will be required to establish the economic feasibility of farming these prawns in Cook Islands. The land-owner has shown interest in commercial prawn production (Koroa Raumea, Fisheries Officer, pers.comm.), though factionalised land-tenure disputes may be problematic (Kelvin Passfield, pers. comm.).

Production And Marketing: There are no figures available for the subsistence production of long-armed prawns in Cook Islands.

6.11.3 Stock Status

There is no information available regarding the status of the stocks.

6.11.4 Management

Current Legislation/Policy Regarding Exploitation: There is currently no legislation concerning long-armed prawns.

Recommended Legislation/Policy Regarding Exploitation: Given the subsistence nature of the fishery, there is currently no requirement for legislation. Should farming of *M. rosenbergii* become widespread, aquaculture guidelines may be required.

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6.12 TROCHUS

6.12.1 The Resource

Species Present: The turban snail or topshell,
Trochus niloticus.

Distribution: The natural distribution of trochus is on tropical reefs from the Andaman Islands in the Indian Ocean to the islands of Fiji and Wallis in the Pacific (Bour, 1990). Since the late 1950's, however, trochus has been successfully introduced into nearly all island groups of Polynesia (Sims, 1988b).

The first introduction of trochus to Cook Islands consisted of 2 air shipments of live, 5.1- 6.4cm basal diameter shells from Fiji to Aitutaki in 1957. The approximately 280 trochus which survived the journey were placed on the barrier reef at Akaiama **motu** (Powell, 1957 in Adams *et al*., in press).

Since the late 1970's, a series of attempts have been made to introduce trochus to other islands in Cook Islands. A summary of the information regarding these introductions is given in Table 19.

Table 19 Trochus introductions to the Cook Islands. (Modified from Sims, 1988b).

	ISLAND		INTRODUCTIONS			
Name	Type	Reef	Year	No.	Status	Success
	Southern	Group	1957	280	Abundant	Yes
Aitutaki	Almost Atoll	Barrier/Bench	1983	200	Common	Yes
Rarotonga	High	Fringe/Bench	1983	300	Rare/Extinct	No
Mangaia	Makatea	Bench	1982	300	" "	No
Atiu	Makatea	Bench	1983	300	" "	No
Mauke	Makatea	Bench	1982	300	" "	No
Mitiaro	Makatea	Bench	1981	500		
Manuae	Atoll	Barrier/Bench	1986	600	Present	Yes
Palmerston	Atoll	Barrier	1981	2,000		
			1982	1,000	Common	Yes
	Northern	Group				
Penrhyn	Atoll	Barrier/Bench	1985	440	Present	?
Manihiki	Atoll	Barrier/Bench	1985	400		
			1986	1,040	Common	Yes
Rakahanga	Atoll	Bench	1985	690		
			1986	1,050	Common	?
Pukapuka	Atoll	Barrier/Bench	1986	1,220	Common	?
Suwarrow	Atoll	Barrier	1985	460		
			1986	1,000	Common	?

Biology And Ecology: Trochus prefer to live on the ocean side of reefs where the wave action is greatest. The larger shells are generally found in 0.6-6m of water, and the smaller trochus on the inter-tidal reef-flats (Bour, 1990). Though on some islands they are found in the deeper waters beyond the reef (Sims, 1988b) trochus are rarely found below 12 m.

The sexes are separate but cannot be determined by any secondary external sexual features. The sex ratio is usually 1:1. Fertilisation occurs externally, the eggs and sperm being released into the surrounding water at night, usually a few days before the new moon (Bour, 1990). It is believed that spawning takes place throughout the year at each new moon but with different females; and each female spawns about every two to four months (Bour, 1990). The fecundity of females increases with age; small, newly mature females of around 7cm basal diameter producing approximately 500,000 eggs while females of 13cm basal diameter produce up to 3 million eggs (Sims, 1988b).

The fertilised eggs become planktonic larvae after 9 to 10 hours, and settle out as juveniles on the reef flat after a few days. Trochus show rapid growth during the first three to four years, the rate being strongly determined by environmental conditions. Sims (1988b) states that trochus attain a basal diameter of 8cm after about 3 years. Subsequent growth is much slower, 11cm basal diameter being reached at an age from 5 to 8 years. The maximum size of up to 15cm basal diameter is reached only after 12 years or more.

The rate of annual natural mortality of trochus is around 0.08 (Bour, 1988). Hermit crabs are probably a significant trochus predator (Sims, 1988b).

6.12.2 The Fishery

Utilisation: There are no records indicating that trochus is considered as a subsistence food by Cook Islanders. In Cook Islands, the sole commercial trochus fishery is that at Aitutaki. Though trochus have been seeded on several of the other islands (Table 19), the experience on Aitutaki suggests that 20 years or more from the time of seeding may be necessary before stocks become established at commercially fishable levels (Sims, 1988b). In early 1991, a survey carried out on Manuae located several trochus of breeding size, but at densities too low for commercial exploitation (Munro, 1991). A survey carried out in April 1993 at several locations on the reef at Rarotonga estimated that at present there is a commercially fishable stock of 13,000 trochus with a dry weight of 4mt (Marurai and Bertram, 1993). These figures indicate that commercial exploitation of trochus on Rarotonga may soon be possible.

The Aitutaki trochus fishery is conducted by snorkeling and wading in the back-reef and reef flat areas. Most fishing is done during the day, but an increasing number of divers work at night when the trochus are more active and easier to find. There was no exploitation of the trochus on Aitutaki until 1981, when a comparatively unregulated harvest took place. More regulated harvests were organised on an annual or biennial basis throughout the 1980's to the point where harvests are now limited to pulses of one or several 24 hour open seasons, latterly under the supervision of the Island Council (Sims, 1988b).

Production: The initial trochus harvest at Aitutaki took approximately 200mt over a period of 15 months. Since then, trochus production at Aitutaki has varied between 20 and 45mt/year (Table 20). The yield of 0.5-1.0mt/km of reef recorded at Aitutaki is among the highest recorded from trochus fisheries (Sims, 1988b).

Marketing: After harvesting, Aitutaki trochus are boiled to kill the animal and allow easier removal of the meat. The cleaned and dried shell is weighed and sold to a buyer for shipping in an un-processed form to Japan and Korea. The value of the trochus shell exported to Japan from the 1988 harvest amounted to NZ$40,000 (Anon., 1988). In 1990/91, the value of trochus harvested was NZ$193,000 and in 1992 it was NZ$250,000 (Cook Islands Ministry of Marine Resources).

Table 20 Trochus abundance and harvests on Aitutaki Atoll, 1981-1992 (Source: Adams *et al.*, in press)

Year	Stock est. ('000)	Declared duration	Actual duration	Declared Quota (mt)	Actual Harvest (mt)	Licenses issued	Harvest ratio (%)	CPUE (kg/man/day)	Remaining Stock ('000)
1981/82	470	3 months	15 months	30	~200.0	-	-	-	-
1983	336	3 months	3 months	20	35.7	42	31.0	7	232
1984	339	3 months	12 days	20	45.7	300	49.8	13	170
1985	305	3 days	3 days	20	27.0	250	26.5	36	224
1986	360			NO HARVEST					
1987	385	2 days	2 days	40	45.1	190/233	12/36	63/141	217
1988	-	1 day	1 day	?	18.0	?	-	-	-
1990/91	300	5 days	5 days	25	26.2	?	36	?	190
1992	413 (297)	-	17 days	25	27.0	-	12(16)?	?	363(248)?

Notes: 1.The Harvest Ratio is the estimated proportion of the total stock taken during the harvest.
2.Two sets of figures are given for some statistics for the 1987 harvest; these are each of the two days of the harvest.
3. Weights of trochus harvested are dry, cleaned shell marketed.
4. Stock estimates were the result of transect surveys (total stock) before harvest, except for 1992 which is the result of the mark-recapture experiment (with the April transect survey estimate in brackets).

There are presently 2 local buyers of trochus in Cook Islands, both based on Aitutaki. At each harvest, there has been only one buyer who has worked closely with the Island Council and the Ministry of Marine Resources. Prices for trochus have continued to increase from NZ$0.85 - 2.00/kg in 1984, NZ$3.00/kg in 1988 and NZ$6-7.00/kg for "A" grade shells in 1991 (Tuara, 1991a).

Attempts have been made to locate local markets for edible trochus meat. Several restaurants on Rarotonga have shown interest in this product, one offering to pay NZ$4-5/kg. It has been reported that trochus meat can be sold in Okinawa, Japan for up to NZ$33.00/kg (Zoutendyk, 1990).

6.12.3 Stock Status

An estimated standing stock of 470,000 trochus was made in 1979. Previous surveys in 1965 and 1974 contain length-frequency information, but no estimates of standing stock. The 1979 figure was obtained using standard belt transects (Tuara, 1991a). The stocks appear to have recovered from initial overfishing in 1989-81 and 1984 harvests to the most recent estimates after the 1992 harvest (Table 19). The most recent trochus survey at Aitutaki in June/July 1993 provided an estimate of total trochus population of 117,784. This approximates to a density of 253 trochus per hectare with 22.6 per cent of the stock in the 8-11cm size range. (Cook Islands Ministry of Marine Resources). Marurai and Bertram (1993) provide an estimate of the total population of trochus at Rarotonga of 154,735, with an upper confidence limit of 242,426 and a lower limit of 109,106.

Up until the 1992 harvest, two survey techniques were used in stock assessment. The first technique is the free-swimming search used for the pre and post 1983/84 harvests in the zones of most intense harvesting. Results were expressed as number of trochus observed per diver hour which was translated into trochus density. For several reasons, the use of this method was later discontinued (Sims in Tuara, 1991a). The second technique is the belt transect used in later pre and post surveys. A transect line is laid perpendicular to the reef front across the entire reef shelf at 12 stations around the island. The transect is divided into 10m lengths and the number of trochus 2m either side of the transect line are recorded. Stock assessment has provided figures for stock numbers, density distribution, size-class distribution and the impacts of harvests and natural disasters such as cyclone damage on stock (Tuara, 1991a).

For the 1992 harvest, a case study on the Aitutaki trochus fishery was undertaken by the SPC's Inshore Fisheries Research Project (IFRP) in collaboration with the Ministry of Marine Resources, Aitutaki Island Council and several regional researchers. The study attempted to use 3 methods; strip transects, mark-recapture and change-in-ratio, to estimate trochus abundance on Aitutaki reef. It was found that each of these methods had clear advantages and disadvantages, the choice being between the much more accurate mark-recapture method and the previously used transect methods. A combination of these methods may prove the most suitable choice, based on local circumstances (Adams *et al.*, in press).

6.12.4 Management

Current Legislation/Policy regarding exploitation: The 2 statutes that apply to the fishery are the Marine Resources Act 1989 and the Aitutaki Fisheries Protection By-Laws 1990. The fishery is currently managed under a system which has evolved between the Ministry of Marine Resources and the Aitutaki Island Council by drawing on examples from other trochus fisheries. Size regulations of between 8-11cm basal diameter are applied. There is a requirement that all harvested trochus be kept alive until approved by an inspector. Licensing of divers is a requirement under current law. A

breeding reserve is in force over a 3km stretch of the windward reef of Aitutaki (Sims in Tuara, 1991a). The harvesting season is very limited in duration. The total absolute catch of trochus is limited by means of a quota set at 60 per cent of the assessed standing stock of 8-11cm shells, normally around 30 per cent. of the total stock In the 1990 harvest an individual transferrable quota system was introduced (Tuara, 1991a).

Recommended Legislation/Policy Regarding Exploitation: Based on the 1992 trochus case study, an Aitutaki Trochus Management Plan has been drafted (Tuara and Adams, in press) which incorporates many of the management tools currently in use for the fishery. Development of this draft Management Plan is continuing.

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6.13 BLACK-LIP PEARL OYSTER [**Parau**]

6.13.1 The Resource

Species Present: The black-lip pearl oyster [**Parau**] (*Pinctada margaritifera*) and the smaller "pipi" pearl oyster (*P. maculata*). The gold-lip pearl oyster (*P. maxima*) is not found in Cook Islands (Sims, 1988a), despite being transferred from Australia to Suwarrow lagoon in the early 1900's by Lever Brothers Ltd., in an attempt to start pearl shell culture.

Distribution: The black-lip pearl oyster ranges from Baja California to the eastern Mediterranean Sea (Sims, 1993). It is distributed throughout the tropical Indo-Pacific, reaching its greatest abundance in the lagoons of the Tuamotu Archipelago of French Polynesia and the northern group of Cook Islands. Mature black-lip pearl oysters have been found only rarely on Rarotonga and Aitutaki though spatfalls of this species have been recorded from the southern group.

Black-lip pearl oysters are not found naturally on Pukapuka and Rakahanga but specimens introduced from Manihiki to these atolls have grown well. No significant spatfalls have resulted from these introductions (Sims, 1988a), although some spat were observed in Pukapuka lagoon in 1989 (Kelvin Passfield, pers.comm.).

Biology And Ecology: *P. margaritifera* occurs in lagoons, bays and sheltered reef areas to around 40m depth, but is most abundant just below low-water. Strong byssal threads attach the oyster to rocks or other oysters.

Pearl oysters are non-selective filter-feeders. High turbidities may exclude *P. margaritifera* from closed lagoons or from areas of heavy terrestrial run-off, while strong currents promote faster shell growth. Temperature limits the black-lip pearl oyster to warmer tropical regions. Lagoon water quality influences sizes, growth rates, shell quality and shell colour (Sims, 1993).

P. margaritifera generally reach maturity at 2 years of age. Initially, the majority are males, but protandric sex changes usually result in an even sex ratio by the fourth or fifth year. Temperature is the main influence on sexual development and spawning patterns. Spawning is usually not limited to distinct seasons and protracted spawnings may occur throughout the year. *P. margaritifera* usually exhibits 2 periods of maximum spawning in Cook Islands, from August-September and the following February-March (Sims 1988a, 1993).

The planktonic larval stage in *P. margaritifera* may extend to 4 weeks. The larvae are obligate planktotrophs after one or two days and have relatively narrow physiological tolerances. Larvae settle out onto suitable available substrate but retain some motility before beginning to secrete byssal threads.

Age-fecundity patterns, density-dependant effects and larval and juvenile survival rates are not well understood. Larval drift patterns are difficult to predict and wind-driven eddies may cause highly patchy spat-falls in enclosed lagoons. Spat collector records and observations of wild stocks suggest that recruitment fluctuates from year to year (Sims, 1993).

Growth rates vary markedly between individuals and between locations. Representative von Bertalanffy parameters are around K= 0.52 and L_∞ = 155mm for cultured *P. margaritifera.* The rapid

initial growth results in shell diameters of between 100-120mm after 2 years. Subsequent growth consists mainly of increasing shell thickness, with the oyster continuing to secrete nacre (the pearl material) throughout its life (Sims, 1993).

Pearl oysters suffer greatest mortalities as larvae and immediately after settlement. Predation in the plankton is high and many spat are carried by currents away from suitable benthic habitats. Juvenile predation produces skewed or bimodal size-frequencies. Predation by fish, octopii and gastropods is the main cause of the annual natural mortality rate (M) in adults. Recent estimates of M for *P. margaritifera* range from 0.1 to 0.2. Shell borers include sponges, bivalves and polychaetes. Older oysters are more prone to borer attack, but regular shell cleaning can reduce the problem on farms (Sims, 1993).

6.13.2 The Fishery

Utilisation: Natural pearls are rarely found in *P. margaritifera* and the fisheries are based on the value of the Mother-of-Pearl or pearl-shell itself which is used in the manafacture of buttons, in-lay and other jewellery work. Black pearls are produced naturally only from the black-lip pearl oyster and because of their rarity and colouration, attract top prices. Cultured black pearls are also much sought-after and half-pearls or "blister pearls" are marketed for use in pendants, brooches and rings. The meat of pearl-oyster adductor muscle [**korori**] has excellent flavour and texture. It is occasionally eaten in the northern group of Cook Islands (Sims, 1988a).

The pearl-shell diving fisheries of Penrhyn and Manihiki lagoons are conducted solely by free diving. Hard-hat and hookah equipment have been used in the past but their use is currently proscribed. Free divers using shot-lines frequently work in depths from 20-30m with some divers working as deep as 40m for short periods. Several divers may work from a single boat with one or two partners to pull up the shot-line and diver after each drop. Alternatively, divers may work independently from floating baskets, each with their own shot-line. Usually, all larger (> 10cm shell diameter) black-lip pearl shells are taken, but only those above the legal size limit are killed, cleaned and sold (Sims, 1988a).

Commercial scale pearl farming is currently only undertaken in Manihiki, although interest has been expressed in Penrhyn and Suwarrow as possible sites. A pilot-scale pearl farm has been established in Rakahanga, though its viability is yet to be proven.

The culture techniques employed are based on those developed in the French Polynesian pearl culture industry, where pearl oysters are drilled and suspended from platforms, rafts or lines. Oysters for culture are collected from either natural stocks, or from spat-collectors of local hardwood or manafactured materials strung on sub-surface lines. Pearl-grafting operations commence on oysters from about 2 years of age onwards. Pearls are produced after 18-24 months incubation and oysters can be re-seeded at the same time that earlier implantations are harvested. Significant percentages of pearl nuclei are rejected from the oyster and mortalities appear to be inevitable. Depending on the expertise of the operating technician, up to 30-40 percent of seeded oysters may eventually produce good quality pearls (Sims, 1988). The cost of seeding is currently NZ$12.00 per shell (Ned Howard, Fisheries Project Implementation Officer, pers.comm.).

Pearl culture began at Manihiki in 1973 with both round and half-pearls being produced. By 1988, there were over 40 local farms at Manihiki which increased to 97 farms in 1990 (Sims, 1991).

Production And Marketing: The pearl shell from Manihiki and Penrhyn is almost all shipped overseas in its unprocessed state. Small quantities are purchased by a Rarotongan handicrafts firm and used in the production of souvenirs which are sold locally to tourists. Other local companies specialise in the trading of natural and cultured pearls (Sims, 1988a).

Reliable production figures are only available for the post-WWII period when Manihiki was the predominant producer. In 1951, 380mt of shell were shipped from Manihiki with no less than 270mt produced in any one year over the six year period from 1949 to 1955. The fishery suffered a classic, catastrophic collapse in the years following and has never approached these levels since.

Pearl shell exports for 1990 were down by approximately 50 per cent. from 1989, primarily because most live pearl shells harvested were sold to pearl culture farms (Anon., 1991b). Pearl shell prices peaked in 1989 at approximately US$8,000 per tonne FOB, but have since dropped to about half that figure (Sims, 1991). In 1991, 21.7mt of pearl shells worth NZ$232,244 were exported to Japan and Germany while in 1992, 36.1mt of shells worth NZ$490,000 were exported to Japan and the Philippines (Anon., 1992b).

The first harvest of round pearls from locally owned farms took place in Manihiki in September 1989. A total of 3,000 pearls to the value of approximately NZ$200,000 from 10,000 seeded oysters were harvested. The quantity of pearls was too low to attract a large number of international buyers. After several low offers were received, the Australian consultant who arranged for the technicians bought the lot for sale through his own outlets (Anon., 1989b).

The first annual pearl auction was held in October 1990 when approximately 6,000 pearls were sold for NZ$1.3 million. This was distributed on a 60/40 basis, with 60 per cent. being shared by 24 Manihikan pearl farmers and 40 per cent. being for the company, "Cook Islands Pearls" for providing the seeding. The auction attracted 4 international buyers with 2 local buyers also participating. The second annual pearl auction was conducted in June 1991. Over 50 international buyers attended the sale of approximately 39,000 pearls which brought in around NZ$3 million. This was the first auction of sufficient size to attract a large number of overseas buyers. Of the 54 lots put up for auction, 34 were sold for prices over the reserve. The remaining 20 were passed in,as they did not reach the reserve price. These were later sold by negotiation (Anon., 1991b). There was no auction in 1992.

6.13.3 Stock Status

Wild pearl oyster populations in Manihiki, Penrhyn and Rakahanga lagoons are far below their optimum standing stock levels. At Suwarrow, stocks appear to be only marginally self-sustaining and have apparently been fished to densities so low that stock recovery is being limited by factors such as predation by fish and octopii (Sims, 1988a). Sims (1991) found that Manihiki stocks had been continually fished from 1982 to May 1991. Over these 10 years, a gradual decline in pearl oyster abundance was noted. Surveys indicated that the stock declined from 1987 to 1988 by 18 per cent per year, with a drop in average densities from 5.6 to 4.6 oysters per 100m².

A density of only 2.9 oysters per 100m² was found during a 1991 re-survey of the same permanent transects in Manihiki Lagoon. Stocks overall have therefore decreased by a further 38 per cent since 1988. Approximately 54 per cent of adults present in 1988 had been removed by fishing and a further 8 per cent. had apparently died due to natural causes. There was a significant spatfall (> 5 per 100m²) at one site or over 100 per cent. of the 1988 stock. However, most recruits were probably quickly removed by divers. Sims (1991) believes that these results confirm the critical state of the wild stock.

The current farmed stock has recently been estimated at 521,000 (> 10.16cm in shell diameter), with another 108,000 undersized shells (approaching 10.16cm) and an unknown number of spat (Tuara, 1991b).

6.13.4 Management

Current Legislation/Policy Regarding Exploitation: The management of the Cook Islands pearl culture industry has developed in an ad-hoc fashion. In 1982, jurisdiction over the pearl industry passed to the Island Council on each island through, "The Pearl and Pearl-shell (Penrhyn, Rakahanga and Manihiki) Act, 1982. In December 1989, the Marine Resources Act 1989 was passed which provides for administration of "designated fisheries" through consultation between Island Councils and the Ministry of Marine Resources, under the framework of an agreed management plan. In early 1991, the Manihiki Island Council declared the lagoon closed to diving for pearl shell.

Draft versions of a Pearl Oyster Management Plan were produced as early as 1988. However, Sims (1991) believes that the early drafts were handicapped by the lack of involvement of the pearl-shell divers, pearl farmers and Island Councils in their formulation.

As part of a consultancy carried out in 1991, Sims (1991) reviewed and updated the earlier draft Plan. A translator was identified to translate the Plan into Cook Islands Maori for distribution to Manihikian farmers prior to a Round Table meeting on the Plan. One of the two outstanding management issues identified by Sims (1991), that of the formal "designation" of the pearl-shell fishery under the Marine Resources Act (1989), was accomplished in August 1991. With the designation of the fishery, Island Council By-Laws and government regulations could come into effect.

The United States Agency for International Development (USAID) is assisting the government in the construction of a black pearl farming research and training facility at Penrhyn. The project has experienced recent delays due to the decision to relocate the project from Suwarrow to Penrhyn, and difficulties in obtaining a lease on Penrhyn for construction of shore-based facilities. These difficulties have now been overcome. In addition to the construction of the facility, USAID is providing technical assistance in the form of a comprehensive programme of logically sequenced complementary activities, which will facilitate expansion of the pearl culture industry for economic improvement in the northern Cook Islands. The main components of this assistance will include:

- Establishment of Pearl Culture Training and Research Facility.
- Improvement of culture technology and stock management of pearl oysters through research and assessment.
- Development of viable marketing strategies for the pearl industry.
- Training and extension for pearl culture development

Recommended Legislation/Policy Regarding Exploitation: Sims (1991) states that 2 basic guidelines for management are repeatedly emphasised in the various reports provided to government and the Manihiki Island Council:

- A lagoon-wide limit to the number of farmed pearl oysters is essential.

- Sound farm management practices governing spacing and cleaning of oysters need to be stablished and adhered to.

He states that ratification and implementation of the Management Plan are essential for the sustainable management of the pearl-shell fishery. The outstanding aspects of the Plan are listed in Sims (1991), many of which are incorporated in a recent draft Plan (Anon, 1992e).

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6.14 GIANT CLAMS [Pa'ua

6.14.1 The Resource

Species Present: The rugose giant clam (*Tridacna maxima*) and the fluted giant clam (*T. squamosa*) occur naturally. The smooth giant clam (*T.derasa*) was recently introduced from the Micronesian

Mariculture Demonstration Centre (MMDC), Palau (Lewis, 1987). These specimens have now reached sexual maturity. In June 1991, 20,000 Giant clam (*T. gigas*) and 50,000 horse's hoof clam (*H. hippopus*) juveniles were imported from James Cook University of North Queensland, Australia and quarantined in the hatchery/nursery at Aitutaki. There are now 5 tridacnid species at Aitutaki: *T. maxima* which is abundant in much of the lagoon despite heavy fishing pressure, *T. squamosa* which is uncommon and the 3 introduced species above (Anon., 1992f).

Distribution: *T. maxima* is the most widely distributed species of giant clams, with a geographic range extending from the Red Sea to the Tuamotus in French Polynesia. The geographic range of *T. squamosa* extends from the western Indian Ocean to Polynesia (Lucas, 1988). The natural range of *T. derasa* does not extend east of Palau in the northern tropical Pacific, but in southern waters extends as far east as Tonga (Munro, 1993).

In Cook Islands, *T. maxima* is abundant in the lagoons of the larger atoll islands but less common on smaller atolls such as Pukapuka and Rakahanga, and on the more populated high islands in the Southern Group. *T. squamosa* is present but not abundant. Its distribution is generally limited to depths greater than 10m, which is probably due to higher fishing pressure in shallower waters. *T. derasa* is only found at Aitutaki, where juvenile specimens were air-freighted from Palau in 1986. This represented the first introduction of *T.derasa* beyond its natural range in Polynesia (Sims and Howard, 1988).

Biology And Ecology: *T. squamosa* seems to favour fairly sheltered lagoon environments adjacent to high islands, but in the closed atoll lagoons of Polynesia appears to be excluded by *T. maxima*. *T. derasa* appears to be characterized by preferentially inhabiting clear offshore or oceanic waters away from high islands with significant run-off of fresh water. All species are depth-limited by their symbiotic algae (Munro, 1993).

Giant clams are facultative phototrophs, being essentially planktotrophic but able to derive all of the maintenance requirements from their symbiotic algae. However, it is likely that they will attain their optimal growth when their nutrition is supplemented by phytoplankton or dissolved organic matter extracted from sea water (Munro, 1993).

All giant clams are protandrous hermaphrodites, becoming simultaneous hermaphrodites in later years (Munro, 1993). *T. maxima* appear to mature as males at around 6cm, with 50 per cent of individuals fully mature (male and female) at 10-11cm and 100 per cent fully mature at 14cm and above (Lewis, 1988). During spawning of fully mature clams, sperm are released first, followed by eggs some hours later. Clams are highly fecund, with millions of eggs being released. Settlement of the planktonic larvae occurs approximately 11 days after fertilisation, metamorphosis shortly after and shell formation after 50 days (Lewis, 1987). In the central tropics there is no evidence of any seasonality in reproduction (Munro, 1993). Spawning can be readily induced, making *T. maxima* and other tridacnid species amenable to culture (Lewis, 1987).

Lewis (1987) states that as the growth of *T. maxima* in other areas of its range is relatively slow, this can be assumed to be the case for Aitutaki giant clam. Though not confirmed for *T. maxima* from Cook Islands, it can be assumed they take 5 years to reach 10cm in length (when 50 per cent are fully mature), 8-10 years to reach 15cm and 15-20 years to reach 20cm. Sims and Howard (1988) provide information on the growth rate of *T. derasa* at Aitutaki, which was only slightly less than that reported elsewhere.

Munro (1993) states that information on mortality rates in the early juvenile stages is very sparse owing to the extreme difficulty in finding specimens of wild juveniles. Mortality after adult size (10cm) is reached is assumed to be very low, the thick shell and partial embedment conferring considerable protection. Estimated annual survival rates for adult *T. maxima* are 81 per cent in an unexploited population and 75-78 per cent in an exploited population (Lewis, 1987).

Judging by the rarity of juveniles in most populations, it is likely that recruitment is very erratic and limited. Giant clams are highly vulnerable to stock depletion which will result in a collapse in the fertilization rates and consequent reduction in recruitment rates. If a reef is denuded of clams, repopulation will depend entirely on planktonic larvae brought in from other reefs by prevailing currents. If the reef is isolated or the current direction unfavourable, the re-establishment of a stock could take hundreds of years (Munro, 1993).

6.14.2 The Fishery

Utilisation: Giant clams are harvested for subsistence purposes throughout Cook Islands. At Aitutaki they are taken almost exclusively for their meat, the heavy shell not being utilised. Meat weight varies between 12-20 per cent of total weight, the percentage decreasing with increasing size (Lewis, 1987). At Palmerston, *T. maxima* forms the basis of a small commercial fishery, the less common *T. squamosa* not being commercially exploited (Anon., in press).

Lewis (1987) states that at Aitutaki, a simple tool [**ranga**] is used in the harvest of giant clams. It is a sharpened piece of reinforcing steel which is inserted into the clam and twisted as the clam clamps shut. The attached byssal threads are thus broken and the clam is lifted out of the coral. The meat is quickly cut out after severing the adductor muscle through the wide byssal opening and removing the kidney. At Palmerston, a sharp knife is thrust around one side of the shell, detaching the adductor muscle. The meat is then lifted to expose the byssus, which is severed (Anon., in press).

Giant clams are collected by walking the reef flat or diving. Selection for larger clams during harvest is practised to some extent although the taste of smaller clams is preferred for personal consumption. Most clams harvested at Aitutaki are in the 10-15cm range (Lewis, 1987).

Production And Marketing: It is reported that people from Manihiki send salted giant clam meat to friends and relatives in Rarotonga (UNEP/IUCN, 1988) and it is assumed that a similar practise exists on other Northern Group islands. At Aitutaki and Palmerston, clam meat is usually sold fresh or frozen. The subsistence giant clam take on Palmerston in 1988 was estimated at 20kg per month (Anon., in press). Lewis (1987) estimated that the 1978/79 giant clam harvest figure for Aitutaki was at least 100-135mt per year.

Apart from subsistence consumption, there is an internal export trade to Rarotonga. In 1988, quantities of between 20-50kg per month were shipped from Palmerston to Rarotonga with infrequent shipments of 100kg (Anon., in press). In 1992 there were two shipments of 357 and 200kg of frozen giant clam meat respectively from Palmerston to Rarotonga and a shipment of 100kg in early 1993. Current retail prices for frozen giant clam meat in Rarotonga are approximately NZ$11.00 per kg, more than double the 1988 price (Bill Marsters, Fisheries Officer, pers.comm.). This may indicate a shortage of supply of giant clam meat on Rarotonga, caused by the ban on giant clam exports from Aitutaki (Kelvin Passfield, pers. comm.).

6.14.3 Stock Status

Following surveys of *T. maxima* on 4 atolls in Cook Islands, Sims and Howard (1988) state that stocks of this species are relatively abundant on most of the atoll islands, though heavy fishing pressure limits stocks on the smaller atolls and high islands of the southern group. *T. squamosa* is found only rarely on the outer reef slopes of Rarotonga and Aitutaki. The introduced *T. derasa* suffered severe mortalities from the predator gastropod *Cymatium muricinum*, but the introduction has been initially successful. The approximate population of introduced *H. hippopus* and *T. gigas* is 4,000. Juveniles are being held in cages in the lagoon and the larger clams are on the sea-bed (Jamie Whitford, Fisheries Biologist, pers.comm.).

6.14.4 Management

Current Legislation/Policy Regarding Exploitation: The Aitutaki Fisheries Protection By-Laws 1990 prohibit the taking and selling of giant clams at Aitutaki and provide for the issue of permits by the Island Council to issue permits for the taking of giant clams greater than 75mm long at a rate of 20 clams per day. Similar By-Laws for Rarotonga are under consideration.

A giant clam hatchery and quarantine facility built with financial assistance from the Australian Centre for International Agricultural Research (ACIAR) on virgin coastal land on Aitutaki Atoll in 1990, commenced regular operations in July 1991. The facilities of the Araura Marine Research Station consist of tanks and plumbing, machine house, hatchery building and storage shed. Munro (1992) states that the objectives in establishing the facility are to:

- produce enough indigenous and/or exotic seed giant clams to allow the enhancement of natural tocks and the establishment of new stocks on Cook Islands' reefs.
- ensure that imported brood stock from other countries are free of any disease or parasites.
- create new areas of economic gain
- further research in spawning, larval culture, juvenile culture and adult grow-out of giant clams
- explore the possibility of culturing other commercial mollusc resources

The hatchery/nursery has no external power or water supplies, which is continuing to cause major problems. It is currently non-operational. Numerous hurricanes since the establishment of the facility have also caused major set-backs, including loss of juvenile clams from successful spawnings (Kelvin Passfield, pers. comm.).

Recommended Legislation/Policy Regarding Exploitation: Management guidelines for Aitutaki recommended by Lewis (1988), namely imposition of a legal minimum size and rotational closure of harvest areas along the lagoon have in part been addressed in current legislation (above). These measures have also been recommended for Palmerston (Anon., in press).

Sims and Howard (1988) recommend the establishment of permanent breeding reserves for *T. maxima* on each island, to ensure continuing, self-sustaining recruitment. They further recommended a system of permanent reserves and /or artificially aggregated broodstock for *T. derasa*.

UNEP/IUCN (1988) state that due to declining stocks of *T. maxima* on Pukapuka, conservation measures should be instituted. Anon.(in press) recommends the identification and consideration of management options for the giant clam fishery at Palmerston.

Because giant clam species other than *T. maxima* present the greatest potential for development of clam fisheries, Anon., (in press) recommended a reef seeding programme using introduced *T. gigas*, *T. derasa* or *T. squamosa* juveniles. This could eventually result in significant populations of these more valuable species becoming established. For this to proceed, the hatchery/nursery facility at Aitutaki will have to be made operational again as soon as possible.

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6.15 OTHER EDIBLE MOLLUSCS

6.15.1 The Resource

Species Present: There are several species of gastropods, including the rough turban snail [**Ariri**] (*Turbo setosus*), turban shell [**Karikao**] (*Astraea rhodostoma*)and star limpet [**Mapi'i**] (*Acmaea* sp.). There are also bivalves such as the large Pacific jewel-box shell [**Pa'uakute**] (*Chama pacifica*), Pacific asaphis [**Ka'i**] (*Asaphis violescens*), burrowing clam (*Arca* sp.) and smaller mussels [**Kakuku**] (*Modiolus* sp.). Also found are octopus [**Eke**] (*Octopus* sp.).

Distribution: The only species of its genus in the Pacific, *A. violescens* ranges from East Africa to the Tuamotu-Gambier Islands (Paulay, 1987). In Cook Islands, it has been noted at Aitutaki by Glude (1972) and Paulay (1987), Rarotonga by Passfield and Zoutendyk (1989), Palmerston by Anon. (in press) and Mangaia by Clerk (1981). Paulay (1987) notes that it is least common on the **makatea** islands, presumably due to the rarity of low intertidal mobile sediments on these islands.

Paulay (1987) states that *C. pacifica* is known to occur from Australia and Borneo in the west to the Tuamotu Islands in the east. It has been noted at Aitutaki by Glude (1972) and Paulay (1987), Mangaia by Clerk (1981) and Manihiki by Paulay (1987).

Astraea sp. is noted on Rarotonga by Glude (1972) and *Astraea rhodostoma* on Mangaia by Clerk (1981). *Arca* sp. is noted on Aitutaki by Glude (1972). *Acmaea* sp. is noted on Palmerston by Anon. (in press) and on Mangaia by Clerk (1981).

T. setosus is noted on Rarotonga by Glude (1972) and Passfield and Zoutendyk (1989) on Aitutaki by UNEP/IUCN (1988) and on Mangaia by Clerk (1981). *Octopus* sp. is recorded on Palmerston by Anon. (in press) and Mangaia by Clerk (1981). *Modiolus* sp. is stated to be present on Mangaia (Clerk 1981) and Palmerston (Anon., in press).

Biology and Ecology: Many of these species are found in the lagoon, on the reef ridge and some in deeper waters. Paulay (1987) states that *C. pacifica*, a cemented sessile heterodont, appears to be restricted to larger lagoonal habitats, while *A. violescens* is a deeply burrowing, shallow water, mostly intertidal species. At Palmerston, these species occur in approximately 5-20cm of damp sand beneath coral slabs, along the seaward reef flat (Anon., in press) while at Aitutaki, *A. violescens* is found in poorly sorted rubbly sediments around the south and eastern side **motus** (Paulay, 1987).

T. setosus are found on reef edges and reef flats, especially in small holes and cracks, apparently preferring an active surf area while *Acmaea* sp. and *Modiolus* sp. are found on beach rocks on the reef flat at Palmerston (Anon., in press). *Octopus* sp. occupy rock holes on the reef flat at Mangaia (Clerk, 1981) and Palmerston (Anon., in press).

6.15.2 The Fishery

Utilisation: Paulay (1987) states that *A. violescens* is the basis for minor subsistence fisheries on Rarotonga and Aitutaki at least. This is confirmed for Aitutaki, where it has been recently reported that there there is heavy subsistence food use of *T. setosus* and *C. pacifica* (Jamie Whitford, Fisheries Biologist, pers.comm.). Sims, *et al.*,1988 list *C. pacifica, T. setosus, A. violescens* and *Octopus* sp. as seafoods of Cook Islands. *Octopus* sp., *A. violescens, T. setosus* and *Acmaea* sp. are reported by Anon., (in press) to support subsistence fisheries on Palmerston. Clerk (1981) reports the subsistence food use by Mangaians of many of these molluscs.

On Palmerston, octopus holes are often identified by shell litter at the opening. Spears and sticks are used mainly by women and children to evict octopus from their holes at low tide. Octopus are possibly the most valued subsistence item taken by reef gleaning. They have never been sold commercially out of Palmerston but some are occasionally sent to family and friends in Rarotonga (Anon., in press).

Women and children on Palmerston usually collect *A. violescens* by digging in the sand with their hands or using rocks or scrapers made from giant clam shells or coconut shells. Specimens of between

4-5cm in length are taken, collecting occurring throughout the year on low tides. *A. violescens* are exclusively a subsistence food and are not sold commercially (Anon., in press).

T. setosus are collected by hand at low tide on Palmerston. They are mainly used for local consumption but some are sent to family and friends on Rarotonga. There is no commercial export of this species from Palmerston at present (Anon., in press).

Anon. (in press) reports that on Palmerston, *Acmaea* sp. are collected at low tide by prying the animals off the reef with a knife. They are eaten fresh, or used to prepare a local dish called **mitiore**. *Acmaea* sp. are not sold commercially.

Production And Marketing: There is very little information available on the production and marketing for any of the species listed. Anon., (in press) reports that in the 1960's and 1970's, *T. setosus* retailed on Rarotonga for approximately NZ$1.50 per kg.

6.15.3 Stock Status

In 1981 it was reported by Aitutaki people that populations of *T. setosus* had declined, perhaps as a result of the proliferation of the introduced trochus (UNEP/IUCN, 1988). Such declines, if indeed they occurred, appear to have halted. On Palmerston, Anon. (in press) reports that recorded densities of *T. setosus* range between 2 to 20 animals per 20m of reef front, with actual numbers being possibly twice this number. There is no information on the status of octopus stocks.

6.15.4 Management

Current Legislation/Policy Regarding Exploitation: The Aitutaki Fisheries Protection By-Laws 1990 provide limits on the size and daily number of *A. violescens* and *T. setosus* for which permits may be issued. For *A. violescens*, the minimum size limit is 50mm and a daily bag limit of 20. For *T. setosus*, the minimum size limit is such that, "...the **Ariri** in its complete shell cannot pass through a metal ring the inner diameter of which is 38mm". The daily bag limit for this species is 20.

Recommended Legislation/Policy Regarding Exploitation: Exploitation guidelines similar to those applied at Aitutaki may be required in other areas of heavy subsistence exploitation. Culture of some of these species for stock enhancement should be investigated as a potential management option. Selected mollusc species may be suitable for commercial aquaculture.

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